Lesson A2–6

Understanding Soil Drainage Systems

Unit A. Mechanical Systems and Technology

Problem Area 2. Soil and Environmental Technology Systems

Lesson 6. Understanding Soil Drainage Systems

New Mexico Content Standard:

Pathway Strand: Natural Resources and Environmental Systems

Standard: **VII:** Apply scientific principles to environmental services.

Benchmark: **VII-B:** Describe soil compositions and properties to demonstrate knowledge of soil science.

Performance Standard: **6.** Test soil samples to determine characteristics. **7.** Explain classification of soil water. **8.** Explain the relationship between soil classifications and land use.

Student Learning Objectives. Instruction in this lesson should result in students achieving the following objectives:

1. Identify the soil characteristics that effect soil drainage.
2. Explain what needs to be considered when designing a drainage system.
3. Identify the different types of soil drainage systems.

List of Resources. The following resources may be useful in teaching this lesson:

Recommended Resources. One of the following resources should be selected to accompany the lesson:

Obtain copies of drainage guide circulars from your local Cooperative Extension Office.

List of Equipment, Tools, Supplies, and Facilities

Writing surface
Overhead projector
Transparencies from attached masters

Terms. The following terms are presented in this lesson (shown in bold italics):

Hydraulic gradient
Natural drainage
Normal water surface
Siltation
Soil depth
Soil permeability
Topographic position
Velocity

Interest Approach. Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

Ask students the question, "What determines how fast water will flow through a funnel?" Relate their answers about the funnel to soil and different soil textures. Explain how these different textures cause a variety of pore sizes in the soil.

Summary of Content and Teaching Strategies

Objective 1: Identify the soil characteristics that effect soil drainage.

Anticipated Problem: What soil characteristics effect soil drainage?

I. Soil types can be grouped into categories of soils with like drainage. These categories are determined by using guidelines that are based upon field tests and upon past experience with drainage practices on various soils. There are four main soil factors that affect the design of man-made drainage systems. These characteristics are:

A. Soil permeability—***Soil permeability*** or hydraulic conductivity is the rate at which water will move through the soil. It is measured in inches per hour.

B. Natural drainage—***Natural drainage*** is the degree of wetness before any drainage practices have been applied.

C. Soil depth—***Soil depth*** refers to the depth of the soil profile from topsoil to subsoil.

D. Topographic position—***Topographic position*** refers to the slope of the land and other physical features.

A variety of techniques may be used to assist students in mastering this objective. Students should use text materials to understand the important aspects of soil characteristics that effect soil drainage. Contact your county soil conservation office to determine the type of soil in your area.

Objective 2: Explain what needs to be considered when designing a drainage system.

Anticipated Problem: What needs to be considered when designing a drainage system?

II. To meet design requirements, a drainage system must have an outlet of adequate capacity, depth, and stability. If the outlet is inadequate, the effectiveness of the entire drainage system can be greatly reduced or lost. There are a number of items that must be considered when designing a drainage system to be certain that it will work properly. Some of them are:

A. Capacity—Crops can tolerate a limited amount of flooding or ponding but this should not be for longer than 24 to 48 hours. To determine what the capacity of the outlet channel must be to remove water quickly enough, a producer can either calculate flood routings of the drainage area or refer to a drainage curve similar to the one shown in TM: A2–6A. On this chart, the curves show the rate of discharge that will provide a certain level of drainage in the watershed area.

B. Velocity—The ***velocity*** or speed of the water flow must be high enough to prevent siltation in the channel but low enough to avoid erosion. ***Siltation*** is the deposition of particles suspended in water. On average the velocity should be no lower than 1.5 feet per second. A lower velocity will cause siltation, which encourages moss and weed growth and reduces the cross section of the channel.

C. Hydraulic gradient—The ***hydraulic gradient*** represents the surface of the water when the outlet channel is operating at its design flow. The hydraulic gradient for the channel should be determined from control points such as the elevation of low areas served by the channel and the hydraulic gradients of tributary ditches.

D. Channel depth—An outlet channel that receives water from subsurface drains should be designed to keep the normal water surface one foot below the bottom of the subsurface drain. The ***normal water surface*** is defined as the elevation of the usual flow during the growing season. The clearance may be less, where there are unusual site conditions.

E. Cross section—The design cross section of the outlet channel should meet the combined requirements of capacity, velocity, depth, side slopes, and bottom width. The side slopes should be stable, meet maintenance requirements, and be designed according to site conditions. In silt, the side slopes should be no steeper than 2:1; in clay and other heavy soils, 1.5:1; and in sands, peat, and muck, 1:1.

