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EROSION AND SEDIMENT CONTROL AUDIOVISUAL TRAINING PROGRAM

WORKBOOK

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EROSION AND SEDIMENT CONTROL AUDIOVISUAL TRAINING

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and

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EROSION AND SEDIMENT CONTROL

THE GOAL, OBJECTIVES AND PRINCIPLES OF EROSION AND SEDIMENT CONTROL

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I. INTRODUCTION

A. Definitions

1. Erosion - the process by which the land surface is worn away by the action of wind, water, ice or gravity.
2. Sediment - soils or other surfical materials transported or deposited by the action of wind, water, ice or gravity as a product of erosion.
3. Waterway - any natural or artificial drainage way in which waters flow in a definite direction or course, either continuously or intermittently, and includes any area adjacent thereto which is subject to flooding.

B. Background

The problem of erosion and sediment control has plagued society and land and water resources since colonial times. Many streams and rivers were severely damaged by early agricultural activities.

The early 1930's saw the start of a nationwide soil conservation movement which has greatly reduced the agricultural erosion problem.

The application of a typical farm conservation plan can reduce soil loss from fifteen tons /acre/ year or greater to only five tons/acre/year.

In recent years, however, the problem of erosion and sediment has again been increased. This time by the trend of greater urbanization. Modern equipment and technology have been used to create vast networks of highways, sprawling subdivisions, large industrial parks, and massive shopping centers. In many cases these activities have resulted in severe damage to our land and water resources.

It is estimated that from all sources over four billion tons of sediment pollute the rivers of this country each year.

In 1972 it cost $2.00 to $3.00 per cubic yard to remove sediment from waterways.

In summary, erosion and sediment damages affect nearly every citizen. Sediment pollution results in:

1. clogged ditches, culverts, and storm sewers.

2. Muddied streams, reduced channel capacities, and increased flood flows.
3. Damaged plant and animal life.
4. Filled-in ponds, lakes, and reservoirs.
5. Damaged vital aquatic habitats.

II. THE GOAL OF EROSION AND SEDIMENT CONTROL

"To achieve effective and reasonable control over erosion and sediment caused by man's activities using the best practical combination of procedures, practices, and people."

A. Achieving effective and reasonable control.

As responsible persons we should try to achieve the greatest control without putting unreasonable demands on the other activities of the construction project.

B. Caused by man's activities.

We are talking about working with people, and how they affect the quality of their natural surroundings - land, air, water, and plant and animal life. Certain of man's activities must be controlled.

C. Using the best practical combination of procedures, practices, and people.

To control erosion and sediment we need workable laws, regulations, and procedures; up-to-date practices and techniques; and responsible people working together.

III. <u>THE OBJECTIVES OF EROSION AND SEDIMENT CONTROL</u>

A. Protect vital land resources from erosion

   1. control erosion at its source

   2. maximum practical extent - reasonable control

B. Establish a sediment control program

   1. cooperation and involvement

   2. prevention

   3. flexibility

C. Protect vital water resources and aquatic wildlife from sediment pollution

   1. prevent damage from occuring

   2. damaged resources are difficult to restore

D. Provide high quality water for human use

   1. vital to man's welfare in the long run

IV. THE PRINCIPLES OF EROSION AND SEDIMENT CONTROL

A. Plan the development to fit the particular topography, soils, waterways, and natural vegetation at a site.

1. "Think ahead and don't fight nature"
2. Less problems and damage occur when structures and grading are designed to fit the site
3. Careful planning can result in both reduced damage and savings in project costs

B. Expose the smallest practical area of land for the shortest possible time.

1. The way in which operations are scheduled and staged can greatly reduce damage due to erosion and sediment
2. Sediment control is another part of the coordination of a job.

C. Apply "soil erosion" control practices as a first line of defense against on-site damage.

1. Use practices that control erosion on a site to prevent excessive sediment from being produced
2. Examples of erosion control:

a. special grading methods

b. runoff control structures

c. temporary and permanent vegetation

d. mulches

D. Apply "sediment control" practices as a perimeter protection to prevent off-site damage.

1. Use practices that control sediment once it is produced, and prevent it from getting off-site.

2. Examples of sediment control:

a. sediment traps

b. vegetative filters

c. sediment basins

E. Implement a thorough maintenance and follow-up operation.

1. A site cannot be effectively controlled without thorough, periodic checks of erosion and sediment control practices.

2. An example of applying *this principle* would be a routine "end-of-day" check to be sure all control practices are working properly.

QUESTIONS 1

Fill in the answers

1. ____________________ is the process by which the land surface is worn away by the action of wind, water, ice or gravity.

2. A flowing stream and a storm drain ditch entering it are two examples of __________________.

3. Application of a typical farm conservation plan can result in a reduction of soil loss from ______/tons/acre/ year to only ______/tons/acre/year.

4. It is estimated that areas undergoing construction produce as much as ______________ times as much sediment excellent forested areas.

5. The problem of erosion and sediment has been increased recently by ________________.

QUESTIONS 2

True or False

_____ 1. One can expect to achieve 100% control over erosion and sediment all the time.

_____ 2. Given experience and a sincere attitude, you can do an effective and reasonable job of protecting the land and water resources.

_____ 3. Certain of man's activities when carried to extremes cause severe damage.

_____ 4. When we are talking about the job of erosion and sediment control we are really talking about controlling nature.

_____ 5. "On-the-ground" field personnel are not very important in erosion and sediment control.

_____ 6. "To achieve effective and reasonable control over erosion and sediment caused by man's activities using the best practical combination of procedures, practices and people" is the goal of erosion and sediment control.

QUESTIONS 3

REVIEW QUESTIONS

Multiple Choice
(circle the correct answer)

1. To establish a sediment control program we need

   a. cooperation and involvement
   b. prevention
   c. flexibility
   d. all the above

2. In order to best protect vital land resources we should

   a. stop sediment
   b. control erosion
   c. prevent construction

3. In our third objective, we want to protect the water by

   a. controlling sediment that gets past our first line of defense
   b. preventing erosion
   c. fluoridation

4. The human use of water is listed after the protection of the land and water because

   a. land and water are more important
   b. land and water are vital to man's welfare in the long run
   c. all of the above

QUESTIONS 4

Fill in the blanks

1. Less damage and problems occur when structures and grading are __________ to fit the site.
2. Careful ___________ can result in both reduced damage and savings in project costs.
3. Sediment ____________ is another part of coordination of a job.
4. Special grading methods and runoff control structures are examples of ___________ control.
5. Examples of _________ control are sediment traps, vegetative filters and _____________ _____________.
6. An example of the fifth principle of erosion and sediment control would be to start a routine "___________ of ___________" check to be sure all control practices are working properly.

POST TEST

1. The process by which the land surface is worn away by the action of wind, water, ice or gravity is known as:

   a. sedimentation
   b. pollution
   c. weathering
   d. erosion

2. A flowing stream and a drainage ditch are examples of

   ________________.

3. A typical farm conservation plan can reduce soil loss from 15 tons per acre per year to only ___ tons per acre per year.

4. It is estimated that from all sources, the amount of sediment that pollutes rivers in this country each year is:

   a. one (1) ton
   b. one (1) million tons
   c. five (5) billion tons
   d. four (4) billion tons

5. The problem of erosion and sediment control has increased due to:

   a. pollution
   b. urbanization
   c. diversification
   d. more leisure time

6. Sediment pollution results in:

   a. clogged ditches
   b. damaged plant and animal life
   c. filled-in ponds, lakes, and reservoirs
   d. a and b
   e. all of the above.

7. Those people considered very important in any erosion and sediment control program are:

   a. field personel
   b. scientists
   c. draftsmen

8. When talking about the job of erosion and sediment control we are really talking about:

    a. controlling wildlife
    b. working with people
    c. controlling technology

9. The three elements needed to establish a sediment control program are cooperation and involvement, prevention and ______________.

10. The best way to protect vital land resources is by establishing a ______________ control program.

11. Careful planning can result in:

    a. reduced damage
    b. savings
    c. a & b

12. An example of erosion control:

    a. gravel inlet filter
    b. runoff control structure
    c. sediment trap

13. A site cannot be effectively controlled without thorough, periodic checks of __________ and __________________ control practices.

EROSION AND SEDIMENT CONTROL

SOILS

WORKBOOK

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I SOIL FORMATION

A. The solid rock lying beneath the soil is called "bedrock." It is made up of a variety of types of rock, including sandstone, limestone, granite, shale, marble, schist, and slate. The depth to the bedrock varies; in some cases it even extends above the surface, as an outcrop. The composition of the bedrock is one of the dominant factors which influence the configuration of the surface topography. Soil forms as a result of the disintegration of the bedrock underneath it. This process of disintegration is called "weathering."

1. Physical weathering is caused by gravity, extreme temperature variations, the pressure of freezing water in cracks and crevices, the movement of rocks carried by glaciers and the action of wind and waves.
2. Chemical weathering
    a. The principal agent of chemical weathering is a weak acid which forms when rainwater combines with carbon dioxide. The acid that results slowly dissolves soluble rocks, like limestone.
    b. Processes involving oxidation, that is, processes similar to the rusting of

iron, are also important types of chemical weathering.

3. In addition to chemical and physical weathering, biological weathering occurs. Biological weathering is actually a combination of chemical and physical weathering, that results from the activities of plants and animals.

B. Residual and Transported Soils

1. Soil that forms immediately above the bedrock from which it is derived is called residual soil.
2. Transported soil is soil which has been moved from the area where it originated, by wind, water, ice, glaciers, or gravity.

C. Soil Horizons

1. The uppermost layer of a soil is the "A" horizon. It is commonly called "topsoil." Topsoil is generally high in nutrients and organic material, and it has a high moisture-holding capacity.
2. The next lower horizon is the "B" horizon.
   a. The "B" horizon contains much less organic material than topsoil, but it does contain materials that have been leached out of the "A" horizon by water percolating downward.

b. The leached materials that collect in the "B" horizon often result in the formation of a "hardpan," that is, a dense layer that makes it difficult for water to pass through it.

3. The soil material beneath the "A" horizon is commonly referred to as "subsoil." When it is exposed by grading operations it is usually easily eroded and difficult to stabilize with vegetation.

4. The lowest horizon is the "C" horizon. This horizon lies just above, and gradually grades into, bedrock.

II SOIL COMPOSITION

A. Soil is made up of solids and voids. The size, shape, and arrangement of the soil components will determine what part of the soil is solids and what percent is voids.

1. The solids are the individual soil particles, together with any organic material that may be present.

2. The voids are the spaces between the particles. These voids are filled with air and/or water.

B. Classification

1. One of the simplest ways of classifying a soil is by texture. The texture of a soil is the relative distribution of the various sizes of particles. Common textural classifications include gravel, sand, silt, and clay.

   a. Particles from one-quarter inch in diameter to three inches may be considered as gravel. Larger pieces are either cobbles or boulders.

   b. Sand ranges in size from about one-quarter inch down to grains that can hardly be detected without some magnification.

   c. Soil particles smaller than sand are generally called "fines." These include both silt and clay sized fractions. Silt particles are larger than clay particles.

   d. Soils seldom contain pure gravel, sand, silt, or clay. Instead, a number of major gradations of sizes are present. Terms such as "sandy loam," "loamy sand," and "silty clay" are often used to describe mixed soils.

2. A more descriptive scheme of classification provides an estimate of the percentage by volume of each of the soil constituents.
   a. In one such scheme, "and" means 35 to 50%; "some" means 20 to 35%; "little," 10 to 20%; and "trace," less than 10%.
3. Soil scientists use another method of classification, involving the textural triangle. This triangle is included as the last page of the workbook.
   a. If a given sample of soil contains 30% clay and 60% silt, to determine the classification of the sample, you would read across the 30% line from the left side of the triangle, which corresponds to clay, and read down the 60% line from the right side of the triangle, which corresponds to silt. Where these two lines cross, the soil is classified as silty-clay loam. It would also contain 10% sand, as you can see by finding the line on the bottom of the triangle, which corresponds to 10% sand, and reading up to the point where the silt and clay lines cross.
4. Two other popular classification systems are the Unified Soil Classification System, and the A.A.S.H.T.O. Soil Classification

System, which stands for the American Association of State Highway and Transportation Officials.

a. Both of these systems of classification use textural properties of the soil as well as engineering properties.

b. They are used extensively by engineers and earth scientists for classifying soil for construction use.

5. Size distribution means the percentages by weight, of sand, silt, and clay as well as larger constituents in the soil.

a. This is accomplished by sieving the soil, through the use of a number of sieve or screens of various mesh sizes, to separate the various sizes of particles in the soil.

b. By dividing the weight of the material in each sieve by the weight of the total soil sample, the percent of each size fraction can be determined. From the percentages of the various size fractions, the texture can be determined.

III SOIL CLASSIFICATION IN EROSION CONTROL

A. The size and weight of the particles influence the susceptibility of a given soil to erosion.

1. Larger, heavier particles are less likely to be detached and carried away by splashing or flowing water than smaller or lighter particles.
2. When a particle is detached and carried away by runoff, size, shape, and weight also determine the distance the particle is transported.
   a. As runoff slows, the larger, heavier particles are deposited first.
   b. Most sand-size sediment particles will settle out of calm water in a matter of seconds, but some of the small, light clay particles will take days, weeks, or even longer to settle to the bottom.

B. The arrangement of the soil particles, that is, the soil structure, is also an important factor in the resistance of a soil to erosion.
   1. A soil in which the individual particles do not stick together is "structureless." Sand is an example of material devoid of structure.
   2. When the particles cling together to form a larger, distinct unit, the soil has structure. Different types of structure occur in natural soil. The type of structure depends on the way the particles are bound together.

3. Common types of soil structure include platey structure, prismatic structure, blocky structure, and granular structure.

C. The binding force that clay provides in a soil is called "cohesion."

1. The shape and arrangement of the clay particles, the moisture in the soil, and other factors, influence the cohesiveness of the soil.

2. As a general rule, the greater percentage of fines, the more cohesive a soil will be.

3. The plasticity of a soil tells a great deal about its cohesiveness. Usually, the more plastic a soil is, that is, the more it can be molded, the more cohesive it is. High plasticity indicates a high clay content.

   a. Provided that the clay does not expand too much when it is moist, a small amount of it in a granular soil will improve the resistance of the soil to erosion.

   b. If a soil contains clays such as bentonite, that expand a great deal when they are wet, the presence of these types of clay in granular soil may actually decrease the ability of the soil to resist erosion.

D. Friction is the resistance created when two surfaces are rubbed together.

   1. Soil particles rubbed together produce friction.

   2. The "shear strength" of a soil is a measurement that combines the frictional resistance between the soil particles and the cohesion.

      a. The measurement of shear strength is used a great deal by soil and geological engineers, in designing earthen structures and foundations, and in predicting potential landslides and slumps.

         1. Slumping or landslides can occur when excessively steep cut slopes or filled slopes are constructed, or when a steep cut slope is undercut by moving water. Undercutting often occurs along waterways and shorelines.

E. In addition to the shear strength of a soil, the density of a particular soil has a major effect on its strength and its erodibility.

   1. Density is the measurement of the unit-

weight of a soil, and it is usually expressed in pounds per cubic foot.

2. The lower percentage of voids in the soil, the greater the density of the soil.

3. Compaction not only increases the density of the soil, by eliminating many of the voids, it also increases the internal strength of the soil, thus reducing erosion.

F. The porosity of a soil is the percentage of the soil occupied by voids, that is, space filled with air or water.

1. You need a certain amount of soil moisture in order to achieve a high degree of soil compaction.

2. The amount of water filling the voids in soil is expressed as the "degree of saturation." This effects the resistance of the soil to erosion.

   a. At 100% saturation, all of the void space is filled with water. The soil is then said to be "saturated."

G. Another important factor in the ability of the soil to resist erosion is the permeability of the soil. Permeability is a measurement of how fast water flows through a soil.

1. It is usually expressed as the number of inches of water passing through the soil in an hour.
2. Permeability is an important property of a soil, because it has a major influence on how much rainfall moves into the soil, and how much remains on the surface, becoming runoff.
3. The greater the runoff, the greater the possibility of erosion.
4. Permeability is not always related to porosity. In fine-textured soils such as clay, the permeability may be very low, even though the porosity is high.
   a. This difference between the permeability and the porosity occurs partly because of the small size of the pores between the individual particles. The small pore spaces make it difficult for water to pass from one pore to another.
   b. Also, there are few connections between pores, thus making it difficult for water to penetrate.
5. On the other hand, in coarse, granular soils, the voids are relatively large, and connected with each other; thus the permeability is high.

H. Another factor effecting the erodibility of a soil is the infiltration rate.

1. The infiltration rate is the rate at which water enters the soil. It differs from permeability in that permeability is the measure of the rate at which water moves through the soil.
2. Infiltration rate is expressed as inches of water entering the soil per hour.
3. The infiltration rate is affected by the permeability of the soil and the condition of the soil surface as well as the permeability of the various soil layers beneath the surface layer. The permeability of a soil can only be as great as the permeability of its least permeable layer. You should never guess the infiltration rate of a soil from surface observations or shallow test cores.
4. Soils that remain saturated for long periods of time because there is a layer of low permeability in the profile, or because of a high level of ground water, are called "poorly drained" soils.
   a. This type of soil is difficult to manage and presents drainage problems when buildings are placed on it.

I. The ability of a topsoil to retain water is known as its "water-holding capacity." The water-holding capacity of a soil affects the ability of the soil to support vegetation, and therefore affects is erodibility.

1. The texture of the soils and the presence of organic material are the primary factors in determining the water-holding capacity.
   a. Soils containing over 25 to 30% silt and clay-size particles are usually able to hold enough water within the voids of the soil to sustain a vigorous vegetative cover.
   b. Soils that contain less than 30% fines are "droughty" soils, and usually require more management to attain a healthy stand of vegetation.
   c. Other factors, such as the location of the groundwater table, the temperature, the precipitation, and the ground slope also effect the availability of moisture and the ability of the soil to support vegetation.
2. When soils are saturated with moisture, frost heaving sometimes occurs, during periods of freezing weather. The moisture in the soil freezes. Ice crystals expand and lift up a

layer of soil. Under extreme conditions, well-rooted vegetation may be uprooted and large chunks of material may tumble downhill.

a. It is almost impossible to prevent erosion in these areas until the problem of water saturation is solved. This problem may be solved by installing tile under the ground to drain the soil. Surface drainage may also be needed.

J. Another important characteristic of the soil that affects the growth of vegetation, and hence, the ability of the surface to resist erosion, is the chemical composition of the soil.

1. The materials most important to the growth of plants are often those which are relatively scarce in soils. In some cases they are absent altogether.

2. The three major nutrients required by plants are nitrogen, phosphorus, and potassium.

   a. Very little nitrogen is present in subsoils. The main source of the nitrogen used by plants are the decayed plant and animal remains present in the topsoil, and the nitrogen which has been removed from the air and converted into usable forms by certain bacteria in conjunction with plants known as legumes.

b. Phosphorus and potassium are present in bedrock minerals, and become part of the soil as the bedrock weathers.

3. The presence of these materials can be determined by testing. Your local agricultural agent can either do the testing or tell you where it can be done.

4. If a soil is deficient in any of these materials, you should add the proper type of fertilizer before planting. Most soils, topsoil included, will require the addition of fertilizers.

5. Plants need many other nutrients in very small amounts. These nutrients are often called "trace elements." Examples include iron, sulfur, magnesium, zinc, and copper. Ordinarily these chemicals are present in great enough quantities that you do not have to add them before planting.

6. Another very important factor that effects plant growth is pH. This term describes how acidic or alkaline a soil is.

   a. A pH of 7 is neutral. A pH between 7 and 14 is alkaline, or basic. A pH below 7 is acidic.

b. If the pH is lower than 4, most plants can not survive. When the pH ranges from 4 to 5, many evergreens, some legumes, and a few other plants will survive.

c. As the pH increases above 5, many more species will flourish. Soil pH above 8.5 is too alkaline for most plants.

d. You can handle the problem of acid soil by selecting plant materials that are compatible with the acidity, by raising the pH by adding lime or by covering the acid soil with soil that is not too acid. Very alkaline soils can be treated with sulfur, sulfuric acid or gypsum depending upon the soil chemistry.

e. As with the minerals, you must perform certain tests to determine the pH. Your local agricultural agent should be able to provide help in getting a soil tested.

Questions 1

Fill in the blanks.

1. The massive area of rock lying below soil is called ______________.

2. Soil is formed by the process of rock disintegration called ________________.

3. ________________ and ________________ are causes of physical weathering.

4. Oxidation is an important type of ________________ weathering.

5. Biological weathering is a combination of chemical and physical weathering resulting from the activities of __________________s and ________________s.

6. Tree roots growing in the crack in a rock, not only exert a pressure that forces the rock apart, they also produce ________________ which slowly ________________ the rock.

Questions 2

Circle the correct answer or answers.

1. Soil that forms immediately above the bedrock from which it is derived is called

    a. topsoil
    b. residual soil
    c. "D" horizon
    d. sandstone

2. When quartz or other materials resistant to weathering occur within the bedrock,

    a. the resulting soil is fairly uniform in appearance.
    b. an acid formed by rainwater and carbon dioxide slowly dissolves the rock
    c. the soil is transported from the area by water, wind, ice, or gravity.
    d. boulders and outcrops result in the soil

3. Transported soil (by water)

    a. particles often have rounded edges
    b. is fairly uniform in appearance
    c. usually continues much the same all the way down to the bedrock
    d. should be stockpiled during construction activities for later use as topdressing

4. Good examples of transported soils include

   a. gravel and slate
   b. marble and granite
   c. clay and silt
   d. sand and gravel

5. The "A" horizon of a soil is

   a. usually called "subsoil"
   b. rich in organic material
   c. able to support a vigorous vegetative cover
   d. difficult to stabilize with vegetation

6. Topsoil

   a. often has a high moisture-holding capacity
   b. contains little organic material
   c. is another name for the "C" horizon
   d. gradually grades into bedrock

7. Leached materials in the "B" horizon

   a. are rich in nutrients and organic matter
   b. have a doughy or plastic consistancy
   c. expand many times their original volume during heavy rainfall
   d. may result in the formation of a "hardpan"

Questions 3

True or False

1.________ Soil is made up of solids and voids.

2.________ The texture of a soil is determined from the size of the individual soil particles, together with any organic material that may be present.

3.________ Soil particles from one-quarter inch in diameter to three inches can be considered as cobbles or boulders.

4.________ Soil particles smaller than sand are generally called "fines."

5.________ Clay particles are generally coarser than silt particles.

6.________ Silt has some plasticity, but not as much as clay.

7.________ Soils seldom contain pure gravel, sand, silt, or clay; instead, a number of major gradations of sizes are present.

Questions 4

Fill in the blanks.

1. When soil particles cling together to form a larger, distinct unit, the soil has ________________.

2. G______________ structure is easily eroded.

3. The binding force of clay in soil is called ______________.

4. The greater the percentage of f________________, the more cohesive the soil will be.

5. ____________________ is more cohesive than silt or sand.

6. The ________ _________ of a soil is a measurement that combines the frictional resistance between the soil particles and the cohesion.

7. The measurement of shear strength is used by soil and geological engineers in predicting potential l_________s and s_________s.

Questions 5

Each of the following sentences contains one error. Write the letter that corresponds to the incorrect word or phrase in the blank provided.

1.________Density is the measurement of the unit-weight of a soil (A), and it is usually expressed in pounds per cubic foot (B). The higher the percentage of voids in the soil, the greater the density (C).

2.________Compaction not only increases the density of the soil (A), by increasing many of the voids (B), it also increases the internal strength (C) of the soil.

3.________The porosity of a soil is the percentage of the soil occupied by voids (A), that is, spaces filled with air or water (B), which is important in order to determine its texture (C).

4. ________ Soils become more resistant to erosion when
the soil is saturated, because the particles
are partially supported by the water and because the bonding strength between the particles
is less when the particles are completely surrounded by water.

(A: become more resistant to erosion when; B: the soil is saturated; C: the particles are partially supported by the water; D: the bonding strength between the particles is less; E: the particles are completely surrounded by water)

5. ________ A soil that is rapidly permeable has many connected void spaces; most clay soils are quite permeable.

(A: A soil that is rapidly permeable has many connected void spaces; B: most clay soils are quite permeable)

Questions 6

Circle the correct answer or answers.

1. The amount of water present in a soil is known as the

   a. moisture content
   b. water-holding capacity
   c. rate of infiltration
   d. porosity

2. The primary factors in determining the water-holding capacity are the

   a. percentage of fines
   b. presence of organic materials
   c. shear strength
   d. chemical composition

3. The materials most important to the growth of plants are

   a. water
   b. plant foods
   c. oxygen
   d. CO_2

4. The main scources of nitrogen used by plants are

   a. legumes

b. lime
c. decayed plant and animal remains
d. zinc and copper

5. Trace elements include

a. phosphorous and potassium
b. copper
c. sericea lespedeza
d. silicon

6. The pH of a soil describes

a. The required fertilization
b. the presence of trace elements
c. how acidic or alkaline a soil is
d. the conversion of nitrogen into forms which plants can use

7. A pH of 7 is

a. alkaline
b. acidic
c. basic
d. neutral

8. Most soils are

a. slightly acidic
b. slightly alkaline
c. unable to support most plant species
d. able to support only evergreens and legumes

Questions 7

True or false

1._________ One way a soil forms is from the breakdown of bedrock, a process called weathering.

2._________ Residual soils form some distance away from the area where their parent materials first originated.

3._________ Transported soils usually show layering.

4._________ The relative distribution of the various soil particles is known as layering.

5._________ Soil textures range from gravel, which is the largest, down to sand, which is the finest.

6._________ Soils are usually made up of various mixtures of sizes.

7._________ Eroded particles of medium sand quickly settle back to the bottom of a stream or pond.

8._________ Cohesion is the binding force in a clay soil.

9._________ A soil containing large amounts of fine sand is highly resistant to erosion.

10.________ The measurement of how fast water can flow through the soil is called the "rate of saturation."

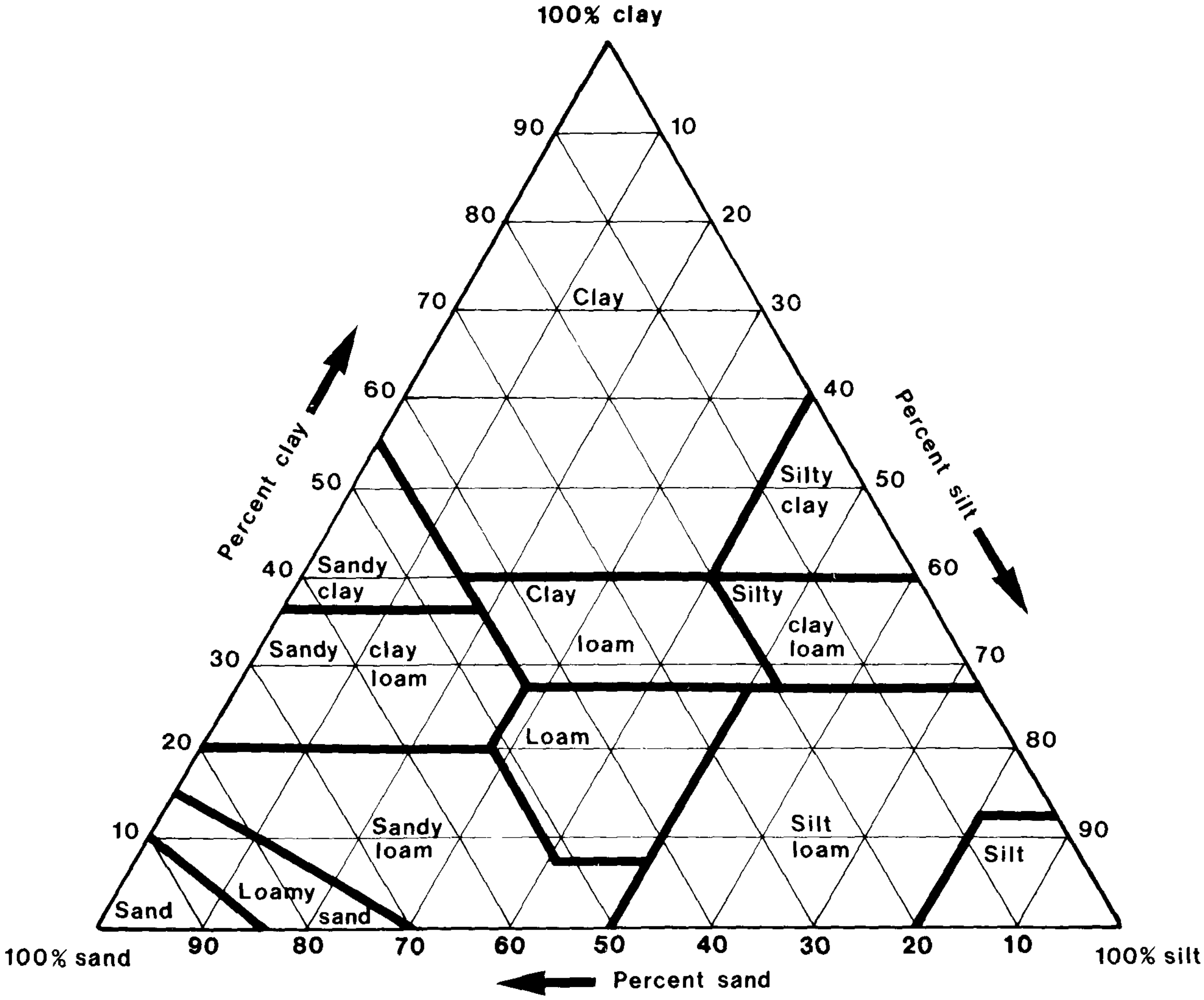
11.________ Sandy soils are more permeable than those containing large amounts of clay.

12.________ The rate of infiltration is the rate at which surface water enters the soil.

13.________ Soils which contain less than 25 to 30% silt and clay, or "fines," usually cannot hold enough water to support a good growth of vegetation.

