Agricultural TVET College

Small Scale Irrigation Development

Level II

Model TTLM

Learning Gide #08

Unit of Competence: Assist Irrigation Drainage System Development

Module Title: Assisting Irrigation Drainage System Development

LG Code: AGR SSI2 08 0816

TTLM Code: AGR SSI2 TTLM08 1218V$_2$

Nominal Duration: 42 Hours

Instruction Sheet # 1	Unit	Assist Irrigation Drainage System Development
	Module	Assisting Irrigation Drainage System Development
	LO#1-5	

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: –

- Prepare for drainage system installation and construction activities
- Installation of subsurface drainage system
- Installation of subsurface drainage system
- Assist construction of surface drainage system
- Complete construction of surface drainage system

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Identifying the construction site for drainage system and construction method
- Selecting materials, tools, equipment, machinery and Personal Protective Equipment
- Carrying out and setting excavation of trenches, Laying bedding materials, Lowering and positioning pipes
- Recognizing symbols and terminology of the surface drainage system
- Identifying layout of services, checking depths against the site or drainage system plan and reporting discrepancies
- Consulting the supervisor and taking remedial action.
- Finishing off earthworks according to the plan specifications
- Recording or reporting work outcomes

Learning Activities

1. **Read the specific objectives of this Learning Guide.**
2. **Read the information written in the "Information Sheet"**
3. **Accomplish the "Self-check".**
4. **If you earned a satisfactory evaluation proceed to the next "Information Sheet". However, if your rating is unsatisfactory, see your facilitator for further instructions or go back to Learning Activity.**
5. **Submit your accomplished Self-check. This will form part of your training portfolio.**
6. **Read and Practice "Operation Sheets".**

7. **If you think you are ready proceed to "Job Sheet".**
8. **Request you facilitator to observe your demonstration of the exercises and give you feedback.**

Information sheet # 1	**Unit**	**Assist Irrigation Drainage System Development**
	Module	**Assisting Irrigation Drainage System Development**
	LO#1	**Prepare for drainage system installation and construction activities**

Introduction:

Land Drainage is the removal of excess surface and subsurface water and soluble salts from the land/soil to enhance crop growth, most of the time using gravity system.

Causes of poor drainage

Poor drainage can occur in arid and humid areas and can be caused by natural or human reasons, including:

- The presence of semi-permeable or impermeable layers of soil
- Over-irrigation
- Proximity to reservoirs or coastal areas
- Canal seepage

Why artificial drainage is needed?

Land drainage, as a tool to manage groundwater levels, plays an important role in maintaining and improving crop yields:

- It prevents a decrease in the productivity of arable land due to rising water tables
- A large portion of the land that is currently not being cultivated has problems of the accumulation of salts in the root zone; water logging and salinity. Drainage is the only way to reclaim such land.

Types of drainage systems

The main types of drains are surface and subsurface.

Surface drains

Also referred to as open drains are typically ditches from which low-gravity conditions remove excess surface water from agricultural land. When deep enough, the ditches can also provide relief to adjacent areas. Surface drainage also can be used as an outlet for collection and disposal of water from subsurface drainage systems.

Surface drainage can be achieved by;

- Building ditches,
- Improving natural channels, or shaping the land.

Open ditches have a low initial cost and are easy to inspect.

Disadvantages to these systems include that they reduce the cropping area, require a right-of-way, and have high maintenance costs.

Subsurface drains

This type is closed drains installed underground to remove excess groundwater below the ground surface. These systems are often perforated clay tile, PVC and concrete pipe sections (laterals) were used to help drain agricultural land.

To keep silt and sand from clogging the system and to increase water flow through the pipe, the laterals are surrounded by a nylon envelope or "sock"

Components of agricultural drainage system

An agricultural drainage system is composed of the following basic components

- Field drains
- Collector drains
- Drain outlets
- Water way

1.1: Identifying the construction site for the *drainage system* and construction method

1.1.1 Understanding and identifying the Site to be installed a Drainage System

When planning a drainage system, it should consider factors such as;

- The types and functions of such systems,
- Methods to detect drainage problems,
- Design options, and
- The environmental effects of drainage installation.

Before implementing the drainage system the following important conditions must be determined;

- The desired depth to which the water table should be lowered
- The amount of rainfall received and the amount of irrigation to be applied
- The proper depth and spacing of the relief and collector lines
- The maximum length of laterals
- The material and diameter of the pipe
- The slope grade at which the lines should be installed

1.1.2: Construction method

Generally, installation and construction of drainage can utilize manual system to sophisticated equipments and machinery.

Construction method of drainage system is decided based on the following conditions

- Availability of tools, equipments and machinery
- Type of material to be installed
- Suitability and accessibility of the land (accessibility, soil wetness during installation, trench backfilling and
- The general quality of the work.

1.2: Selecting materials, tools, equipment and machinery

The selection of adequate materials, ***tools, equipment and machinery*** and their proper installation and maintenance are essential for the effective and lasting performance of land drainage systems.

1.2.1: Drainage materials

Materials for drainage systems include drainpipes and their accessories, envelope materials and auxiliary structures.

Drainpipes and Their Accessories:- PVC and PE are generally used as pipe materials for corrugated plastic lateral drains. Concrete pipes are used for larger collector drains. Specifications and standards for clay, concrete and corrugated plastic pipes are required. Pipe accessories, such as end caps, couplers, pipe fittings and reducers, and rigid pipes for drain bridges and lateral outlets are also mandatory.

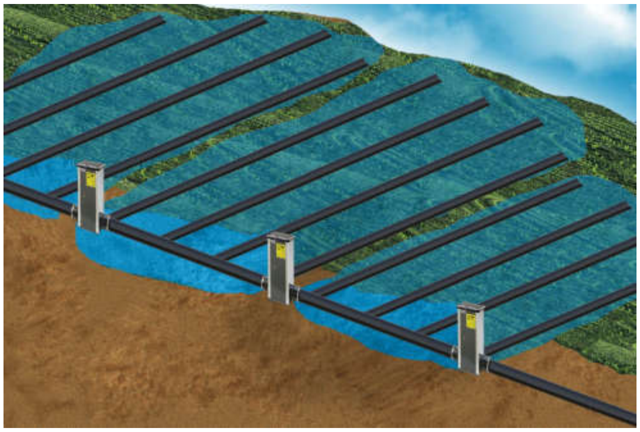


Figure_1. Drainpipes and Their Accessories

Envelopes:- Drain envelopes restrict the entrance of soil particle into the drain, improve the hydraulic conductivity at the soil-drain interface and provide structural stability around the drain.

Mineral granular envelopes and pre-wrapped fibrous organic and synthetic envelopes have been used. Specifications and standards for envelope materials must be also provided, as well as rules and recommendations to predict the need of an envelope and design criteria for the selected material. However:

- Methods validated by field experience to assess the need for drain envelopes;
- Selection criteria for the most appropriate envelope material, depending on local soil conditions, need verification;
- Case studies on the evaluation of the performance of drain envelopes in the field, especially for synthetic envelopes are important.

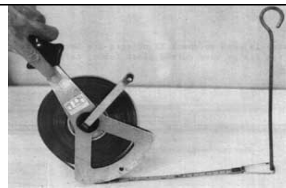
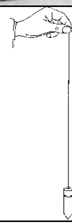
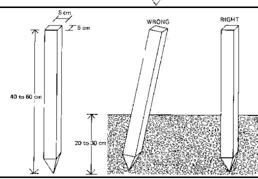
Fig_2. Envelope materials

Auxiliary Drain Structures:- Connection structures, inlets and outlets of water and special structures, such as cleaning facilities and structures for controlled drainage and sub-irrigation, are common auxiliary structures of drainage systems. In this order the following issues can be covered:

- Quality control and maintenance of outlet structures.
- In composite drainage systems, junction boxes and manholes are sometimes hardly used or not used at all and may be unnecessary with GPS availability.
- Designs for special structures for controlled drainage in the lateral and collector outlets must be available, but examples of construction and operation of such structures are not frequent.

Equipment: -

Drainage equipments include land survey equipments and accessories involve in locating and measuring both man-made and natural features in the field. Some of these accessories and equipments are;

Equipment/ accessories		Purpose
Chain and Tape		- Chains or tapes are used to measure distances on the field.
Plumb Bob		- A plumb bob is used to check if objects are vertical. A plumb bob consists of a piece of metal (called a bob) pointing downwards, which is attached to a cord
Pegs		- Pegs (see Fig. 8) are used when certain points on the field require more permanent marking.
Auto level		- Useful during site surveys and building construction to gather, transfer or set horizontal levels and grade applications.

Drainage Machinery

Some special machines are used for construction, installation and maintenance of subsurface drains.

Installation Machinery:- Trenchers of various types have been used in the past and still are used with success to install subsurface drains, especially for clay and concrete pipes and for granular mineral envelopes.

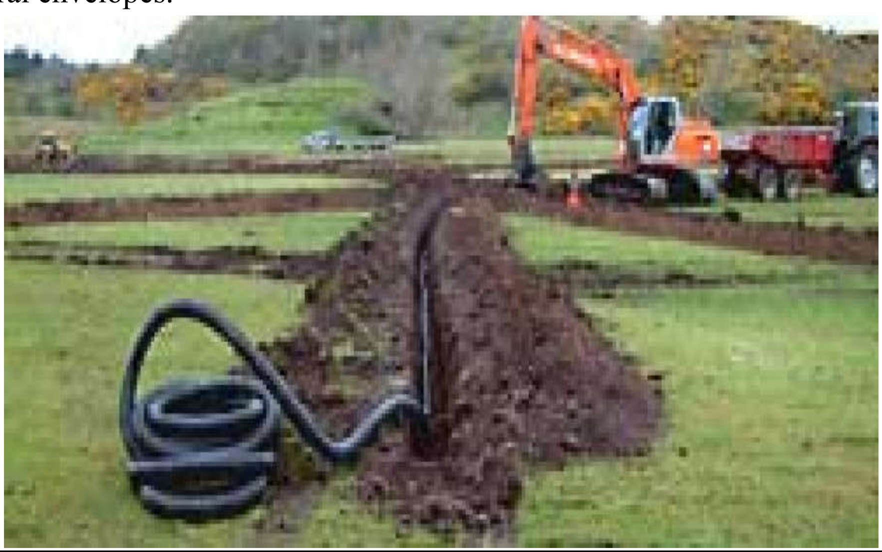


Fig_3. Installing machine

Maintenance Equipment:- Drainage systems adequately installed with appropriate drainage materials should have low maintenance requirements. Dry rodding is sufficient to remove slight clogging, fresh ochre and roots proliferating inside the drainpipe, especially near the lateral outlet.