A variety of techniques may be used to assist students in mastering this objective. Students should use text materials to understand the important aspects of needs to be considered when designing a drainage system. Use TM: A2–6B thru TM: A2–6D to assist in the discussion on this topic.

Objective 3: Identify the different types of soil drainage systems.

Anticipated Problem: What are the different types of soil drainage systems?

III. There are two basic soil drainage systems. They are surface drainage and subsurface drainage.

A. Surface Drainage—Surface drainage is the removal of water that collects on the land surface. A surface drainage system consists of shallow ditches and should include land smoothing or land grading. This type of system is suitable for all slowly permeable soils. The rate at which water is removed by surface drainage depends on several interrelated factors, including rainfall, soil properties, and cropping patterns.

B. Subsurface Drainage—Subsurface drainage is used where the soil is permeable enough to allow economical spacing of the drains and productive enough to justify the investment. A complete subsurface drainage system consists of a surface or subsurface outlet and subsurface main drains and laterals. Water is carried into the outlet by main drains, which receive water from the laterals. The system will function only as well as its outlet. Four basic patterns are used in the design of subsurface drainage systems. It is important for the producer to select the pattern that best fits the topography of the land, that can be located near enough to the sources of excess water, and that is suited to other field conditions. The four patterns are:

1. Random—The random pattern is suitable for undulating or rolling land that contains isolated wet areas. The main drain is usually placed in the swales rather than in

deep cuts through ridges. The laterals in this pattern are arranged according to size of the isolated wet areas.

2. Parallel—The parallel pattern consists of parallel lateral drains located perpendicular to the main drain. The laterals in the pattern may be spaced at any interval consistent with site conditions. This pattern is used on flat, regularly shaped fields and on uniform soil.
3. Herringbone—The herringbone pattern consists of parallel laterals that enter the main at an angle, usually from both sides. The main is located on the major slope of the land, and the laterals are angled upstream on a grade. This pattern is often combined with others to drain small or irregular areas. Its disadvantages are that it may cause double drainage and that it may cost more than other patterns because it contains more junctions. However, it can provide the extra drainage needed for the less permeable soils that are found in narrow depressions.
4. Double Main—The double main pattern is a modification of the parallel and herringbone patterns. It is applicable where a depression divides the field in which drains are to be installed. The pattern is also chosen where the digressional area is wet because of seepage coming from higher ground. Placing a main on each side of the depression serves two purposes:
   a. The main intercepts the seepage water.
   b. It provides an outlet for the laterals.

A variety of techniques may be used to assist students in mastering this objective. Students should use text materials to understand the important aspects of the different types of soil drainage systems. Use TM: A2–6E to assist in the discussion on this topic.

Review/Summary. Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. Questions at the end of each chapter in the recommended textbooks may also be used in the review/summary.

Evaluation. Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activity. A sample written test is attached

Answers to Sample Test:

Part One: Matching

1 = a, 2 = f, 3 = c, 4 = e, 5 = h, 6 = b, 7 = g, 8 = d

Part Two: Completion

1. Surface
2. one foot

Part Three: Short Answer

See Objective 3 in lesson.

Sample Test Name____________________________

Test

Lesson A2–6: Understanding Soil Drainage Systems

Part One: Matching

Instructions. Match the term with the correct response. Write the letter of the term by the definition.

a. hydraulic gradient	b. natural drainage	c. normal water surface
d. siltation	e. soil depth	f. soil permeability
g. topographic position	h. velocity	

_______ 1. Represents the surface of the water when the outlet channel is operating at is design flow.

_______ 2. The rate at which water will move through the soil.

_______ 3. Defined as the elevation of the usual flow during the growing season.

_______ 4. Refers to the depth of the soil profile from topsoil to subsoil.

_______ 5. Speed of the water flow.

_______ 6. The degree of wetness before any drainage practices have been applied.

_______ 7. The slope of the land and other physical features.

_______ 8. The deposition of particles suspended in water.

Part Two: Completion

Instructions. Provide the word or words to complete the following statements.

1. ________ drainage is the removal of water that collects on the land surface.
2. An outlet channel that receives water from subsurface drains should be designed to keep the normal water surface _____ __________ below the bottom of the subsurface drain.