14.________ Most subsoils generally contain sufficient nutrients and do not require the addition of fertilizers.

Textural Triangle U.S.D.A.



ERROSION AND SEDIMENT CONTROL

RAINFALL - RUNOFF RELATIONSHIPS

WORKBOOK

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I. BASICS OF PRECIPITATION

A. Precipitation includes rain, snow, sleet, and hail.

1. Rain falling, accumulating, and flowing over poorly protected soil, causes the majority of soil erosion and sediment pollution.

B. Climatology, Hydrology, and Hydraulics

1. Climatology is the science that deals with climates, their phenomena, and the causes involved.

   a. It includes the study of temperature, wind velocity and direction, and precipitation.

2. Hydrology is the science that deals with the waters of the earth.

   a. It is the study of the occurence of the earth's waters, their circulation, and their distribution.

   b. Hydrology is the study of the reactions of the earth's waters with their environment, and the relations between these waters and living things.

   c. It also deals with the full life history of water on the earth and includes rainfall amounts and intensities.

3. Hydraulics is the field that deals with practical applications of water, as well as other liquids, in motion. As erosion and sediment control specialists, we are concerned with the practical applications of water in motion, our main concern is the energy of water moving over bare soil.

4. These three fields are closely related and embrace a number of sciences and engineering disciplines.

II. THE HYDROLOGIC CYCLE

A. Rainfall is part of a cycle, the "hydrologic cycle." This cycle is the continuous circulation of water, from the earth to the atmosphere, and back again.

B. Masses of air carry clouds through the atmosphere. These clouds are actually composed of billions of small droplets of water.

C. Eventually, when the conditions are right, the water vapor condenses enough, so that precipitation forms.

D. The precipitation falls.

E. Most of the precipitation reaches the surface of the earth. Here, much of it soaks into the soil. This process is called "infiltration."

F. The part of the precipitation which does not soak into the soil eventually runs into the ocean by way of streams and rivers. It is called runoff.

G. These rivers and streams, along with the lakes, ponds, and oceans, belong to the surface water portion of the hydrologic cycle. Any water on the surface of the ground is surface water.

   1. We are most interested in surface waters, because flowing surface water acts as the primary agent of erosion, in most areas of country, and it transports sediment to its point of deposition.

H. Another major part of the hydrologic cycle is the groundwater portion. This includes all water below the surface of the ground.

   1. Some of the water that soaks into the soil is used by plants. These plants, in turn, give off water vapor, through leaves, back into the atomsphere. This process is known as "transpiration."

   2. Part of the water that soaks into the ground percolates beyond the reach of the plant roots. This water then joins

the vast amount of water which is stored underground.

3. A portion of this underground water reappears as surface water, in the form of seeps or springs.
4. Eventually, part of the groundwater returns to the ocean.

I. The water in the ocean evaporates at roughly the same rate as the rate at which water flows into the ocean.

J. It is from this evaporation, as well as the water transpired by plants and the water evaporated from plants and the surface of the land, that clouds form. This completes the hydrologic cycle.

III. PRECIPITATION

A. There are four basic processes by which moist air releases rainfall and other forms of precipitation: orographic, frontal, convective, and cyclonic. Some of these processes are more active than others, depending upon the part of the country.

B. Orographic precipitation is caused by the interaction of moist air with mountains. It occurs when the prevailing winds carry moist air, usually from an ocean, over a mountain range.

1. As warm air rises, it becomes cooler, and as cold air falls, it becomes warmer.
2. The cooling of moisture-laden air may cause it to drop its water on the side of the mountains toward which the wind is blowing. This side is called the "windward" side. The air is now colder and dryer.
3. As the air that is now colder and dryer crosses the mountains, it begins to fall on the sheltered side of the range. This is the "lee" side.
4. As these air masses fall, they become warmer.
5. Because of the dryness and the warmth, little precipitation occurs on the lee side of the range. These conditions can create a desert. This type of desert is called a topographic desert, because it is the topography which is responsible for its formation.

C. Frontal precipitation is that which occurs when a warm air mass and a cold air mass collide. The warm air mass is often referred to as a "warm front," and the cold air mass as a "cold front." As the warm air mixes with the cold air, it is cooled and the moisture condenses to form rain or other forms of precipitation.

D. Convective precipitation is caused by the upward flow of warm air into the cooler air above. As the warm air rises, it "piles up" the water vapor into gigantic clouds, commonly called thunderheads, which produce thunderstorms.

E. Cyclonic storms include hurricanes and typhoons. These storms are characterized by winds which rotate about a center of low atmospheric pressure. Very heavy rains usually accompany these storms.

F. Local factors have an enormous effect on the amount of rainfall or other forms of precipitation which fall on the area.

   1. As with anything in nature, the amount of rain that reaches the earth varies widely from place to place.

   2. The average rainfall for Maryland is about 40 inches per year.

   3. Other factors, besides mountains, which affect the chance of precipitation include winds, temperatures, and the location of the area relative to bodies of water,

such as oceans and large lakes. Large bodies of water may provide additional moisture for precipitation in downwind areas. They may also cool air masses sufficiently so that they drop their precipitation over the water rather than on the surrounding land.

4. By "intensity of rainfall" we mean how hard it rains. The intensity of rainfall is usually measured in inches of water falling in an hour of time. A rain which produces two inches in a one-hour period is a much "harder" rain that one which measures only one-half inch in the same one-hour period.

G. Average Yearly Hydrologic Cycle

1. In a normal year enough precipitation falls to cover the United States with 30 inches of water.

2. Of the water that falls, two-thirds, or 21 inches, return to the atmosphere by evaporation and transpiration, 30 percent, or 8.9 inches, returns to the ocean through surface runoff,

and the remaining one-tenth of an inch infiltrates and becomes groundwater, which ultimately returns to the ocean.

H. Precipitation and Runoff

1. The primary aspects of the hydrologic cycle that erosion and sediment control specialists deal with are precipitation and runoff.

   a. Precipitation falling as rain exerts tremendous amounts of energy on exposed soil. The impact of the raindrops dislodge and displace soil particles. Ensuing runoff displaces and carries away additional soil particles.

   b. Runoff begins as overland or sheet flow. This is the relatively thin layer of water which begins flowing over the surface of the ground when all of the rain that reaches the surface of the ground does not infiltrate into the soil.

c. When sheet flow begins to concentrate in small channels, these are called rills. These rills join other surface runoff and the water concentrates in continuously larger channels. All too often, these channels turn into large, destructive gullies. Our streams were formed through this process.

IV. FLOODING AND WATERSHEDS

A. For adequate erosion control and stormwater management planning, we need to know how much of the total precipitation will become surface runoff, and the rate and speed this water will flow off the land surface. These factors affect the frequency and severity of flooding.

B. Floods and Floodplains

1. Flooding occurs when flow is greater than the capacity of the channel.
2. The flat area on one or both sides of the channel where the water flows and spreads out is known as a "floodplain." (Soils in a floodplain are alluvial soils.)

3. Floods are more frequent in some parts of the country than in others.

   a. We can estimate the average frequency and severity of flooding by observing the flows in a waterway over a period of many years.

   b. The normal amount of water in a channel is known as "base flow."

   c. When a stream receives a large amount of water from the surrounding area, the water may overflow the channel banks and begin to cover the floodplain. The extent of flooding is described by the frequency with which a particular water level is reached.

   d. A "two year flood" occurs, on the average, once every two years. Such a flood has a fifty percent chance of occurring in any year.

   e. Heavier floods may occur, on the average, once every 10 years. A flood of this size would have a ten percent chance of being equaled or exceeded in any year and would be known as a "ten year flood." This does not mean that if one flood of this size has occurred, the next one will not come for another 10 years. Such floods can come at any time - whenever there is a rainfall or melting snow event great enough to cause a 10 year flood. But on the average, they occur once in 10 years, twice in twenty years, and so forth.

4. To allow unrestricted flow of floodwater, and to prevent damage to life and property, all restrictive structural and inhabited development should be kept out of the 100 year floodplain.
5. If extensive areas in a given watershed have been made impermeable through construction activities or other measures, and steps are not taken to detain runoff, the frequency and severity of flooding downstream may be greatly increased.

C. To evaluate the liklihood of floods, we have to examine the whole watershed. A watershed, or "drainage basin," is the total ground area which contributes surface water runoff to a given point.

1. A given watershed is separated from all adjacent watersheds by a ridge, or "divide."
2. In a given watershed, all the surface runoff will eventually run to the lowest point through which the main stream passes.

3. The shape and area of any watershed will depend upon what point you are interested in. As a result, any large watershed can be broken down into a number of smaller watersheds. These smaller watersheds are often called "subwatersheds."

   a. Whether you choose to consider a major watershed, or a subwatershed, depends on the purpose of your investigation.

V. RUNNING WATER AS AN AGENT OF EROSION

A. There are a number of factors which increase the speed of water and therefore its erosive force.

   1. One factor which increases the rate of flow is the slope. The steeper the slope, the faster the water will flow.

      a. One way to measure slope is by finding the ratio of the horizontal distance to the vertical distance.

      b. It is customary to reduce the numbers to the lowest possible ratio, such as 1 to 1, 2 to 1, 3 to 1, and so on. Therefore, if a slope goes for 100 feet horizontally, with a 50 foot change in vertical distance, it would have a slope of 2 to 1.

      c. Slope can also be expressed as a percentage. The percentage represents the amount of vertical distance that would be covered, if the slope continued for a horizontal distance of 100 feet. For a 50 foot rise, over 100 feet of horizontal distance, the slope is 50 percent.

2. Another factor that affects the speed of running water is the roughness or smoothness of the surface over which the water flows.
    a. Water flows faster over a smooth surface, than over a rough one.
    b. This principle is very useful for controlling erosion. For example, if a slope has been properly "tracked" with a dozer, the horizontal grooves will slow the flow of water down the slope. More of the water will tend to soak into the soil.
3. The total length of the slope also affects the speed of water flowing over it.
    a. This is primarily because the longer the slope, the greater the total volume of precipitation falling on the slope.
    b. The increased volume causes an increased depth of flow and an increased depth of flow and an increased velocity.
    c. We can shorten the effective length of

the slope, by using diversion structures.

VI. FACTORS AFFECTING AMOUNTS OF SURFACE RUNOFF

A. In any given watershed, the amount of surface runoff depends on a number of factors. We need to understand these factors, because in many cases we can reduce the amount of surface runoff, and hence, erosion, if we understand how these factors work.

B. One factor influencing the amount of runoff is precipitation, especially rainfall.

1. We can make measurements and predict, with some accuracy, the amount of runoff we can expect during any given rainfall.

2. We can also predict the amount of rainfall in a particular place and season, with respect to the frequency ot a runoff event.

a. Rainfall is measured in inches. If the rain that falls at a certain point is collected in a container with a flat bottom and vertical sides, the total depth of the water in the container is equal to the amount of rainfall.

b. All rain gauges work on this principle. More sophisticated raingauges include mechanisms for automatically recording the rain with respect to the time it falls.

4. Using these more sophisticated devices, you can measure the intensity of the rainfall, as well as the total amount. The intensity is particularly important, because a rainstorm with a heavy intensity will generally produce more runoff than one with low intensity.

   a. The reason for this is that the amount of water the soil can take in is relatively constant, after an initial rainfall period that soaks the soil surface.

   b. During low intensity rainfalls, most of the water may soak in, or "infiltrate." But during high intensity rainfalls, if the infiltration rate remains the same, a greater portion of the rainfall runs off.

5. The soil can only allow a certain amount of water to infiltrate, at a fixed rate, because it is composed of a large number of soil aggregates, with open spaces, or "pores," within and between the aggregates.

a. Water, pulled by the force of gravity and by other forces, can infiltrate and seep downward not exceeding some maximum rate. This rate depends on the permeability of the soil.

b. If the rain falls faster than the water can seep downward through the soil, the water begins to accumulate on the surface of the ground and eventually begins to flow over the ground as surface runoff.

c. At the beginning of a low-intensity rainfall, the water has plenty of time to infiltrate. If the rain is light enough, no overland flow will occur, until all the pores in the soil are filled with water, that is, until the soil is "saturated." When the soil is saturated, the infiltration rate is controlled by the soil permeability. It then accumulates, becoming surface runoff.

6. The total quantity of rain which falls is one of the factors that determine the amount of runoff. Even a light rainstorm may produce a large amount of runoff if it rains for a long period of time.

   a. The duration of the rainfall, as well as the intensity, has an effect on the amount of surface runoff.

C. The type of soil present is another factor influencing the amount of surface runoff.

1. The permeability of the soil limits the rate at which water can infiltrate; beyond this rate, rainfall becomes runoff. Different soils have different permeabilities.

    a. Increased soil permeability decreases surface runoff. A highly permeable soil (sands) permit water to seep downward at a rapid rate. This rapid seepage prevents water from accumulating on the ground surface as runoff.

2. During construction activity, much of the soil is altered from its natural state. Construction traffic constantly moving over the surface of the ground compacts the soil, thus making it less permeable.

    a. Increased compaction causes more of the rain to become runoff.

3. The texture of the soil also effects the amount of runoff generated by rainstorm.

    a. Clay soils are usually much less permeable than sandy soils. This is because the structure and arrangement of the clay particles do not allow water to pass through as rapidly as it can through the more permeable sandy materials.

D. Another factor that influences the amount of surface runoff is the topography.

1. The steepness of the slope and the total length of the slope influence the amount of surface runoff.
2. More surface runoff occurs on steep slopes than on more gentle ones.
3. The roughness of the surface also effects the amount of runoff, by effecting the speed at which the water flows down the slope. A roughened slope will slow the flow of water, allowing more time for it to soak into the ground. The opposite is true for a smooth slope.
4. Another topographic factor which effects the amount of runoff within a watershed, is the total distance over which the water flows.
   a. The more direct the route overland runoff takes, as it flows to the major drainage channel, the less time the water has to infiltrate into the ground.

   b. If the overland flow takes more circuitous routes to the major drainage channel, the overall

E. In addition to topographic factors, vegetative factors have an enormous influence over the amount and speed of surface runoff.

1. Vegetation acts as a natural buffer, that slows the flow of runoff and increases the infiltration.
2. Vegetation improves the ability of the soil to absorb water by providing organic matter on the surface and in the soil.
3. Vegetation also improves the ability of the soil to absorb water, by loosening the soil, and thus increasing infiltration.
4. Plants also remove water from the soil, thus enabling the soil to accommodate more infiltrating surface water.
5. Furthermore, vegetation shields the surface of the soil from the direct impact of falling rain, thus preventing compaction detachment and sealing of the soil surface.

VII. FACTORS RESULTING FROM MAN'S ACTIVITIES

A. With modern technology, we can remove the vegetation from vast areas. But by so doing, we may greatly increase the amount of runoff and the resultant erosion.

B. Making areas of the soil impervious to water by constructing pavements, buildings, and storm drainage systems also increases the amount of runoff.

1. Instead of a major portion of stormwater infiltrating into the soil, most of it becomes runoff.

a. The massive inflow that results in the natural waterways, causes erosion and flooding.

b. The result is sediment pollution, aesthetic damage, and danger to property and lives.

C. This damage is avoidable. Man can control it without banning all development.

1. Through far-sighted planning, and use of proper designs and construction practices, we can develop an area and, at the same time, manage it in a way that will protect the environment.

2. Stormwater management is one very important

means of controlling the amount and speed of runoff.

a. Stormwater management is a program designed to slow the runoff, and, in some cases, actually decrease the amount.

b. A number of structures are useful for managing stormwaters. These include gravel filled infiltration structures, retention basins, and man-made ponds.

Questions 1

Fill in the blanks.

1. Rain, falling, accumulating, and flowing over poorly protected soil, causes the majority of ________________ ________________ and ________________.

2. ____________________ is the science that deals with climates, their phenomena, and the causes involved.

3. ____________________ is the science that deals with the waters of the earth.

4. ____________________ is the field that deals with practical applications of water in motion.

5. It is surface waters which we are interested in, because flowing surface waters act as the primary agents of ______________________ and still surface waters are the most subject to ______________________.

6. The four basic processes of precipitation are ______________, ____________________, ________________________, and ________________________.

Questions 2

True or false.

1. ________ Local factors such as mountains effect the amount and intensity of rainfall in a given area.

2. ________ In a normal year, enough precipitation falls to cover the United States with approximately 40 inches of water.

3. ________ The energy exerted by raindrops striking exposed soil surfaces is relatively insignificant as an erosive factor.

4. ________ Runoff over bare soil detaches and carries away soil particles.

5. ________ To allow an unrestricted flow of floodwater, and to prevent damage to life and property, all development should be kept out of the 100 year floodplain.

6. ________ Watersheds are separated by a ridge or "divide."

Questions 3

Circle the correct answer or answers.

1. If a slope has a horizontal distance of 100 feet and a 50 foot change in vertical height, the slope would be a:

   a. 2 to 1 slope
   b. 1 to 2 slope
   c. 50% slope
   d. 200% slope

2. While in motion, water carries soil particles, but as water loses its motion,

   a. it is more likely to cause serious erosion
   b. it tends to deposit these transported materials
   c. neither of the above

3. Factors affecting the speed of flowing water include

   a. the slope
   b. the type of diversion structures present
   c. the roughness or smoothness of the surface which the water flows over
   d. the total length of the slope

Questions 4

True or false.

1. _______ We have little control over the amount of rainfall, its frequency, or its intensity.

2. _______ We cannot predict with any accuracy, the amount of runoff we can expect during a rainfall of a particular frequency.

3. _______ We can predict, with some accuracy, the amount of rainfall in a particular place for a particular frequency.

4. _______ The rate of infiltration of rainfall into the soil depends primarily on the intensity of the rainfall.

5. _______ A moderate rainstorm will produce little runoff, even if it rains for a long period of time.

6. _______ As soil permeability decreases, surface runoff increases.

7. _______ Clay soils are usually less permeable than sandy soils.

8. _______ Increased compaction, resulting from construction activities, is likely to increase soil permeability.

Questions 5

True or false.

1. ________ The steepness of the slope and the total length of the slope influence the speed of the runoff.

2. ________ The roughness of the surface affects the rate of runoff.

3. ________ Vegetation slows the flow of runoff and increases the infiltration.

4. ________ Vegetation improves the ability of the soil to absorb water by providing organic matter on the surface and in the soil.

5. ________ Vegetation decreases the ability of the soil to absorb water, by loosening the soil.

6. ________ Plants remove water from the soil, thus decreasing infiltration.

Questions 6

Fill in the blanks.

1. With modern equipment we can remove the vegetation from vast areas, but by so doing, we may greatly increase the amount of ________________ and resultant ________________.

2. Making areas of the soil impervious to water, by constructing pavements, buildings, and storm drainage systems, increases the amount of __________________.

3. ______________________ management is one very important means of controlling the amount and speed of runoff.

4. The speed of water influences its _______________ force.

5. A ___________________ is the total ground area which contributes surface water runoff to a given point.

6. The factors which affect the amount of precipitation which will become runoff are intensity and total quantity of rainfall, the ______________ of the soil, and its surface __________________, as well as the _______________ of the area

7. ____________________ velocity increases as slopes become longer, steeper and smoother, and as drainage patterns become straighter.

EROSION AND SEDIMENT CONTROL

EROSION AND SEDIMENTATION

WORKBOOK

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IX REVIEW QUIZ

I INTRODUCTION

A. Erosion and Sedimentation is the process whereby soil particles are detached from the ground surface, transported, and deposited.

1. This is a combination of two problems: erosion and sedimentation.

2. These processes are interrelated, but they cause different types of environmental damage.

II EROSION

A. Definition. Erosion is the process by which the land surface is worn away by the action of wind, water, ice or gravity.

III NATURAL OR GEOLOGIC EROSION

A. It is the action of the wind, water, ice and gravity in wearing away rock to form soil and shape the ground surface.

B. Except for some stream and shore erosion, it is a relatively slow process, continually taking place.

C. This type of erosion is reported to produce about 30 percent of all sediment in the United States.

IV ACCELERATED EROSION

By accelerated, we mean a speeding up of erosion. Whenever we destroy the natural vegetation or alter the contour of the ground without providing some sort of compensation, we increase the rate of erosion.

This type of erosion is reported to account for about 70 percent of all sediment generated in this country.

A. Causes of Accelerated Erosion

1. Farming and construction are the principal causes of accelerated erosion. These activities radically upset the delicate balance that nature has developed between rainfall and runoff.

B. Contributing Factors to Erosion in Urbanizing Areas

1. The destruction of natural vegetation.
2. The removal of organic matter from the ground surface.
3. Reshaping of the ground contour.
4. Exposure of subsoils during construction.
5. The placement of impermeable features like paving and rooftops on the soil.

All of these factors increase runoff and in turn increase

- the rate of erosion from the land surface.
- the rate of stream channel erosion.
- the amount of sediment that enters the waterways.

C. <u>Major Categories of Erosion</u>

1. <u>Overland Erosion</u>

   a. It occurs on denuded slopes above the natural waterways as a result of rain drop splash and runoff.

   b. It is the largest source of sediment during construction operations.

   c. It includes such types of erosion as sheet, rill and gully.

2. <u>Stream Channel Erosion</u>

   a. It occurs in intermittent or permanent waterways.

   b. It is brought on by

      - increased runoff from urbanizing areas
      - the removal of natural vegetation along the waterway
      - channel alterations as a result of construction activities.

   c. It includes both streambank and streambed erosion.

   d. Clear water may increase this kind of erosion.

3. <u>Shore Erosion</u>

   a. It occurs along bodies of water as a result of the impact of waves against a shore line and is one shore erosion process.

   b. Erosion by littoral currents, the movement of water along the shore line is another process.

   c. Accelerated shore erosion is brought on by man's activities. They include:

      (1) the destruction of natural vegetation along the shoreline.

(2) construction encroachment onto the shoreline.

(3) the generation of waves as a result of boating activity.

d. It is severe in highly-developed areas found in the coastal regions of the country and along the Great Lakes.

4. Wind Erosion

a. In most urbanizing areas, because of obstructions to wind abundant soil moisture, and vegetation, wind erosion does not constitite as serious an environmental threat as water erosion.

b. In an urbanizing area, the most damaging aspect of wind erosion is dust. It causes a traffic hazard, adds to cleaning costs, and equipment maintenance and blights the appearance of the structures.

V OVERLAND EROSION

A. Sheet Erosion -- It is the removal of a fairly uniform layer of soil from the land surface as a result of raindrop splash and runoff.

1. Raindrop splash is the impact of raindrops on the soil surface. The splash detaches soil particles and forms a muddy slick on the soil surface, which is often referred to as "puddling." The magnitude of soil loss resulting from raindrop splash can best be seen on a gravelly or stoney soil.

2. Runoff carries away soil particles detached by raindrop splash, and the flowing water detaches additional soil.

B. Rill Erosion. It is caused when runoff is heavy and water concentrates in rivulets.

1. It is evidenced by the development of small grooves spaced fairly uniformly along the slope.
2. Individual rills range in depth and width up to about one foot and reflect a tremendous loss of soil.
3. If rilling is not corrected immediately, it may develop into gully erosion.
4. It can be obliterated by normal tillage practices, that is, plowing or discing and harrowing.

C. Gully Erosion.

1. Like rills, gullies are also grooves washed into the soil.
2. The greater depth of erosion makes the distinction between rills and gullies.
3. A gully can not be covered over by normal tillage practices.
4. All gullies do not represent the culmination of unchecked rill erosion. Improperly designed, constructed, or protected diversion structures, in which runoff is concentrated, may cause gullying first rain. The improper disposal of concentrated runoff from a development may also cause serious gully erosion.

c. Temperature influences the type of precipitation that occurs.

(1) Falling snow does not erode.

(2) Heavy snow melts in the spring can cause considerable runoff damage.

d. It is related to the amount of organic matter which collects on the ground surface

(1) The warmer the climate the thinner the organic cover.

(2) Organic matter protects the soil by shielding it from the impact of falling rain forming more stable soil aggregates and by soaking up rainfall that would otherwise become runoff.

B. Vegetation is one of the more important factors influencing soil erosion.

1. A good cover of vegetation

a. shields the soil from the impact of raindrops.

b. binds the soil together to protect against runoff.

c. provides organic matter.

d. slows runoff velocities.

2. On a graded slope, the condition of the installed vegetation will determine whether or not erosion will be stopped or only slightly halted.

3. A dense, robust, cover of vegetation is one of the best protections against soil erosion.

.C. Soil properties have a major bearing on erodibility.

VI PHYSICAL FACTORS AFFECTING EROSION

A. Climate - The amount, intensity, and frequency of rainfall, as well as temperature, have a major influence on erosion.

1. Rainfall Factors

   a. Intensity - the rate at which the rain falls. It is measured in inches of water falling in an hour of time.

   b. Infiltration Rate - the rate that water is absorbed into the soil. It is also measured in inches per hour.

   c. Frequency of Rainfall - the number of separate rainfall events occurring during a period of time. During periods of frequent rainfalls a greater percentage of the rainfall will become runoff. This is the result of soil moisture. As the moisture content of the soil increases, its ability to absorb water decreases.

2. Temperature is another part of climate influencing erosion.

   a. Frozen soil is highly resistant to erosion.

   b. Rapid thawing brought on by warm rains can lead to serious erosion.

   c. Freezing and thawing action during winter weather lossens the soil surface and increases the susceptibility to erosion.

1. Soil Properties Influencing Erodibility.

b. Texture

- It refers to the size of the soil particles.
- Soils having high concentrations of silt and fine sand, as well as those containing highly expansive clay materials are most susceptible to erosion from raindrop splash and runoff.
- coarse sands resist erosion.

c. Structure

- influences a soil's erodibility
- refers to the arrangement of the soil particles.
- influences both the ability of the soil to absorb water and its physical resistance to erosion.

(1) Cohesion

- has a significant effect on the structure of a soil.
- refers to the binding force between soil particles.
- When moist, the individual soil particles in a cohesive soil cling together to form a doughy consistency. Clay soils fall in this category.
- A sandy soil with a clay binder is usually

relatively resistant to erosion, as are most other soils containing significant amounts of clay.

<u>EXCEPTIONS</u> -- soils containing highly expansive clays like bentonite. These soils can be highly erodible.

When rapid expansion occurs on a natural clay soil surface, a soft and soupy film develops that is highly susceptible to erosion.

(2) <u>Topsoil</u> -- The presence of organic material in a soil also has an effect on soil structure.

- In clay soils, it loosens the structure and allows more water to infiltrate.
- In granular-structured sand or silt soils, it tends to bind the soil into a mass that is more resistant to erosion.
- In all cases, it absorbs water and thus stores more water for plant use.

D. <u>Length and Steepness of Slope</u> is another major factor affecting soil erosion.

1. <u>Length of Slope</u>

   - when runoff occurs on long slopes the soil lying at the base of the slope, over which all of the runoff must pass, is subjected to severe erosion. To avoid this problem, long slopes are often broken up so that they function as a series of short slopes rather than one long slope. This is accomplished by using various runoff control structures including diversions, diversion dikes, and benches. (these structures function to intercept runoff and thereby prevent it from flowing over the lower slope.)

2. Steepness of Slope may be expressed in percent.

   (a) a 10% slope would indicate a 10-foot vertical change for every 100 feet of horizontal distance.

   (b) Slope steepness, surface roughness, and the amount and intensity of rainfall are all factors affecting the speed at which runoff flows down a slope. The steeper the slope, the faster the water will flow, and the faster it flows, the greater will be its ability to remove soil particles from the slope.

VII SEDIMENTATION

A. Definition - Sedimentation is the deposition of detached soil particles.

B. Sediment Pollution causes damage to natural waters by reducing the quality of water itself and reducing the quality of the organism or wildlife habitat the water flows through.

It affects man be increasing flooding, damaging water supplies, destroying recreational facilities, and increasing maintenance costs. Some sediment may benefit organisms & nourish beaches & other shorelines.

C. Minor changes in stream flow alter whether transport of sediment and deposition of sediment occurs. These parts are so closely interrelated that the same set of physical factors determine whether sediment is transported or deposited.

1. Transport of Sediment is divided into two parts.

   a. Suspended Sediment is the smaller particles that are actually carried and supported by the water itself.

   b. Bedload Sediment is the larger soil particles that slide, roll, or bounce along the channel bottom.

D. Physical Factors Affecting Sedimentation - The interactions of these factors will determine how sediment is transported and deposited.

1. Characteristics of Flow relates mainly to the velocity and turbulence of the moving water.

   a. The greater the velocity and turbulence of flow, the greater will be the ability to carry sediment transported in suspension and as bedload.

   b. The lesser the velocity and turbulence of flow, the greater will be the chances of sediment deposited.

2. Nature of the Particles relates to the size, shape and density of the particles in the water.
    a. Smaller, lighter particles are more easily transported.
    b. Larger, heavier particles are harder to transport and thus are more easily deposited.
3. Nature of the Fluid relates to the density of the fluid the particles are located in. Due to its density, water has a certain ability to "hold" particles and keep them from being deposited.

VIII SOIL LOSS MEASUREMENTS

A. Universal Soil Loss Equation (A=RKLSCP) is a tool that provides an approximate measurement of the potential erosion that may occur at the site during development. This equation is based on experiment and observation and takes a number of factors into consideration in arriving at a measurement of the average annual soil loss from sheet and rill erosion.
   1. "R" is the rainfall erosion factor and takes into account the characteristics of rainfall in the area of the site.
   2. "K" is a measure of the erodibility of the soil at the site.
   3. "L" takes into account the influence of slope length on erosion potential.
   4. "S" is the slope steepness factor and accounts

for the influence of slope steepness on erodibility.

5. "C" the cropping-management and cover factor takes into account soil cover and vegetative erosion control practices.

6. "P" is the erosion control practice factor that accounts for the structural erosion control practice used on the site.

The product of multiplying all the factors together ($A = R \times K \times LS \quad \times C \times P$) is the average amount of potential soil loss in tons of sediment per acre per year caused by sheet and rill erosion.

B. Stream Gaging

1. - This is used to measure the rate of flow of a stream.

2. - The device frequently used is a standard weir.