To remove sediments and serious ochre deposits and to clean clogged perforations jet flushing is necessary. Medium pressure equipment is also most recommended and flushing should be used only in case of dissatisfaction with or deterioration of drainage system performance.

Fig_4. Maintenance machine

1.3. Carrying out pre-operational and safety checks

During installing and constructions safety checks on tools, equipment and machinery must be carried out. These safety check tasks are carrying out according to;

- Manufacturer's specifications which are provided as manuals and tags.
- Enterprise work procedures which are provided as instructions and supervisory service.

Safety equipment may include signage and barriers

- Signage:- Gives as instructions and instruction to keep us from hazards
- Barriers:- Are physical matters which protects us from hazards

1.4: Identifying OHS hazards, risks assessed controls

1.4.1 Hazard Identification

There are a number of quite simple methods used to identify workplace hazards. For example:

- Workplace inspections, using a formal checklist or spot checks
- Referring to information recorded in incident/injury report of previous occurrences
- Communication with employees and through OH& consultations
- Observing work areas, work tasks, work processes or work methods

- Sharing information with other internal workgroups
- Information supplied by the HR Manager or General Manager Operations, Work Cover Authority or other safety organizations

1.4.2 Hazard Control

Workplace hazards arise as a result of the activities performed, equipment used and the physical and environmental conditions of the workplace.

The factors that create hazards can best be controlled by managers and employees at the workplace. Therefore managers and employees must be equipped with adequate knowledge, skills and an understanding of the application of simple hazard management techniques in relation to their own work environment.

Hazard: a condition or situation that has the potential to cause harm to people at work

Risk: the likelihood that exposure to the hazard will cause harm to people at work and the seriousness of that harm

1.4.3 Risk Assessment

The authority shall carry out risk assessment for its sites. The assessment will involve the identification of hazards present (whether arising from work activities or from other factors, e.g. the layout of the premises) and then evaluating the extent of the risk. These assessments will be carried out on an annual basis in conjunction with the staff representatives

In addition, risk assessments can be called by staff or management side representatives for issues which require urgent consideration

The risk assessments shall:

- ❖ ensure that all significant risks or hazards are addressed;
- ❖ address what actually happens in the workplace or during work activity
- ❖ ensure that all groups of employees and others who might be affected are considered;
- ❖ identify groups of workers who might particularly be at risk
- ❖ take account of existing preventative or precautionary measures
- ❖ be carried out on a regular basis and the significant findings recorded

Risk Control

The rated value of the risk (high, medium or low) will determine the most suitable and practicable method of risk control. The most suitable method of risk control must be selected in relation to the work environment following the hierarchy of control process described below.

The order of preference of selecting risk control is as follows:

- ✓ Elimination /substitution
- ✓ Engineering control /Isolation
- ✓ Administrative controls
- ✓ Personal Protective Equipments (PPE)

✓ **Selecting Suitable safety and personal protective equipment (PPE)**

Personal protective equipment (PPE)

Before you begin, use this checklist to confirm you have followed good safety procedures and have all the right resources.

SAFETY CHECKLIST ACTIVITY		✓
Long trousers, shirt and boots		
Hat (hard hat if necessary) and gloves		
Sunscreen, insect repellant and sunglasses		
Water		
First aid kit		

Self-Check 1	Written Test

Name: ___________________________ **Date:** ________________

Directions: Answer all the questions listed below.

1. Describe the basic components of any drainage system? (8 pts)
2. Define what an envelope is and describe its function? (4pts)
3. What are the disadvantages of subsurface drainage system? (3pts)

Note: satisfactory Rating-8 and above pts. Unsatisfactory Rating-below 8 pts.

You can ask your teacher for the copy of the correct answers

Information sheet # 2	Unit	Assist Irrigation Drainage System Development
	Module	Assisting Irrigation Drainage System Development
	LO#2	Installation of subsurface drainage systems

Introduction

A sub surface drainage system is required for water table control and for maintaining a favorable salt balance in crop root zone.

Subsurface drainage aims at controlling the depth water table - a control that can be achieved by tube well drainage, open drains, or subsurface drains (pipe drains or mole drains) and the level of salinity in the root zone by evacuating the excess ground water. The discussion will be restricted to parallel drains which may be either open ditches or pipe drains. The implementation of subsurface drainage should result in a long lasting system, functioning according to design.

Advantages of Sub-surface Drainage:

- Removes the gravitational on free water, which is not directly available to plants and thus provides aeration and optimum soil temperature.
- Increase the volume of the soil from which the roots can obtain food.
- Permits increase of the bacterial activity in the soil, which improves the soil structures, and makes the plant food more readily available.
- Increase the moisture available to the more plants because the root zone is deepened.
- Reduce soil erosion, since the well –drained soil has more capacity to hold rainfall resulting in less runoff.
- Improves soil moisture condition in relation to the operations of tillage, plantings and harvesting machines.
- Removes toxic sub-stances such as alkali from the root zone.
- Aeration of the soil for maximum development of plant roots and desirable soil microorganism.
- Increased length of growing season because of earlier possible planting dates.
- Decreased possibility of adversely affecting soil tilt through tillage at excessive soil water levels.
- Greater storage capacity for water resulting in less runoff and a lower initial water table following rains.

Factors to be considered while Laying Sub-surface Drainage

The movement of water into sub-surface drains is influenced by the following main factors.

- The hydraulic conductivity of the soil.
- The configuration and location of free water surface and pressure and magnitude of the artesian pressure or the back pressure of the drains.
- Depth of drain below ground surface and location of drain with respect to various soil horizons.
- The spacing between individual drains.
- The diameter of drains.
- The title joint spacing or diameter and spacing of holes in case of PVC pipes.
- Depth to impervious layer below the ground surface.

2.1 Transporting materials and stacking in a safe position

Any stockpiling of pipe should be as near as possible to where the pipe will be installed. Small diameter pipe should be layered in the same manner as they were loaded on the truck. The bottom layer should be placed on a flat base, adequately blocked to prevent shifting as more layers are added. Each layer of bell and spigot pipe should be arranged so that all the bells are at the same end. The bells in the next layer should be at the opposite end, and projecting beyond the spigots of the pipe sections in the lower layer. Where only one layer is being stockpiled, the bell and spigot ends should alternate between the adjacent pipe sections. All pipes should be supported by the pipe barrel so that the joint ends are free of load concentrations. Pipe sections generally should not be stockpiled at the job site in a greater number of layers than would result in a height of 6 ft. (2 m).

All flexible gasket materials not cemented to the pipe, including joint lubrication compounds, should be stored in a cool dry place to be distributed as needed. Rubber gaskets and preformed or bulk mastics should be kept clean, away from oil, grease, and excessive heat and out of the direct rays of the sun.

Transport of corrugated pipes over long distances is rather expensive, because of the high volume/weight ratio (it boils down to the expensive transport of air). To counteract these pipes ought to be produced as close as possible to the site of installation. Comparative studies indicate that transporting the production facilities to a location close to the construction site is economical if the distances are more than 300-500 km. The importing of large quantities of plastic drain pipes is therefore not considered to be a rational option.

Transport of concrete drain pipes over long distances is hardly economical as the weight of adiameter100 mm is about 18 kg/m and, in addition, there is the breakage (5%) to consider. One of the redeeming features of concrete pipes is that they can be produced near the installation site.

Transport of clay pipes over long distances is not considered to be economical. The weight of adiameter100 mm pipe is about 12 kg/m and there is also the added breakage risk of 5% to consider.

Since the quantity of fittings is rather limited and neither the weight nor volume considerable transporting over long distances and/or importing can be considered.

The way of transporting materials and stacking in a safe position is to determine the important criteria for safety and to set specific parameters which may be used, such as planning, the provision of information, training and instruction, and to set the framework for supervision and control the materials.

The materials used for drainage are also used for other civil engineering constructions work. Materials specific to subsurface pipe drainage systems are:

- Field drains pipes and fittings like: - Perforated plastic (PVC or HDPE); Concrete; Clay (tile); Couplers; End caps and joints;
- Collector drains pipes are normally made of plastic (PVC or HDPE) or concrete;
- Drain envelopes; Drain envelopes can be made of granular (or mineral), organic and synthetic materials. It is a porous material placed around a perforated drain pipe to perform the following functions:
  - ✓ Filter function: to prevent or restrict soil particles from entering the drain pipe where they may settle and eventually clog the pipe;
  - ✓ Hydraulic function: to provide a porous medium of relatively high permeability around the pipe to reduce entrance resistance.
- Drainage structure.

2.2. Carrying out and setting excavation of trenches

Setting out alignments and levels

The location and alignment of the drain lines must be set out before the actual digging can begin, (Figure1). First, the downstream location of the drain is marked off by placing a row of pegs along the collector drain at the design drain spacing. Next, the centre line of each drain is set out by placing another row of pegs at the upstream end. Stakes are placed in the soil at both ends of the drain line with the top of the stakes at a fixed height above the future trench bed using a leveling instrument. This very clearly indicates the drain line. The direction of the field drains is assessed standing at the starting point at the collector line, thereafter marking off the location of the field drains with pegs.