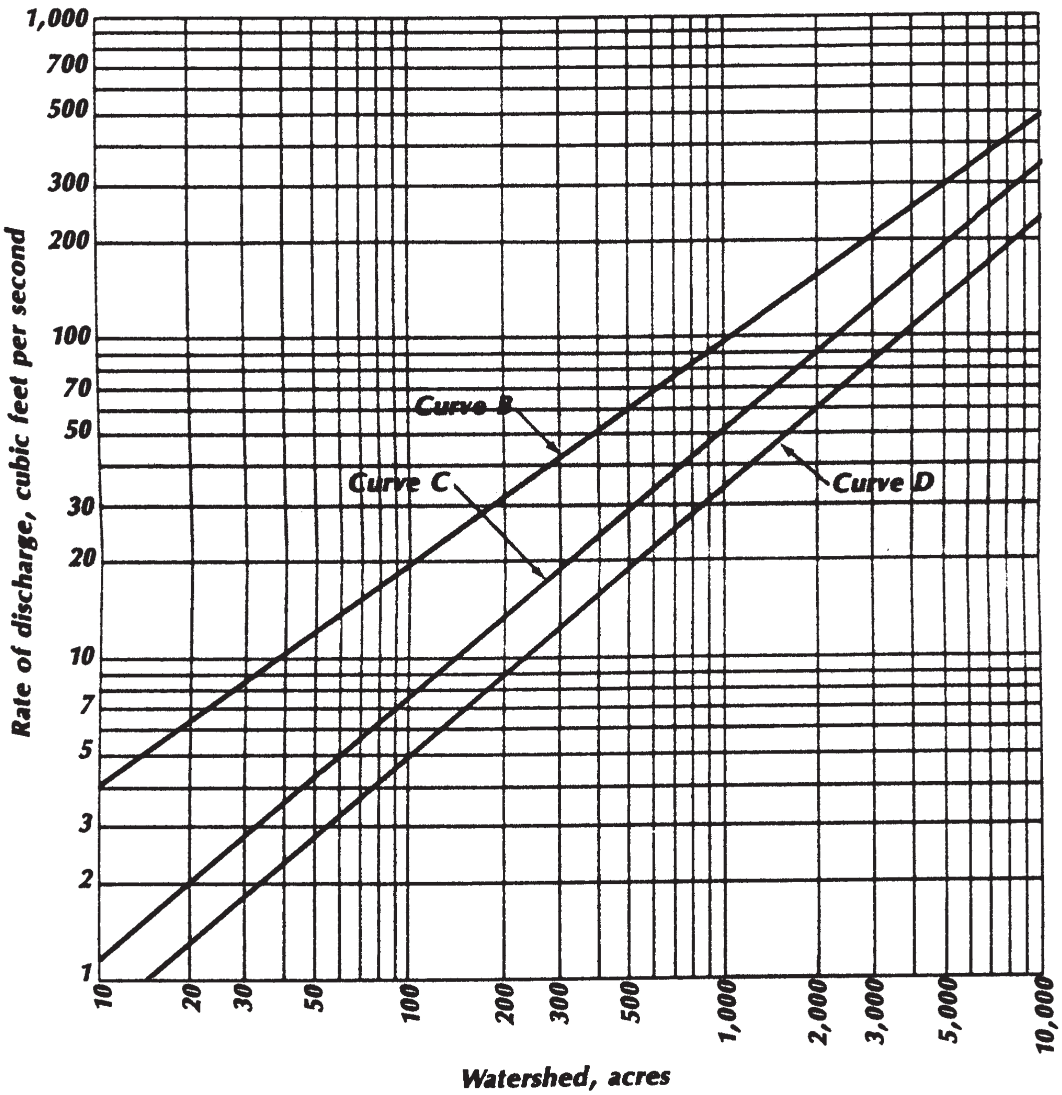
Part Three: Short Answer

Instructions. Provide information to answer the following questions.