3. - For more detailed hydrologic information, a rain gage is installed to measure the amount of rainfall in the watershed.

C. Sediment Sampling

1. - It is used to measure the amount of sediment moving in a stream.

2. - Sediment samples are often collected by hand to measure the sediment load in the stream.

3. - Automatic samplers are used to collect samples at staggered time intervals throughout a significant rainfall event, whether it occurs during the day or night.

QUESTIONS 1

Fill in the blanks

1. ___________________ is the process by which the land surface is worn away by the action of wind, water, ice or gravity.
2. Natural or _______________ erosion is a relatively slow process, continually taking place.
3. ________________ erosion is reported to account for about 70 percent of all sediment generated in this country.
4. Farming and _______________ are the principal causes of _______________ erosion.
5. The destruction of natural v_______________ and the reshaping of the ground are contributing factors to erosion in urbanizing areas.

QUESTIONS 2

True or False

_____1. Overland erosion occurs on denuded slopes above the natural drainageways as a result of rain splash and runoff.

_____2. Wind erosion is the largest source of sediment during construction operations.

_____3. Stream Channel erosion includes both streambank and streambed erosion.

_____4. Littoral currents play a part in shore erosion.

_____5. Dust from wind erosion concentrates in waterways.

QUESTIONS 3

Multiple Choice

1. Which of the following are types of overland erosion?

   (a) sheet erosion
   (b) rill erosion
   (c) gully erosion
   (d) shore erosion
   (e) a + b + c
   (f) a + b + d

2. Sheet erosion is the removal of a fairly uniform layer of soil from the land surface as a result of ______________.

   (a) rill and gully
   (b) rainsplash and rill
   (c) rainsplash and runoff
   (d) rill and rainsplash
   (e) gully and runoff

3. If rilling is not corrected immediately, it may develop into ____________ erosion.

   (a) sheet
   (b) gully
   (c) shore
   (d) stream channel
   (e) all of the above

4. The distinguishing difference between rills and gullies is

   (a) depth
   (b) length
   (c) weight
   (d) volume
   (e) none of the above

QUESTIONS 4

Fill in the Blanks

1. T_____________ can be related to erosion in several ways.
2. The amount, intensity and frequency of r___________ have a major influence on erosion.
3. During periods of frequent rainfalls a greater percentage of the rainfall will become r_______________.
4. As the m_____________ c_______________ of the soil increases, its ability to absorb water decreases if other conditions are constant.
5. O_________________ m________________ on the soil surface protects the soil by shielding it from the impact of falling rain.

QUESTIONS 5

True or False

_____1. On a graded slope, the condition of the installed vegetation will determine whether or not erosion will be stopped or only reduced.

_____2. Soil type has a major bearing on erodibility.

_____3. Cohesion refers to the binding force between soil particles.

_____4. Typical beach sand has cohesion.

_____5. The presence of organic material in a soil has no effect on soil structure.

QUESTIONS 6

Multiple Choice

1. In our discussion of length of slope we saw that long slopes were converted to a series of short slopes by using various runoff control structures like

   (a) diversions (d) both a & b

   (b) diversion dikes (e) both a & c

   (c) benches (f) a & b & c

2. A 10% slope would indicate

   (a) a 10-foot horizontal change for every 100 feet of vertical distance.

   (b) a 10-foot vertical change for every 10 feet of horizontal distance.

   (c) a 100-foot vertical change for every 10 feet of horizontal distance.

   (d) a 5-foot vertical change for every 50 feet of horizontal distance.

3. Slope steepness, surface roughness, and the amount and intensity of rainfall are factors controlling

   (a) amount of water falling on a slope .

   (b) speed at which a rill erodes.

   (c) amount of rain in a watershed .

   (d) soil erosion.

QUESTIONS 7

Fill in the blanks

1. S________________ is the deposition of detached soil particles.

2. S_______________ p_______________ causes damages to natural waters by reducing the quality of water itself and by reducing the quality of the habitat the water flows through.

3. While being t_____________ sediment is divided into two types: suspended sediment and bedload sediment.

4. The factors affecting sedimentation are so closely interrelated that the same set of p____________ f_____________ determine whether sediment is t____________ or d_____________.

QUESTIONS 8

<u>True or False</u>

_____1. The interaction of the physical factors affecting sedimentation will determine whether sediment is transported or deposited.

_____2. Characteristics of flow relates mainly to the velocity and turbulence of the moving water.

_____3. Small light particles are harder to transport than larger heavier particles.

_____4. Nature of the fluid relates mainly to the density of the fluid the particles are located in.

QUESTIONS 9

<u>Fill in the blanks</u>

The Universal Soil Loss Equation

$$A = RKLSCP$$

1. "___" is the measure of erodibility of the soil at the site.
2. "___" is the rainfall erosion factor.
3. "___" takes into account the influence of slope length on erosion potential.
4. "___" is the erosion control practice factor.
5. This equation is used to measure the soil loss caused by s______________ and r____________ erosion.

QUESTIONS 10

<u>True or False</u>

_____1. Stream gaging is used to measure the amount of sediment entering a waterway.

_____2. A standard weir may be used in stream gaging.

_____3. Hand methods are often employed to collect sediment samples.

_____4. Automatic samplers are used to collect samples at staggered time intervals.

QUESTIONS 11

REVIEW QUIZ

1. E______________ is the process by which the land surface is worn away by the action of wind, water, ice or gravity.

2. N___________ or g____________ erosion is the natural action of the wind, water, ice and gravity in wearing away rock to form soil and shape the ground surface.

3. Except for some stream and shore erosion, g__________ erosion is a relatively slow process, continually taking place.

4. By a____________ , we mean erosion in excess of geologic erosion.

5. Whenever we destroy the natural vegetation or alter the contour of the ground without providing some sort of compensation, we greatly i__________ the rate of erosion.

6. About 70% of all the sediment generated in this country is caused by a___________ erosion.

7. The principal causes of accelerated erosion are f_____________ and c_______________. These activities radically upset the delicate balance that nature has developed between r_____________ and r_____________.

8. U_______________ areas are least able to accept the damages resulting from soil erosion.

9. The destruction of natural vegetation, reshaping of the ground contour, and the exposure of subsoils during construction are c__________ factors to erosion in urban areas.

10. S__________ erosion occurs on denuded slopes above the natural streams as a result of raindrop splash and runoff.

11. Accelerated s__________ c__________ erosion occurs in intermittent or permanent streams. It is brought on by increased __________ from urbanizing areas, the r__________ of natural vegetation along the waterway, and c__________ alterations as a result of c__________ activities.

12. S__________ erosion occurs along large bodies of water as a result of the impact of waves against a shore line

L__________ currents, the movement of water along the shoreline, also may cause shore erosion.

13. In many urbanizing areas w__________ erosion does not constitute as serious an environmental threat as water erosion.

14. S__________ erosion is the removal of a fairly uniform layer of soil from the land surface as a result of rain splash and runoff.

15. R__________ is caused when runoff is heavy and water concentrates in rivulets.

16. D__________ is the distinction between rills and gullies.

17. I__________ is the rate at which the rain falls.

18. I__________ is the rate at which water is absorbed into the soil.

19. O__________ m____________ protects the soil by shielding it from the impact of falling rain and also by soaking up rainfall that would otherwise become runoff.

20. A dense, robust cover of v___________ is one of the best protections against soil erosion.

21. Two soil properties influencing erodibility are t___________ and s____________.

22. C_____________ refers to the binding force between soil particles.

23. A 15-foot vertical change for every 75 feet of horizontal distance would be called a _____ percent slope.

24. S_______________ is the deposition of transported soil particles.

25. S_______________ p_____________ affects man by increasing maintenance costs.

26. While in transport sediment is divided into two types s______________ sediment and b__________ sediment.

27. The ______________ soil loss equation is a tool that provides an approximation of the potential erosion that may occur at the site during construction.

28. The letter ____ is a measure of soil erodibility of the soil at the site.

29. The letter ____ takes into account the influence of slope length on erosion potential.

30. The letter C is the c____________ and m____________ factor that takes into account vegetative and other soil cover control practices.

31. G_____________ refers to the measurement of the flow of water in a stream channel.

32. To measure the sediment load in a stream, s___________ are taken.

EROSION AND SEDIMENT CONTROL

PLANT MATERIALS

WORKBOOK

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Note: The plant materials discussed in this and following chapters are the better plants for the Mid-Atlantic region. They are intended as example and not nationwide application.

I INTRODUCTION TO PLANT MATERIALS

A. An erosion and sediment control specialist has to know how to use plant materials to control soil erosion. Certain publications can help guide you in their use. The publication "Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas" is particularly useful.

1. To use a publication of this sort, you have to know about the common categories and types of plant materials, their physical characteristics in relation to erosion and sediment control, the factors you must consider in selecting plant materials, and the essential requirements you must meet, to insure that the plants grow vigorously.

B. Importance of Plant Materials

1. Plant materials help control soil erosion, sedimentation, and stormwater runoff in at least four important ways.

a. First, they form a protective cover which shields the surface of the soil from the impact of raindrops.

b. The second beneficial effect of a good plant cover is that the stems, foliage, and debris slow the flow of water along the surface of the soil.

c. The third important way in which a good plant cover protects against soil erosion is by holding soil in place with its roots.

d. Fourth, plants provide organic materials for the soil as the surface litter and root material decays, through the action of soil builders, such as microorganisms and earthworms. This organic material conserves moisture and provides a better environment for plant growth. It usually speeds up soil infiltration rates.

II CLASSIFICATION OF PLANT MATERIALS

A. All plants are useful in erosion control, but some plants, because of their physical structure and their adaptability to the physical and climatic conditions at a given site, are more desirable than others. The best plant is the one that will provide the necessary control, and will need the least maintenance.

B. In order to choose the proper plants, you must understand some of the terms used to describe them.

1. Plants used for erosion control are grouped into annuals and perennials.

a. An annual completes its entire life cycle in one growing season. For this reason, some annuals are useful for providing quick, temporary soil stabilization.

b. Perennials, in contrast to annuals, live for many seasons.

   1. Examples of perennials include trees, shrubs, vines and many grasses.

   2. Perennials used in stabilizing soil include long-lived legumes such as birdsfoot trefoil, bermudagrass, vines, such as honeysuckle, and ground covers, including ivy, and lily turf.

   3. Because of their ability to control soil erosion year-round, and because of their long lifespan, perennials are used for long-term or permanent soil stabilization.

2. There are both evergreen and deciduous plant materials.

   a. Evergreens keep their foliage alive throughout the year, despite normal seasonal changes in the climate.

      1. Evergreens include ground covers, vines, shrubs, and trees.

2. Periwinkle is an example of an evergreen ground cover.

3. Ivy is an evergreen vine.

4. Creeping juniper is an evergreen shrub which is often used as a ground cover.

5. Evergreen trees include those with needle-like leaves, such as white pine, and those with broad leaves, such as holly.

b. In contrast to evergreens, deciduous plants shed their foliage at a given season, usually fall.

1. Examples of deciduous plants include crownvetch, which is used as a ground cover, kudzu, a vine, forsythia, a shrub, and black locust, a deciduous tree.

III BASIC STRUCTURE OF PLANTS

A. The basic structure of a plant consists of the roots, the stem, and the crown.

B. The roots, in addition to serving the plant, hold soil in place and aid the infiltration of water into the soil.

1. Depending on the type of plant, roots vary considerably in size, physical makeup, and density.

2. The spread of a tree's root system is normally equivalent to the spread of its crown.

3. Roots are grouped as either tap or fibrous.

   a. A tap root grows vertically, downward. Secondary roots branch out from the tap root.

   b. A fibrous root system, on the other hand, does not have a main root. Instead, many roots radiate downward and outward from the base of the stem.

      1. Fibrous root systems control soil erosion and runoff better than tap root systems because these roots bind the soil tightly in place and form a spongy layer beneath the ground surface, which resists compaction and absorbs water.

C. Stems vary considerably in physical appearance, strength, and ability to aid in controlling soil erosion.

   1. Plant stems can be classified as either herbaceous or woody.

      a. Herbaceous stems are soft and green. They have virtually no tough, woody tissue.

      b. Woody stems, on the other hand, are thicker, harder, and stronger.

         1. Plants may have either single or multistems. The multistems are most beneficial for erosion and sediment control purposes.

2. Multistemmed plants provide a dense canopy of foliage that protects the surface of the soil from the impact of falling raindrops. Examples include the bristly locust and sumac.
3. Still other plants have stems that emerge from along the trunk roots; the roots run under the surface of the ground.
4. An example of a plant with stems that emerge from the roots is the black locust.

D. The branches and foliage of plants such as trees and shrubs are referred to as the "crown." The "crown" can also refer to the branching foliage of many herbaceous plants.

1. The crown is the manufacturing center of the plant. Here minerals and water, brought up from the roots, along with carbon dioxide from the atmosphere, utilizing energy from sunlight, are converted into food and energy needed for the growth and maintenance of the plant.
2. In addition to supplying nourishment for the plants, the crowns of plants such as trees and shrubs aid in controlling soil erosion. Crowns protect the soil from the full impact

of raindrops, especially when the crowns form a thick canopy.

3. The crowns of trees, shrubs, and other plants help control wind erosion and moderate extreme changes in temperature.

4. Crowns produce leaves which form a mulch; this protects the surface of the soil from erosion, provides soil nutrients, and assists in the development of desirable tilth of the soil, that is, its structure.

IV GRASSES AND LEGUMES

A. One of the most important families of plants, for stabilization, is the grass family. Grasses are by far the most widely used materials for vegetating critical areas.

1. There are many varieties of grasses, each differing in physical structure and adaptability to climatic conditions.

2. The varieties differ, as well, in the way they should be established: some are established by seeding, some by sprigging, some by sodding, and some as clumps, or culms.

3. Properly managed, selected grasses will form a close, dense ground cover. Many grasses are able to bear fairly heavy traffic and continuous close mowing. They are therefore useful for vegetating roadway shoulders and medians.

4. Where some light traffic is expected, such as in parking lots used only for overflow parking, grasses can be used alone or in conjunction with a reinforcement, such as MONOslabs or checker blocks.
5. Certain grasses are also widely used for stabilizing waterways.
6. According to the way they grow, grasses commonly used for soil stabilization can be classified in the following three categories: rhizomitous, stoloniferous, and bunch grasses.
   a. Rhizonitous and stoloniferous grasses spread by producing "runners" that extend out from the main plant.
      1. Rhizomes are runners below the surface, which spread out and produce new runners. American beachgrass spreads in this way. Stolons are runners on top of the ground which roots at many points along its length. Bermudagrass spreads this way.
      2. When properly maintained, these rhizonitous and stoloniferous grasses spread rapidly to form a dense cover. For this reason, they are normally used on lawns, recreational areas, and waterways. Examples include bermudagrass and Kentucky bluegrass.
      3. Many of the grasses used to stabilize shores and waterways spread by producing runners or rhizomes. Examples

include reed canarygrass, beachgrass, and smooth cordgrass.

b. As opposed to rhizomitous and stoloniferous grasses, bunch grasses do not spread by means of runners. Instead, the blades radiate upward and outward from the surface of the ground, thus forming a bunch.

1. Because Kentucky 31 tall fescue adapts to a wide range of climatic conditions, it is an example of a popular bunch grass for stabilizing critical areas.

2. When an area has been heavily seeded with selected bunch grasses, a dense cover will form, but it will need some maintenance.

B. Legumes are primarily used to stabilize slopes that are hard to maintain, because legumes require little maintenance.

1. Legumes not only provide an excellent cover, they also help maintain grasses, when the two materials are planted together. The legumes help the grass by converting atmospheric nitrogen, which cannot be used by grasses, into forms of nitrogen, which are available for plant use.

2. Legumes include a wide variety of plants, from large trees, such as the locust, to crownvetch

a small herbaceous plant.

3. A common characteristic of all legumes is that their seeds develop in pods.

4. Crownvetch is a legume that is widely used to form a low-maintenance ground cover on slopes that may be mostly subsoil.

5. Sericea lespedeza is another legume widely used for stabilizing critical slopes. It holds the soil on highly critical slopes because it has deep roots, and it can survive on droughty poor, acid soils.

6. On mass-graded developments, where areas may not be developed for one or more growing seasons, Kentucky 31 tall fescue and a legume are often used as a semi-permanent cover.

7. It is becoming more common to seed legumes and grasses which provide fast cover with slow-growing native herbaceous and woody plants, such as shrubs, vines, and trees, to stabilize critical areas. This mixture provides a long-term cover that requires little maintenance. As some species of plants lose their vigor, other longer-lived types succeed them.

V PLANNING FOR THE USE OF PLANT MATERIALS

A. A site investigation is required to provide a long-term, low-maintenance cover, that will adequately stabilize the soil. Developing an adequate plan for revegetation includes selecting the proper materials and developing a maintenance program.

B. At a given site, not all types of vegetation commonly used for stabilization will perform satisfactorily. Each type of plant differs in its ability to adapt to a given set of environmental factors.

   1. You must determine what the environmental factors are for each site, and utilize these findings in developing a plan for revegetating a site.

   2. Climatic conditions are a major factor to be considered at each site before selecting the plant materials to be used for stabilization.

      a. In considering temperature and precipitation, you must determine in which climatic zone the site occurs, and then select those types of plants which are known to grow successfully in this zone.

      b. Temperate regions have marked seasonal changes in temperature and precipitation.

         1. In such areas you must consider the time of year during which you will be planting.

2. Plants such as weeping lovegrass and bermudagrass grow best during the summer months, while Kentucky bluegrass grows better during the cool and moist fall and spring months.

c. Another climatic condition to consider is exposure. On a highway running east and west, for example, the two sides, if they are both cuts or both fills, will differ widely in the kinds of vegetation they can support.

1. During most of the day, slopes facing northward will be shaded, and therefore more moist.
2. Slopes facing southward, on the other hand, will be exposed to direct sunlight, and will therefore tend to be more droughty.
3. Sericea lespedeza and lovegrass would do well on the slope facing southward.
4. On the slope that is shaded most of the day, a grass that tolerates the shade, such as creeping red fescue or Kentucky 31 tall fescue, will perform well.

3. You should also consider the condition of the soil.

a. Is the soil naturally fertile? Does it contain an adequate supply of organic material and essential nutrients? For a reliable evaluation, have the soil tested.

b. Examine the soil to see if it may be droughty at certain times of the year. Also check climatic records for temperature and rainfall data.

c. Generally, droughty soils contain less than 30% fines, that is, the very small silt - and clay-size particles which hold moisture. Many sandy soils are droughty.

d. If you encounter a droughty soil, use plants that are drought-resistant, such as weeping lovegrass.

e. Excessively droughty soils may be improved by adding organic mulches or topsoil. These materials are commonly called "soil conditioners."

4. Seasonal high water tables may also present a problem. Where the water table occurs near the soil surface, the soil at the surface may be wet during much of the year.

   a. When this condition exists, you will have to choose plant materials, such as reed canarygrass, which tolerate wet soils.

5. Test the pH of the soil. The pH is a measure of the alkalinity or acidity of a soil.

   a. Soils with a pH of 7 are neutral; those with a pH above 7 are alkaline, or basic, and those with a pH below 7 are acidic.

6. Tidal banks and shorelines present special problems. These include soil conditions, salt spray, and strong winds.
   a. Among the plant materials which may be used in these areas are smooth cordgrass, American beachgrass, and Tufcote bermudagrass.
   b. The use of various plant materials depends on the vegetative zone to be stabilized.
7. Before consulting the literature for the final selection of plant materials, determine the physical factors limiting the selection, and the intended use of the site. One publication you should definitely consult is "Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas," Written by the Soil Conservation Service for the Maryland Water Resources Administration.

VI MAINTENANCE

A. Plant materials usually require maintenance.

B. Selection of Plant Materials.

1. Selecting good materials is a form of preventive maintenance. To protect against plant disease, you must insure that the seeds or vegetative materials are free of diseases.

2. See that seed and sod materials are properly certified; only purchase them from approved sources. Make sure other plant materials are free from major diseases and insect infestation.

   a. State certification is the best guarantee of the purity of a variety. The State Board of Agriculture analyzes and carefully controls the weed-seed content, the inert matter, and the contaminants.

C. Another important kind of maintenance is the control of insect damage. The control of insect damage, using approved pesticides and other means, is sometimes vital to the maintenance of vegetation used for stabilization.

D. Another vital form of maintenance is the prevention of plant starvation.

   1. Plant starvation results either from excessive competition for moisture and nutrients by weeds or a nurse crop, or from a deficiency of plant nutrients in the soil.

      a. As with plant disease, the best defense against a problem involving weeds is to select good-quality seed or vegetative material.

      b. Be aware, when you use topsoil, that it may contain noxious weed seed.

c. In some areas, herbicides may be an effective means controlling weeds. Check with local weed control specialists.

d. Mowing is another way to control weeds. Try to mow weeds above the tops of desirable plants.

2. Plant Nutrients

a. Even the desirable plant materials will eventually deplete the available supply of plant nutrients.

b. Plant materials established on subsoils rather than topsoil will usually require more frequent applications of fertilizer and lime if required.

c. The three major nutrients are nitrogen, potassium, and phosphorus. All of these major plant nutrients have an important influence on the development of a plant.

d. Nitrogen tends to encourage the above ground growth of plants.

1. Nitrogen also helps the plant regulate its use of potassium and phosphorus.

2. A deficiency of nitrogen will cause stunted growth and restricted root development.

3. Nitrogen deficiency will also make the plant more susceptivle to attack by diseases and insects. If the foliage of the plant yellows, it often means that the plant is deficient in nitrogen.

4. Inoculated legumes will not usually show nitrogen deficiency after plants are old enough to fix nitrogen.

e. Phosphorus plays an important role in the ability of a plant to assimilate other nutrients.

   1. It is also essential for the full development of sturdy, healthy roots and crown.

   2. A purplish color that develops on the leaves and the new growth of a plant often indicates a phosphorus deficiency.

f. Potassium is also essential for the growth of a plant.

   1. Potassium is furnished by potash.

   2. Potassium, along with phosphorus, has an important role in the development of the root system of a plant.

   3. Potassium is essential for manufacturing and storing plant food.

   4. In addition, potassium increases the resistance of a plant to disease.

   5. A dry, scorched appearance in the leaves of a plant may indicate a potassium deficiency.

3. <u>Fertilization</u>

   a. To determine whether a soil will support a particular vegetative cover, you must have certain chemical tests made. State universities, in cooperation with local county agricultural extension agents, make low cost laboratory testing available.

b. Fertilizers are marketed in a variety of combinations of available nitrogen, phosphorus, and potassium. The percentages of these available nutrients are labeled on the container. For example, an 80-pound bag of fertilizer labeled 10-6-4 would contain 10 percent, or 8 pounds of available nitrogen, 6 percent, or 4.8 pounds, of available phosphorus, and 4 percent, or 3.2 pounds, of available potassium.

c. For acid soils, lime is also essential for maintaining vigorous growth.

   1. Lime (calcium carbonate) is primarily used to neutralize acid soil, and to make many of the essential nutrients more available to plants. Legumes require more lime than grasses.
   2. The lime also provides nutrients essential for plants, such as calcium and magnesium. Dolomitic lime is preferred, because it supplies magnesium as well as calcium.
   3. In addition, lime increases the ability of certain tight, clayey soils to hold moisture, by improving the structure.

Questions 1

True or False.

1.______ Plant materials offer excellent protection against the ravages of soil erosion.

2.______ Plant materials generally allow falling raindrops to strike the surface of the earth, with their full impact.

3.______ The impact of a raindrop striking the bare surface of the soil can dislodge soil particles. These particles are thrown into suspension, and carried away by the runoff.

4.______ Sediment, in suspension, passes as easily through grass as the water itself.

5.______ Plants also protect against soil erosion by holding soil in place with their roots.

6.______ Roots help prevent water from infiltrating into the ground.

7.______ Roots benefit the soil by aerating it.

Questions 2

Circle the correct answer or answers.

1. All plants are useful in erosion control, but some plants are more desirable than others because of
   a. their physical structure
   b. their weed-seed content
   c. their adaptability to the physical and climatic conditions at a site
   d. their ability to grow on soils low in nitrogen

2. The best plant is
   a. the one that requires the most nutrients
   b. the one that will provide the necessary erosion control
   c. the one that will need the least maintenance
   d. the one that is most susceptible to damage by insects

3. The most common ways of grouping plants are
   a. by the color of their flowers
   b. by cost
   c. by their lifespans
   d. by their physical characteristics

4. As for lifespans, plants used for erosion control are grouped into
   a. annuals and perennials
   b. deciduous and evergreen
   c. rhizominous, stoloniferous, and bunch
   d. tap root and fibrous root

5. An annual completes its growing season in

   a. more than two years
   b. two years
   c. one growing season

6. Annuals used for permanent stabilization, because of their ability to reseed themselves year after year, include

   a. Korean lespedeza
   b. millet and sudangrass
   c. cereal grains
   d. Kentucky 31 tall fescue
   e. corn

7. Perennials used in stabilizing soil include

   a. cereal grains
   b. birdsfoot trefoil
   c. long-lived grasses
   d. millet and sudangrass
   e. vines, such as honeysuckle
   f. Korean lespedeza
   g. ivy and lily turf

8. Evergreens

   a. lose their leaves once a year, usually in the fall
   b. keep their foliage alive throughout the year, despite normal seasonal changes in climate
   c. include cereal grains
   d. include periwinkle and ivy
   e. include creeping juniper, white pine, and holly

9. Deciduous plants

   a. lose their leaves once a year, usually in the fall
   b. keep their foliage alive throughout the year, despite normal seasonal changes in the climate
   c. include sericea lespedeza and kudzu
   d. include periwinkle and ivy
   e. include forsythia and black locust

Questions 3

Fill in the blanks.

1. The spread of a tree's root system is normally equivalent to the spread of its ___________.

2. Roots are grouped as either ____________ or fibrous.

3. A _____________ root grows vertically, downward. Secondary roots branch out from the _____________ root.

4. _____________ root systems control soil erosion and runoff better than _____________ root systems.

5. An example of a plant with stems that emerge from the roots is the ______________ ______________.

6. The branches and foliage of plants such as trees and shrubs are referred to as the _____________.

7. The crowns of trees, shrubs, and other plants help control wind erosion and moderate changes in _________.

8. Crowns also provide a__________ ___________ , which protect the surface of the soil from erosion, provides soil nutrients, and assists in the development of the tilth of the soil, that is, its structure.

Questions 4

True or False.

1.________ Grasses play a relatively minor role in vegetating stabilized areas.

2.________ There are many varieties of grasses, each differing in physical structure and adaptability to climatic conditions.

3.________ Some varieties of grasses are established by seeding, some by sprigging, and some by clumps, or culms.

4.________ Grasses are classified as bunch grasses and legumes.

5.________ Rhizomitous and stoloniferous grasses spread by producing "runners" that extend out from the main plant.

6.________ Kentucky bluegrass spreads by rhizomes.

7.________ Bunch grasses also spread by producing "runners," that extend out from the main plant.

8.________ Selected legumes can be used to stabilize slopes that are hard to maintain ; some legumes require little maintenance.

Questions 5

Each of the following sentences contains one error. Write the letter that corresponds to the incorrect word or phrase in the blank provided.

1.________ Developing an adequate plan for revegetation includes a site investigation (A), selecting the proper materials (B), little or no planning for a long-term, low-maintenance cover (C), and developing a maintenance program (D).

2.________ One of the major environmental factors which you must investigate at each site before selecting plant materials is climatic conditions; these include temperature (A), pH (B), precipitation (C), and exposure to sunlight and wind (D).

3.________ Plants such as bermudagrass and weeping lovegrass grow best during the hot summer months (A), and in the late fall (B), while Kentucky bluegrass grows better during the cool and moist spring months (C) and in the fall (D).

4.________ During most of the day, slopes facing northward
will be shaded and therefore more moist; slopes
A B
facing southward will be exposed to direct sunlight
C
and will therefore tend to be unlikely to support
D
vegetation.
D

5.________ Soil conditions you should consider before selecting
a plant material include fertility, the moisture content,
A B
and the exposure. (Exposure is important but it is a site condition.)
C

6.________ Generally droughty soils contain more than 25 to 30%
A
fines; many sandy soils are droughty, while most
A B C
clayey soils are not, but the best way to tell if a
C
soil is potentially droughty is to determine the
D
distribution of the various grain sizes in the
D
laboratory.
D

7.________ If you encounter a droughty soil, use plants that are
A
highly susceptible to drought, such as weeping lovegrass;
A B
these plants are able to regulate their consumption of
C
water, and they have deep roots, which penetrate below
C D
the droughty zone.
D

Questions 6

Fill in the blanks.

1. Where the water table occurs near the soil surface, the soil at the surface may be _____________ during much of the year.

2. When this condition exists, you will have to choose plant materials, such as ________ __________, which tolerate __________ soils.

3. Test the ____________ of the soil. The ______________ is a measure of the alkalinity or acidity of a soil.

4. _____________ is an example of a plant that tolerates fairly acidic soil.

5. Among the plants which may be used on tidal banks and along shorelines are _______________ and _____________.

6. Before consulting ___________________________ for the final selection of plant materials, determine the physical factors limiting the selection, and the intended use of the site.

Questions 7

Circle the correct answer or answers.

1. To protect against plant disease, you must
   a. spray the plants with DDT
   b. insure that the seeds or vegetative materials are free of diseases
   c. use applicable pesticides according to label instructions.

2. One way of protecting against plant diseases is
   a. to see that seed and sod materials are properly certified
   b. to make sure that the seed or sod materials contain a sufficient percentage of inert filler
   c. to make sure the soil does not contain any noxious substances, such as nitrogen

3. The control of insect damage can be legally achieved by
   a. the use of DDT
   b. planting a nurse crop, together with legumes
   c. the use of approved pesticides and other means

4. Plant starvation results from
   a. excessive competition for moisture and nutrients, by weeds or a nurse crop
   b. the use of certified turfgrass sod
   c. a deficiency of plant nutrients, or soil moisture in the soil

5. Weeds can usually be controlled by

    a. the use of topsoil
    b. the selection of a good quality seed or vegetative material
    c. herbicides
    d. the use of disease free plant materials
    e. mowing

6. The time required for desirable materials to deplete the soil nutrients will vary depending on

    a. the type of plant material
    b. the certification of the seed and sod materials
    c. the physical structure of the soil
    d. the natural level of the nutrients in the soil
    e. the intensity of precipitation
    f. pH

Questions 8

Each of the following statements contains one mistake. Write the letter that corresponds to the incorrect phrase in the blank provided.