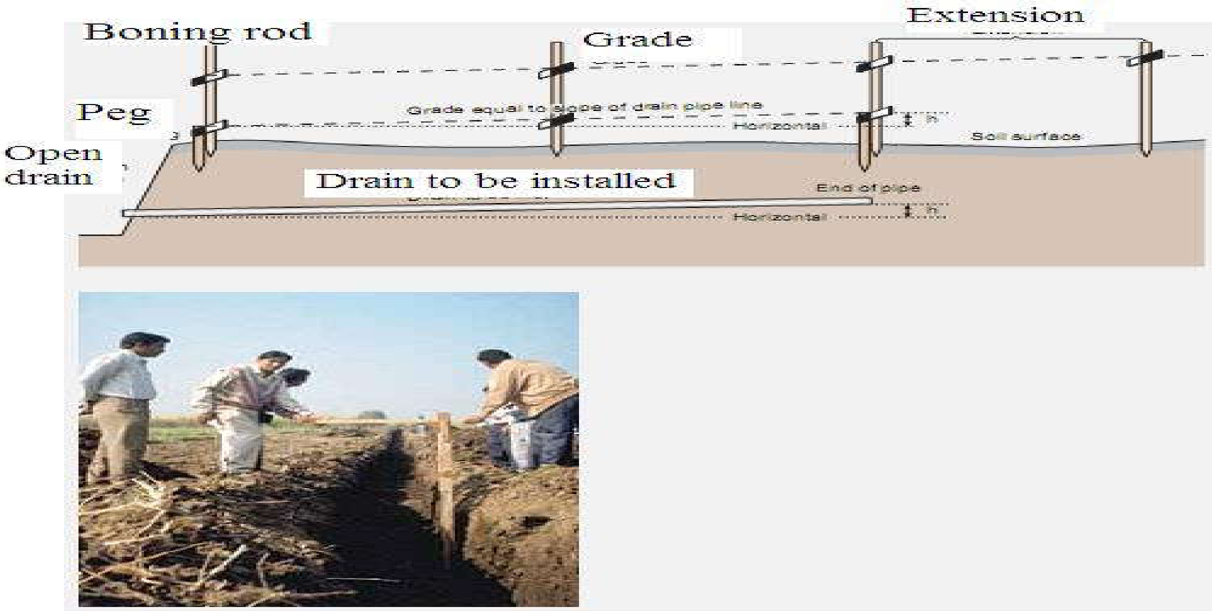


Figure_5: Settingout alignments and levels

Setting out trench location

- ✓ Setting out the drainage system (with pegs in the field indicating where the drainage system will come, where the manholes are to come etc.);
- ✓ Giving reference levels for the installation of the drainage system (for adjustment of the laser);
- ✓ Managing the laser: transporting, charging and setting up the emitter and adjusting the slope;
- ✓ Giving levels for installation of manholes and checking the levels during installation.

Excavating the trenches

Excavation work generally means work involving the removal of soil or rock from a site to form an open face, hole or cavity using tools, machinery or explosives.

Specific duties apply in relation to the higher-risk excavations such as trenches, shafts and tunnels. However, these requirements do not apply to a mine, a bore to which a relevant water law applies or a trench used as a place of interment.

There are three methods of mechanical installation (Figure 2):

- ✓ Excavator. All steps in the implementation process are separate steps, implemented one after the other. The trench is dug by the excavator to about 5 cm above the required drain depth and up to the last few centimeters, when the leveling and placing the drain pipes is done by manual labor;
- ✓ Trencher. Digging the trench, placing the drain pipes and (if applicable) the envelope, is done in a one-time operation. The pit from where the laying of the pipe will start is either dug by the trencher itself or an excavator;

- ✓ Trenchless. Just like the trencher method, it is a one-time operation, but instead of digging a trench the pipe is directly ploughed into the soil.

Figure_6: Excavating the trench

2.3. Laying bedding materials

Porous material placed around a subsurface drain, to protect the drain from sedimentation and improve its hydraulic performance, should be referred to as a drain envelope. It is worthwhile to distinguish between the definition and function of an envelope and that of a filter.

Envelopes have the task to improve the permeability around the pipe, and act as permeable constraints to impede entry of damaging quantities of soil particles and soil aggregates into drainpipes. Yet the majority of small particles of soil material and organic matter, suspended in water moving toward a drain, will actually pass through a properly selected and installed drain envelope without causing clogging. The relatively coarse envelope material placed around the drain should stabilize the soil mechanically and hydraulically, but should not act as a filter.

In addition to the functions described above, drain envelopes can improve the bedding conditions. This bedding function is primarily associated with gravel envelopes in unstable soils. Gravel provides a mechanical improvement in the drain-envelope-soil system, serving as bedding and side support for large diameter plastic pipes (Framji et al., 1987).

Envelope materials used to protect subsurface drains have included almost all permeable porous materials that are economically available in large quantities. Based on the composition of the substances used, they can be divided into three general categories: mineral, organic, and synthetic envelopes.

Figure_7: Envelopes can be made of wrapped polypropylene fibers (a, f & g), polystyrene granules (b) and coconut fibers (c), non-woven nylon (d) and woven type (e)

2.4. Lowering and positioning pipes

Placing the pipes

Several methods can be used to place the drain pipes, depending on the type of pipe (Figure4):

- Concrete/clay drainpipe. The drain pipes are loaded to a platform on the machine and then put along the chute in the trench box to the bottom of the trench. This requires one lab our on the platform to put the pipe in the chute and one lab our in the trench box to put cloth or other sealing around the joints;
- Flexible corrugated drain pipe. The field drain pipes are delivered in coils and the coils are put on reels attached to the machine. The drain pipe is guided over rollers into the trench box. A press pulley puts the pipe at the bottom of the trench;
- Plastic collector pipes are larger in diameter and cannot be coiled. The pipes are delivered in sections of 6-12 m. These larger diameter pipes are usually laid out on the field beforehand. The pipe sections need to be connected in the field over the full length of the collector drain before the pipe laying starts and then guided through the machine.

a. b. c.

Figure_8: placing the pipes: (a) concrete/clay pipes (b) flexible corrugated pipes and (c) large diameter plastic pipes

Back filling Pipes to specifications.

Backfill of the drain trench is a three-step operation (Figure5&6):

Blinding. Careful placing of an initial backfill of 0.15 to 0.30 m of soil around and over the drain is referred to as blinding. This is done to ensure that the drain will remain in line when the remaining excavated material is placed in the trench. Blinding the drain may be done by shaving off the topsoil at the top of the trench with a spade or with an attachment (scraping knife) to the trench box. Care should be taken that the alignment of the drain is not changed;

Backfill. The fill should be firm but not compacted too much so that it prevents the passage of water to the pipe. All trenches should be filled to a sufficient level above the surface of the ground to allow for settlement. Trenches are preferably backfilled the same day they are dug to avoid a possible destabilization of soil under wet conditions, such as irrigation, rain or high water table. Only in unripe soil is it advisable to leave the trenches opens for some time to initiate ripening;

Compaction. Compacting is required to avoid serious problems arising in irrigated areas when water moves rapidly through the unconsolidated trench fill causing severe erosion (piping).

Trench backfilling is done by the following methods:

- ✓ Hand with shovels;
- ✓ Bulldozer;
- ✓ Grader;
- ✓ Tractor equipped with a dozer blade;
- ✓ Screw augers mounted on the trenching machine.

Figure_9: Backfilling of the drain: using a dozer and grader

Figure_10: Backfill equipment: tractor with dozer blade (a) and V-shaped disc-blade mounted at the rear end of a subsoil type trenchless drainage machine (b)

2.5. Clearing site and removing excess soil, debris and unwanted materials

Surplus soil that is not injurious in nature should be spread over the surrounding field. Material such as large stones and roots that are likely to damage implements or livestock, or of a size and character abnormal to material found on the surface of the field, should be removed. The contractor should arrange to remove surplus pipe material, bands and ties, wood, glass, metal cans, and containers rubbish from the work area. Finally, all temporary passages, breaches in canals etc. should be repaired and fencing and other farm property should be repaired or replaced.

2.6. Cleaning, maintaining and storing tools and equipment.

Drainage machines need maintenance, spare and wear parts. Since a considerable amount of hydraulic drives and hydraulic commands are integrated into modern drainage machines, it is essential for maintenance facilities for hydraulic systems to be either available or created. The wear parts consumption, such as the digging knives and chains belonging to drainage trenchers machines is relatively high. These parts are made of highly specialized steel. To permit a continuous and smooth operation it is vital that the supply of these spare parts (including financing and import facilities) is available or organized.

The maintenance process consists of the following activities:

- Regular checking of the functioning of the different elements of the system;
- Regular routine minor cleaning/maintenance;
- Periodic integral check of the functionality of the system;
- Periodic general cleaning (flushing) of the system;
- Repairing broken or obstructed parts of the system, when needed;
- Carrying out preventive maintenance and repairs of pumps (if relevant).

Maintenance should be based on accurate as-built drawings of the drainage system that have been checked and approved by both the implementing authority and the beneficiaries. Records of the construction process also need to be handed over to the maintenance units. This will facilitate the maintenance activities, especially when obstructions in the drains have to be located.

Self-Check 2	Written Test

Name: ________________________ **Date:** ______________

Directions: ***Answer all the questions listed below.***

1. What is sub surface drainage systems means?(5pt)
2. Explain the advantage of sub surface drainage system?(5pt)
3. Write the factors to be considered while laying sub surface drainage system?(5pt)
4. Write the materials used for the installation of sub surface drainage systems?(5pt)
5. Write the advantage of equipment safety requirements for excavating, filling trenches and laying pipes for sub surface drainage installation?(5pt)

Note: **Satisfactory rating – 25 points** **Unsatisfactory – below 25 points**

Operation sheet # 1	**Unit**	**Assist Irrigation Drainage System Development**
	Module	**Assisting Irrigation Drainage System Development**
	LO#2	**Installation of subsurface drainage systems**

Project Title: Carrying out and setting excavation of trenches

Materials, Tools and equipments used:- surveying and leveling equipment such as automatic level, laser level, dumpy level, Cowley level, staff, boning rods, pegs, notebook, pencil and calculator; hand tools such as rakes, shovels, spades, rollers, wheelbarrows, hoses and hose fittings; machinery such as bobcats, ditch witches, backhoes, front-end loaders, graders, mechanical rollers, trucks, hydraulic trailers, and tractors and 3-point linkage equipment; pumps and pump fittings; and fitting and welding, , PPE, etc….

Objective: The main objective of Carrying out and setting excavation of trenches of drainage systems is to facilitate the timely delivery of the required installation of sub surface drainage to the field.

Procedure:- The following procedures should be taken into account to Carrying out and setting excavation of trenches.