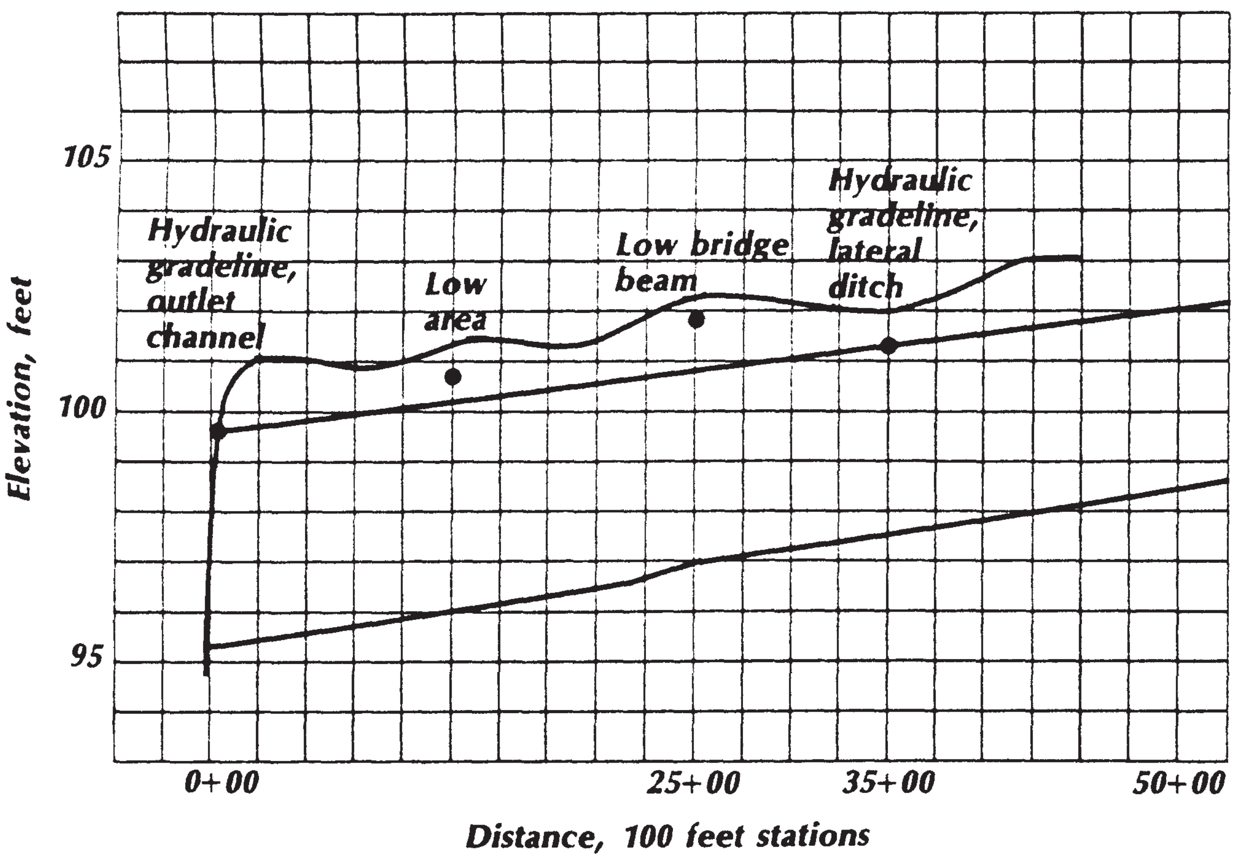
Compare and contrast the various patterns of subsurface drainage systems.

TM: A2–6A

Drainage curves for determining what the capacity of an open ditch must be to provide a certain level of drainage in a specified area. Channels based on curve B provide excellent agricultural drainage; those on curve C, good drainage; and those on curve D, satisfactory drainage. (Adapted from Soil Conservation Service, National Engineering Handbook, Section 16, Chapter 5.)