1.______ Plants, in order to grow well, $\underline{\text{require sixteen elements, or nutrients}}_{A}$. However, the three major nutrients are $\underline{\text{nitrogen}}_{B}$, $\underline{\text{phosphorus}}_{C}$, and $\underline{\text{calcium}}_{D}$.

2.______ Nitrogen $\underline{\text{tends to moderate the growth of plants above the ground}}_{A}$; it $\underline{\text{gives the foliage a deep-green color}}_{B}$. If the foliage of the plant yellows, $\underline{\text{it often means the plant is deficient in nitrogen}}_{C}$.

3.______ Phosphorus $\underline{\text{plays an important role in the ability of a plant to assimilate other nutrients}}_{A}$. It is essential for $\underline{\text{the full development of sturdy, healthy roots and crown}}_{B}$. $\underline{\text{A dry, scorched appearance in the leaves}}_{C}$ may indicate a deficiency of phosphorus.

4.________ Potassium is furnished by legumes. Potassium has
A
an important role in the development of the root
B
system. Potassium is also essential for manufacturing
B C
and storing plant food. A dry, scorched appearance
C D
in the leaves may indicate a potassium deficiency.
D

5.________ An 80 pound bag of fertilizer labeled 10-6-4 would contain 10 percent, or 8 pounds of available nitrogen,
A
6 percent, or 4.8 pounds of available potassium, and
B
4 percent or 3.2 pounds of available potassium.
C

6.________ Lime is primarily used to supply magnesium, but it
A
also neutralizes acid soil, makes many of
B C
the essential nutrients more available to plants,
C
provides nutrients such as calcium, and increases the
D E
ability of certain tight, clayey soils to hold moisture.
E

Questions 9

True or False.

1. ________ Plants aid in controlling erosion by protecting the soil from the direct impact of the falling rain, by slowing the flow of water over the surface of the ground, by holding the soil, and by adding organic matter to the soil.

2. ________ Annuals live for several years; they often flower and produce seeds each year.

3. ________ Plants with tap roots are more beneficial in controlling soil erosion than those with fibrous roots.

4. ________ Bunchgrasses are useful in controlling soil erosion, while grasses with stolons or rhizomes are not.

5. ________ Legumes are useful because selected legumes require little maintenance; some legumes can be used in areas which are hard to maintain.

6. ________ Legumes add nitrogen to the soil. Because of this they are often used along with other plants.

7. ________ In order to develop an adequate plan for revegetating a graded area, it is usually sufficient to select the proper plant materials.

8. __________ Environmental factors you should investigate include temperature, precipitation, and exposure to sun and wind.

9. __________ It is usually unnecessary to investigate the soil's pH.

10. __________ Once plants have been established, they will usually need no further attention.

11. __________ The main plant nutrients present in fertilizers are nitrogen, phosphorus, and potassium.

12. __________ For soils too acid for plants being planted you should add lime to the soil, before planting.

13. __________ Legumes, when planted with grasses, help the grass by converting atmospheric nitrogen into a form useable by the plants.

14. __________ Legumes include crown vetch, Korean lespedeza, locust trees, and Sericea lespedeza.

15. __________ It would be a serious error to seed legumes and grasses, together with native herbaceous and woody plants, such as shrubs, vines, and trees, to stabilize veritical areas.

16. __________ Soils with a pH of 7 are neutral.

17. __________ Soils with a pH below 7 are basic.

EROSION AND SEDIMENT CONTROL

CONTROL OF RUNOFF DURING CONSTRUCTION

WORKBOOK

I. INTRODUCTION

A. Definitions

1. Stormwater Runoff - rain that is not absorbed when it comes in contact with the soil. This runoff may carry soil with it The faster it travels, the more soil it can erode and carry.

2. Sediment - soil that is transported by runoff and deposited on the ground surface or in waterways.

B. Factors that Increase Runoff

1. Grading during construction that destroys natural vegetation - which is nature's greatest runoff protection.

2. Construction changes the natural balance of the land. Grading practices during construction may turn gentle slopes into steep slopes.

3. Construction covers large portions of soil surface with roof and concrete or asphalt pavement. (A 20% loss of soil area will cause runoff to more than double during heavy rainfall.)

II. CONTROL OF RUNOFF - OVERVIEW

There are two ways to control runoff:

A. Decrease the amount of runoff by using special grading practices that increase the detention and intake of water into the soil.

B. Diversion is another method used to control runoff. With a diversion structure, runoff is intercepted and diverted to an area where it will be absorbed or safely discharged.

III. SPECIAL GRADING PRACTICES

A. Preserving Vegetated Buffer Areas. Preserving a buffer zone above and below a graded area will trap much of the rainfall before it has a chance to erode and will filter runoff from the graded area.

B. Staging - dividing a construction site into different areas. With staging, grading and stabilization are finished in one area before proceeding to the next. This limits the amount of soil exposed to erosion at any given time.

C. Surface Roughening - is an easy and economical method that simply creates an uneven or bumpy condition on the soil surface. Horizontal grooves tend to spread runoff over the slope, slowing it down and allowing more of it to be absorbed by the soil. Scarification is one way to roughen the soil surface. It is often performed by back blading along a slope with the teeth of a loading bucket mounted on a crawler tractor. Roughening produces a soil surface very suitable for the growth of vegetation.

IV. DIVERSION STRUCTURES

A. Temporary and Permanent

Diversion structures are built to intercept and divert runoff at a safe or non-erosive velocity. Temporary structures are designed only for the construction period, while permanent structures are built to remain both during and after construction.

B. Interceptor Dikes

1. Interceptor Dikes are built across a roadway to intercept runoff flowing down the graded right of way. Runoff can be directed into any safe disposal area such as a vegetated area or completed storm sewer. Because the soil dike slows down runoff, sediment may be deposited on the uphill side of the dike. This sediment must be checked after every storm and removed before it impairs the efficiency of the dike.

2. Gravel Interceptor Dikes

are used when the weight of construction traffic would be too much for a wet soil interceptor dike to withstand. It is similar to a soil dike, except that it is made from gravel or crushed rock. A gravel dike is less likely to be damaged or washed out during a heavy storm. It must be checked and properly maintained.

C. Diversion Dikes collect runoff and channel it safely away from an erodible soil surface to a safe disposal area. It is made of compacted soil and is commonly used along the top of a slope.

When the channel along the diversion dike is steep, soil reinforcement measures such as netting, mulching, and chemical stabilizers are helpful. The diversion dike also requires maintenance. It should be inspected after each storm, and any damage repaired.

D. Diversions are often used on hillsides

The soil excavated from the channel of the diversion is used to build a dike down hill from the channel. This combination of channel and dike will create a larger flow capacity.

A standard diversion dike with side slopes of two to one and a two-foot wide top and 1.5 feet high will have good flow capacity for drainage areas less than 5 acres.

A "top of cut" diversion is widely used in building highways.

CAUTION: If a diversion structure is used, be careful when working on a steep slope - a SLIDE could occur. The major cause of sliding is the saturation of the soil by water concentrated behind and within the diversion.

V. DISPOSAL OF DIVERTED FLOW

A. Onto Vegetation

The best way to dispose of diverted runoff is directly onto a well vegetated ground surface. When the amount of concentrated runoff is not too great, the vegetation will filter the runoff, and the soil will absorb some of the water. Grass is the best vegetative filter.

B. The Level Spreader

A level spreader is often required when the amount of runoff is too great to be disposed of directly onto a vegetated area. The level spreader changes a concentrated flow into non-erosive sheet flow.

C. Downdrain Structures are used to carry runoff from one level to another.

1. Flexible Downdrains

A flexible downdrain consists of a metal inlet or end section (the front lip is very important. It anchors the device and prevents the seepage of water beneath the drain.) A metal extension collar, normally about six feet long, and a collapsible drain tube made of heavy duty fabric are the other components of a flexible downdrain.

If the flexible downdrain is to perform properly, the inlet section must be tilted downward. The soil should be tightly compacted around the inlet. This measure is taken to prevent piping - the flow of water along the outside rather than the inside of the inlet. It is necessary also to have adequate fill over the pipe entrance - at least 12 inches over the top of the pipe.

2. Sectional Downdrains

A sectional downdrain is a half-round or third round pipe made from bituminized fiber, galvanized steel or other material. A formal design is needed to determine what size sectional downdrain you need to carry your flow without water spilling out of the pipe.

When used as a temporary downdrain, the pipe can be placed directly on the finished ground and secured in place with wooden stakes. Where two pieces of sectional downdrain are joined together, the uphill section overlaps the downhill by about three inches. The sectional downdrain can also experience piping.

3. Flumes

A flume is a flat bottomed ditch lined with either concrete or asphalt. A formal design is required to properly size a flume for the expected water flow. Piping can be a problem unless a good bond is maintained between the diversion structure and the flume inlet.

4. Energy Dissipators

Energy dissipators are used to slow down the flow of water at the drain outlet to lessen the chance of erosion. On temporary concrete flumes, stones or concrete blocks are sometimes set into the concrete so they protrude up into the flume. This slows the water. Placing a blanket of large crushed stone or concrete at the outlet will accomplish the same thing.

STORMWATER RUNOFF

Review Questions - Fill in the blanks

1. During construction, grading often causes ______________ ____________________________.

2. The ______________________ runoff travels, the more soil it disrupts and carries.

3. Soil deposited into our waterways where runoff concentrates is called __________________.

4. ______________________ is nature's greatest runoff reducer.

5. During a heavy rainfall, runoff will more than double when just 20% of a _______________ area is made impervious

Review Questions — True or False

_____ 1. There are two ways to control runoff on an area
struction; decreasing the amount of runoff and use of a diversion.

_____ 2. By staging, we mean getting all grading accomplished at one specific time during construction.

_____ 3. In using scarification as a form of surface roughening, we simply loosen the soil to a shallow depth without turning it over.

_____ 4. To be most effective, surface roughening must be vertical or up and down a slope.

DIVERSION STRUCTURES

Review Questions - Pick the best answer for the following and fill-in the answer space with the correct letter.

1. An example of a permanent diversion structure would be

   a. a flexible downdrain
   b. a top of cut ditch
   c. a soil interceptor dike
   d. a level spreader

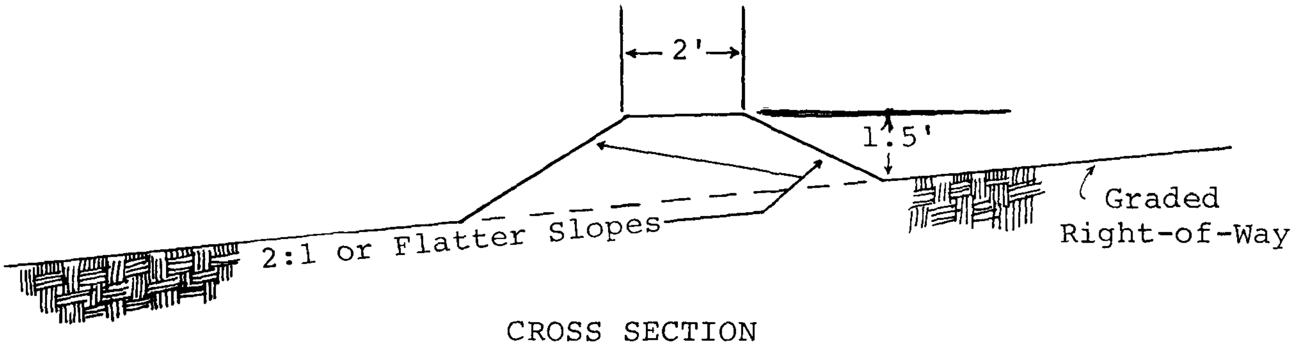
ANSWER ______________

2. To prevent excess buildup, sediment must be removed from soil interceptor dikes

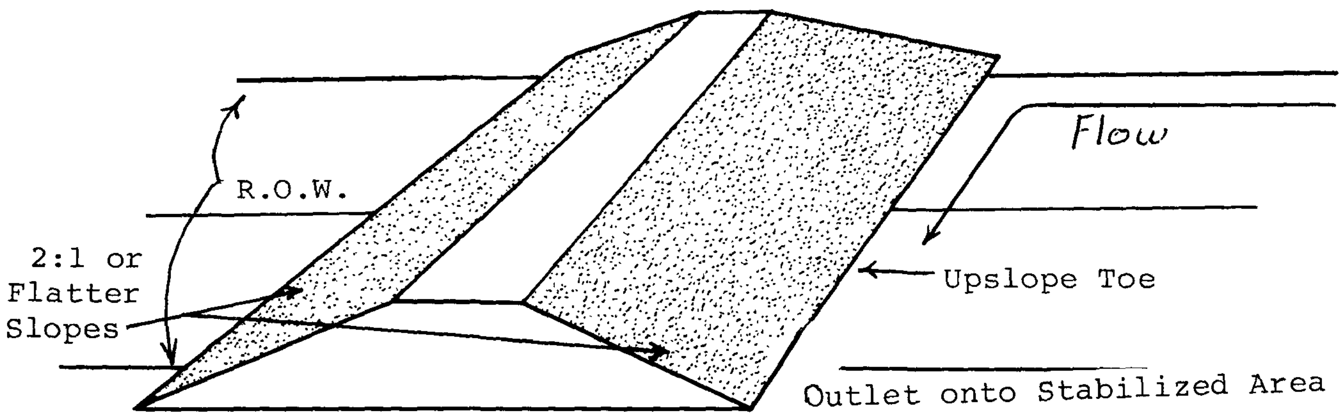
   a. after every storm
   b. after every other storm
   c. at least once per month
   d. daily

ANSWER ______________

TYPICAL DESIGN CRITERIA FOR A SOIL INTERCEPTOR DIKE



CROSS SECTION

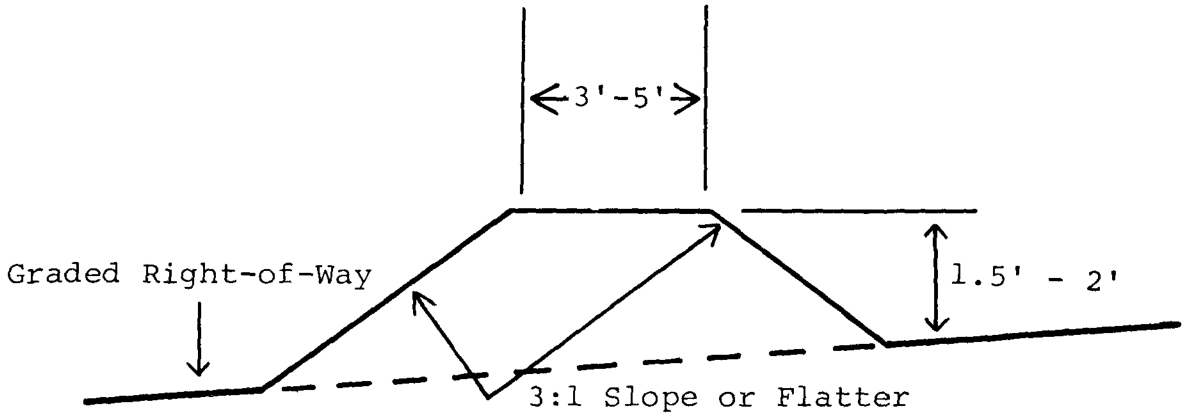


ISOMETRIC VIEW

GENERAL NOTES:

a. Drawings not to scale
b. Top width may be widened, slopes may be flattened
c. Outlet should function with minimal erosion

TYPICAL DESIGN CRITERIA FOR A GRAVEL INTERCEPTOR DIKE



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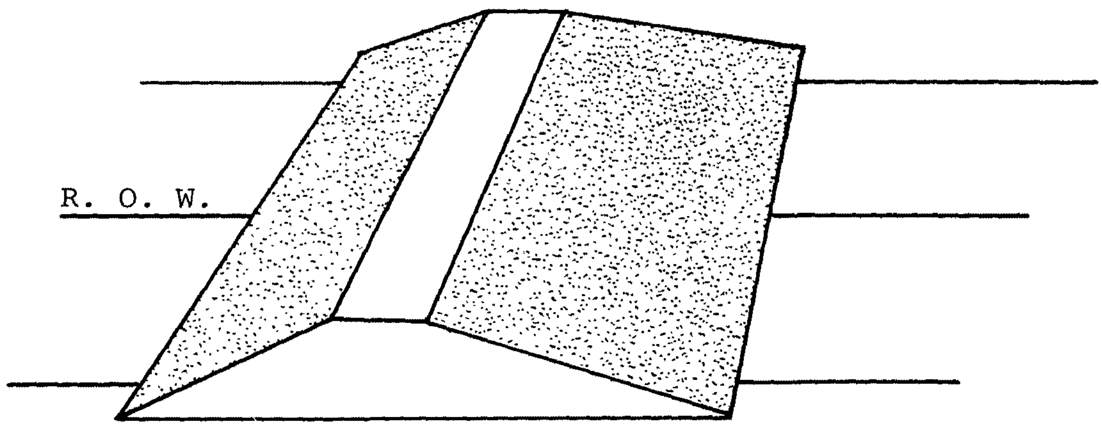
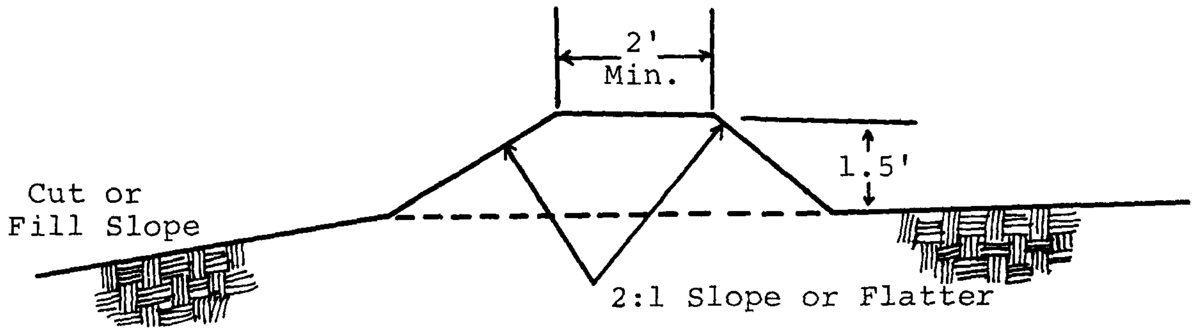


TOP ISOMETRIC VIEW

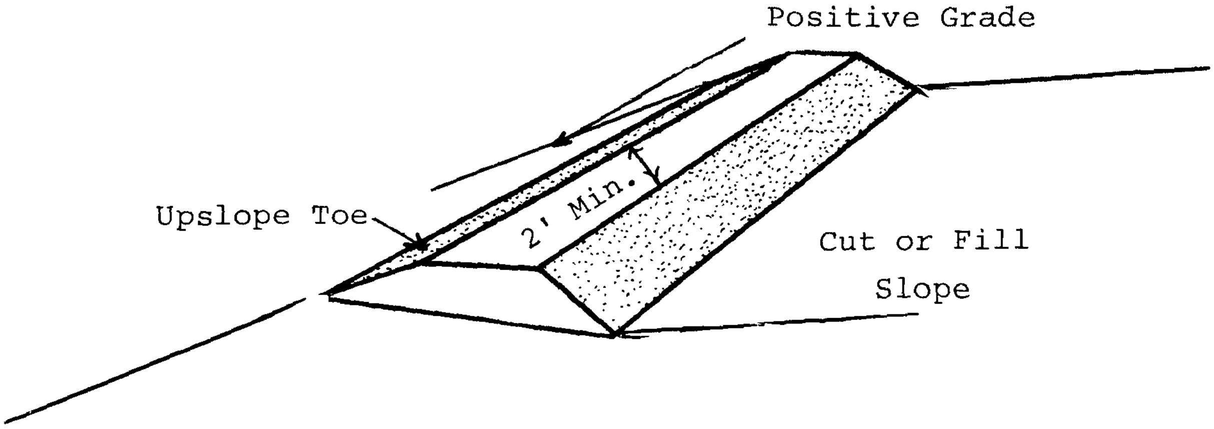
GENERAL NOTES:

a. Drawing not to scale
b. Top width may be widened; Slopes may be flattened
c. Outlet should function with minimal erosion

TYPICAL DESIGN CRITERIA FOR A DIVERSION DIKE



CROSS SECTION



GENERAL NOTES:

a. Drawings not to scale.
b. Outlet to stabilized area.

DIVERSION STRUCTURES

Review Questions - Fill in the blanks

1. Another name for the dike is ______________ ________.

2. The main function of the gravel interceptor dike is not to filter but to ____________ runoff.

3. The diversion dike is usually a dike of __________ soil built along the top of a cut or fill.

4. One place where a diversion dike may not be compacted is a ____________ area.

5. On hillsides, a ___________ is constructed by excavating from the channel and constructing the dike on the downhill side.

6. In building any kind of diversion structure, you must be careful to avoid the possibility of a __________ on the lower lying slope.

LEVEL SPREADER

Review Questions | True or False

_____ 1. The best way to dispose of diverted runoff is directly onto a well vegetated area.

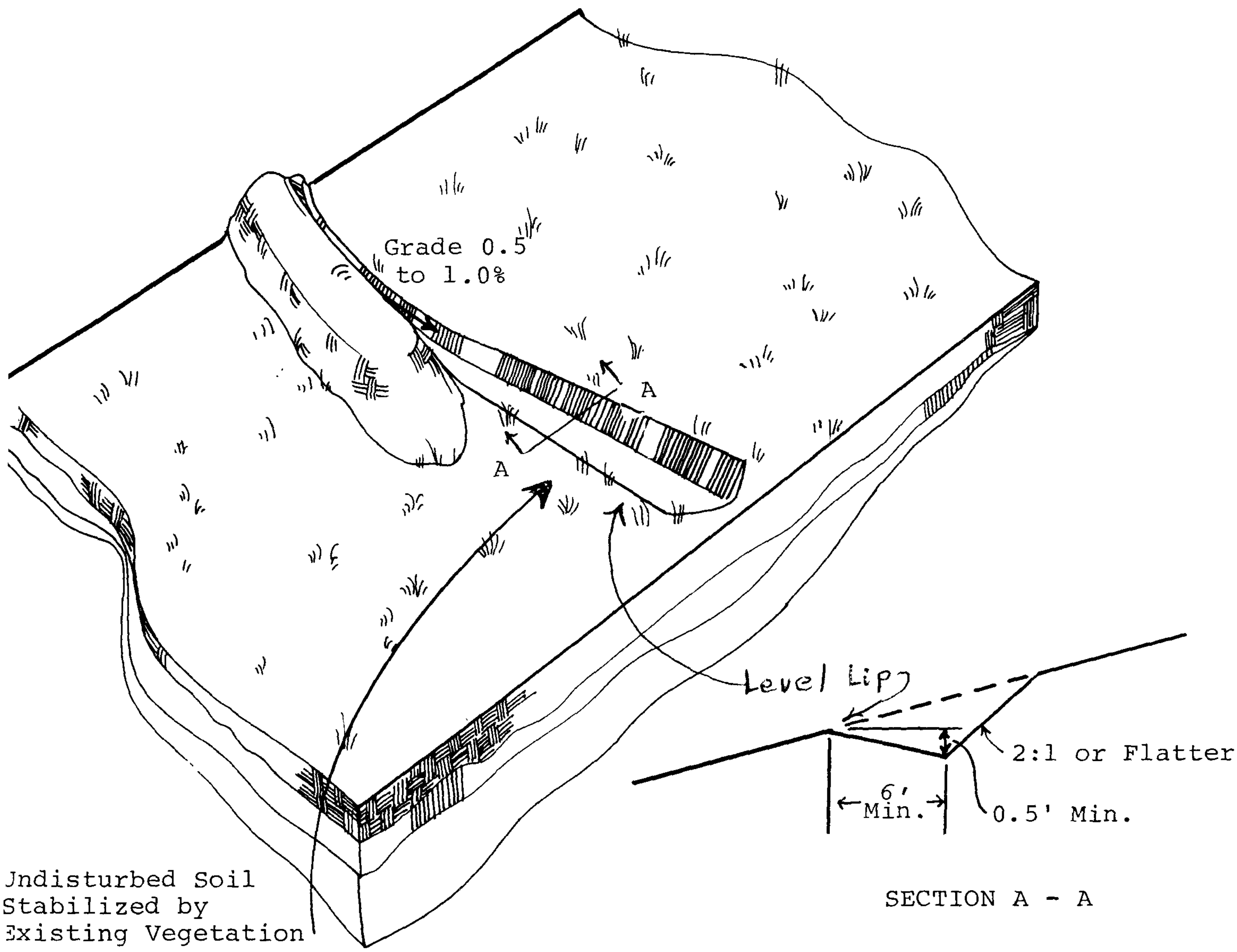
_____ 2. The level spreader is very similar to a diversion ditch.

_____ 3. The length of the level spreader will vary with the amount of water to be disposed of.

_____ 4. Being well stabilized with vegetation is helpful but not a must for a level spreader.

_____ 5. The most important feature of a level spreader is its depth.

TYPICAL DESIGN CRITERIA FOR THE LEVEL SPREADER



ISOMETRIC VIEW

GENERAL NOTES:

Drawing not to scale

Review Questions - Pick the best answer for the following and fill-in the answer space with the correct letter.

1. The metal inlet of a flexible downdrain has a front lip. Its function is to:

   a. anchor the device
   b. prevent the seepage of the water beneath the drain
   c. filter sediment
   d. both a and b

ANSWER ______

2. The flexible downdrain is subject to the piping effect. This is:

   a. too much flow
   b. flow alongside the inlet
   c. a tear in the tube
   d. none of the above

ANSWER ______

DOWNDRAIN STRUCTURES

Review Questions - Fill in the blanks

1. When used as a temporary downdrain structure, the sectional downdrain is secured in place with ________ stakes.
2. To avoid ____________, the soil must be tightly compacted around the entrance to a sectional downdrain.
3. A ______________ is a flat bottomed ditch lined with either concrete or asphalt.
4. Whatever your downdrain structure, severe _____________ at the outlet is often a problem.
5. The role of the energy dissipator is to ________________ down the flow of water before it flows onto the soil surface.
6. Probably the most frequent cause of failure of the flexible drain is inadequate fill over the entrance end of the pipe - this should be at least ___________ inches over the top of the pipe.

FINAL REVIEW QUESTIONS

Answer the Following

1. R__________ that is not a_________ when it comes in contact with the soil becomes s__________ r____________.

2. Three basic causes of runoff during construction are:

   a. G___________ during construction that destroys v_______________.

   b. Construction that changes the n______________ b_____________ of the land, turning g______________ slopes into s___________ slopes.

   c. Construction that covers large portions of soil surface with r__________ and c_________ or a___________ pavement.

3. Runoff can be controlled by:

   a. D____________ amount of runoff by using s____________ treatment p__________

   b. D____________ diverting runoff to a safe outlet.

4. Three special grading practices used to control runoff are:

   a. s________________

   b. s_______________ r____________

   c. preserving v______________ b__________

5. True or False - A permanent diversion structure can be defined as one that will serve both during and after the construction period. ______

6. The two basic kinds of interceptor dikes are:

   a. ________________

   b. ________________

7. A d______________d_____________ is a runoff control structure formed with c___________ soil and usually built along the t_________ of a slope or around the perimeter of a c__________________ site.

8. On natural hillsides where fill soil for a dike is not available we often use a d______________ d__________.

9. The best way to dispose of diverted runoff is directly onto a w__________ v______________ ground surface.

10. A l__________ s____________ is a bench cut into an undisturbed area which changes concentrated flow into sheet flow.

11. Three downdrain structures used to carry runoff from one level to another are:

    a. f_____________ d___________

    b. s_____________ d___________

    c. f_____________

12. __________________ is the flow of runoff alongside rather than through a downdrain structure.

13. When large amounts of runoff must be disposed of at a downdrain outlet, we often use an e_____________ d____________ to slow down the r________________ as it flows onto the ground surface.

EROSION AND SEDIMENT CONTROL

VEGETATIVE SOIL STABILIZATION

WORKBOOK

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I. <u>CRITICAL VS. NONCRITICAL AREAS</u>

A. Critical area - a sediment producing or highly erodable area. It may be an area where grading operations have stripped away the fertile topsoil to expose subsoil or an area bare of vegetation due to too much foot traffic.

II. <u>VEGETATIVE STABILIZATION</u>

A. <u>Temporary vegetative stabilization</u> is the use of certain fast growing, robust plant materials to stabilize a site for a temporary period of time (less than one year). Both annual and perennial plants are used.

1. Temporary stabilization becomes necessary when grading leaves an area exposed for a prolonged period of time.
2. The type of temporary vegetation used will depend on
   a. time of year
   b. site location
   c. soil type and condition

B. <u>Permanent vegetative stabilization</u> is performed when it is necessary to stabilize an area for more than one year. Perennial plants must be used; temporary annuals may be used in mixtures with permanent plants.

1. The life of this type of cover will depend on

    a. type of vegetation

    b. maintenance

    c. type of use received

III. PERMANENT AND SEMIPERMANENT PLANT MATERIALS

A. Grasses

1. Grasses are the most widely used plant material for stabilizing critical areas.
2. Grasses commonly used for critical stabilization in Maryland include:
   a. Kentucky 31 tall fescue
   b. Creeping Red fescue
   c. Tufcote Bermudagrass
   d. Red Top
   e. Weeping Lovegrass

B. Legumes

1. Legumes are also very popular for stabilizing critical areas.
2. They are long-lived and some require less maintenance than grasses.
3. Commonly used legumes include:
   a. Crownvetch
   b. Sericia lespedeza
   c. Korean lespedeza
   d. Sweet clover
   e. Birdsfoot trefoil

C. Herbaceous Plants

1. They play an important role when an area is to be returned to natural cover.
2. In residential areas they may be considered weeds.
3. Along major highways these materials play an important role in protecting soil from erosion.