- Setting out alignments and levels
- Setting out trench location
- Excavating the trenches

Operation sheet # 2	Unit	Assist Irrigation Drainage System Development
	Module	Assisting Irrigation Drainage System Development
	LO#2	Installation of subsurface drainage systems

Project Title: **Installation of subsurface drainage system**

Materials, Tools and equipments used:- surveying and leveling equipment such as automatic level, laser level, dumpy level, Cowley level, staff, boning rods, pegs, notebook, pencil and calculator; hand tools such as rakes, shovels, spades, rollers, wheelbarrows, hoses and hose fittings; machinery such as bobcats, ditch witches, backhoes, front-end loaders, graders, mechanical rollers, trucks, hydraulic trailers, and tractors and 3-point linkage equipment; pumps and pump fittings; and fitting and welding, , PPE, etc….

Objective:-How to install sub surface drainage systems by using proper materials, tools and equipments within the design specification.

Procedure:- The following procedures should be taken into account to Installation of subsurface drainage system

- Mark out the location of all the lines with either lime or spray paint
- Check for any service lines that may intercept your drainage line. Establish levels
- Excavation of trench
- Install components
- Backfill the trench with the topsoil originally removed and consolidate
- Finish off according to the plans and specifications.

Information sheet # 3	**Unit**	**Assist Irrigation Drainage System Development**
	Module	**Assisting Irrigation Drainage System Development**
	LO#3	**Prepare the site for construction of surface drainage system**

Introduction to surface drainage

Surface drainage is the orderly removal of excess water from the surface of land through improved natural channels or constructed ditches and through shaping of the land surface.

Surface drainage applies primarily on flat land where slow infiltration, low permeability, or restricting layers in the soil profile, or shallowness of soil over rock or deep clays, prevent ready percolation of rainfall, runoff, seepage from uplands, or overflow from streams through the soil to deep stratum. The land surface to be drained should have a continuous fall to the field ditch and the field ditch should have a continuous grade to the field lateral. The water surface in the field lateral at design depth should be low enough to drain the field.

Surface drainage systems, when properly planned, eliminate ponding, prevent prolonged saturation, and accelerate flow to an outlet without siltation or erosion of soil. In some cases, orientation of crop rows with the land slope may accomplish this purpose, in other cases, use of a diversion or a complete system of ditches and crop row drains is necessary as shown in figure 1. Combinations of both surface and subsurface drainage, such as land grading and smoothing over subsurface drains, often provide better and more economical results. Surface drainage systems include both collection and disposal ditches.

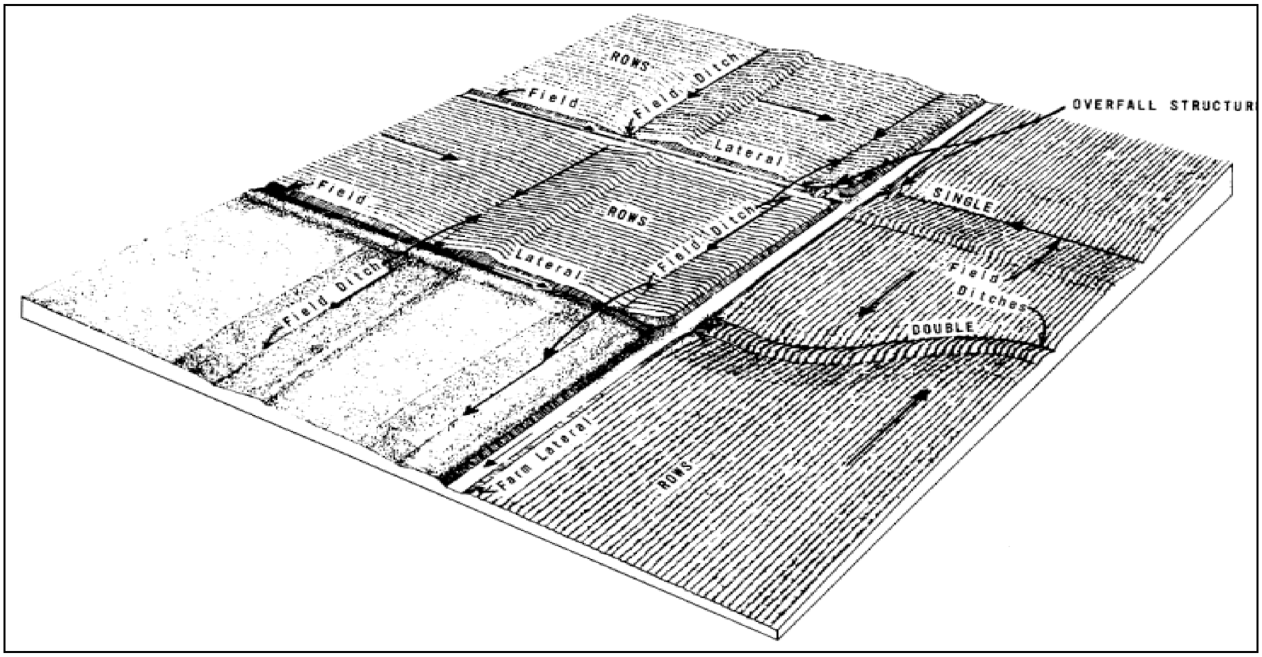


Figure_11, typical layout - individual farm drainage system (Where the ground surface is undulating, ditches and drains will meander).

Drainage to control ponding

To remove ponding water from the surface of the land, ***surface drainage*** is used. Normally, this consists of digging shallow open drains. To make it easier for the excess water to flow towards these drains, the field is given an artificial slope. This is known as land shaping or grading (Figure 2). **Surface drainage** is the removal of excess water from the surface of the land by diverting it into improved natural or constructed drains.

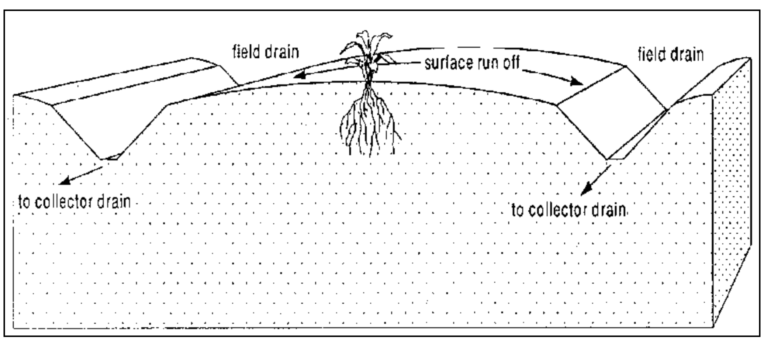


Figure 2. Surface drainage

Components of a drainage system

As shown in Figure 3, a drainage system has three components:

- *A field drainage system*, which prevents ponding water on the field and/or controls the water table.
- *A main drainage system*, which conveys the water away from the farm.
- *An outlet*, which is the point where the drainage water is led out of the area.

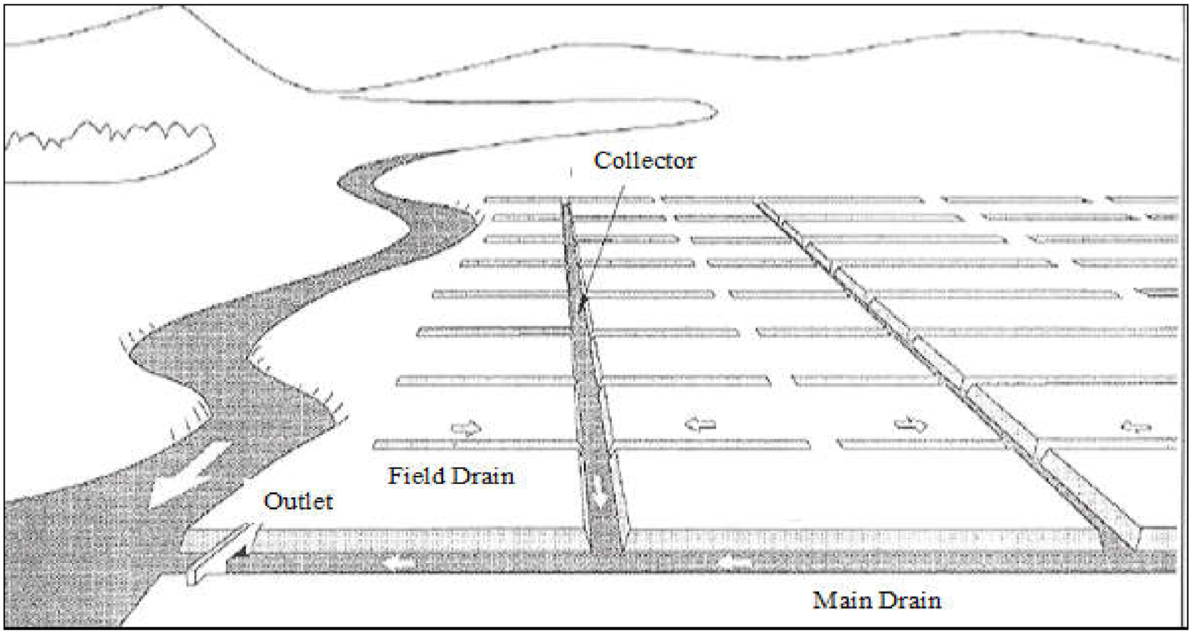


Figure 3. Components of surface drainage system

The **field drainage system** is a network that gathers the excess water from the land by means of field drains, possibly supplemented by measures to promote the flow of water to these drains.

The **main drainage system** is a water-conveyance system that receives water from the field drainage systems, surface runoff and groundwater flow, and transports it to the outlet point. The main drainage system consists of some collector drains and a main drainage canal. A collector drain collects water from the field drains and carries it to the main drain for disposal. Collector drains can be either open drains or pipe drains.

The main drain is the principal drain of an area. It receives water from collector drains, diversion drains, or interceptor drains (= drains intercepting surface flow or groundwater flow from outside the area), and conveys this water to an outlet for disposal outside the area. The main drain is often a canalized stream (i.e. an improved natural stream), which runs through the lowest parts of the agricultural area (Figure 4).


Figure 4. Main drain

The **outlet** is the terminal point of the entire drainage system, from where the drainage water is discharged into a river, a lake, or a sea.