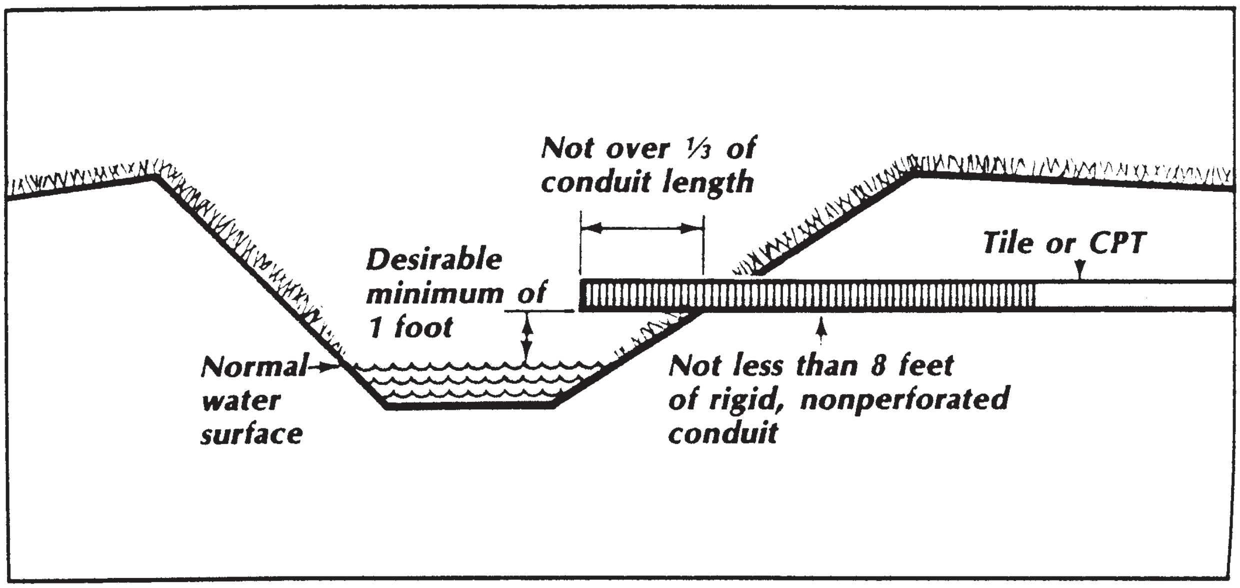


Profile of an outlet channel showing the hydraulic gradeline designed through or below critical control points.

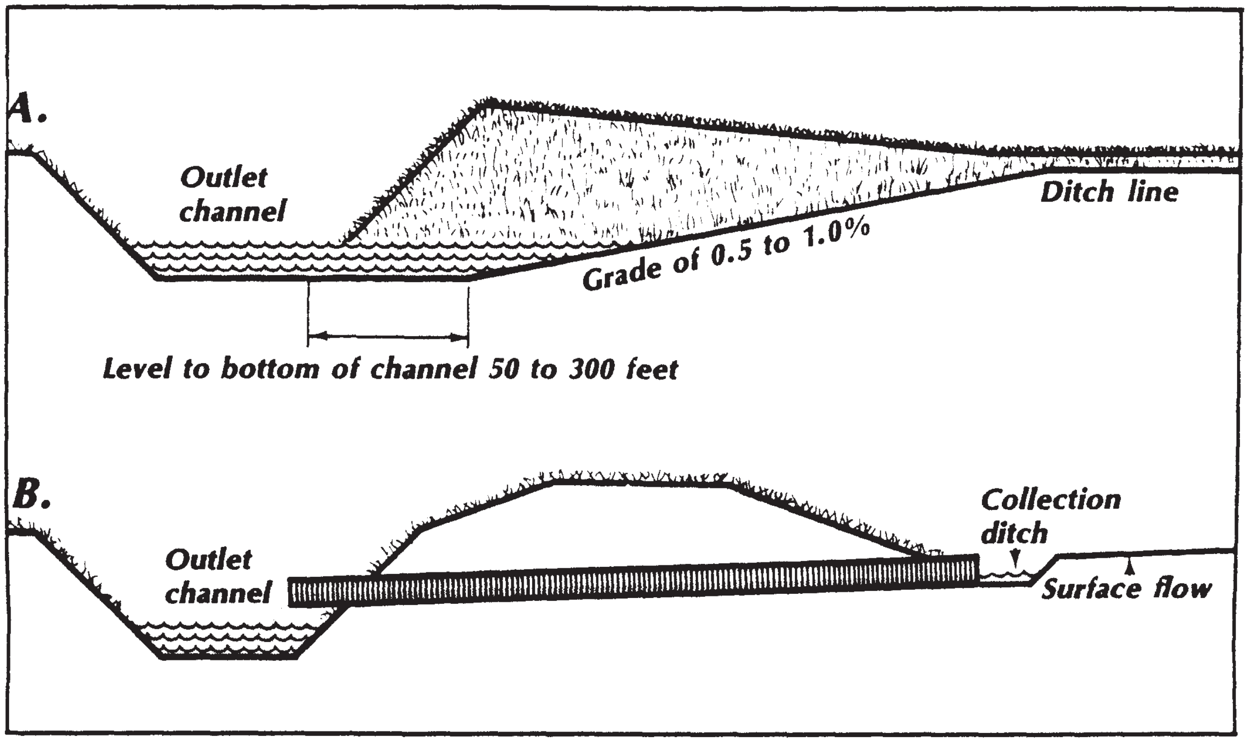


TM: A2–6C

Entrance of a subsurface drain into an outlet channel.



Drawing A shows a lateral ditch graded through a spoil bank to discharge directly into an outlet channel. Drawing B hows how a pipe can be used to move water through a spoil bank to an outlet channel.



TM: A2–6E

Basic patterns for subsurface drainage systems (the arrows indicate the direction of water flow).