D. Ground Covers

1. Because of their high cost as compared to grasses and legumes, these materials are not extensively used for critical area stabilization. However, on terrain with very severe problems, where less durable grasses and legumes are not able to perform properly, these plant materials are of great value.

2. "Ground covers" refers not to grasses or legumes specifically, but to such plant types as vines and low growing plants. Crown-vetch is a legume which is considered a very good ground cover plant in some areas.

E. Vines

1. some do well on poor soil and steep slopes.

2. are used for area beautification as well as soil stabilization.

3. examples are:

   (a) Kudzu

   (b) Honeysuckle

F. Shrubs

1. are used for area beautification as well as soil stabilization.

2. are used to reduce maintenance costs.

3. may serve as screens and barriers.

G. Trees are planted for erosion control, area beautification, shade, privacy, and sound abatement.

IV. SELECTING PROPER PLANT MATERIALS

A. Climatic Conditions

1. Temperature
2. Rainfall
3. Exposure
   a. wind
   b. sunlight - an important consideration
4. The first two conditions, and to a certain extent exposure, are related to the geographic area in which the site is located.
5. The most critical exposure problems are found in wooded areas where tall trees provide additional shade.

B. Soil Conditions

1. Fertility - subsoils are usually low in fertility and may be acid - fertility refers to the supply of plant nutrients in the soil.
2. Acidity - acid soils are those having pH values of less than 7. A value of 7 is neutral. A value above 7 is basic or alkaline.

(a) Plant nutrients are furnished by adding fertilizers and the acidity is usually reduced or controlled by adding lime.

(b) Maintenance can be minimized by selecting plant materials that are adaptable, as nearly as possible, to the natural condition of the soil.

(c) Some plant materials do better in poor soils than others. Likewise, some plants prefer or tolerate an acid soil, while others require a basic or alkaline soil.

(d) On low fertility soil, plant materials like grasses can be made more effective by mixing with a legume, like clover, which can furnish nitrogen, an important plant nutrient.

3. Droughty Soil

(a) Unable to retain an adequate supply of water

(b) To prevent this problem the soil should contain at least 25 to 30% silt and clay size particles (fines).

(c) The problem can be taken care of in three ways:

(1) by selecting drought-resistant plant material.

(2) by top-dressing with 4 to 6 inches of non-droughty subsoil or good topsoil.

(3) by soil conditioning - mixing silt and clay soil or organic material into the upper 3 - 4 inches of droughty soil.

4. Wet Soil

a. Soils that stay saturated for prolonged periods of time.

b. Seepage areas become difficult to stabilize with vegetation and can cause considerable erosion.

c. The problem of wet soil can be handled by

(1) using plant materials tolerant of wet soil.

(2) installing gravel and pipe underdrains.

C. Site Usage refers to the type of usage plant materials receive at a site. Must be considered when selecting plant materials.

D. Site Maintenance will also influence the type of plant materials being used. Some sites are easy to maintain, while others are nearly impossible because of physical barriers.

V. METHODS OF ESTABLISHING VEGETATION

A. Seeding

1. Most grasses and legumes are established by seeding.

2. The quantity of seed required to vegetate an area will depend upon what type or types of plant materials are being used.

3. Check application rate in "The Standards and Specifications for Soil Erosion and Sediment Control".

4. Use a small test plot to observe performance prior to planting any large areas.

5. Common bermudagrass can be established satisfactorily by seeding. Other bermudagrasses may only only be established by sprigging.

B. Sprigging

1. This involves the planting of sprigs of live vegetation rather than seed.

2. Many ground covers and vines are established by sprigging.

C. Sodding

1. This method uses live vegetation to quickly stabilize a site.
2. Completely covers the surface.
3. Often the most desirable and effective means of quickly stabilizing highly critical areas such as waterways.

VI. TIME OF PLANTING

The success of a vegetative stabilization program will depend to a large degree on the weather occuring during the critical period immediately following planting. This is especially true for seeding.

A. Cool Season Plants

1. require cool, moist conditions to germinate
2. best planted during early fall and early spring.

B. Warm Season Plants

1. best planted during late spring or summer
2. some moisture essential

VII. SOIL ADDITIVES

Critical area planting requires the addition of fertilizers and may need lime to the soil. The amount of these additives needed will depend upon the type of plant materials used and the condition of the soil.

Soil testing should be performed to determine the additive requirements.

When testing cannot be performed, use the standard application rates, found in the Standards and Specification for Erosion and Sediment Control.

A. <u>Fertilizer</u>

   1. contains important plant nutrients

      a. Nitrogen (N)

      b. Phosphorus (P)

      c. Potash (K)

   2. "10-10-10" is a "well balanced" fertilizer and is the percentage of "N-P-K" in the fertilizer.

   3. Quick release fertilizer acts quickly.

   4. Slow release fertilizer acts at a controlled rate.

B. <u>Lime</u>

   1. Neutralizes acid soil conditions

   2. Crushed dolomitic limestone may be used rather than regular limestone.

   3. Avoid using too much lime around plants that require acid soil.

VIII. MULCHING

A. very essential after preparation of a seedbed, as well as for the establishment of ground covers, vines, shrubs, and trees.

B. involves the placing of material on the soil to protect it from erosion and to provide a proper environment for the growth of vegetation.

C. shields the soil from the impact of rainfall and from the scouring effect of runoff.

D. insulates the soil from intense heat and cold.

E. conserves moisture.

F. Mulch Materials

   1. straw - most commonly used
   2. wood chips
   3. wood fiber (poor)
   4. chemical emulsions
   5. fiberglass products

G. Application Rates

   1. straw - 1 to 2 tons per acre
   2. wood fiber mulch - 1000 to 1500 lbs. per acre
   3. wood chips - 40 to 60 cubic yards per acre
      a. The heavier application rates should be used on steep slopes and along waterways where the potential for soil erosion is

greatest. Lighter application rate applies to relatively flat areas that do not carry concentrated runoff.

IX. TOPSOILING

A. Involves the placing of 4 to 6 inches of good quality topsoil on the final graded subsoil surface prior to preparing a seedbed.

B. Usually topsoil is acquired by salvaging and stockpiling the surface material at the beginning of grading operations.

C. Tests should be performed to insure that the topsoil is of adequate quality.

D. Topsoiling Slippage becomes a possibility when topsoiling steep slopes. There are three factors that combine to cause this problem.

1. High moisture content. Because it contains organic material, a topsoil is able to absorb and retain a large amount of water. By absorbing the water, the weight of the topsoil increases, and at the same time it becomes more fluid.

2. Slope steepness. The steeper a slope, the easier it is for a heavy, wet topsoil to slip down the slope.

3. Poor Bond. Lack of a good bond between the topsoil and the underlying subsoil. The underlying soil should be roughened to a depth of 2 - 3 inches prior to spreading the topsoil. After it is spread, the topsoil should be firmed.

X. ESTABLISHING VEGETATION ON CRITICAL SOIL SURFACES

A. Soil Preparation

1. The first step in the preparation of a seedbed involves the placing of lime and fertilizer on the soil.
2. Tilling to a depth of at least 3 inches with a disc.
   a. mixes the lime and fertilizer into the soil.
   b. allows more air and moisture to penetrate the root zone.
   c. breaks up clods of soil.
   d. should be performed along the contour of the ground surface, if feasible.

B. Seeding

1. Seeding is usually done after the lime and fertilizer have been worked into the soil.
2. Rolling or cultipacking should follow the application of seed - where conditions permit.
3. Inaccessible areas can be limed, fertilized and seeded with a hydroseeder.

C. Mulching is done immediately after the seeding operation. There are several methods for applying and securing mulch.

1. Mulch Blower is a labor saving device used when mulching large seedbeds.
2. Emulsified Asphalt is sprayed on straw mulch to prevent it from being blown or washed away. Upon curing the asphalt binds the individual straw fibers together to form a mat that is more resistant to erosion. It is often undesirable in residential areas because of its sticky nature.
3. Chemical Binders are used to avoid the sticky problem of asphalt. These chemicals are mixed with water and sprayed on the straw. Upon curing, the chemical binds the straw fibers together.

4. Peg and String method is used in small areas where spraying cannot be performed. Wooden stakes or metal pins are driven into the ground and a strong twine is strung in a criss-cross manner between them.

5. Netting is used to secure straw mulch where heavy flow is expected. Either a plastic, fiberglass, or jute netting is used. The netting is firmly secured to the ground with metal pins. Jute netting also acts as a mulch.

6. Mulch anchoring tool is often used to anchor straw on accessible areas. It consists of a gang of notched coulters, resembling a disc used for tilling except they are blunt. When pulled over the mulch, the revolving discs punch some of the straw into the soil.

7. Hydroseeder is used to apply seed, fertilizer, lime and wood fiber to inaccessible areas. The materials are mixed with water to form a slurry and are then sprayed onto the seeded area.

8. Excelsior Blanket is made up of coarse wood fibers reinforced by netting. Mattings of this type are used on drainageways and other critical areas exposed to a concentrated flow of water during storms. A slow-release nitrogen should be used with excelsior blanket.

9. Glassroot consists of long strands of fiberglass which are sprayed onto the ground surface with a special apparatus powered by compressed air. This material is used on highly critical areas where long-lasting mulch protection is desired.

D. Sodding

1. The soil must be conditioned by applying needed lime and fertilizer and disking it into the top 4" of soil.
2. Large stones or debris must be removed from the surface
3. The surface is graded to remove irregularities.
4. Strips of sod must be tightly butted together on the contour with staggered joints.
5. After placing, the sod is watered and then rolled.

XI. MAINTENANCE OF CRITICAL AREAS

A. Follow-up

1. Required when seeding, sodding, or other vegetative practices do not achieve the desired degree of stabilization.

2. Materials planted in the spring should be inspected during the summer or early fall so that corrective action can be taken during the fall planting season.
3. Areas stabilized in the fall should be inspected early in the spring so that maintenance can be performed during the spring planting season.
4. If the cover did not develop properly, the area should be seeded and fertilized with half the rates originally applied.
5. If stand is over 60% damaged, complete seedbed preparation and seeding must be performed - before doing this, check plant material and soil condition.

B. Periodic Maintenance

1. Performed after the vegetation has been established.
2. Periodically inspect plant cover to see if a top dressing of fertilizer or lime is required.
3. Spray if insect damage is severe.
4. Spot seed areas damaged by traffic or by other means.
5. Mowing is a periodic maintenance practice.

QUESTIONS 1

Fill in the blanks

1. A ____________ area is a sediment-producing or highly e__________ area.

2. Utility easements, waterways, and building sites are common _______________ areas.

3. _______________ stabilization uses certain fast growing plant materials to stabilize a site for ___________ than one year.

4. _______________ stabilization uses perennial plants.

5. The type of temporary vegetation to be used on a site will depend upon:

   a. t___________ of y___________
   b. site l___________
   c. s___________ type and c___________

QUESTIONS 2

Multiple Choice - circle the correct answer

1. Which of the following is not a permanent plant?

a.	grass (Perennial)	d.	mulch
b.	shrub	e.	legume (Perennial)
c.	tree	f.	Crownvetch

answer (s) __________

2. Grasses commonly used for critical area stabilization include:

   a. Crownvetch
   b. Weeping lovegrass
   c. Kentucky 31 tall fescue
   d. both a. and c.
   e. both b. and c.
   f. all of the above

answer (s) __________

3. The chief reason for the durability of legumes is:

   a. they are able to add phosphorus to the soil
   b. they are able to withstand freezing temperatures
   c. they are able to remove nitrogen from the air, utilize it, and add it to the soil
   d. they are able to remove nitrogen from the soil and release it into the air

answer (s) __________

(Go on to next page)

4. During the winter, the foliage of legumes

   a. stays green
   b. grows back
   c. dies
   d. does none of the above

(Applies to certain areas of U.S. only)

answer (s) __________

5. Where mowing must be performed, the preferred plant material to use is

   a. legume
   b. grass
   c. shrubs
   d. herbaceous plants

answer (s) __________

6. In residential areas, what material may be considered weeds?

   a. mulch
   b. shrubs
   c. turf grass
   d. trees
   e. herbaceous plants

answer (s) __________

QUESTIONS 3

True or False

_____1. The term "ground covers" refers to grasses and legumes specifically.

_____2. Trees, vines, and shrubs are not used extensively to reduce maintenance costs.

_____3. The primary reason for planting trees is noise abatement.

_____4. Periwinkle is a ground cover.

QUESTIONS 4

Fill in the blanks

1. Climatic conditions include ______________, __________ and ______________.

2. Wind and sunlight are two types of ________________.

3. ___________________ exposure is a very important consideration.

4. The most critical exposure problems are found in _________________ areas, due to shading.

5. Subsoils are generally low in _____________ and may be ___________________.

6. A pH value of 7 is _________________.

True or False

_____7. We would usually plant a tall legume or shrub in the channel of a waterway.

_____8. Legumes are more suitable than grasses in areas receiving a great deal of foot traffic.

_____9. Not all plant materials require the same degree of maintenance.

QUESTIONS 5

Multiple Choice

1. Some grasses and legumes may be established by

   a. sodding c. seeding
   b. sprigging d. all of the above

   answer (s) __________

2. Bermudagrass is usually established by

   a. sodding c. fertilizing
   b. sprigging d. seeding

   answer (s) __________

3. English ivy is usually established by

   a. sodding c. seeding
   b. sprigging d. fertilizing

   answer (s) __________

4. The most desirable and effective means of quickly stabilizing certain highly critical areas, such as waterways is

   a. seeding c. sprigging
   b. sodding d. none of the above

   answer (s) __________

QUESTIONS 6

Fill in the blanks

1. The success of a vegetative stabilization program will depend to a large degree on the ____________ occuring during the critical period immediately following planting.

2. Critical area planting involves the addition of ______________ and possibly lime to the soil.

3. Fertilizer contains nitrogen, p____________ and p______________, N-P-K.

4. The addition of dolomitic limestone ____________ th of acid soils.

5. Dolomitic Limestone adds calcium and m____________ the soil and helps correct __________ soil conditio

QUESTIONS 7

Multiple Choice

1. ________________ is the most commonly used mulch material.

   a. wood chips c. chemical emulsions
   b. wood fiber d. straw

2. Which of the following is a characteristic of mulch?

   a. protects the soil c. conserves moisture
   b. insulates the soil d. all of the above

   answer (s) ________

3. ________________ is usually acquired by salvaging and stockpiling the native material at the beginning of grading operations.

   a. mulch c. topsoil
   b. lime d. sod

4. Which of the following is not a contributing factor to soil slippage?

   a. high moisture content
   b. poor shear strength
   c. slope steepness
   d. high acid content

   answer (s) ________

QUESTIONS 8

True or False

_____1. The first step in the preparation of a seedbed is sodding.

_____2. Cyclone spreaders can be used to apply fertilizers.

_____3. Pelletized fertilizer can be applied with a truck mounted spreader bar.

_____4. After applying (lime and) fertilizer, the area is tilled to a depth of at least twelve inches.

_____5. Tilling should be performed along the contour of the ground surface, if feasible

_____6. On steep slopes where rolling cannot be performed, a cleated dozer is often used to produce the desired surface texture by moving up and down the slope.

QUESTIONS 9

Fill in the blanks

1. Immediately after seeding operations are completed, the area should be ______________.

2. In residential areas receiving heavy foot traffic, a__________ t__________ is often undesirable because of its sticky nature.

3. E____________ b____________ is a mulch material that is sometimes used in the revegetation of waterways.

4. On accessible areas, a m__________ a____________ t_________ is often used to anchor straw mulch.

5. W__________ ___________ mulch is applied with a hydroseeder.

6. Before placing sod, the soil must be c__________.

QUESTIONS 10

True or False

_____1. Follow-up maintenance is required when seeding, sodding, or other vegetative practices do not achieve the desired degree of stabilization.

_____2. Areas stabilized in the fall should be inspected early in the spring.

_____3. When inspection reveals that the cover did not develop completely the area should be seeded and fertilized with the same amounts originally applied.

_____4. Spot seeding is required when inspection reveals that sixty percent of the cover is damaged.

_____5. Mowing is another follow-up maintenance practice.

QUESTIONS 11

1. A critical area is any g__________ surface that is s________ producing or severely e__________.

2. Some common critical areas are u__________ e__________, w__________ and b__________ s__________.

3. Temporary vegetative stabilization is used to stabilize a site for a time period of __________ than one year. By reseeding an annual may be effective for several years.

4. The type of temporary vegetation will depend on:

   a. _______ of year that seeding is done
   b. site _______
   c. soil _______ and _______

5. Permanent vegetative stabilization is performed when an area has to be stabilized for _________ than one year.

6. The most widely used plant materials for stabilization are ________________.

7. Two grasses commonly used for stabilizing critical areas in Maryland include k__________ and w_______________ or creeping red fescue, tufcote bermudagrass or red top.

8. ________________ are also very popular for stabilizing critical areas with low fertility soils.

9. The chief reason for the durability of the legume is that it is able to remove ____________ from the air and utilize it.

10. C ____________ is a close-growing, legume that may be established on subsoils.

11. When an area is returned to a natural cover of vegetation ____________ ____________ play an important role.

12. In ____________ ____________ any plants out of place may be considered ____________.

13. Canada thistle is a n____________ herbaceous plant that must be controlled, while the black-eyed Susan is a non-____________ one.

14. Deciduous plants are those on which the f________ dies in the ____________.

15. In residential areas vines, shrubs and trees are used for a____________ b____________ as well as n____________ a____________.

16. Lily turf, English ivy, and periwinkle are examples of ____________ ____________.

17. Three reasons for planting trees are:

(1) ____________ b____________
(2) p____________
(3) n____________ a____________

18. The four factors governing the proper selection of plant materials are:

(1) C____________ c____________
(2) S____________ c____________
(3) S____________ u____________
(4) S____________ m____________

19. ________________ conditions include temperature, rainfall and exposure.

20. The two types of exposure are ____________ and ________________.

21. The most critical exposure problems are found in w________________ areas, if heavily shaded.

22. Subsoils are generally low in f__________ and are frequently ____________.

23. A pH value of more than 7 is _____________.

24. The acidity of the soil is neutralized by adding ______________.

25. On low fertility soil we can benefit plant materials like grasses by mixing in a l___________.

26. Droughty soil is not able to retain an adequate supply of w_________ for p_________ use.

27. What are two ways the problem of droughty soil can be taken care of?

    a. Select a plant m_________ that is drought r___________.
    b. T_____________ the droughty soil with _____________ to___________ inches of non-droughty subsoil or good topsoil.

28. In seepage areas where vegetation is difficult to maintain, it may be necessary to cover the seepage area with a protective cover of c_____________ s_______________. Better yet, drain it.

29. Three methods used to establish ground covers, grasses and legumes on critical areas are:

    (1)____________ (2)____________ (3)____________
    Not all plants are suitable for each method.

30. Almost all grasses and legumes are established by ________________.

31. ____________ involves the planting of sprigs of live vegetation rather than ____________.

32. ____________ is often the most desirable and effective means of Q___________ stabilizing highly critical areas.

33. Plant materials may be categorized as either _______________ season plants or _________ season plants.

34. Critical area planting requires the addition of ____________ and possibly __________ to the soil.

35. Fertilizers contain three important plant nutrients:

(1)____________ (2)____________ (3)____________

36. Lime performs several very important functions. Its most important function is in correcting a_________ s_________ conditions.

37. Three ways that mulching helps the establishment of vegetation are:

a. P________ the soil from the impact of r________ and from the scouring effect of r__________.
b. I________ the soil from intense ______ and _____.
c. Conserves m_____________.

38. Name three types of mulch materials:

(1)____________ (2)____________ (3)____________

39. T______________ is usually acquired by salvaging and stockpiling the surface material at the beginning of grading operations.

40. Two of the three causes of soil slippage are:

(1) ________________ (2) ________________

41. Soil preparation involves working l____________ and f__________ into the soil.

42. Straw mulch must be ____________ to keep it from blowing away.

43. Three materials for securing straw mulch are:

(1) E______________ a______________
(2) N______________
(3) C______________ b______________ (or peg & string)

44. Before placing sod, the soil must be c______________.

45. There are two types of maintenance; ______________ and ______________.

46. ________________ maintenance is performed after the vegetation has been successfully established.

47. ________________ maintenance is required when seeding, sodding, or other vegetative practices do not achieve the desired coverage.

48. Mowing is a ____________ maintenance practice.

 EROSION AND SEDIMENT CONTROL

STREAM EROSION CONTROL

WORKBOOK

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G. Stream Channel Control and Floodplain Storage

VII MAINTENANCE - ESSENTIAL IN GOOD STREAM EROSION CONTROL PLANNING

I INTRODUCTION TO STREAM EROSION CONTROL

A. There are two basic ways to control waterway erosion. The first is by protecting the channel against erosion. The second is by managing the water that runs off after a storm, so that it is less likely to cause erosion.

B. Most of the damage done to streams and other waterways occurs during heavy rains, or just after them, when the water is flowing at its maximum or "peak."

1. Proper control of this stormwater, before it enters the streams, and while it flows along them, will do a great deal to solve this problem.
2. Proper vegetative practices and good structures built to control erosion, will help as well.

II CAUSES OF STREAM EROSION

A. Water exerts a force against the soil, as it flows along. The force of flowing water is called "hydraulic" force. Hydraulic force is responsible for a major portion of waterway erosion.

B. Another way in which water can erode is by solution. Water can slowly dissolve rock materials. The solution of limestone to form caves or sinkholes is a good example of this form of degradation.

C. A third way in which water can remove material from a waterway is through corrasion. Corrasion occurs, when materials such as bits of soil or rock being carried by the water strike the bottom or sides of the waterway, and dislodge or displace other materials.

III FACTORS EFFECTING THE AMOUNT AND RATE OF EROSION

A. The amount and rate of erosion you can expect in a given stream depends on several factors. One of these factors is the turbulence of the flow of water. In any channel, smoothly flowing water causes less erosion than turbulent water.

B. Another factor that effects the rate of erosion is the meandering of the stream, that is, how much it deviates from a straight course. Where the stream bends, the water erodes the outside of the channel more than it does the straight stretches, because the force of the water is directed at the outside bank at this point.

C. Obstructions also have an effect. Obstructions in the channel, such as brush or boulders, may deflect the flow toward the bank, and cause additional erosion.

D. During periods of high water the velocity usually increases, thereby accelerating the rate of erosion. Not only does the water flow faster, during periods of high water flow, the turbulence increases. The flowing water, with its increased turbulence and velocity, scours the bed and erodes the banks of the stream.

E. The amount and rate of erosion also varies depending on the materials in the bed and bank. Many bank materials are likely to slide or slough off into the channel when the base of the bank is saturated or when the stream has undercut the bank.

F. The texture or makeup of the soils in the channel and banks will have an important effect on the rate the stream erodes.

    1. Those soils in which the particles are strongly bound together will erode less easily than soils made up of loose grains. Larger materials, such as gravel, cobbles, and boulders will erode very slowly.

    2. Sand, silt, and clay particles will erode much more rapidly, because they are lighter and more easily carried away.

    3. Water flowing over soils which contain a mixture of materials, including gravel or larger stones, will sort the particles by size until the bottom is covered or "armored" with only the larger materials.

G. Another factor that effects the rate of erosion is the slope or "gradient" of the channel.

    1. The gradient is the change in elevation of a stream, over a certain horizontal distance.

2. Gradients are measured in feet of vertical change per mile of horizontal distance, feet per hundred feet, expressed as percent, or feet per foot.
3. The steeper the gradient, the more rapid the erosion of the streambed, other factors being equal.

H. Another factor that effects erosion is the presence and condition of vegetation in the channel and on the banks of the stream. The roots of trees, shrubs, vines, grasses, and other plants help hold the soil in place.

I. Wherever man's activities have altered the natural watershed there are a number of new factors that will have an effect on the rate and amount of run-off and resultant erosion.
   1. These factors include the removal of natural vegetation, the compaction of the soil, any change in the topography, and the use of impervious coverings such as pavements or roofs.
   2. Increased erosion may also be caused by altering the natural channel of a stream. This process is called "channel realignment."
      a. It is often performed to make more room for development. Although channel realignment may make more land available for development, it also has some drawbacks.
         1. Since the change in elevation remains the same, and the distance the stream

travels is less, the gradient becomes steeper. As a result, the water in the new channel flows faster. The increased velocity will increase the erosion.

2. Channel realignment also exposes bare soil along the banks to the severe erosive action of concentrated flow.

3. Before developing any watershed, you should carefully study the natural streams to make sure they can handle the higher rate of flow, without causing increased erosion or flooding.

IV USE OF VEGETATION IN STABILIZING STREAMS

A. Along natural streams, an effective and economical way to help reduce erosion from surface runoff, is to preserve a buffer strip of natural vegetation.

1. In intermittent streams, you can often stabilize the waterway by planting a cover of grass over the entire channel.

2. Even when the bed of a channel cannot be vegetated, you can usually stabilize the banks and floodplain with vegetation.

B. Before choosing a plant material, you must consider several factors. These include the erosive forces, the soil and soil moisture, the exposure to sunlight, and the steepness of the slope to be planted.

1. To find out what type of vegetation is most suitable for a given site, consult the Standards and Specifications, or the local soil and water conservation district, or a university extension service.

C. Once you have selected suitable plant materials, there are certain procedures you should follow to establish the vegetation.

   1. Along ditches, swales, and other intermittant streams, you should usually plant vegetation in strips. Plant moisture-tolerant vegetation, that resists erosion extremely well, in the critical area near the water line, and in the bottom of the channel.

   2. Plant conventional, robust grasses and legumes above the critical zone.

   3. For added protection, in critical locations where the soil is very wet, you can plant bushes and trees such as alder and willow, along the banks.

   4. Before planting a channel, check the slope of the bank.

      a. It is usually not recommended to grade banks to greater than 50% or 2:1, if they are to be stabilized vegetatively.

      b. If the area to be planted is steeper than

50% (2:1), the banks should be graded back. will greatly facilitate necessary maintenance later.

c. Vegetated waterways should be constructed with gently graded sides that slope smoothly into a wide bottom.

d. With this type of construction, it is easy to vegetate the channel, the waterway blends into the surrounding area, and you can mow and maintain the grass without any unusual problems.

e. Not only are grass waterways pleasant to look at, they slow the flow of runoff and allow the water to infiltrate more easily into the soil.

5. Usually, you would seed streambeds in streams which carry water only during and immediately after runoff from a rainfall. These channels generally should not be seeded, if the flow of water exceeds four feet per second.

6. Where the waterways are designed to handle a flow of water greater than four feet per second, but less than seven, you should apply sod instead of seeding.

   a. Seasonal requirements also make it necessary to apply sod.

   b. However, if the soils erode at these velocities, you will have to take certain structural measures to prevent erosion, as well as using seeding or sodding.

V SECONDARY REINFORCEMENTS

A. Whether you establish vegetation by seeding, sodding, or sprigging, it will take some time before the vegetation will provide its best protection. Until that time, you will have to provide some secondary reinforcement, such as mulches, nettings, or blankets.

1. Some of these materials are intended to provide maximum protection at the time of planting and degrade as the vegetative cover matures. These materials include straw and other organic mulches, jute netting, and excelsior blanket.
2. When you need a reinforcement that lasts longer, you can use more permanent materials. Examples include fiberglass mulches, plastic netting, or any of several types of mattings.
3. When the flow of water is expected to be severe, you will have to secure the mulch with nettings. These include fiberglass and plastic nettings. A common problem in the use of netting in waterways is the movement of water beneath the protective material, and the subsequent loss of soil by erosion. Permeable,

granular soils are particularly susceptible. To prevent this, establish erosion checks across the waterway and beneath the netting at intervals along the channel.

VI STRUCTURAL STABILIZATION

A. In certain places in streams, vegetative practices alone are not enough to prevent erosion; you will have to use structural devices to protect the stream from scour or erosion.

B. Critical area along streambeds which may need structural stabilization include: the outside of bends where the flow impinges or impacts against the streambank, restrictions in the channel, junctions where tributaries enter the main channel, and places where the channel gradient is excessive.

C. Revetments are useful in areas where you need to protect the streambanks.

1. The most popular material used in constructing revetments is stone riprap. Stone riprap is durable, heavy, and flexible.

    a. By "flexible," we mean that the stone riprap adjusts to changes in foundations that result from erosion beneath the stone, and adjusts to scouring along the lower edge, or "toe."

b. In addition, the rough surface dissipates some of the energy present in the flowing water.

2. Other popular materials used in constructing revetments are gabions and revet mattresses.

   a. Gabions are wire baskets filled with stone. Like riprap, they are usually used in areas requiring heavy duty materials.

      1. They are cubic, generally 3 feet by 3 feet by 3 feet.

      2. Gabions are often used to hold very steep slopes, and construct check dams.

   b. Revet mattresses are similar in principle; however, they are not as thick. They vary in thickness from 6 to 12 inches, and usually cover an area 3 feet by 9 feet.

      1. The advantage of this type of structure over loose riprap or gabions is that you can use a thinner layer of stone; you can also use smaller stone. And, they are more flexible than gabions or concrete.

      2. Revet mattresses provide protection for slopes, under bridges, and along streams.

      3. Once the revet mattress is installed, you can spread lime, fertilizer, and seed over the revet mattress. Within a

short time, if conditions permit, plants will grow through the mattress, anchoring it to the soil underneath, as well as making the area more visually pleasing.