An outlet can be one of two kinds: a *gravity* outlet or a pumping station. A gravity outlet is a drainage structure in an area which has outside water levels that rise and fall. A *pumping* station is needed in areas where the water levels in the drainage system are lower than the water level of the river, lake or sea.

A **field drainage** system can be a surface drainage system (to remove excess water from the surface of the land) or a subsurface drainage system (to control the water table in the soil). In surface drainage, field drains are shallow graded channels, usually with relatively flat side slopes (Figure 5).

Figure 5. A field drains for surface drainage

Surface drainage systems

A surface drainage system always has two components:

- Open field drains to collect the ponding water and divert it to the collector drain.
- Land forming to enhance the flow of water towards the field drains.

A surface drainage system is a system of drainage measures, such as *open drains* and *land forming*, to prevent ponding by diverting excess surface water to a collector drain.

Land forming means changing the surface of the land to meet the requirements of surface drainage or irrigation. There are three land-forming systems:

- bedding,
- land grading and
- land planing.

I. Bedding

Bedding is the oldest surface drainage practice. With this system, the land surface is formed into beds. This work can be done by manual labour, animal traction, or farm tractors. The beds are separated by parallel shallow, open field drains, oriented in the direction of the greatest land slope (Figure 6). The water drains from the beds into the field drains, which discharge into a collector drain constructed at the lower end of the field and at right angles to the field drains.

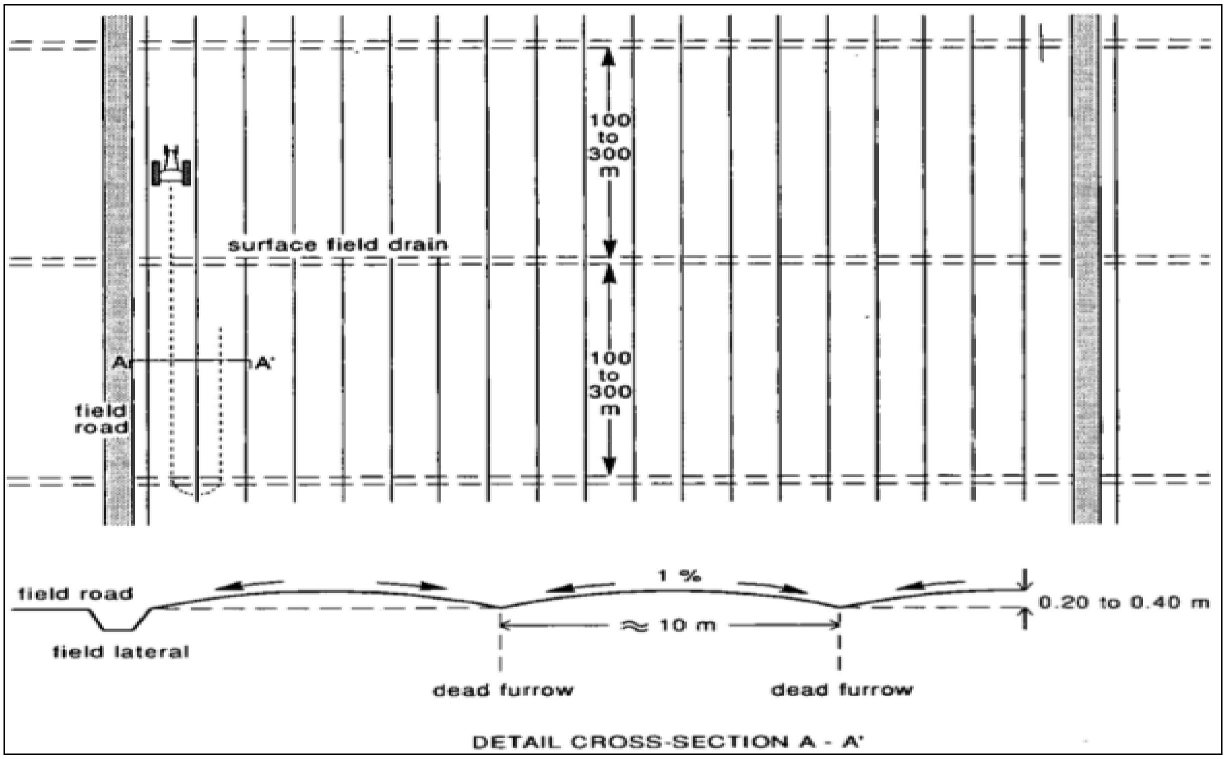


Figure _12. The bedding system

Bedding is a surface drainage method achieved by ploughing land to form a series of low beds, separated by parallel field drains.

The bedding system is normally used for grassland. In modern farming, bedding is not considered an acceptable drainage practice for row crops, because rows near the field drains will not drain satisfactorily. To overcome the disadvantages of the bedding system, the two other methods of land forming have been developed: *land grading and land planing*.

II. Land grading

Land grading for surface drainage consists of forming the land surface by cutting, filling and smoothing it to predetermined grades, so that each row or surface slopes to a field drain (Figure 7). It is a one-time operation.

Land grading for surface drainage differs from land levelling for irrigation in that, for drainage, the grades need not be uniform. They can be varied as much as is needed to provide drainage with the least amount of earthmoving.

Land grading is forming the surface of the land to predetermined grades, so that each row or surface slopes to a field drain. Compared with bedding, land grading reduces the number of field drains, thus reducing the need for weed control and maintenance. Land grading also means that more land is available for use.

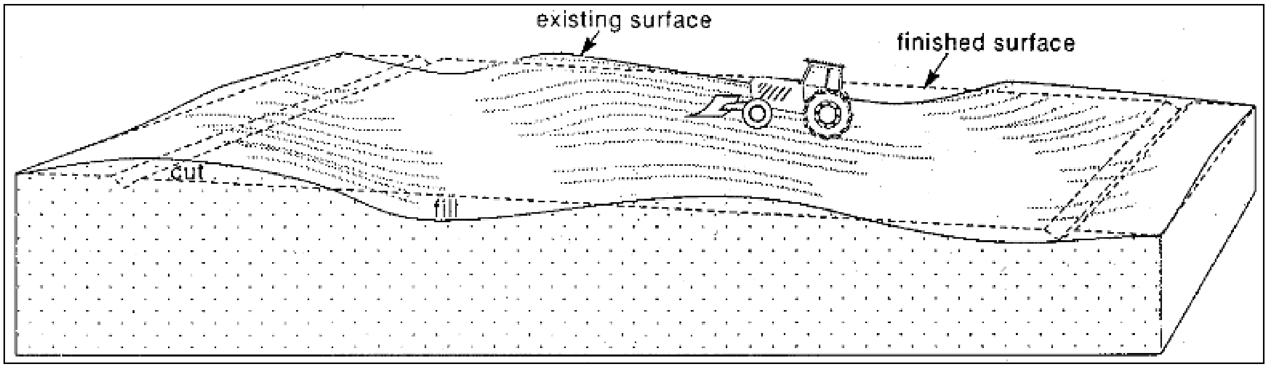


Figure _13. Land grading for surface drainage

III. Land planning

Land planing is the process of smoothing the land surface to eliminate minor depressions and irregularities, but without changing the general topography (Figure 8). It is often done after land grading, because irregular micro-topography in a flat landscape, in combination with heavy soils, can cause severe crop losses.

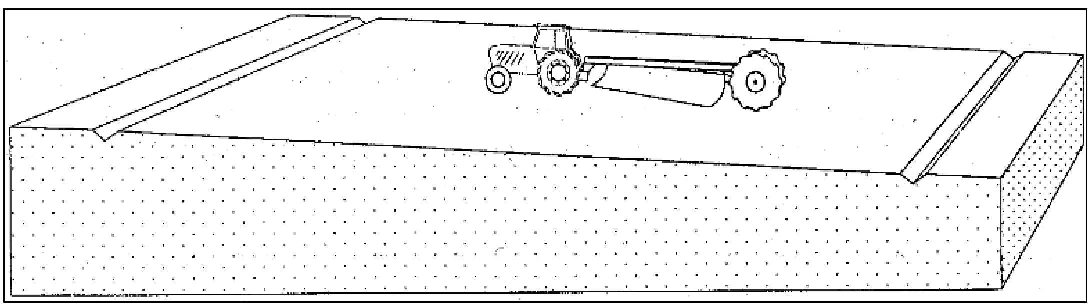


Figure _14. Land planning for surface drainage

The basic surface-drainage systems layouts are:

- *The parallel,*
- *The random, and*
- *The cross-slope or diversion system.*

The system to be used will depend upon the requirements of the site. The system used should:

1. Fit the farming system.
2. Cause water to flow readily from land to ditch without harmful erosion or deposition of silt.
3. Have adequate capacity to carry the flow.
4. Be designed for construction and maintenance with appropriate equipment locally available.

A. Random field drainage system

The random field drainage system is applied where there are a number of large but shallow depressions in a field, but where a complete land-forming operation is not considered necessary. The random field drainage system connects the depressions by means of a field drain and evacuates the water into a collector drain (Figure 9). The system is often applied on land which does not require intensive farming operations (e.g. pasture land) or where mechanization is done with small equipment.