3. MONOslabs or checkerblocks or "grass pavers" are also useful in stablizing critical areas. MONOslabs and checkerblocks are concrete grids, approximately 2 feet by 1 1/3 feet by 4 1/2 inches. Each grid contains several open spaces.
   a. Laid side by side, they can be used to pave parking areas as well as to stabilize streambeds and atreambanks with slopes up to 2:1. MONOslabs are relatively flexible, because the individual blocks are not rigidly attached to each other.
   b. The open spaces in the grids can be filled with soil and seeded. This provides an attractive appearance.
   c. In addition to stabilizing vulnerable areas, riprap, revet mattresses, gabions, and MONOslabs or checkerblocks also allow more runoff to infiltrate into the soil than most other types of pavings or bank revetments would. this reduces the runoff which would otherwise increase the flow in the stream.

4. Fabriform is another good armor material to use in constructing revetments, as well as other structures for protecting the channel.

a. Fabriform consists of a double layer of heavy nylon fabric; a slurry of sand-cement is pumped into the nylon fabric and allowed to harden.

b. The finished product takes on a rough, tufted look. At each depression in the fabric surface there is a filter point. This filter allows the water underneath the Fabriform revetment to escape, while retaining soil particles in place.

5. Other popular materials used to stabilize waterways are concrete, concrete block, and sandbags filled with a sand-cement mixture.

6. For all revetments, to prevent seepage from beneath the revetment from undermining it, place a filter between the soil and the revetment. Use a cloth filter or a properly designed sand-gravel filter for this purpose.

D. In certain areas, you will need to provide extra protection for the streambed, as well as for the streambank. To prevent erosion of the streambed, use a grade-control structure. Grade-control structures physically prevent the streambeds from being eroded, and reduce the gradient, thus slowing the flow of water.

1. A grade-control structure consists of some durable material placed across the bottom of the channel. It can be a narrow strip of large

stone, placed across the channel, or it can be a complete lining across the channel. The structure causes the water to drop abruptly onto a stabilized pad, thereby reducing the effective gradient.

2. The same materials used to construct revetments are also used to build grade-control structures.
3. Common examples of grade-control structures include riprap energy-dissipators, placed at the outfall of stormdrains; riprap check dams, which are placed at regular intervals along a waterway; and ditches or other waterways lined with some material such as riprap, concrete, gabions, or Fabriform.

VII STORMWATER MANAGEMENT

A. The first basic principle of stormwater management is: assure that the peak rate of runoff after development is no greater than it was prior to development.

B. In order to accomplish this, it will often be necessary to hold back surface runoff, as close as possible to the place where it originates, and then release this water slowly enough so that it will not damage streams.

1. Rooftop detention is often practical on large commercial and industrial buildings. The flat roofs are equipped with

detention drains to store the water temporarily.

2. Parking lots can be constructed so as to detain a large amount of water, temporarily.

3. Another method of reducing stormwater runoff from parking lots and other paved areas, is to **use porous asphalt paving or surface the area with crushed stone.**

C. Recreation areas, such as parks and ball fields, can temporarily store large amounts of runoff from adjacent areas.

1. Creating permanent ponds, designed to store stormwater, not only helps control the flow of streams,during peak periods, but also adds to the beauty of an urban environment.

2. Such ponds are equipped with devices that release water at a controlled rate.

D. One of the most popular structures for controlling stormwater is the detention basin.

1. Detention basins store runoff when the flow is at its peak, and release the stored water through an outlet, at a controlled rate. These basins can impound the water either temporarily or permanently.

2. When the volume of water exceeds the storage capacity of the basin, the excess runoff exits through an emergency spillway located on the edge of the basin.

3. After a storm, temporary basins slowly drain dry.

E. Holding tanks are structures similar to detention basins. They are built of concrete or metal, and are located underground; these structures temporarily detain runoff from parking lots or rooftops.

F. Infiltration systems have been used for years, to control runoff. Infiltration systems consist of holes in the ground, filled with coarse, clean stone, or lined with bricks or perforated concrete blocks.

1. These structures store stormwater and allow it to infiltrate into the soil. The water, as it slowly percolates, replenishes the groundwater.
2. The usefulness of infiltration systems depends largely on the type of soils and the topography at the site, as well as the location of the groundwater table. A permeable subsoil is necessary, to dispose of the water at an adequate rate. Maintenance is very important.

G. Several types of stormwater controls involve the stream channel or the stream channel and its floodplain. These controls detain the water or slow its rate of flow, in order to reduce the peak rates of runoff.

1. Some of these controls function within the channel. One example of in-channel storage and control is the exaggeration of a meandering stream. By making a winding stream even more winding, you increase the distance the water

flows and reduce the rate at which it flows.

2. Another example of in-channel storage and control is the use of check dams or wiers. These prevent excessive erosion by reducing the rate of flow.
3. Another kind of stream channel storage is side-channel storage. Side-channel storage is the use of the flood plain on the sides of the stream channel to store water temporarily during heavy rains.

VIII MAINTENANCE

A. For stormwater management and other waterway erosion control practices, maintenance is essential if they are to continue to function over a long period of time.

1. Check controls periodically, for evidence of deterioration.
2. You should examine the plantings and structures periodically. Any sign of weakness will require corrective measures. Remove accumulated sediment and debris periodically, so that the structures for controlling stormwater will function properly.
3. Fertilize the vegetated area regularly,so that the plants in the waterways and around them will continue to grow vigorously.

Questions 1

Fill in the blanks.

1. The first basic method of controlling stream erosion is to protect the ______________; and the second is by ______________ the ______________ after a storm.

2. Most of the damage done to streams and other waterways occurs during ______________.

3. Proper ______________ practices and good ______________ built to control erosion, will help as well.

4. Streams where the water only flows after a heavy rain are called ______________ ______________.

5. The force of running water is called __________ force.

6. ____________ and ___________ are ways in which water causes waterway erosion.

Questions 2

Each of the following sentences contains one error. Write the letter that corresponds to the incorrect word or phrase in the blank provided.

1.______ The amount and rate of erosion you can expect in a given waterway depends on several factors, including $\underset{A}{\underline{\text{obstructions in the channel}}}$; $\underset{B}{\underline{\text{the turbulence of the flow of water}}}$; $\underset{C}{\underline{\text{intermittent streams}}}$; $\underset{D}{\underline{\text{the meandering of the stream}}}$; and $\underset{E}{\underline{\text{bank materials}}}$.

2.______ During periods of high water the velocity $\underset{A}{\underline{\text{usually increases}}}$. $\underset{B}{\underline{\text{The water flows faster}}}$, the $\underset{C}{\underline{\text{turbulence decreases}}}$, and the flowing water $\underset{D}{\underline{\text{scours the bed and erodes the banks}}}$ of the stream.

3.______ Soils in which the particles are strongly bound together will $\underset{A}{\underline{\text{erode more easily}}}$ than soils made up of loose grains. Larger materials, such as $\underset{B}{\underline{\text{gravel, cobbles or boulders}}}$ will $\underset{C}{\underline{\text{erode more slowly}}}$. Sand, silt, and clay particles will $\underset{D}{\underline{\text{erode more rapidly}}}$ because they are $\underset{E}{\underline{\text{lighter and more easily carried away}}}$.

4.______ Water flowing over soils which contain a mixture of materials, $\underset{A}{\underline{\text{will sort the particles by size}}}$, until the bottom is covered $\underset{B}{\underline{\text{or "armored"}}}$ with only the

smaller materials. The water carries the small part-
C D
icles downstream, until the energy of the flow
D
decreases enough to allow them to settle out.
E

5.________ The gradient is the change in elevation of a stream,
A
frequently measured in feet of vertical change per mile of
B
horizontal distance. Generally the steeper the grad-
B
ient, the less rapid the erosion of the streambed.

Questions 3

Circle the correct answer or answers.

1. Where man's activities have altered the natural watershed, a number of factors will have an effect on the rate and amount of erosion, including:

    a. removal of natural vegetation
    b. compaction of the soil
    c. bank and bed materials
    d. use of impervious materials

2. Channel realignment

    a. is the process of installing water-holding tanks
    b. increases the gradient
    c. helps to control floodplain spillage

3. Before developing in a watershed, you should

    a. consult the Standards and Specifications
    b. study the streams to make sure they can handle the higher rate of flow without causing erosion.
    c. make as much room as necessary available for development
    d. construct revetments to control erosion

4. Effective and economical ways to protect streams against excessive erosion from surface runoff include

    a. reinforcements such as mulches and netting
    b. check dams
    c. clearing the area of vegetation
    d. preserving a buffer strip of natural vegetation

5. Intermittent streams

    a. require the planting of willows and alders along the banks
    b. are often planted with a cover of grass over the entire flow area
    c. need only a mulching of the soil with straw or hay
    d. do not maintain a continuous flow

Questions 4

Circle the correct answer or answers.

1. Before choosing a plant material for stabilizing a stream you should consider several factors, including:

   a. the soil and soil moisture
   b. exposure to sunlight
   c. steepness of slope

2. Along ditches, swales, and other intermittent streams plant vegetation

   a. that is drought-resistant
   b. that is attractive in the surroundings
   c. in patches
   d. that is moisture-tolerant

3. On bank slopes greater than 50%

   a. vegetation should be planted profusely
   b. slopes should be graded back
   c. plant conventional grasses and legumes
   d. plant alders and willows for extra protection

4. Grass waterways

   a. are difficult to vegetate
   b. need periodic maintenance
   c. help prevent water from infiltrating into the soil
   d. blend into the surrounding areas

5. Seeding

   a. should be done only in permanently flowing streams
   b. sometimes requires the use of mulches
   c. is best employed in intermittent streams
   d. can be employed almost any time of year

Questions 6

Each of the following sentences contains one error. Write the letter that corresponds to the incorrect word or phrase in the blank provided.

1. ________ Critical areas along streambeds which may need
structural stabilization include the outside of
A
bends, where the flow impacts against the stream-
A
bank; restrictions in the channel; junctions
A B C
where tributaries enter the main channel; and
C
places where the channel gradient is excessively
D
low.
D

2. ________ Stone riprap is used in constructing revetments
A
because its rough surface dissipates the energy
B
in the flowing water; it adjusts to changes in
C
the foundation resulting from erosion; and it aids
C D
scouring along the lower edge or "toe."
D

3. ________ Gabions are wire baskets filled with stone, used
A B
to hold back steep slopes and construct check
B C
dams. They are more flexible than revet mattresses
C D
or concrete.
E

4. ________ Revet mattresses are concrete grids containing
A
several open spaces, which, when laid side by side,
can be used to pave parking areas as well as
B

provide slope protection. They also allow more runoff to infiltrate the soil, and can be filled with soil and seeded.

C: provide slope protection; D: allow more runoff to infiltrate the soil; E: can be filled with soil and seeded

5. ________ Grade control structures help control erosion of the streambed by eliminating the hydraulic force of the water, by slowing the flow of the water, and by reducing the gradient.

A: erosion of the streambed; B: eliminating the hydraulic force of the water; C: slowing the flow of the water; D: reducing the gradient

Questions 7

Fill in the blanks.

1. The first basic principle of stormwater management is: assure that the peak rate of flow _________ development is no greater than it was __________ development.

2. One method of accomplishing stormwater management is to ______________ surface runoff as close as possible to the place where it _________________.

3. Effective management of stormwater prevents the ___________ of the amount of water flowing downstream. The rate at which the water flows is also ________________.

4. Holding stormwater back also helps to control _______________ downstream.

5. _______________ _______________ is often practiced on large commercial and industrial buildings, as a means of stormwater management.

6. To achieve control of stormwater on parking lots, ___________ the size of the stormwater inlet and provide for _______________ of stormwater on a part of the lot.

7. Another method of reducing stormwater runoff from parking lots and other paved areas, is to use p_______________ a_______________ paving.

8. Detention basins _______________ runoff when the flow is at its peak, and release the water through an outlet, at a c_______________ r_______________.

9. Holding tanks temporarily d_______________ r_______________ from p_______________ l_______________ or rooftops.

Questions 8

True or false.

1. ________ Infiltration systems consist of holes in the ground, filled with stone or brick; they store stormwater and allow it to slowly infiltrate the soil.

2. ________ The usefulness of infiltration systems depends largely on the type of soils, the topography, and the groundwater table.

3. ________ Infiltration systems are most useful at sites where the groundwater table is consistently high, and there is a large amount of water to be detained.

4. ________ By making a winding stream even more winding, you increase the distance the water flows and increase the rate at which it flows.

5. ________ Side-channel storage is the use of check dams placed at intervals along the channel to reduce the peak flow from the watershed.

6. ________ When floodplain storage is used, you must construct an emergency spillway to release flows that exceed the amount of water the structure was designed to hold.

7. ________ Remove accumulated sediment and debris periodically from stormwater control structures, so that they will function properly.

8. ________ Vegetated waterways do not require regular maintenance once the vegetation has become well established.

Questions 9

True or false.

1. ________ Among the factors that effect the rate of erosion in streams are turbulence, the degree of meandering, the obstructions, and the vegetation present.

2. ________ Improper channelization can result in flooding further downstream.

3. ________ Where conditions permit, new streams should be stabilized with vegetation.

4. ________ Stormwater management consists of the preservation of a buffer strip of vegetation, along natural waterways.

5. ________ In intermittent streams it is generally sufficient to plant only along the channel banks.

6. ________ Sodding, sprigging, or seeding can be employed in any streams provided that the plant materials are native to the area.

7. ________ To prevent erosion under the netting, you can secure straw much by anchoring at intervals along the channel.

8. ________ A grade-control structure consists of some durable material placed on the bottom of the channel, either in a strip across the channel, or in a complete lining to reduce the effective channel gradient.

9. ________ The same materials used to construct revetments are also used to build grade-control structures.

EROSION AND SEDIMENT CONTROL

TEMPORARY SOIL STABILIZATION

WORKBOOK

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A. Cost, How Long, How Well

B. Vegetative

C. Non-vegetative

I GENERAL INTRODUCTION

A. Temporary soil stabilization means protecting the soil from excessive erosion, for a short time. Usually, temporary stabilization is designed to last for less than a year.

B. Permanent stabilization is done for long-time use. For permanent stabilization, you establish a ground cover with long-lived vegetation, or cover the soil with concrete, asphalt, stone, or some other durable material.

C. Temporary stabilization is often necessary because grading operations frequently last several months or more - sometimes for an entire construction season.

1. During this period, the bare soil is exposed to damage by wind and water.

2. And when the developer has finished final grading, there is often a period of time before the season is right for permanent stabilization.

D. Of course, you have to consider how much temporary stabilization will cost, and how much damage from erosion and sedimentation will result, if you don't stabilize the soil.

1. Factors determining how long a delay may be allowed, before the soil must be stabilized include the climate, the topography, the erodibility of the soils, and the sorts of protections against erosion that exist, at the border of the area being developed.

2. Because of all the factors involved, determining how long a graded area may be exposed is highly variable; usually local or state agencies evaluate the conditions, and decide how long graded areas may be left uncovered.

II PROCEDURES AND PRACTICES

A. All fill material should be compacted, as a first step in achieving temporary stabilization.

B. Use of Plant Materials

1. For temporary soil stabilization, fast-growing and hardy annual and perennial plants, such as grasses, will provide adequate protection.

   a. Contour roughening improves the growth of grasses and legumes, as well as helping to slow the overland sheet flow.

   b. Annual grasses that are widely used for temporary stabilization include oats, sudangrass, wheat, and rye. (millet, ryegrass)

2. Legumes such as clover are also useful for temporary cover.

   a. Not only do they provide temporary cover, they also take nitrogen from the air and add it to the soil, in a form which can be used by other plants.

   b. Once homes have been built on a site, the clover can be plowed under; plowing this clover under enriches the soil by adding organic matter. This helps the growth of permanent vegetation.

3. Soil Conditions Necessary

   a. On subsoil and even on some topsoils, you will have to add fertilizers and sometimes lime to the soil, before plants will grow well.

   b. For temporary stabilization, in such cases, you need less fertilizer than you do for permanent stabilization, but it is still necessary.

   c. For standard application rates, consult the Soil Conservation Service office, or the University Agricultural Extension Agency.

   d. Pay attention to the way you apply lime and fertilizer. To get the most out of the lime and fertilizer, mix it with the soil to a depth of 3 to 4 inches.

e. To reduce erosion, perform tilling operations along the ground contour, if needed and feasible.

f. The roughened surface will also provide a better environment for seed germination and plant establishment.

g. On slopes, you may also need to use mulch on the seedbed, to reduce erosion until the plant materials are adequately established.

h. For further information, consult the publication "Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas." This publication, prepared by the Maryland Soil Conservation Service, is invaluable for anyone who wants information about temporary vegetative stabilization.

C. Mulches

1. Mulches shield the soil from water and wind. The most popular mulches for temporary stabilization are straw and woodchips, especially straw.

   a. When hay is substituted for straw, remember that it may contain noxious weed seeds.

   b. The application rates for mulches used for temporary stabilization are the same as those for mulches used on seed beds.

      1. As a rule of thumb the application rate for straw or hay is about 3000 to 4000 pounds per acre.

      2. For woodchips, 60 cubic yards per acre.

   c. On large areas, the usual way to apply straw is to use a mulch blower. The operator feeds straw bales into the blower, which shreds the bales and blows the straw onto the ground. Correctly used, it covers a large area evenly and rapidly.

2. Liquid emulsified asphalt can be used to bind the individual straws into a resistant mat.

3. In areas where you don't want to use asphalt, because it becomes sticky when it is warm, use a chemical tack.

   a. Various chemicals are available for this purpose. For a partial list, consult "Guidelines for Erosion and Sediment Control Planning and Implementation" or "Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas."

   b. These chemicals are binders, which are diluted with water and sprayed onto the straw with standard spraying equipment. A hydroseeder can be used.

   c. To aid the operator in judging whether or not he has sprayed enough chemical tack, a coloring agent may be added to the solution.

4. Another method of anchoring straw is to use a mulch-anchoring tool.

   a. The mulch-anchoring tool is a special piece of equipment, with a series of notched, flat-sided circular blades.

   b. When pulled over straw mulch, the blades punch some of the straw into the ground, leaving straw stems protruding from the soil.

   c. This technique of anchoring straw provides even more protection against erosion, when the crimping follows the contour of the land.

   d. The grooves and straw aid in controlling runoff, by slowing the flow of the water over the soil, and by increasing the rate at which the water soaks into the soil.

e. When anchoring follows seeding, it improves seed germination and plant establishment. The grooves conserve moisture and nutrients and provide depressions, which trap the seed until it germinates.

f. However, the anchoring tool can only operate on slopes up to three-to-one.

5. Tracking is a method of securing straw mulch on slopes steeper than 3 to 1. This is accomplished by running a cleated dozer up and down the slope. In addition to anchoring the mulch, this compacts the soil and provides horizontal depressions in the surface, where rainfall and seed can collect; in this manner the roughened surface helps prevent erosion.

6. In highly critical areas, such as waterways, nettings may be required to anchor the straw.

7. Woodchips are another mulch material used for temporary stabilization.

   a. They are also very effective as well as economical, but not cheap.

   b. As you clear woodland areas, you can salvage woodchips, or stockpile them for later use.

   c. Woodchips are an excellent material for restoring the essential ground litter in forested areas that have been damaged by construction activity.

   d. Sometimes woodfiber mulch, mixed with a chemical binder, is used as a short-term stabilizer. The mulch and the chemical, together with water, are mixed in a hydroseeder, and sprayed onto the soil.

8. <u>Other Materials Used for Temporary Stabilization in Highly Critical Areas</u>.

   a. Jute netting which is often used for waterways.

b. Excelsior blankets, which are often used in areas exposed to concentrated flows of water.

c. Ground-up corn cobs.

d. Gravel, or crushed rock.

Experts are taking a hard look at our present techniques for controlling erosion and sediment, and they are continually coming up with new methods and products that will work better and cost less. We have to be constantly on the alert for new developments in the field of erosion and sediment control.

D. <u>Chemical Soil Stabilizers</u>

1. A partial list of these would include ÆErospray 52 binder®, Curasol AE® and AH®, and Terratack®.

2. These products are all water emulsions, and are supplied as liquids or concentrates.

3. These chemicals are relatively easy to use. They are simply mixed in a hydroseeder and sprayed onto the soil. Other standard sprayers can also be used.

4. The chemical stabilizers coat the soil surface temporarily, shielding it from damage by water and wind; they may also penetrate the soil to bind the particles into a mass that resists erosion.

5. The effectiveness of chemical stabilizers, however, will vary from site to site, depending on the soil conditions, the climate, and the slope steepness.

6. The texture and moisture content of the soil will determine how far into the soil the diluted chemical will penetrate, and how effectively it will bind the soil.

7. Proper dilution rates and application rates will vary, depending upon the soil texture, the climate, the way the site is used, and the topography.

8. To avoid expensive mistakes, when you use chemical soil stabilizers, spray a test plot with a recommended mixture and application rate, and examine the results, before you spray the entire site. If the soil and slope conditions vary from place to place on one large site, use several test plots.

9. You should keep an open mind about chemical soil stabilizers. Although one of the chemical stabilizers may fail miserably, another may work very well. Also, remember that many of the products are being continually improved, and that new products are being developed.

III CHOICE OF PROPER STABILIZERS

A. Cost will be a major consideration, but you also have to consider how well the materials work, and how long they will have to keep working.

B. Vegetative

1. Properly established, vegetation is an effective and durable soil stabilizer.

2. The type of vegetation to be used will depend on the season when planting will occur, and the length of time that protection will be required.

   a. For example, winter wheat and rye will provide excellent protection if they are planted in the fall.

   b. Other grasses will be better suited for spring and summer.

   c. Most annual plants provide protection for only one growing season. If protection must extend into another growing season, a perennial plant material is usually needed.

3. Some temporary plant materials, such as weeping lovegrass, are also used for permanent stabilization. If an adequate cover of such a grass can be established in an area which has been final-graded, even though the planting may take place during a season when regulations do not permit permanent planting, there is no reason to plow the cover under and reseed.

    a. Top dressing with additional quantities of fertilizers and lime may be the only operation necessary before final acceptance of the work.

C. Non-vegetative

1. If you decide against plants, the kind of non-vegetative temporary soil stabilization you use will depend on the effectiveness, the cost, and the length of time the temporary stabilization must last.

2. Straw vs. Woodchips

    a. Straw and woodchips work equally well, but one may be less expensive than the other, or more readily available.

    b. Woodchips last longer than straw, as a temporary stabilizer. As a general rule, straw will function up to six months or more, whereas woodchips will function for a year or longer.

3. Some applications of chemical stabilizers will only be effective for a few weeks; others may last for months. There is not enough information about chemical stabilizers to be more specific. This is especially true, because soils and terrains are so different.

Questions 1

Mark the statements true or false.

1. ______ Temporary soil stabilization means protecting the soil from excessive erosion, for a short time.

2. ______ Temporary stabilization is designed to last for several years.

3. ______ Temporary stabilization is often necessary, because grading operations rarely leave bare soil exposed for more than a week.

4. ______ Factors that determine how long a delay may be allowed, before the soil must be stabilized include climate, topography, the erodibility of the soils, and the protections that exist.

5. ______ When a developer has finished final grading, there is often a long period of time before the season is right for permanent vegetative stabilization, or before paving can be laid.

Questions 2

Fill in the blanks.

1. All fill material should be ____________ as a first step in achieving temporary stabilization.

2. For temporary stabilization, fast-growing and hardy annual and perennial ____________, such as grasses, will provide additional protection.

3. ____________ ____________ improves the growth of grasses and legumes, as well as helping to slow overland sheet flow.

4. Annual grasses that are widely used for temporary stabilization include ____________, ____________, and ____________.

5. ____________ such as clover are also useful for temporary cover.

6. Not only do they provide temporary cover, legumes also take ____________ from the air and add it to the soil, in a form which can be used by other plants. ____________ is an essential plant nutrient.

7. Once homes have been built on a site, the clover can be plowed under; plowing this clover under ____________ the soil by adding ____________ matter.

Questions 2 Continued

8. On subsoil and even on some topsoils, you will have to add ____________ and ____________ to the soil, before plants will grow well.

9. For temporary stabilization, in some cases, you will need less ____________ than you do for permanent stabilization.

10. To reduce erosion perform tilling operations along the ground ____________ as needed and feasible.

11. On slopes, you may also need to use ____________ on the seedbed, to reduce erosion until the plant materials are adequately established.

12. The most popular mulches for temporary stabilization are ____________ and ______________.

13. As a rule of thumb, the application rate for straw or hay is about ____________ pounds per acre. For woodchips ____________ cubic yards per acre.

14. On large areas, the usual way to apply straw is to use a ____________ ____________.

Questions 3

Circle the correct answer or answers.

1. For tacking mulches, you can use

    a. liquid emulsified asphalt
    b. polyvinyl chloride
    c. various chemical binders

2. To aid the operator in judging whether or not he has sprayed enough chemical tack a coloring agent may be added to the solution. (T or F)

3. Another way to secure straw mulch is

    a. to apply a thin layer of topdressing
    b. to anchor it with a mulch-anchoring tool
    c. to compact it with a sheep's foot roller

4. Anchoring

    a. should run up and down the slope
    b. should follow the contour of the ground
    c. creates grooves that aid in controlling runoff
    d. improves seed germination
    e. can be performed on any slope

Questions 3 Continued

5. Tracking

   a. is a recommended method of securing straw on slopes flatter than 3 to 1
   b. is an approved method of securing straw on slopes steeper than 3 to 1
   c. is accomplished by running a cleated dozer along the contour of the slope
   d. is accomplished by running a cleated dozer up and down the slope

6. In highly critical areas, such as waterways, to anchor straw mulch, use

   a. chemical binders
   b. nettings
   c. liquid emulsified asphalt
   d. anchoring

7. Woodchips

   a. are effective and economical mulch materials used for temporary stabilization
   b. should only be used on wooded sites
   c. are excellent for restoring the essential ground litter

8. Other mulch materials include

   a. crimping
   b. jute netting
   c. top soil
   d. excelsior blankets
   e. ground up corncobs
   f. fill
   g. gravel or crushed rock

Questions 4

Fill in the blanks.

1. Chemical stabilizers have come into major use in the last few years. Chemical stabilizers coat the soil surface temporarily, ___________ it from damage by water and wind; they may also penetrate the soil to _________ the particles into a mass that resists erosion.

2. The effectiveness of chemical stabilizers will vary from site to site, depending on the ________________ __________, the ________________ and the slope ___________________.

3. To avoid expensive mistakes, when you use chemical soil stabilizers, spray a ______________ ______________ with the recommended mixture and application rate, and examine the result, before you spray the ____________ ____________.

4. If the soil and slope conditions vary from place to place on one large site, use ________________ ________________ __________________.

Questions 5

Mark the statements true or false.

1. ______ Cost will be a major factor in determining which form of temporary stabilization to use.

2. ______ You don't need to consider how well the materials work, or how long they will have to keep working.

3. ______ Properly established, vegetation is the most effective and durable soil stabilizer.

4. ______ Any plant can be used, during the spring, summer, and fall.

5. ______ Winter wheat and rye will normally provide excellent protection if they are planted in the fall in areas of adaptation.

6. ______ Most annual plants provide protection for several growing seasons.

7. ______ No plants used in temporary stabilization are used for permanent stabilization.

8. ______ If you decide against plants, the kind of non-vegetative temporary soil stabilization you use will depend on the effectiveness, the cost, and the length of time the temporary stabilization must last.

Questions 5 Continued

9. ______ Straw and woodchips work equally well, but one may be less expensive than the other, or more readily available.

10. ______ Straw lasts longer than woodchips.

11. ______ Some applications of chemical stabilizers will only be effective for a few weeks; others may last for months.

Questions 6

Circle the correct answer or answers.

1. Temporary stabilization is designed to last

    a. for more than a year
    b. for less than a year

2. Usually, the maximum length of time a graded area may be exposed

    a. is six months
    b. can be determined by the contractor
    c. is determined by state bureaus or local agencies

3. One of the best ways to stabilize areas temporarily is to use fast-growing annual or perennial plants, such as grasses; these grasses include

    a. Kentucky 31 tall fescue
    b. oats
    c. clover
    d. wheat
    e. Sericea lespedeza
    f. Sudangrass
    g. rye
    h. rye grass
    i. weeping lovegrass

4. Legumes

    a. are sometimes useful for temporary cover
    b. add nutrients to the soil

Questions 6 Continued

5. The most popular mulches are

    a. corncobs
    b. straw
    c. hay
    d. Kentucky 31 tall fescue
    e. woodchips

6. On large areas, the usual way to apply straw is

    a. with a mulch blower
    b. with a rake

7. Mulches require tacking on large areas. This can be done with

    a. seeding
    b. liquid emulsified asphalt
    c. chemical binders
    d. fertilizer and lime

8. The choice of methods will depend on

    a. cost alone
    b. effectiveness, cost, and length of time
    c. state regulations

EROSION AND SEDIMENT CONTROL

CONTROL OF SEDIMENT GENERATED ON CONSTRUCTION SITES

WORKBOOK

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3. Straw Bale Barrier

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1. Dry

2. Wet

IV. REVIEW QUIZ

I. BASIC PRINCIPLES OF CONTROLLING SEDIMENT

A. Erosion control is the first line of defense. It reduces the amount of sediment that will be generated.

B. Sediment control is the second line of defense. It prevents much of the sediment from uncontrolled soil erosion from leaving the construction site.

C. Sediment traps are designed to slow the flow of water. This reduces the ability of the water to transport sediment, and the sediment settles out of suspension.

D. The amount of sediment removed from the runoff is dependent upon these three factors:

1. Speed that the water flows through the trap.
2. Length of time the water is detained.
3. Size and weight of the sediment particle carried into the trap.

The slower the flow of water and the longer it is detained, the greater will be the quantity of sediment deposited. The size and weight of the sediment particles determine the speed at which they settle out of suspension. The larger and heavier a particle, the faster it settles out.

E. Efficiency of sediment trapping is expressed as the percent of sediment removed from the runoff.

$$\% \text{ Efficiency} = \frac{\text{Amount trapped}}{\text{Total Load}} \times 100$$

II. <u>VEGETATIVE PRACTICES</u>

A. Natural Vegetative Buffers

1. A vegetative buffer at the base of a steep slope is an effective means of trapping sediment.

2. This involves maintaining a strip of natural vegetation along the sides of a stream to slow and filter overland flow coming from higher-lying graded areas.

3. This is one of the more effective and economical methods of removing small amounts of sediment from overland flow.

4. Except for essential roadway crossings, no construction should be allowed within the buffer area.

B. Graded Buffers

1. Provisions for construction must be made during early design stages of development.

2. The flatter and longer it is, the more sediment it will retain.

3. A positive grade of at least two percent should be provided to prevent ponding.
4. Timely establishment of vegetation on the buffer is a must in order to provide effective sediment trapping.

C. Contour Stripping

1. A method borrowed from the farmer.
2. It is used to break the flow of runoff on long hillsides.
3. It involves the establishment of strips of vegetation, usually grass sod, along the ground contour at regular intervals on the slope.
4. These strips slow the flow and reduce the amount of runoff, thus reducing erosion and trapping much of the sediment generated from erosion occurring between the strips.

D. Woodland Areas

1. Woodland litter can provide a high degree of filtering action as well as aiding in the absorption of runoff, but care must be exercised because the deposition of a few inches of sediment around a tree can cause it to die.

2. Use woodland areas only for the filtering of overland flow.

E. Sod Inlet Filter

1. Made up of strips of sod placed around the storm drain inlet.

2. The grass slows the flow of water into the inlet and filters out some of the sediment.

3. The size of the sodded area is varied depending upon the amount of runoff and sediment expected at the inlet. The larger the sodded area, the more effective it is.

4. This practice should only be used to handle light concentrations of sediment and low rates of runoff.

5. Best used after final grading is complete and during the establishment of a vegetative cover.

III. STRUCTURAL PRACTICES

A. Filters and Dikes

1. Gravel Inlet Filter

a. Used at storm drain inlets.

b. Made of coarse gravel or crushed stone.

c. Will temporarily impound runoff.

d. Provides a negligible amount of filtering action.

e. Is highly resistant to erosion.

f. Standard concrete building blocks are placed on the inside of the gravel filter to keep stones from being washed into the storm drain inlet.

g. The configuration of the filter will depend upon the type of inlet being protected.

h. Prompt maintenance is very essential.

B. Sediment Traps

1. Sandbag Sediment Trap

   a. A quick and economical method of temporarily disrupting flow and trapping the coarser sediment particles.

   b. A small degree of sediment control can be achieved by positioning these barriers at regular intervals along the ditch.

   c. Bags are filled with soil or sand and stacked in an overlapping fashion which provides additional strength for resisting the force of the flowing water.

   d. Undercutting is a major cause of the failure of many sandbag sediment traps.

   e. The sandbags should be set in a trench at least six inches in depth. This will greatly reduce the chance of undercutting failure.

   f. Inspection and prompt maintenance is required.

2. Straw Bale Sediment Trap

   a. Fast and economical temporary trap.

   b. Made of bales of straw or hay.

   c. Deteriorates rapidly.

   d. Can slightly increase durability by using wire-tied bales.

e. When constructing the trap the bales are laid on their sides and staked into place.

d. Undercutting can render the trap ineffective.

f. Straw bale trap should be entrenched at least six inches and excavated soil should be compacted along the upstream face.

g. Inspection and prompt maintenance is required.

3. Straw Bale Perimeter Barrier

   a. Used to provide a sediment barrier along the downhill perimeters of small graded sites where area restrictions or other factors prevent the use of other practices.

   b. Close inspection is required.

4. Excavated Sediment Trap

   a. Its function is to temporarily detain the runoff and thereby allow some sediment to settle out.

   b. Costs little to construct.

   c. Once the sediment-yielding area is stabilized, the pit area can, in some instances, be filled in with soil and covered with sod.

C. Sediment Basins

1. Sediment basins are the most effective structures for trapping sediment.

2. Used on construction sites where concentrations of both runoff and sediment are anticipated.

3. Dry Sediment Basin

   a. Designed to only temporarily impound runoff during rainfalls.

   b. It is drained by a standard metal riser pipe with 1/2" perforations which allow the water to be released at a controlled rate.

   c. It requires a formal design for size and safety reasons.

   d. Only suitable soils must be used to construct the dam.

   e. A high degree of compaction must be achieved.

   f. Proper positioning of the riser pipe is essential to proper performance.

   g. Piping failures are too common in temporary dry sediment basins.

h. Consult state and local regulations governing their design and construction prior to starting to build one.

i. Periodic cleaning is essential if the basin is to do its job.

   (1) usually cleaned with a backhoe or dragline

   (2) smaller basins with firm foundations are sometimes cleaned with front-end loaders

j. Construction specifications for the basin must specify the required freeboard - the vertical distance between the design high water and the top of the dam.

k. Failing to provide enough freeboard may result in overtopping during heavy storms and breeching of the dam.

4. <u>Wet Basin - Sediment Pond</u>

   a. Used when it becomes necessary to dam permanent streams in order to trap sediment.

   b. On large residential developments, recreational impoundments also function as sediment traps.

c. Requires a formal design and strict construction control for safety reasons.

d. Cleaning a wet sediment basin is costly.

   (1) dragline is used.

   (2) portable dredges used on large ponds.

QUESTIONS 1

Fill in the blanks

1. E______________ c______________ is the first line of defense. It ____________ the amount of sediment that will be generated.

2. S______________ c______________ is the second line of defense.

3. Sediment traps are designed to slow the flow of _______________.

4. The amount of _____________ removed from the runoff is dependent upon three factors:
   a. S_________________ that the water flows through the t_____________.
   b. L________________ of time the water is d________________.
   c. S_______________ and w_____________ of the sediment particles carried into the trap.

QUESTIONS 2

Multiple Choice

1. The best vegetative filters are

   a. legumes b. grasses
   c. trees d. periwinkle.

   answer(s) __________

2. No construction should be allowed within a buffer area

   a. at all.
   b. except for essential roadway construction.
   c. except for residential construction.
   d. except for normal roadway construction.

   answer(s) __________

True or False

_____1. Leaving a buffer at the base of a steep slope is an effective means of trapping small amounts of sediment.

_____2. A buffer speeds the flow of runoff coming off a steeper slope.

_____3. The flatter and longer a buffer area, the more sediment it will retain.

_____4. Adding vegetation to a buffer area increases its ability to trap sediment.

_____5. To prevent ponding, a positive grade of at least two percent should be provided.

_____6. A natural vegetative buffer is one of the more effective and economical methods of removing amounts of small sediment from overland flow.

QUESTIONS 3

1. Contour stripping is a method borrowed from

   a. the farmer.
   b. the contractor.
   c. nature.
   d. the foreman.

   answer(s) __________

2. The use of a vegetative buffer near the base of a highway slope serves the same function as

   a. the storm drain.
   b. the top of cut.
   c. the interceptor dike.
   d. the contour strips.

   answer(s) __________

3. The sod inlet filter

   a. should only be used to handle light concentrations of sediment.
   b. is made up of pads of sod.
   c. is best used after final grading is complete.
   d. all of the above.
   e. none of the above.

   answer(s) __________

QUESTIONS 4

Fill in the blanks

1. S______________ p____________ are employed on construction sites to trap sediment.

2. The ______________ ____________ filter is used at storm drains.

3. The gravel inlet filter is h____________ r________ to erosion.

4. The configuration of the filter will depend upon the t__________ of i__________ being protected.

QUESTIONS 5

True or False

_____1. The sandbag sediment trap is a quick and economical method of temporarily disrupting flow and trapping the coarser sediment particles.

_____2. Undercutting is a major cause of failure of many temporary sediment traps.

_____3. Straw bale sediment traps last indefinitely.

_____4. Close inspection is not required of a straw bale perimeter barrier.

_____5. The function of an excavated sediment trap is to temporarily detain the runoff.

_____6. The most effective structures for trapping sediment are straw bale barriers.

QUESTIONS 6

Multiple Choice

1. A dry sediment basin is

   a. designed to only temporarily impound runoff.
   b. drained by a metal riser pipe.
   c. requires a formal design.
   d. all of the above.
   e. only a and c.

   answer(s) __________

2. The vertical distance between the top of the dam and the design high water within the basin is known as the

   a. sediment valve.
   b. freeboard.
   c. safety factor.
   d. ruler.

   answer(s) __________

3. The device at the top of the riser pipe is called

   a. a barrel.
   b. an antivortex device and trash rack.
   c. an emergency spillway.
   d. none of the above.

   answer(s) __________

QUESTIONS 7

1. Erosion control r__________ the amount of sediment that will be generated.

2. Sediment control is the s__________ line of defense.

3. The three factors upon which the amount of sediment removed from the runoff is dependent are:

   a. S__________ that the water flows through the t__________.

   b. L__________ of time the water was d__________.

   c. S__________ and w__________ of the sediment particles carried into the trap.

4. Leaving a v__________ b__________ at the base of a steep slope is an effective means of trapping sediment.

5. M__________ a natural buffer is one of the more effective and economical methods of removing small amounts of sediment from overland flow.

6. The ability of a graded buffer area to trap sediment is improved by adding v__________.

7. The best vegetative filter is __________.

8. Woodland areas should be used only to filter o__________ flow.

9. C__________ s__________ is a method borrowed from the farmer.

10. It is used to break the f__________ of r__________ on long hillsides.

11. The use of a v______________ b__________ near the base of a highway slope serves the same function as ______________ strips.

12. G________________ b__________ are employed on construction sites to retain or trap sediment.

13. The sod inlet filter should be used to handle l___________ concentrations of sediment.

14. The g______________ i__________ filter is highly resistant to erosion.

15. The configuration of the filter will depend upon the t__________ of i__________ being protected.

16. The interceptor dike is used on r__________ rights of way to divert flow onto vegetated areas.

17. Straw b______________ and s______________ traps are quick and economical methods of temporarily disrupting flow.

18. U________________ is a major cause of the failure of many temporary sediment traps.

19. Undercutting is reduced in temporary sediment t__________ by placing either the s______________ traps or s__________ b__________ traps a minimum of ____________ inches in the ground.

20. A straw bale perimeter barrier is used to provide a s____________ barrier along the downhill perimeter of small graded sites, where area restrictions or other factors prevent the use of other practices.

21. An e______________ sediment trap c__________ l___________ to construct.

22. S______________ b______________ are the most effective structures for trapping sediment.

23.

23. A dry sediment basin is designed to only t___________ impound r___________ during and for a short time after rainfalls.

24. A dry sediment basin is drained by using a standard metal r___________ p___________ with p___________, which allow the water to be released at a controlled rate.

25. Both wet and dry sediment ponds must be

    a. vegetatively stabilized.
    b. emptied.
    c. washed.
    d. none of the above.

answer(s) __________

EROSION AND SEDIMENT CONTROL PLANNING

WORKBOOK

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I. NECESSITY OF EROSION AND SEDIMENT CONTROL PLANNING AND IMPLEMENTATION

A. As we reshape the land, for urban or industrial uses, erosion and sedimentation problems often result, which could have been avoided, with proper planning and implementation.

B. In any erosion and sediment control plan, you will try to protect the landscape.

1. As the population of the United States increases, landscapes come under more and more pressure. In the last 200 to 300 years, much of the land has been converted from its natural state to farms and cities, or suburbs.

2. If we continue to transform natural landscapes at an ever-increasing rate, we may speed up the rate of soil loss, and, as a result, damage our land and water.

C. Certain types of landscape are more easily damaged than others.

1. Critical areas include forests. We should make every effort to preserve as much forest land as possible, and to protect forest land that is being developed.

2. Another critical area is the floodplain, an area of land on either side of a channel that is nearly level and is subject to periodic

flooding. Floodplains are important because they store excess runoff temporarily, thus helping to avoid problems further downstream.

3. Steep slopes are critical. Within certain watersheds there often are areas where the soil is subject to droughts, sliding, and erosion. Such soils are particularly susceptible to damage, but nearly all soils on steep slopes are likely to erode if they are unprotected.
4. Wetlands occur in many parts of the country. These areas are extremely valuable as drainage basins, for flood and sediment control, and for the preservation of wildlife resources. They are the critical link in the aquatic food chain.
5. Another critical area is the shoreline of bays and large inland lakes. We must take care to protect these areas from wave action.
6. Waterways and streams, whether or not they are navigable, are other critical areas. Good planning is necessary to avoid excessive erosion and sedimentation.
7. Any man-made impoundment, such as a reservoir,

is a critical part of the landscape and must be protected from sediment.

II. RESPONSIBILITIES OF PRELIMINARY PLANNING

A. One of the main principles of site planning is to see that there is a minimum of grading and that it procedes in an orderly manner.

1. Grading operations can greatly change the natural arrangement of soil particles. One of the major causes of this alteration is compaction.

a. Of course, there are many ways to restore the structure of a soil once it has been lost, but soil compaction still presents a problem. Many years of diligent effort on the part of soil bacteria and other living things, like earthworms and grass roots, plus materials such as nitrogen and oxygen are required to get the soil back to its previous condition.

b. Clearing and grading have other effects, too. Once the protective vegetative cover has been stripped away, the soil is exposed to the erosive or dispersive action of water and wind.

B. In most areas of the country, heavy rainstorms are most frequent from May to September. This is also the time when construction activity is most intense. Therefore, this is the time when exposed soil is most likely to be badly eroded.

1. As the intensity of rainfall increases, water collects on the soil surface and flows downslope, as surface runoff.
2. On steeply sloping areas, large amounts of sand, silt, and clay particles are dislodged and carried off in sheets of water moving down the newly-exposed slopes.
3. On slopes that are not as steep, the rainfall carries off smaller amounts of soil.

C. One of the key strategies in erosion and sediment control planning is to see to it that runoff water is controlled on the site.

1. Diversion structures often can help control the runoff.
2. Water concentrated in waterways can be controlled with ponds, with check dams, and with other structures.

D. Another key strategy is to minimize grading.

1. To minimize grading, develop the land

along the natural contours of the ground surface.

2. Wherever possible, plan the grading so as to minimize slope length and limit the amount of area exposed at any time.

3. How much soil the moving water will dislodge and carry away depends on the resistance of the soil particles to dispersion, and on the speed and volume of water moving over the soil.

4. We can increase the resistance of soil to dispersion, while construction takes place, and also control the volume and velocity of the water, as it moves over the soil and concentrates in waterways.

III. THE PRELIMINARY STUDY

A. Each site has its own earth history and character. Not only do the plants, animals, and human beings vary, from place to place, on the surface of the earth, so do the bedrock, the soils, and the topography. Each landscape, in turn, imposes certain restrictions on the way it can be developed.

B. Before development commences, the developer must determine the impact that erosion and sediment, produced during and after the work, will have on his own site, and on the areas lying downslope and downstream from the site.

1. This requires a preliminary study of the land, including its use, soils, topography, climate, and the general nature of the watershed.
2. The developer should evaluate the present uses of other upstream areas in the watershed, and the potential for future expansion in these areas.
3. Local zoning and planning officials must take considerable responsibility to insure that the developer knows the plans for future expansion in these areas. These officials must set adequate standards, and enforce them, to protect the present and future conditions of the region.
4. Comprehensive planning, involving all of a given watershed, is essential to insure that adequate erosion and sediment control planning is achieved.

C. In making a preliminary study, look for critical land features and evaluate them. These include waterways and their floodplains, steep or long slopes, soils which may be highly erodible, droughty, or of low fertility, tree stands, and areas with high groundwater tables. Include provisions for stormwater management.

IV. THE DESIGN STAGE

A. After the preliminary study has been made, the design stage of development begins. Roadways, utilities, buildings, and other structures are located, designed, and shown on a site plan during this stage.

1. These plans will show what is to be constructed, where it is to be constructed, and how it will be constructed.

2. As with the preliminary study, the developer must have the critical land features assessed at the outset of the design stage of construction, so as to minimize disturbance to these features.

3. Much of the information on erosion and sediment control, which was gathered during the preliminary study, can be used in the final design plans. However, you should gather more detailed information, both from literature and field studies.

B. The proper siting of structures can reduce erosion and sediment damage; when it is possible, locate these structures in order to minimize grading, so as to reduce erosion.

   1. The designer cannot totally prevent erosion and sedimentation. It is necessary to develop an erosion and sediment control plan, as part of the overall site development plan.
   2. This plan shows the necessary procedures and measures which the developer must take, to eliminate excessive erosion and sediment damage.

C. Erosion and sediment control planning and design, as it relates to construction, is a relatively new discipline.

   1. Therefore we must rely a great deal on those people who have on-the-ground construction experience.
   2. It is essential that the inspector and the foreman be able to interpret erosion and sediment plans, prepared for specific sites.

D. Procedures

   1. The owner or site developer is responsible for the preparation of the erosion and sediment control plan.

a. He may call upon competent engineers, architects, scientists, and other qualified people, to engage in the preparation of the plan.

b. The plan must then be approved by an authorized approving office, whereupon a grading permit is issued to the owner.

2. The owner must also notify the inspector's office, usually about two working days in advance, of his intent to begin clearing and construction work described in the erosion and sediment control plan.

3. The owner must have both the official grading permit and the erosion and sediment control plan on the site during grading and construction.

   a. The developer has the responsibility to implement the plans, as well as to have them on hand.

V THE COSTS OF CONTROLLED VS UNCONTROLLED DEVELOPMENT

A. Based on 1974 prices, removal of soils from reservoirs can cost $2 or more per cubic yard; from streets, $8 per cubic yard; and from storm sewers, $100 per cubic yard. Removal of clay particles and other materials from municiple water supplies can cost $25 or more per cubic yard.

   1. Soils washed off building sites can damage structures, waterways, wildlife, and scenic values. The disposal of these scenic values once they are removed, becomes an additional cost.

B. For a 10 acre site, experience has shown that the cost of setting up and following an erosion and sediment control plan, including the cost of building sediment basins, stabilizing exposed soil with mulch and grass, and following up with maintenance, averages $1500 or more per acre, depending on physical and climatic factors, as well as the size of the area.

   1. This cost is minor compared with the price of uncontrolled development. For example, the cost of removing 200 cubic yards of sediment from storm sewers alone will range from $12,000 to $30,000. And it's

not unusual for an acre of exposed soil to yield 200 cubic yards per year.

C. The planner must prepare good plans at the lowest practical cost of execution. Owners and developers can render real service by developing sites so that drainage is good, the slopes are moderate, and the area resists erosion to a maximum extent.

VI. SOURCES OF INFORMATION FOR SITE PLANNING IN RELATION TO EROSION AND SEDIMENT CONTROL

A. Soil survey reports furnished by the Soil Conservation Service provide information on the suitability of various soil types for locating pipelines, roads, ponds, reservoirs, drainage systems, etc.

   1. The exact location of woodlands, wetlands, and other critical areas can be obtained from aerial maps and photographs furnished by the Soil Conservation Service.

B. U.S. Geological Survey Offices in most states provide information on the location of important mineral deposits, critical underground water supplies, the location of rock outcrops, and other pertinent items.

C. Highway offices at the county and state level provide information on the location of present and future highways.

D. The Soil Conservation Service and county planning boards can furnish information on soil engineering properties and areas having drainage or flooding problems

E. You can obtain information on local ordinances from local planning and zoning agencies.

F. You can obtain information on new regulations pertaining to erosion and sediment control from the State Department of Natural Resources or other agencies responsible for water pollution control. These offices can also provide updates on technical information required by developers and planners.

G. Historical reports in county libraries provide other useful information.

H. Don't overlook regional land use plans for various watersheds.

VII. TOOLS USED IN PLANNING PROCESS

A. One of the most important maps for site planning is the topographic or base map.

1. Most base maps prepared for site development have a scale in the range of 40 to 200 feet

per inch, and contour intervals of two to five feet.

B. For preliminary site evaluations, the quadrangle maps prepared by the United States Geological Survey are often useful.

   1. They generally have a scale of 1320 feet per inch and a contour interval of 20 feet.

C. Often an enlarged aerial photograph or stereoscopic pairs of air photos giving a three-dimensional persepctive, are useful for locating woodlands, wetlands, and other critical features.

   1. When these critical locations have been delineated on a base map, the planner can begin to design the site development plan, including the erosion and sediment control plan.

   2. During on-site studies, you can consult with staff persons of the soil and water conservation district, members of the State Natural Resources Department, representatives of City Departments of Public Works, and other public officials.

   3. For problems that are particuarly difficult, it is often desirable to retain a professional consultant. Public agencies having responsibility for erosion and sediment control can generally furnish names of competent consultants.

VIII. GOALS OF SITE PLANNING

A. One of the prime goals of site planning is to organize construction in such a way as to minimize damage to the land.

   1. The best erosion and sediment control is one that works closely with nature.

B. Five Key Requirements of Erosion and Sediment Control Planning.

   1. Identify and protect critical features.

      a. Delineate critical features on the base map, before construction begins. The physical factors of the landscape, soils, drainageways, woodlands, and wetlands, taken together, should help determine the layout and design of the development.

      b. The proposed construction and its location with respect to critical areas should help determine what measures must be taken to control erosion and sediment.

   2. Soil should be kept on the site by reducing erosion and runoff. By keeping the soil on the site, we reduce sediment pollution.

   3. The third requirement of an erosion and sediment control plan is: trap sediment.

4. The fourth requirement of a plan is: stabilize the soil.

5. The final requirement of any plan is inspection and maintenance.

   a. Even the best-designed erosion and sediment control plan will be a wasted effort, if the owner or his representative fails to inspect and maintain all measures on a day-to-day basis.

   b. Where sediment control or stormwater management structures are to remain on the site, permanently, the owner should furnish evidence that he will adhere to a long-range agreement.

IX. IMPORTANT ASPECTS OF AN EROSION AND SEDIMENT CONTROL PLAN

A. No two erosion and sediment control plans will ever be exactly alike. Each plan must be tailored to the physical and climatic conditions at the site.

B. Most plans are somewhat similar, however, because they contain the same basic features. Only the more specific information differs.

   1. A typical erosion and sediment control plan is a drawing showing present and proposed grading contours and elevations. The scale should be one inch equals forty feet.

2. The plan shows proposed construction, the location of erosion control measures and sediment control structures, typical or detailed designs for various structures, and general or specific notes regarding the implementation of the plan.
3. The plan should include the owner's or developer's certification and statement that development and/or construction will be done according to this plan of development and erosion and sediment control.
4. Where local standards exist, the plan should also be certified by the designer as having been prepared in accordance with the standards adopted by the approving agency.
5. Finally, the approving officer of the district should affix his signature to the plan.
6. Many erosion and sediment control plans utilize certain standard symbols. You should familiarize yourself with these symbols, since they are used so widely. The meanings of all these symbols are explained in the legend.
7. Erosion and sediment control plans usually have certain general notes containing general sediment and erosion control requirements which cannot be shown graphically on the plan.

8. The sequence of implementation or "staging" is also important and should be indicated on the plan.

9. Certain specific notes concerning the approved methods of soil stabilization should be included on the plan.

   a. The notes must include information on temporary stabilization practices and on permanent stabilization, both vegetative and non-vegetative.

   b. For vegetative soil stabilization, the notes should cover seedbed preparation, seeding procedures, and/or sodding procedures.

   c. Approved temporary non-vegetative stabilization techniques, which include mulching with various materials, and chemical stabilization techniques, should also be included in the notes.

   d. In order to insure that adequate stabilization is achieved, especially with respect to vegetative techniques; seeding dates, and application rates, etcetera, should be included in the soil stabilization notes.

10. Another major area which the erosion and sediment control plan should cover is the

maintenance of sediment control structures. Notes on this subject can be included in the general notes or set out under a separate heading. The portion of the plan dealing with maintenance must cover the cleaning of all structures and the disposal of the sediment removed.

11. The plan must illustrate all structures which call for formal designs. These structures include sediment basins, ponds, flumes, permanent diversion structures, and so forth.

12. Temporary structures which do not require formal designs, like diversion dikes and sediment traps, are often not illustrated on the plan. Instead, the plan includes references to standard documents, recognized by the approving agency, which contain drawings and construction requirements of the structures.

Questions 1

Fill in the blanks.

1. Critical areas, where the potential for erosion is high, include ____________, ______________, and ________________.

2. Most erosion and sediment problems can be avoided by proper __________________ and __________________.

3. In most areas of the country, most construction activity takes place during the same seasons as heavy _____________ occur.

4. One of the key strategies in erosion and sediment control planning is to see to it that ______________ ____________ is controlled on the site.

5. Another key strategy is to minimize _________________.

6. There is a great deal we can do to control the ____________ and ______________ of water, as it moves over the soil and concentrates in waterways.

Questions 2

True or false.

1. ________ All landscapes impose the same restrictions on the way in which they can be developed.

2. ________ Before development commences, the developer must determine the impact that erosion and sediment, produced during and after the work, will have on his own site, and on the areas lying downslope and downstream from the site.

3. ________ The first step in an erosion and sediment control plan is the design stage.

4. ________ Measures designed for the management of stormwater should be an integral part of the planning process, in any sediment and erosion control plan.

5. ________ The proper siting of structures will have no effect on erosion and sediment damage.

6. ________ When it is possible, grading should be minimized, so as to reduce erosion.

Questions 3

Circle the correct answer or answers.

1. The owner or site developer is responsible
   a. for the preparation of the development plans only.
   b. for the erosion and sediment control plans only.
   c. for the preparation of both the development plans and the erosion and sediment control plans.

2. During and after construction, the developer
   a. must have the plans on hand, and must implement them.
   b. can rely on the storm sewers, to handle runoff and sedimentation.
   c. has the responsibility to abate sediment pollution and comply with local ordinances.

3. For a 10 acre site, the cost of setting up and following an erosion and sediment control plan, may be $1500 or more per acre; the cost of removing 200 cubic yards of sediment from storm sewers alone, an amount that can easily be generated by an acre during a year, will range from
   a. $1200 to $3000
   b. $12,000 to $30,000
   c. $120,000 to $300,000

4. It is crucial to
   a. make long-range studies of the landscape
   b. prevent further development
   c. allow developers to proceed as they see fit

Questions 4

Write the letter that corresponds to the correct source of the information described, in the blank provided.

a. County planning boards;
b. U.S. Geological Survey Offices;
c. Aerial maps and photographs furnished by the Soil Conservation Service;
d. Highway offices;
e. Soil survey reports furnished by the Soil Conservation Service;
f. Local planning and zoning agencies;
g. State Department of Natural Resources or other agencies responsible for water pollution control.

1. ________ Suitability of various soil types for locating pipelines, roads, ponds, reservoirs, drainage systems, and so forth.

2. ________ Exact location of woodlands, wetlands, and other critical or historical areas.

3. ________ Important mineral deposits, critical underground water supplies, location of rock outcrops, etc.

4. ________ Location of present and future highways.

5. ________ Soil engineering properties and areas having drainage or flooding problems.

6. ________ Local ordinances.

7. ________ New regulations pertaining to erosion and sediment control and updates on technical information.

Write the letter that corresponds to the appropriate tool for planning, in the blank provided.

a. Public agencies, such as the Soil and Water Conservation District;
b. U.S.G.S. quadrangle map;
c. topographic or base map;
d. Professional consultant;
e. Enlarged aerial photograph or stereoscopic pairs of air photos.

1. ________ For site development (scale: 40 to 200 feet per inch; contour interval: 2 to 5 feet).

2. ________ For preliminary site evaluations.

3. ________ For locating woodlands, wetlands, and other critical features.

4. ________ For consultation, during on-site studies.

5. ________ For problems that are particularly difficult.

Questions 5

Each of the following statements contains one error; write the letter that corresponds to the incorrect word or phrase in the blank provided.

1. ________ One key requirement in the design of an erosion and sediment control plan is: identify and protect
A
critical features. The physical factors of protective mulches,
A B
soils, landscape, drainageways, woodlands, and wetlands,
C D E F
taken together, should help determine the layout and design of the development.

2. ________ The second requirement is to reduce erosion and
A
runoff, in order to keep soil on the site. Expose the
A B
largest practical area, for the shortest time. Prompt
B C
revegetation is essential to reduce runoff and erosion.
C
Other techniques include surface roughening, diversion
D E
structures, and detention structures.
E

3. ________ The third requirement is preserve all woodland.
A
Sediment collection structures may be temporary or permanent,
B C
depending on the needs of a specific site. Sediment traps will have to be cleaned out, from time to time during
D
construction.

4. ________ The fourth requirement is stabilize the soil, as
A B
soon as possible after each grading step. With cut or fill
B
slopes, stabilization measures are normally applied in 20-foot vertical increments. During any type of grading
C
activity, the sooner an area is stabilized, the more
D
inspection and maintenance will be required.
D

5. ________ The final requirement of any plan is inspection and
A
maintenance. The best-designed erosion and sediment control
A
plans will function adequately, if the owner or his representative inspects and maintains all measures on a year-to-
B
year basis. Where sediment or stormwater management
B
structures are to remain on the site, permanently, the developer should furnish evidence that he will adhere to
C
a long-range agreement.
C

6. ________ A typical erosion and sediment control plan must
A
be tailored to the physical and climatic conditions at the
A A
site, and should include enlarged aerial photographs,
A B
proposed construction, the location of erosion control
C D
measures, and general and specific notes regarding the
D E
implementation of the plan.
E

7. ________ Specific notes included in the erosion and sediment control plan contain information such as "the Order of Procedure," (A) the temporary stabilization procedures (B), historical reports (C), and the maintenance of sediment control structures (D).

8. ________ Temporary structures which do not require formal designs, like ponds (A), diversion dikes (B), and sediment traps (C), are often not illustrated on the plan. Instead, the plans include references to standard documents, which contain drawings and construction requirements (D) of the structures.

Questions 6

Fill in the blanks.

1. The first step in the development of a site is the ________________ ________________.

2. After this step, the ________________ ____________ begins.

3. An erosion and sediment control plan is part of the overall ________________ ________________

4. The five most important requirements for an erosion and sediment control plan are: 1. ________________ and ________________ critical features; 2. ________________ erosion and runoff; 3. ________________ sediment; 4. ________________ the soil; and 5. ________________ inspection and maintenance of all control practices.