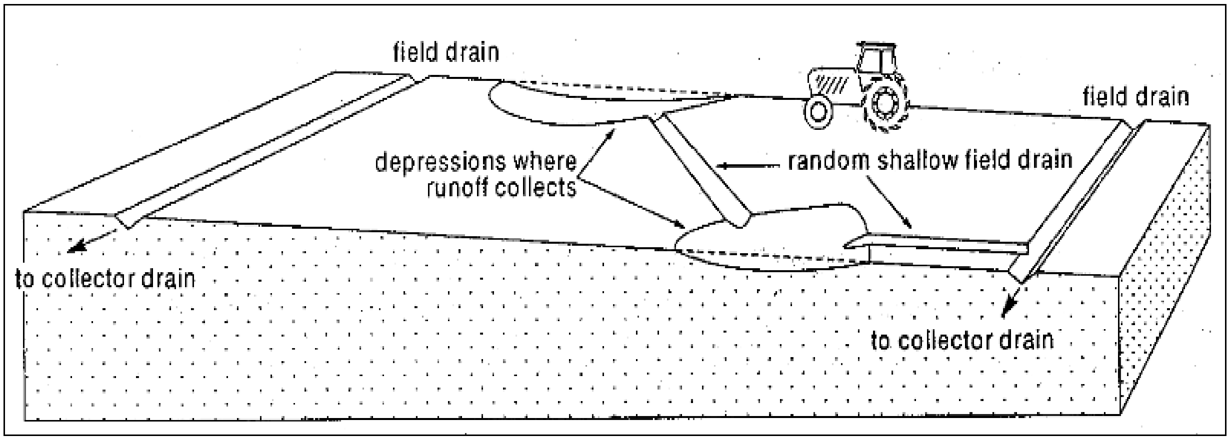


Figure _15. A random field drainage system

B. Parallel field drainage system

The parallel field drainage system (Figure 10), in combination with proper land forming, is the most effective method of surface drainage. The parallel field drains collect the surface runoff and discharge it into the collector drain. The spacing between the field drains depends on the size of fields that can be prepared and harvested economically, on the tolerance of crops to ponding, and on the amount and costs of land forming. The system is suitable in flat areas with an irregular micro-topography and where farming operations require fields with regular shapes.

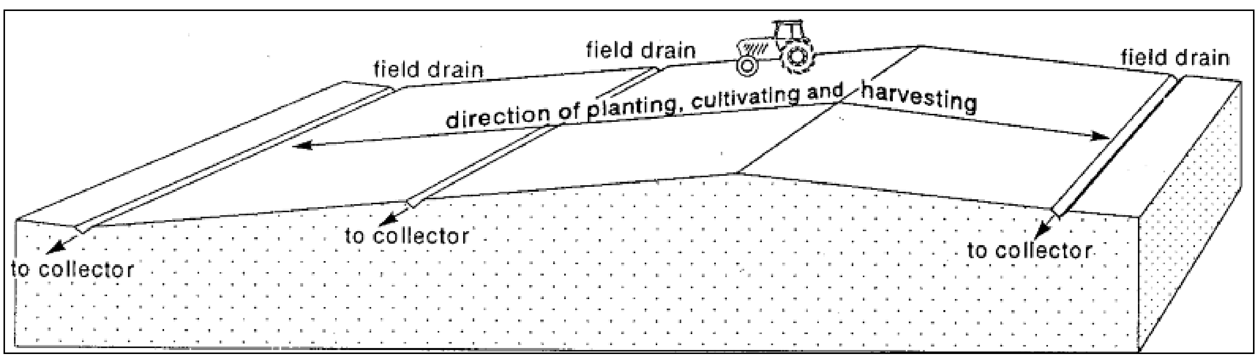


Figure_16. A parallel field drainage system

C. Cross-Slope Ditch System

The drainage of sloping land may be feasible with cross-slope ditches. Such channels usually function both for surface drainage and for erosion control. Where designed specifically for the control of erosion, these drains are called terraces. Diversion ditches are sometimes used to divert runoff from low-lying areas, thereby reducing the drainage problem (Figure 11).

The cross-slope ditch system is adapted primarily to soils with poor internal drainage where subsurface drainage is not practicable and for land with slopes of 4% or less having numerous shallow depressions. This land is generally too steep for bedding or field drains because farming up and down the slope results in excessive erosion.

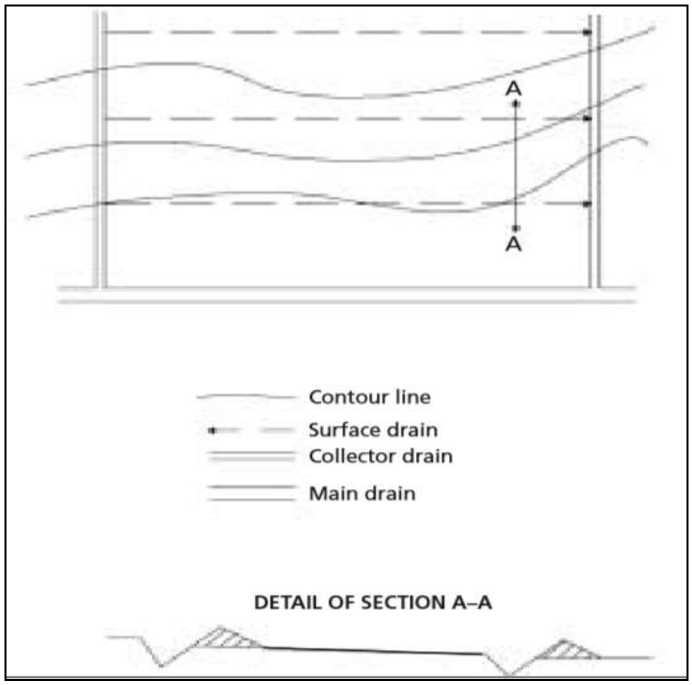


Figure_17. Surface drainage with small cross-slope ditches in a sloping field

3.1. Recognizing symbols and terminology to ensure the concept of the surface drainage system plan

A plan should be made of every subsurface drainage layout. The size and detail of the plan vary in different locations; however, the plan should have the basic information required for the construction of the subsurface drainage system. Figures 12 and 13 are an example of surface &subsurface drainage plan and layout.

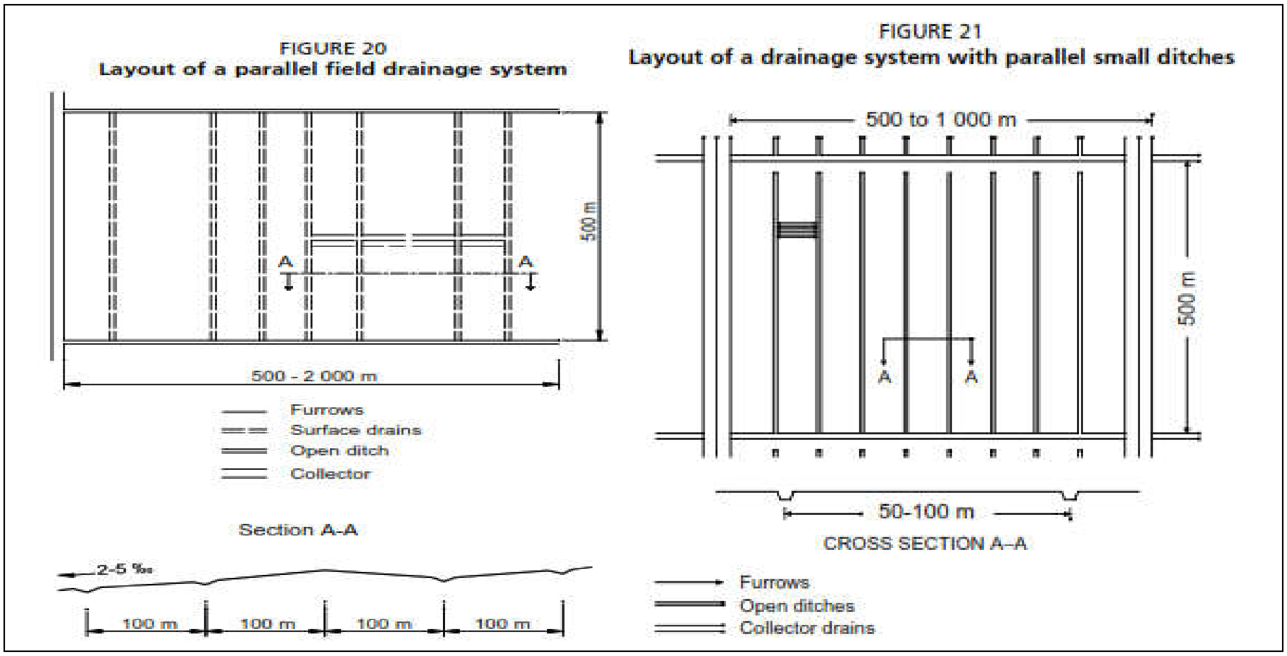


Figure_18. Surface drain plan

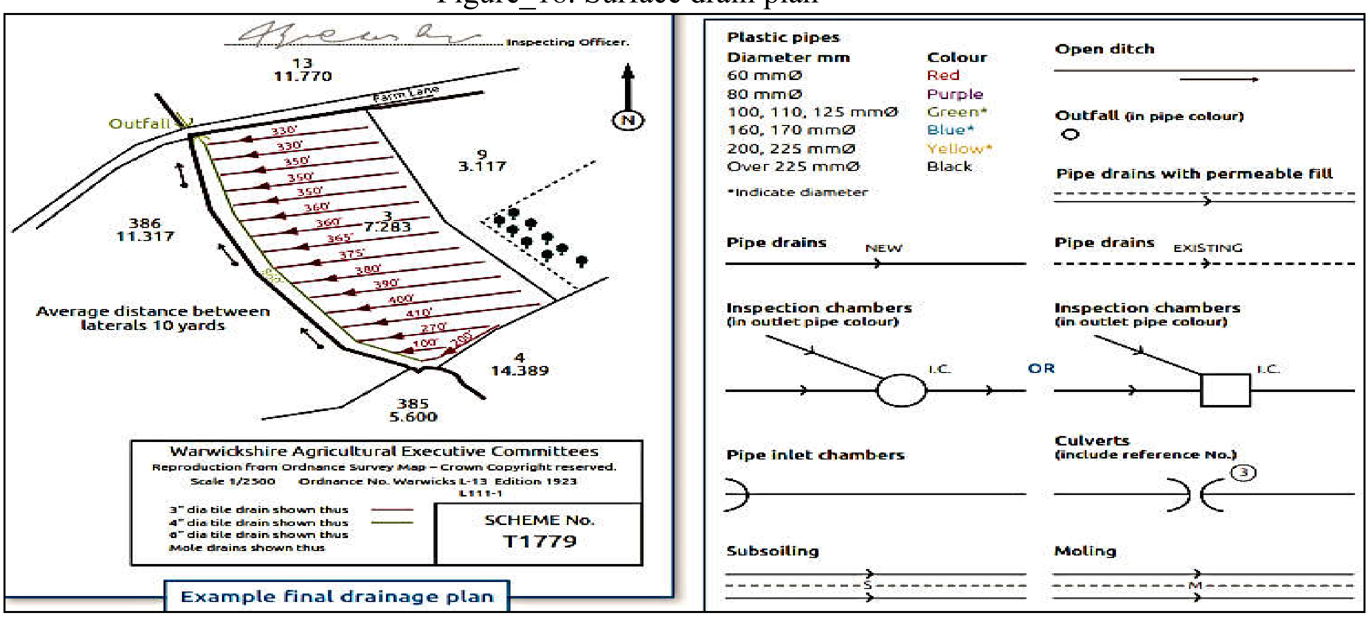


Figure_19. Final subsurface drainage plan symbols

Terminologies

Blind drain : Type of drain consisting of an excavated trench, refilled with pervious materials (coarse sand, gravel, or crushed stones) through whose voids water percolates and flows toward an outlet (also called a trench drain).

Blind inlet: Surface water inlet to a drain in which water enters by percolation rather than through open flow conduits.

Blinding: Material placed on top of and around a drain tile or conduit to improve the flow of water to the drain and to prevent displacement backfilling of trench.
Buffer strip: A strip of grass or other close-growing perennial vegetation that separates a watercourse from an intensive land use area to prevent sediment entry into drainage channels (preferred term is filter strip).
Bullet (drainage): Round-nosed cylindrical point of a mole drain plow which forms a cavity as the plow is drawn through the soil (also referred to as a torpedo).
Bypass ditch: a waterway for carrying water from a drainage area directly to a gravity outlet, bypassing any pumping plants.
Capillary fringe: a zone in the soil just above the water table that remains saturated or almost saturated. The extent depends upon the size-distribution of pores.
Chain trencher: an excavator that uses a chain with cutters attached to cut, remove, and deposit spoil to the side of the trench or on to a discharge conveyor.
Clay tile: Short lengths of pipe used for subsurface drains. The pipe is made from shale or clay.
Closed drain: subsurface drain, tile, or perforated pipe, which may also receive surface water through surface inlets (no longer in common use).
Corrugated plastic pipe: extruded plastic pipe with a corrugated wall and, when perforated, used for subsurface drains.
Drainage: Process of removing surface or subsurface water from a soil or area.
Drainage coefficient: Rate at which water is to be removed from a drainage area, expressed as depth per day or flow rate per unit of area. Sometimes called *drainage modulus.*
Drainage pattern: (1) Arrangement of a system of surface or subsurface drains. (2) Arrangement of tributaries within a watershed.
Drain envelope: Generic name for materials placed on or around a drain- age conduit, irrespective of whether used for mechanical support, hydraulic purposes (hydraulic envelope), or to stabilize surrounding soil material (filter envelope).
Hydraulic envelope: Permeable material placed around a drainage conduit to improve flow conditions in the area immediately adjacent to the drain.
Filter envelope: Permeable material placed around a drainage conduit to enhance water entry and stabilize the structure of the surrounding soil material. A filter envelope may initially allow some fines and colloidal material to pass through it and into the drain.
Field ditch: a ditch constructed within a field either for irrigation or drainage.
Field drain: a shallow-graded channel, usually having relatively flat side slopes that collect surface water within a field.
Field lateral (drainage): the principal ditch for draining adjacent fields or areas on a farm. Field laterals receive water from row drains, field drains, and field surfaces and carry it to drainage outlet channels.
Herringbone system: Arrangement of a pipe drainage system where laterals enter a main from both sides at angles less than 90 degrees.
Hydraulic conductivity: the ability of a porous medium to transmit a specific fluid under a unit hydraulic gradient; a function of both the characteristics of the medium and the properties of the

fluid being transmitted. Usually a laboratory measurement corrected to a standard temperature and expressed in units of length/ time. Although the term hydraulic conductivity is sometimes used inter- changeably with the term permeability (water), the user should be aware of differences.

Hydraulic gradient: Change in the hydraulic head per unit distance.

Interceptor drain: a channel located across the flow of ground water and installed to collect subsurface flow before it resurfaces. Surface water is also collected and removed.

Junction: (1) Point of intersection of two drains. (2) Accessory used to create a connection between two pipelines.

Junction box: Box, manhole, or other structure that serves to join two or more pipes.

Lateral: Secondary or side channel, ditch, or conduit. Also called *branch drain* or *spur.*

Leaching: Removal of soluble material from soil or other permeable material by the passage of water through it.

Leaching fraction: the ratio of the depth of subsurface drainage water (deep percolation) to the depth of infiltrated irrigation water.

Leaching requirement: Quantity of irrigation water required for transporting salts through the soil profile to maintain a favorable salt balance in the root zone for plant development.

Mole drain: Drain formed by pulling a vertical blade and a bullet-shaped cylinder through the soil.

Open ditch outlet: Excavated open channel for disposing of drainage water from a surface or subsurface drainage system, or for carrying flood water.

3.2. Identifying layout of services, checking depths against the drainage system plan and reporting discrepancies to the supervisor.

A field can contain a combination of different layout or be drained irregularly, depending on the surface slopes across the field. If smaller field have been merged into one, the outfalls may be found at the low points of each original field and not the current field.

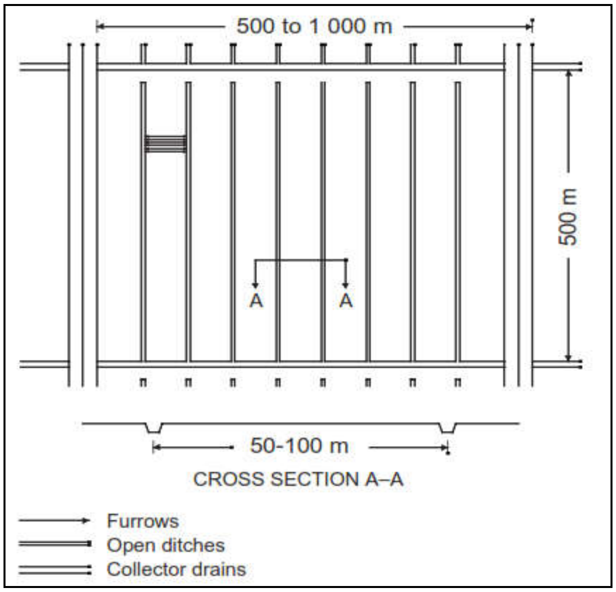


Figure_20. Typical layout of surface drainage

Special caution must be taken when trench work is performed because of the danger if utilities are too near. Many jurisdictions have systems in place that require notification and location of utility lines before any excavations. Most require advance notification when excavation is to take place and have special telephone numbers for notification.

Utilities should be located when preparing plans, and procedures are needed to assure contractors have noted the utilities and have taken the necessary precautions. The location of all underground utilities and structures should be indicated on construction plans or drawings. Safety is the primary concern, but interruption of services can create tremendous economic problems.

Whether underground utilities are shown on the plans or not, the contractor is required by possibly local or state law to contact local utility companies to ascertain if there is a potential for involvement.

3.3. Completing survey, measurement and marking out of the site and confirmation of soil characteristics relevant to the planned drainage system.

Field surveys are taken to establish the alignment of the system for construction of collector and field drains. Proper alignment and grade is important to assure system will function as designed. Once the alignment of the system is established, the excavation of the trench/open ditch can begin. The width of trench should be decided based on the:

- Kind of crops to be grown
- Farming operations on beds and
- Soil characteristics:

Layout of field drainage systems

The length of the field drains is determined either by fixed (farm) boundaries or by a fixed length for the drain. It is often decided to place the field drains at right angles to the collectors (Figure 15). If so, it may happen that the field drains do not run parallel to the minor infrastructure (e.g. irrigation canals or farm roads). In such a case, it is better to install the field drains at such an angle to the collector that the number of crossings with the minor infrastructure is minimized.

The spacing of the collectors is often determined by the length of the field drains. The collector alignments are further fixed by the field boundaries. The length of a collector is restricted either by a field boundary or by the available slope. The available slope is fixed by the shallowest permissible drain depth, the maximum water level in the main drain, and the slope of the land surface.