5. Each erosion and sediment control plan will contain a drawing showing present and proposed ________________ ________________ and elevations, the location of erosion and sediment control ____________, typical or detailed ________________ for various structures, and other general and specific ______________ regarding implementation and maintenance.

EROSION AND SEDIMENT CONTROL

WOODED - SITE DEVELOPMENT

WORKBOOK

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I INTRODUCTION

A. Trees may appear not to be doing anything, but in reality they are constantly active, taking in food and water, giving up oxygen and taking in carbon dioxide and moving nutrients from one part of their systems to another.

B. Not only do they provide shade, they also protect the soil from erosion, provide homes and food for wildlife, reduce the runoff after heavy rainfall, decrease the noise, slow down strong winds, and add to the beauty of an area. They also enhance our environment, by adding oxygen to the air, while consuming carbon dioxide during the process of growth.

C. Parts of Tree

1. Roots anchor the tree firmly in place. They take in water and minerals from the soil, through feeder roots, most of which are within 18 inches of the ground surface.

   a. Feeder roots need oxygen to survive; they can easily be suffocated by fill, compaction, or asphalt.

   b. The root system provides transportation routes for water and plant food.

   c. Roots store food manufactured by the tree.

2. The trunk is primarily composed of dead cells; the trunk supports the tree and transports water.

a. The inner bark, or "cambium," is composed of living tissue and transports nutrients.

b. The cambium is especially fragile and can easily be damaged by careless operation or fire.

c. Girdling, the removal of a continuous strip of bark all the way around the trunk, will cause the tree to die.

d. Any damage to the outer bark allows disease-causing organisms and destructive insects to enter. This leads to rot and decay.

3. The leaves use the water taken in by the roots, in combination with air and sunlight, to manufacture food for the entire tree.

   a. If many branches are removed from a tree, the entire tree may die, because it does not have enough leaves to make food for the whole tree.

D. A stand is a community of trees having the same age and general appearance. Most construction occurs in second-growth stands, which have grown up following logging, fire, or some other large-scale removal.

E. Classification of Trees by Size

   1. Seedlings are trees whose height does not exceed four feet; while they are usually too small to consider in planning development, they do serve to hold the soil.

2. Saplings are trees that are taller than four feet and have diameters up to five inches. Almost any of them may be selected for preservation.
3. Pole-size trees have diameters ranging from five to eleven inches.
    a. Growing in stands, they usually have small crowns and restricted root systems.
    b. A tree's root system is roughly the same size as its crown.
    c. They are therefore liable to suffer "wind-throw" when the protection of surrounding trees is removed. "Wind throw" is the damage that results when trees are tipped or blown over by the wind.
    d. Pole-size conifers are especially vulnerable to wind throw.
4. Trees whose diameters measure between 11 and 16 inches are often called "small sawtimber." Trees whose diameters exceed 16 inches are called "large sawtimber."
    a. When selecting these trees for preservation, look for a well-developed crown, strong crotches, and a trunk without rot or decay.

5. Veteran trees are older trees that usually exceed 24 inches in diameter. Their root systems are large and cannot withstand the stresses of construction activity as well as younger trees can.

II PLANNING FOR PRESERVATION OF TREES

A. Questions to Consider in Planning Stage

1. Which trees do I want to save?
2. What will those trees need to survive?
3. How am I going to get equipment in and out of the site?
4. Where am I going to put the earth I move?
5. Where am I going to store my supplies?
6. How can I protect the trees I want to save?
7. Are the trees I have selected going to be suited to this site once construction has been completed?
8. Will the trees be in harmony with the surrounding site development?

B. The proper development of a wooded site depends on the completion of an overall plan for the preservation of the trees before clearing and construction begins.

1. First, look over the entire area to find out where the most valuable trees are growing and where the most desirable building sites are found.

2. Locate floodplains and areas of highly erodible soil or high groundwater.

3. Mark desirable tree stands and valuable individual trees on the site map, for the office personnel to assess in determining the layout of the site.

4. Areas that are valuable for their beauty, but undesirable for building or roadway construction should be left as natural or only partially improved open space.

C. <u>Selection of Individual Trees for Preservation</u>

1. When considering a tree for preservation, keep in mind its age. If it is past its prime, it may be unable to survive the stresses imposed by construction.

2. Some trees, such as white oaks, beeches, and maples, have longer life expectancies and can withstand the stress of development better than others, such as tulip poplars. Short-lived trees such as willows are also less desirable than longer-lived ones.

3. It may be better to save a smaller tree of a desirable species than a nearby larger one; not only will the younger tree live longer, it can withstand the shock of construction better, and if the older tree dies, the landowner ends up paying the high cost of having it removed.

4. Examine the tree to see if its health is satisfactory.
    a. Look for scarring caused by fire or lightning.
    b. Make sure the tree is not growing from an old stump. This may result in a weak trunk.
    c. Inspect the tree for damage by insects or diseases.
    d. Check for rotted trunks or limbs.
    e. Check the tree for stuctural defects.
    f. Large trees with severe overhangs that endanger life or property need pruning or removal. If your knowledge of trees is limited, hire an expert to evaluate the trees.

D. The size of individual lots must be large enough for the contractor to site the house properly and conduct operations efficiently. The smallest lot size for wooded-site development should be one-half acre or one-third acre at the very least, if you desire to protect the trees adequately.

E. Roadways should be located so as to do the least damage to the more valuable stands. Follow the ground contour as much as possible, to minimize cuts and fills.

F. Provide a cleared strip of at least fifteen feet around a structure, to prevent serious root damage caused by excavation and to provide storage area and space for working, separate from the wooded area.

G. Position utility spurs to avoid damaging the roots of trees.

   1. Plan to place as many utilities in one trench as possible, to minimize trenching.

III <u>CONSTRUCTION PRACTICES FOR PROTECTION OF TREES</u>

A. <u>Marking</u>

   1. On clearings for roadways, mark the border of the area to be cleared with flags, paint, or fencing.

      a. Use one color for trees to be removed and another for trees to be saved.

      b. Marking with paint is more permanent and less subject to tampering.

      c. Protect the trees outside the border when you fell trees inside it.

      d. Don't allow any traffic but essential equipment in the protected areas.

B. <u>Salvage</u>

   1. Large trees that are removed should be salvaged for timber. Large limbs and smaller trunks can be cut up for firewood and stacked on the site.

2. Woodchippers are useful for processing smaller trees and branches. The woodchips are useful for erosion control or for mulch for woody plants.

C. Stump cutting machines are best for removing stumps, except where foundations are being excavated.

1. Removing stumps by blasting or dozing exposes more soil to erosion and does more damage to adjacent trees. But for roadways and building foundation areas, the conventional techniques are still necessary.

D. Pole-Size Stands

1. Because of their limited root systems, the individual trees depend upon their neighbors for protection.
2. If too many are removed, the remaining trees are liable to topple during heavy winds.
3. Because their bark is thin, the rapid changes in temperature that result from exposure to direct sunlight and wind may cause serious bark damage.
4. Leave clumps of trees rather than individual ones. As the trees mature they can be thinned out, leaving the best ones room to grow.

E. Traffic Control

1. When grading begins, traffic control becomes vital.

2. When access routes are necessary, locate them so as to do the least amount of damage.

3. Careless operators damage or destroy many trees. To avoid root and trunk damage, construction traffic must be confined to the right-of-way.

F. Cut Slopes

1. Along major routes where cut slopes are large, provide a fifteen foot wide cleared zone in back of the slope.

2. For less severe cut slopes in residential areas, cribbings can help save valuable trees.

G. Roadway Filling

1. Roadway gradings can alter the natural moisture of the soil.

   a. A cut slope placed too close to a treeline may lower the moisture table. A drop in the moisture table of only six inches may kill trees.

   b. Roots exposed on the slope can cause "water piping." Water flows along the roots, and removes soil.

c. The roots that are not exposed take up moisture that the grasses need to grow.

d. Trees left too close to the edge of a cut may shade the slope, thus preventing a dense ground cover from developing. This results in increased erosion.

e. Further erosion occurs when water drips off the leaves or branches. To prevent damaging sheet erosion, provide a fifteen foot wide cleared zone in back of a large cut, or cribbing along less severe cut slopes.

G. <u>Roadway Filling</u>

1. Roadway filling can cause problems.

    a. It may impound water, preventing feeder roots from obtaining oxygen, thereby causing damage to trees.

    b. It also causes damage when it covers the feeder roots of a tree.

2. Do not fill beneath the crown of a tree, as a general rule.

3. In all cases, provide a minimum cleared zone of fifteen feet, to prevent the fill from covering the feeder roots.

4. Good surface drainage at the base of the fill will prevent excessive soil moisture.

H. Correct Operating Procedures

1. Operators should stay within the right-of-way.
2. Watch where you swing backhoes and other high-profile equipment.
3. Striking the bucket against a tree causes severe damage to the bark.

I. Trenching

1. Try to keep trenching outside the crown of the tree. A narrow trench that cuts the feeder roots off from the rest of the tree can destroy a tree as quickly as a fifty-foot roadway cut.
2. Because the feeder roots are close to the ground surface, a trench only eighteen inches deep can inflict major damage.
3. When a utility spur leading to a home cannot be relocated to avoid major root damage from trenching, tunnel the utility under the feeder roots of the tree. Special equipment for doing this is available.

J. To avoid damage to the roots, keep all construction activity outside the dripline of the crown (the outward extent of the major portion of the feeder roots).

K. <u>Soil Stockpiling</u>

1. Soil not needed for foundation backfilling should be removed from the site.
2. The remaining soil must be placed where it will cause the least damage. Scattering the soil in small piles, away from the trunks of trees, minimizes damage.

L. To provide maximum protection, place fencing at the dripline around the trees that you want to preserve. This rule also applies to clumps of trees.

1. Fencing can be used to mark the limit of clearing.

M. <u>Fill</u>

1. Grading and excavation should be kept outside the dripline of any tree you wish to protect.
2. Most trees will tolerate up to six inches of fill, but additional fill will cause damage. Tulip poplars are particularly susceptible.
3. When filling to a depth of more than six inches is necessary, construct a tile and porous stone well.
   a. Place the tile and porous stone on the ground out to the dripline.

b. Cover with fill, leaving an open well around the trunk. The well will allow air to circulate to the root zone under the fill.

N. Do not place paving underneath the crown of a tree. Asphalt and concrete paving cut off the supply of oxygen and moisture, resulting in serious damage.

O. Failure to provide adequate surface and subsurface drainage is also a cause of tree damage. Proper grading practices help, but tile drains may also be needed, if the problem is below the surface.

IV CORRECTIVE ACTION

A. When major root or bark damage occurs, remove some foliage to reduce the demand for nutrients and water. This operation is called "crown pruning."

1. In time, as the damage heals, more foliage will grow back.

B. To treat bark damage, remove all loosened bark from around the wound, provide drainage at the base of the wound, and apply a proper wound dressing to the damaged area.

C. If the soil has become compacted, aerate the ground, by punching holes with an iron bar.

1. Drive the bar a foot deep and then move it back and forth until the surrounding soil is loosened.

2. Repeat this procedure every eighteen inches, until all the compacted soil beneath the crown of the tree has been loosened.

D. Fertilization

1. Fertilization helps trees recover from the stress imposed by construction activities.

2. To fertilize a tree, punch holes at regular intervals into the ground inside the dripline of the tree, then fill the holes with a recommended fertilizer such as 16-8-8.

V ORGANIC LITTER

To preserve a natural setting of trees, make sure the cover of organic litter or mulch is adequate. It holds water, protects the roots, returns nutrients to the soil, and reduces erosion.

VI NECESSITY OF CORRECT PLANNING AND PROCEDURE

A. Trees damaged by improper construction activity die slowly. It may take three years or more for a damaged tree to die.

B. Severe root damage caused by improper grading can easily be hidden during final grading. The homeowner may not discover this damage for several years.

C. To a homeowner, few things are more distressing than paying thousands of dollars more for a wooded lot, only to discover a few years later that he will have to pay more money to have these cherished trees removed, or risk major property damage and, possibly, loss of life.

Questions 1

Circle the correct answer or answers.

1. Trees . . .

    a. take in food and water.
    b. exchange nitrogen for helium.
    c. move nutrients from one part of their system to another.

2. Trees . . .

    a. cause destructive erosion.
    b. provide homes and food for wildlife.
    c. reduce the runoff after heavy rainfall.
    d. decrease surface water infiltration.
    e. slow down winds.
    f. add to the beauty of an area.

3. Trees . . .

    a. enhance our environment.
    b. add oxygen to the air.
    c. consume carbon monoxide.

4. The root system . . .

    a. anchors the tree firmly in place.
    b. pumps water and minerals from the tree into the soil.
    c. is impossible to suffocate.
    d. transports vital materials from the feeder roots to other parts of the tree.
    e. stores food manufactured by the tree for later use.

5. T or F Trunks have little to do with the well-being of trees.

6. The wood inside the trunk. . .

   a. supports the tree.
   b. transports mostly minerals.

7. The inner bark, or "cambium,"

   a. transports nutrients.
   b. is hard to damage.

8. T or F If you remove a continuous strip of bark all the way around the trunk the tree will continue its formal development.

9. Damage to the cambium

   a. allows *diseases and pests to enter.*
   b. leads to rot and decay.

10. T or F The leaves consume food manufactured elsewhere in the tree.

Complete the following sentences by filling in the blanks:

1. Most construction occurs in __________ ______________ stands.

2. _______________ are the youngest trees (less than 4 feet tall).

3. _______________, which are taller than four feet, have diameters up to five inches. Almost any of them may be selected for preservation.

4. ______________ ____________ trees have diameters ranging from five to eleven inches. As a result of their small root systems, these trees often suffer ____________ _____________.

5. Trees whose diameters measure between 11 and 16 inches are called _______________ ________________.

6. Trees whose diameters measure between 16 and 24 inches are called _______________ _______________.

7. When selecting mature trees for preservation, look for a well developed _____________, strong ____________, and a ____________ without rot or decay.

8. __________________ trees usually exceed 24 inches in diameter. They are often over-mature.

Questions 2

Mark each statement True or False.

1. ________ Before beginning a project you should decide which trees you want to save.

2. ________ Each different piece of equipment should use its own access road.

3. ________ You should decide ahead of time where to put earth and where to store supplies.

4. ________ The proper development of a forested site depends on waiting until construction begins, to see what steps should be taken.

5. ________ First the planner should look over the entire area, to find out where the most valuable trees are growing and where the most desirable trees are found.

6. ________ Areas that are valuable for their natural beauty, but undesirable for building or roadway construction, should be left as natural or only partially improved open space.

7. ________ Trees should be left to provide shade, whether or not they will survive construction.

8. ________ White oaks, beeches, and maples adapt poorly to the stress of development.

9. ________ Tulip-poplars adapt poorly to the stress of development.

10. ________ In selecting a tree for preservation, a planner should inspect it for damage by insects or diseases, should check for rotted limbs or trunks, and should look for structural defects.

11. ________ The smallest lot size for wooded site development is one acre.

12. ________ It is better to rely on deep cuts and long fills than to follow the ground contour as much as possible.

13. ________ Providing a cleared strip of at least fifteen feet around a structure will help prevent serious root damage caused by excavating the foundation.

14. ________ The positioning of utility spurs does not effect trees.

Questions 3

Circle the correct answer or answers.

1. If you're going to clear woods for roadways, mark the border of the area to be cleared

    a. with flags, paint, or fencing.
    b. with lime.

2. When you fell trees inside the border, be careful to protect the trees

    a. inside the border.
    b. outside the border.
    c. inside and outside the border.

3. When you clear selected trees mark

    a. all the trees with the same color
    b. the trees to be saved with one color, and the the trees to be cleared with another color.

4. Large trees that are removed should be salvaged

    a. for timber.
    b. for woodchips.

5. Stump cutting machines are best for removing stumps

    a. where foundations are being excavated.
    b. where roadways will be located.
    c. except for roadways and building foundation areas.

6. T or F   Pole-size trees should be left as individuals.

7. Access routes

   a. can be left to the discretion of the operators.
   b. should be located so as to do the least amount of damage.
   c. can be ignored, if the operator wants to drive through a wooded area you hope to protect.

8. T or F Along major routes where cut slopes are larae, provide a fifteen-foot wide cleared zone in back of the cut.

9. Roadway filling

   a. cannot harm the feeder roots of a tree.
   b. should not be allowed beneath the crown of a tree.

10. In all cases where filling is being done provide

   a. a minimum clear zone of fifteen feet to prevent the fill from covering the feeder roots.
   b. underground drainage tiles

Questions 4

Mark each statement true or false.

1. ____________ Operators should stay within the right-of-way.

2. ____________ Striking the bucket against the tree causes severe damage to the bark.

3. ____________ You should try to keep trenching outside the crown of the tree.

4. ____________ When a utility spur leading to a home cannot be relocated to avoid major root damage from trenching, you should tunnel the utility under the feeder roots of the tree.

5. ____________ All construction activity should be kept outside the dripline of the crown.

6. ____________ Soil that is needed on the site should be placed where it will cause the least damage, preferably scattered in small piles.

7. ____________ To provide maximum protection, place fencing at the dripline around the trees that you want to preserve.

8. ____________ Grading and excavation should be kept outside the dripline of any tree you wish to protect.

9. ____________ When filling to a depth of more than six inches is necessary, construct a tile and porous stone well.

10. ________ Do not place paving underneath the crown of a tree.

11. ________ Tile drainage may be necessary, where there is a subsurface drainage problem resulting in inadequate surface and subsurface drainage.

Complete the following sentences by filling in the blanks:

1. When major root or bark damage occurs, remove some ________ to reduce the demand for nutrients and water.

2. To treat bark damage, remove all loosened ________ from around the wound, provide ________ at the base of the wound, and apply a proper ________ ________ to the damaged area.

3. If the soil becomes compacted, aerate the ground by ________ ________ with an iron bar. Drive the bar a foot deep and then move it back and forth, until the surrounding soil is ________. Repeat this procedure every ________ inches, until all the compacted soil beneath the crown of the tree has been loosened.

4. ________ is another maintenance procedure that helps trees recover from the stress imposed by construction activities. To ________ a tree, punch holes at regular intervals in the ground inside the ________ of the tree. Then fill the holes with a recommended ________.

5. To preserve a natural setting of trees, make sure the cover of ________ ________ is adequate.

6. Trees damaged by improper construction activity usually die ________. (rapidly? slowly?)

Questions 5

Each of the following sentences contains one error. Write the letter in the blank that corresponds to the part of the statement that is incorrect.

1. ______ The roots absorb minerals and water from the soil, (A) transport these nutrients to the trunk, (B) take in carbon dioxide from the air, and release oxygen, (C) and store important materials. (D)

2. ______ The trunk supports the crown, (A) transports material between the roots and the crown, (B) and manufactures food for the whole tree. (C)

3. _____ The cambium is difficult to damage, (A) and it does most of the work of transporting material (B) in the trunk.

4. ______ The inner wood moves upward as the tree grows, (A) supports the crown, (B) and transports water. (C)

5. ______ The leaves manufacture food for the whole tree (A) and contain little or no living tissue. (B)

6. ______ *Seedlings* are up to four feet high (.A) and have no effect on the amount of erosion. (B)

7\. _____ Saplings are smaller than seedlings and
A
have diameters less than 5".
B

8\. _____ Pole-size trees have diameters greater than 5"
A
but less than 11"; during clearing, they should be left
B C
as individuals.
C

9\. _____ Sawtimber includes trees greater than 11";
A
sawtimber cannot withstand the stress of development.
B

10\. _____ Veteran trees are insensitive to the stress of
A
development; their trunks usually exceed 24" in diameter.
A B

11\. _____ The proper development of a forested site depends
mainly on seasonal conditions but also on the completion
A B
of an adequate overall plan, before clearing and construction
B C
begins.
C

12\. _____ First, look over the entire area to see whether
A B
soil stabilization will be necessary, and to locate the
B C
most valuable and desirable trees.
C

13\. _____ Areas that are valuable for their natural beauty,
but undesirable for building and roadway construction
should be cleared or left as natural or only partially
A B
improved open space.
B

14\. _____ When considering a tree for preservation, consider
its age, species, health, need for fertilizer, size, and
A B C D E
structural defects, if any.
F

15. ______ Trees that adapt well to the stress of construction include <u>white oaks</u>, <u>tulip-poplars</u>, <u>maples</u>, and <u>beeches</u>.
A B C D

16. ______ Home lots in wooded areas should be at least <u>one-half acre</u>, or <u>one-eighth acre, at the very least</u>.
A B

17. ______ <u>After construction begins</u> locate the <u>roadways</u>,
A B
<u>utilities</u>, <u>homesites, and other features</u> so as to do
C D
<u>the least damage</u> to the more valuable stands.
E

Mark each statement true or false.

1. ____________ Before clearing wooded areas, trees should be marked clearly to distinguish between valuable trees for preservation, and undesirable trees, for removal.

2. ____________ Trees which have been removed should be promptly burned.

3. ____________ The stump-cutter should be used for removing stumps only as a last resort.

4. ____________ Badly damaged or diseased trees should be left alone.

5. ____________ Generally, trees located within fifteen feet of a structure should be removed.

6. ____________ Fencing around the dripline of trees helps protect them from construction activities.

7. ____________ Pruning, root aeration, treating wounds, and. fertilization, do little to help a tree recover from injuries or the stresses imposed by construction activities.

8. ____________ When trees are injured beyond repair, you should remove them promptly, rather than hide the damage and leave them to die later.

EROSION AND SEDIMENT CONTROL

FOREMAN - INSPECTOR RESPONSIBILITIES

WORKBOOK

CONTENT

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 B. The Inspector

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   (a) Know the law

   (b) Have working knowledge of current practices

   (c) Know the plans

   (d) Organize your activities

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   (a) Checking the implementation of plans

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  4. Follow-up Action

  5. Working with people

III. SOCIAL CONTROL OR ENFORCEMENT

 A. Enforce

 B. Implement

IV. PUBLIC CONTRACT

V. REVIEW

I. ROLES OF THE FOREMAN AND INSPECTOR

A. The Foreman

1. Is a key man in the effective control of erosion and sediment.
2. Serves "as a first line of defense".
3. Has the best working knowledge of the site.
4. Must assume much of the responsibility for ensuring that the public's goal of controlling erosion and sediment is accomplished.

B. The Inspector

1. Serves as a "back-up or reinforcement".
2. Has a better overall view of erosion and sediment control.
3. Is in the best position to objectively evaluate the total performance of the erosion and sediment control efforts on a site.
4. Must share the responsibility for ensuring that the public's goal of controlling erosion and sediment is accomplished.

II. FOREMAN-INSPECTOR TEAM - the role of the foreman and inspector cannot be viewed as separate.

A. Responsibilities

1. General - Field Implementation

a. Responsible for the "on-site" phase of the erosion and sediment control program.

b. Responsible for making the vital link between successful planning and effective on-site control of erosion and sediment.

2. Preparation

a. Know the law.

(1) Specialists must have a clear understanding of the laws, ordinances, regulations, and procedures affecting their activities.

(2) Effective field implementation is directly related to the knowledge of the provisions of the laws and regulations.

b. Have working knowledge of current practices

(1) needed for proper implementation of sediment control plans.

(2) needed to solve on-site problems.

c. Know the plans.

   (1) Foreman and inspector must be thoroughly familiar with the actual sediment control plans and specifications for a project.

   (2) Pay attention to the type, scheduling, staging and location of practices detailed in the plan.

   (3) When possible, schedule an on-site meeting to review the plans in order to establish open communication and prevent needless misunderstanding.

d. Organize your activities.

   (1) Control practices require periodic checking and maintenance.

   (2) The foreman must plan and schedule time for sediment and erosion control.

   (3) The inspector must determine how many inspections he can make in an average day, and relate this figure to his total workload to establish a regular return interval. He may also plan for unexpected visits to vary his routine.

3. <u>On-site evaluation and control</u>

a. Checking the implementation of plans.

(1) Determine if the approved erosion and sediment control plans and permits are being properly carried out.

(2) Should be a joint operation.

(3) Check the entire site.

(4) Visualize the measures shown on the plans.

(a) Is the scheduling and staging of the plans being followed?

(b) Are the practices shown on the plan installed as per design and located properly?

(c) Are the practices shown on the plan being adequately maintained?

b. Checking the performance of plans.

(1) During and after rainstorms the foreman and inspector must check to see if there is any significant damage occuring off-site.

(2) If obvious deposits of sediment are visible off-site, significant damage is occuring and additional or improved control is necessary.

(3) Watch the following activities:

(a) utility construction

(b) traffic control and storage areas

(c) changes in the staging of a project

4. Follow-up action

a. Document on standard report forms the findings of inspections conducted.

b. Decisions should be made and recorded regarding action to be taken to correct problems.

(1) Minor modifications and corrections can be made directly by the field specialists.

(2) Major modifications or corrections will usually require additional review by the consultant for the project and the inspector's supervisor.

c. Sometimes official enforcement action is the only way of obtaining compliance with approved plans and permits.

5. Working with people

    a. Controlling people - learning how to communicate with, educate, and gain the cooperation of people.

    b. The foreman needs to inform and train his men in order to achieve effective erosion control.

    c. The inspector needs to make sure that the foreman adequately understands and carries out an effective sediment control effort.

    d. Both field specialists are really "amateur psychologists".

III. SOCIAL CONTROL OR ENFORCEMENT is a vital activity needed for the health, safety, and welfare of the people. It is made up of two ideas:

A. Enforce

    1. Refers to laws.

    2. Implies the exercise of police power or force.

B. Implement

    1. Action necessary to bring into effect some agreed-on plan or policy.

    2. This idea is often ignored.

IV. PUBLIC CONTACT - putting into effect what everyone agreed to do in the first place.

The foreman and inspector are "regulators", they have taken on the responsibility of making sure that the goals and objectives are met in the field.

QUESTIONS 1

True or False

_____1. The inspector serves "as a first line of defense".

_____2. The foreman is a key man in the effective control of erosion and sediment.

_____3. The inspector has the best working knowledge of a site.

_____4. The inspector is in the best position to objectively evaluate the total performance of the erosion and sediment control efforts on a site.

_____5. The foreman has a better overall view of erosion and sediment control.

_____6. The foreman serves as "a back up or reinforcement".

QUESTIONS 2

Multiple Choice

1. The effectiveness of an erosion and sediment control program depends upon:

   a. planners.
   b. consultants and technical specialists.
   c. citizens and elected officials.
   d. field specialists.
   e. all of the above.

   answer(s) ________

2. The responsibility for preparation includes:

   a. knowing the law.
   b. having working knowledge of current practices.
   c. knowing the plans.
   d. organizing your activities.

   answer(s) ________

3. Knowing the law means that a field specialist must have a clear understanding of ___________ affecting their activities.

   a. laws
   b. ordinances
   c. regulations
   d. procedures
   e. all of the above

   answer(s) ________

4. Having a working knowledge of current practices is needed:

   a. for proper implementation of sediment control plans.
   b. to solve on-site problems.
   c. both a and b.
   d. none of the above.

   answer(s) ________

QUESTIONS 3

Multiple Choice

1. Checking the implementation of plans includes:
   a. checking the entire site.
   b. visualizing the measures shown on the plans.
   c. determining if the approved plans and permits are being properly carried out.
   d. foreman and inspector working together.

   answer(s) ________

2. For effective erosion and sediment control, practices must be installed:
   a. any time.
   b. at the proper time.
   c. at the beginning.

   answer(s) ________

3. In checking the performance of plans one should watch:
   a. utility construction.
   b. traffic control.
   c. changes in staging.

   answer(s) ________

QUESTIONS 4

Fill in the blanks

1. ________________ modifications and corrections can usually be made directly by the field specialists.

2. Sometimes official e______________ action is the only way of obtaining compliance with approved plans and permits.

3. By ______________ people, we really mean learning how to c______________ with, e______________, and gain the cooperation of people.

4. The word ______________ refers to laws and implies the exercise of police power or force.

5. By implementing, we mean action to bring into effect some agreed upon __________________.

6. A public c______________ involves putting into effect what everyone agreed to do in the first place.

QUESTIONS 5

Fill in the blanks

1. The __________ serves "as the first line of defense".
2. The __________ serves "as the back up of reinforcement".
3. The __________ has a better overall view of the problems and conditions in the area.
4. The __________ has the best working knowledge of a site.
5. The responsibility of preparation includes:
   a. Know ____________________
   b. Have ____________________
   c. Know ____________________
   d. Organize ________________
6. The responsibility of on-site evaluation includes:
   a. Checking the i____________ of plans.
   b. Checking the p____________ of plans.
7. When checking performance one should watch out for the following activities:
   a. _______________ construction.
   b. ______________ control.
   c. Changes in _______________.

8. M_______________ modification will usually require additional review by the consultant for the project and the inspector's supervisor.

9. Sometimes official e____________ action is the only way of obtaining compliance with approved plans and permits.

10. By _______________ people, we really mean learning how to communicate with, ______________, and gain the c________________ of people.

11. In order to achieve effective erosion control, the foreman needs to i _______________ and t______________ his men, and the inspector needs to make sure the __________ understands and carries out an effective sediment control effort.

12. The word enforce refers to l____________ and implies the exercise of p_______________ p_______________ or force.

13. By i_____________ we mean action necessary to bring into effect some agreed upon p__________.

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16. ABSTRACT A series of technical presentations and a certification plan for erosion and sediment control specialists are presented. Thirteen lessons complete with visual aids, student handouts and audiovisual handouts consisting of slides, vidiotape and tape narration, workbooks and instructor's manuals are developed. These materials are designed to provide an effective education program for qualifying construction personnel and others to pass a certification examination. The list of the lessons is as follows:

1. Goals, Objectives and Principles of Erosion and Sediment Control
2. Soils
3. Rainfall-Runoff Relationships
4. Erosion and Sedimentation
5. Plant Materials
6. Control of Runoff During Construction
7. Vegetative Soil Stabilization
8. Stream Erosion Control
9. Temporary Soil Stabilization
10. Control of Sediment Generated on Construction Sites
11. Erosion and Sediment Control Planning
12. Wooded Site Development
13. Foreman-Inspector Responsibilities

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