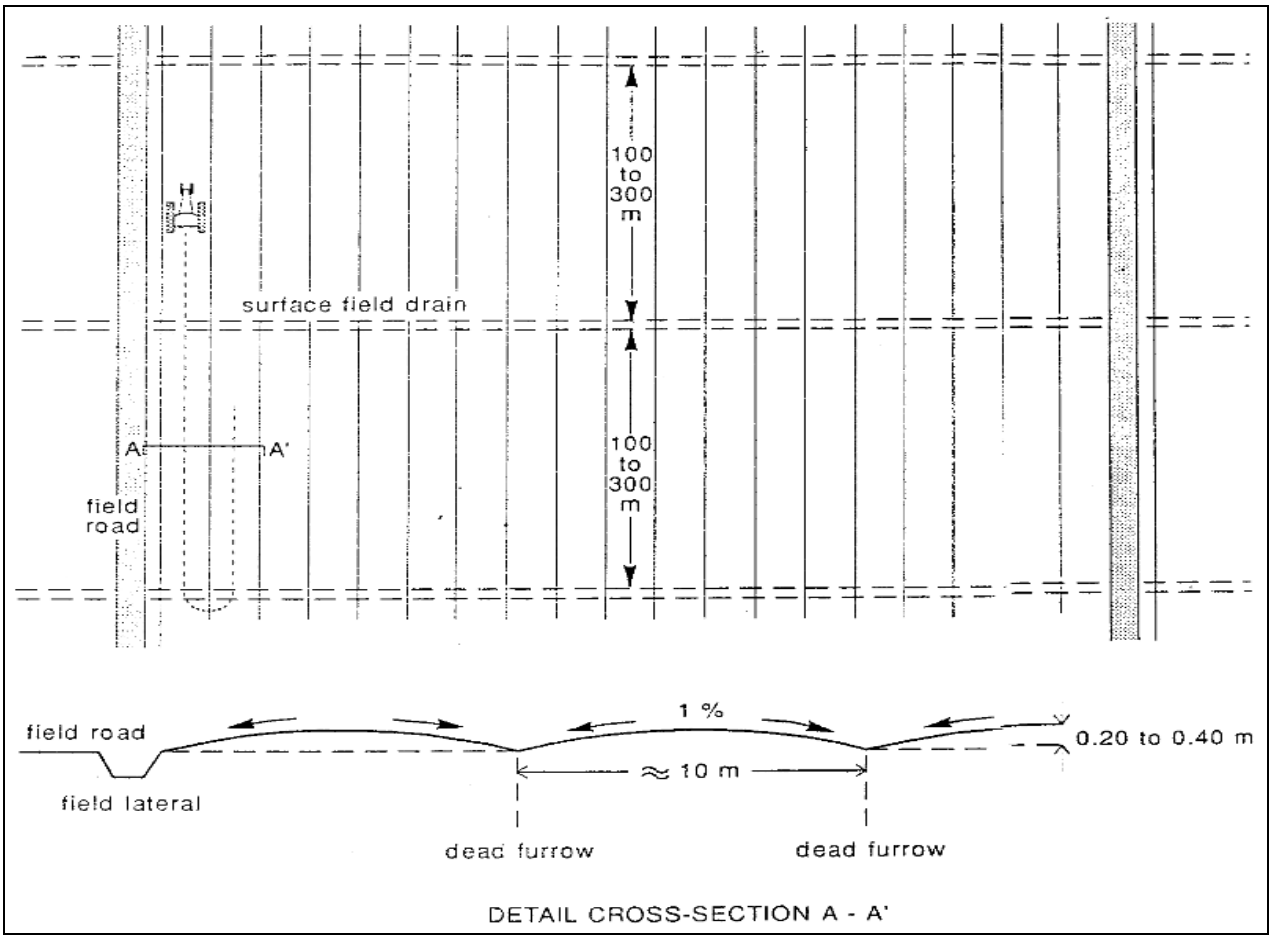


Figure_22. Layout of a field drainage system

Self-Check 2	Written Test

Name: ___________________________ **Date:** ________________

Directions: Answer the questions listed below.

1. List and discuss the major component of surface drainage system and show by sketch? 5pts
2. List the general factor considered for planning effective drainage system in irrigation areas? 5pts
3. Explain the main benefit of surface drainage? 5pts

Note: Satisfactory Rating; 7and above **UN satisfactory rating:** below 7

You can ask your teacher for the copy of the correct answer

Information sheet # 4	**Unit**	**Assist Irrigation Drainage System Development**
	Module	**Assisting Irrigation Drainage System Development**
	LO#4	**Assist construction of surface drainage system**

4.1. Completing excavations without damage to services, facilities, features and established plants.

Care must be taken when constructing surface drainage channel construction work is performed because of the danger if utilities are too near. Many jurisdictions have systems in place that require notification and location of utility lines before any excavations. Most require advance notification when excavation is to take place and have special telephone numbers for notification.

Construction Requirements: Earthwork for ditches and channels shall consist of:

- clearing, stripping,
- excavation,
- grading and
- disposal of excess excavated material.

a. Stripping. First the site should be cleared. When stripping is indicated on the plans or otherwise specified by the supervisor, strip the soil from the designated areas to the depths specified. The material obtained from stripping shall be disposed of away from the site unless otherwise specified.

b. Excavation: Channel excavation shall be performed in an open cut according to the lines shown on the plans or as specified by the Engineer. The faces of the excavation should be firm, hard and unyielding and should stand or be made to stand without sloughing. Where it becomes necessary to excavate beyond the normal lines of excavation in order to remove boulders or other interfering objects the excavation shall be backfilled and properly compacted. During the progress of the excavation, if material is encountered deems unsuitable, it should be remove it below the lines shown on the plans.

c. Grading: Grading of the unlined channels shall conform to the following tolerances: A vertical tolerance of zero above and three inches below the specified grade will be allowed for:

- ➢ The channel bottom.
- ➢ The channel side slopes in both cut and fill. Regardless of the construction tolerance specified, the excavation and grading shall be performed so that the finished surfaces are in uniform planes with no abrupt breaks in the surface.

4.2. Constructing the drainage system according to the drainage system plan

From this collector point, water should flow to the area's natural or constructed main drainage system of field and collector drains. The design of a surface drainage system therefore has two components: -

- ➢ The shaping of the surface by land forming,
- ➢ The construction of open drains to the main outlet

Construction of surface drainage systems

A. Bedding

Design considerations and construction

To ensure good drainage in a bedding system, the beds should not be more than 10 m wide. Further, the width of the beds is governed by the following:

- ➢ The kind of crops to be grown: Field crops require narrower beds than permanent pasture or hay crops do.
- ➢ Farming operations on beds: Ploughing, planting, and cultivating should fit the width of a bed. Bed width should be a multiple of the effective width of farm equipment.
- ➢ Soil characteristics: Soils with low infiltration and low hydraulic conductivity require narrower beds than soils with better characteristics.

Construction

Figure16 shows how a bedding system is constructed. It often takes several years of ploughing to obtain an adequate bedding system. During the first ploughing, care should be taken to make beds of uniform width throughout the field and to have the field drains running in the direction of the greatest slope. Any obstructions or low points in the field drains should be eliminated because they will cause standing water and loss of crops. The collector drain should be laid out in the direction of the lesser field slope, and should be properly graded towards the main drainage system.

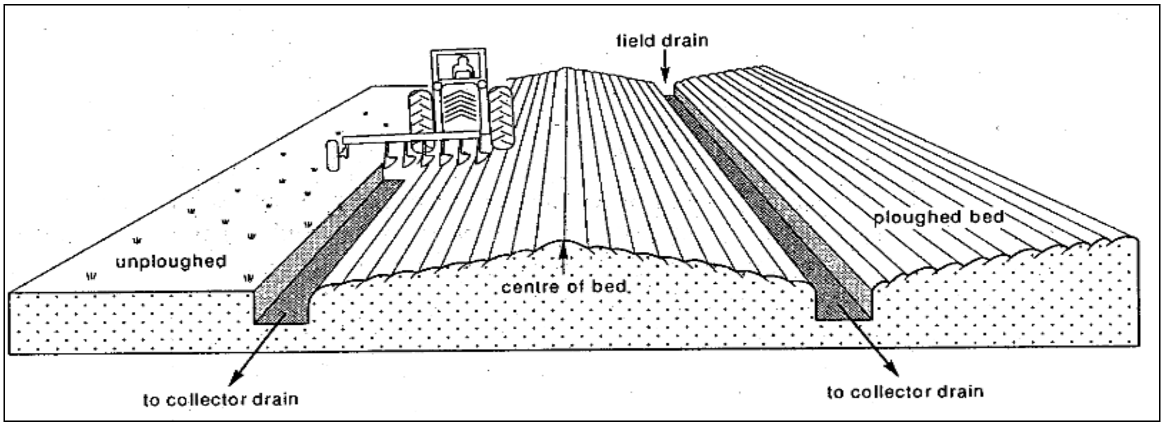


Figure 24. Construction of bedding system

B. Land grading and land planning

In addition, the types of crop and how they will be grown have to be considered. Crops like maize, potatoes, and sugar cane are grown in rows with small furrows in between. For such crops, the length of the rows and the slopes of the field must be selected so as to avoid erosion and overtopping of the small furrows. To prevent erosion, it is recommended that the flow velocities in the furrows should not exceed 0.5 m/s. In highly erodible soils, the row length is limited to about 150 meter. Slightly erodible soils allow longer rows, up to 300 m. The direction of the rows and furrows need not necessarily be at right angles to the slope, but can be selected in any way that meets the above recommendations.

Small grains and hay crops are grown by broadcast sowing or in rows, but on an even surface (i.e. no furrows). For such crops, surface drainage takes place by sheet flow. This flow is always in the direction of the maximum slope. With sheet flow, the flow resistance is much higher than in small furrows, and the flow velocity on the same land slope is less. With the transport duration for low flow velocities in mind, it is recommended that the field length in the flow direction be limited to 200 m or less.

Construction

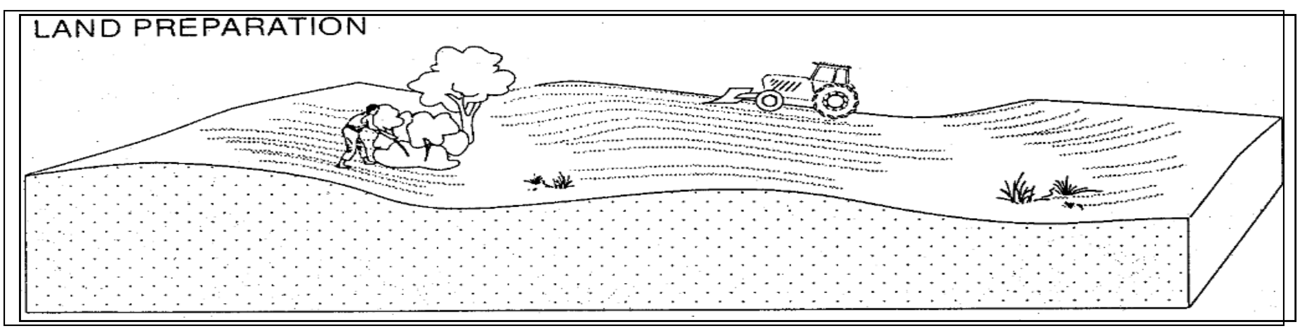
In general, land grading is done with a combination of conventional earthmoving equipment and specially designed machinery. Normal farm equipment, even if mechanized, can only handle small-scale grading operations or the maintenance of already established grades. Large-scale land grading is done by contractors with conventional earthmoving equipment or with laser-guided motorized graders.

Steps in grading operations

Grading operations involve a number of steps (Figure 25). The *first* step is to prepare the site. If the land has already been cleared, the work mainly involves removing or destroying vegetation and other obstacles, and levelling ridges or rows. This can normally be done with farm equipment. The surface should be dry, firm, and well pulverized to enable the equipment to operate efficiently.

The *second* step is rough grading. This can be done with various types of equipment (e.g. dozers, motor graders, scrapers). The choice will depend on the soil conditions, the amount of earthwork needed, the time and equipment available, the size of the fields to be graded as one unit, and local experience.

The *third* step is the finished grading. On small fields, drags, harrows, and floats can be used. These implements can be pulled by a farm tractor or by animal traction. On larger fields, a land plane (a bottomless scraper) pulled by a farm tractor is used. For the final smoothing, several passes are usually made at angles to one another



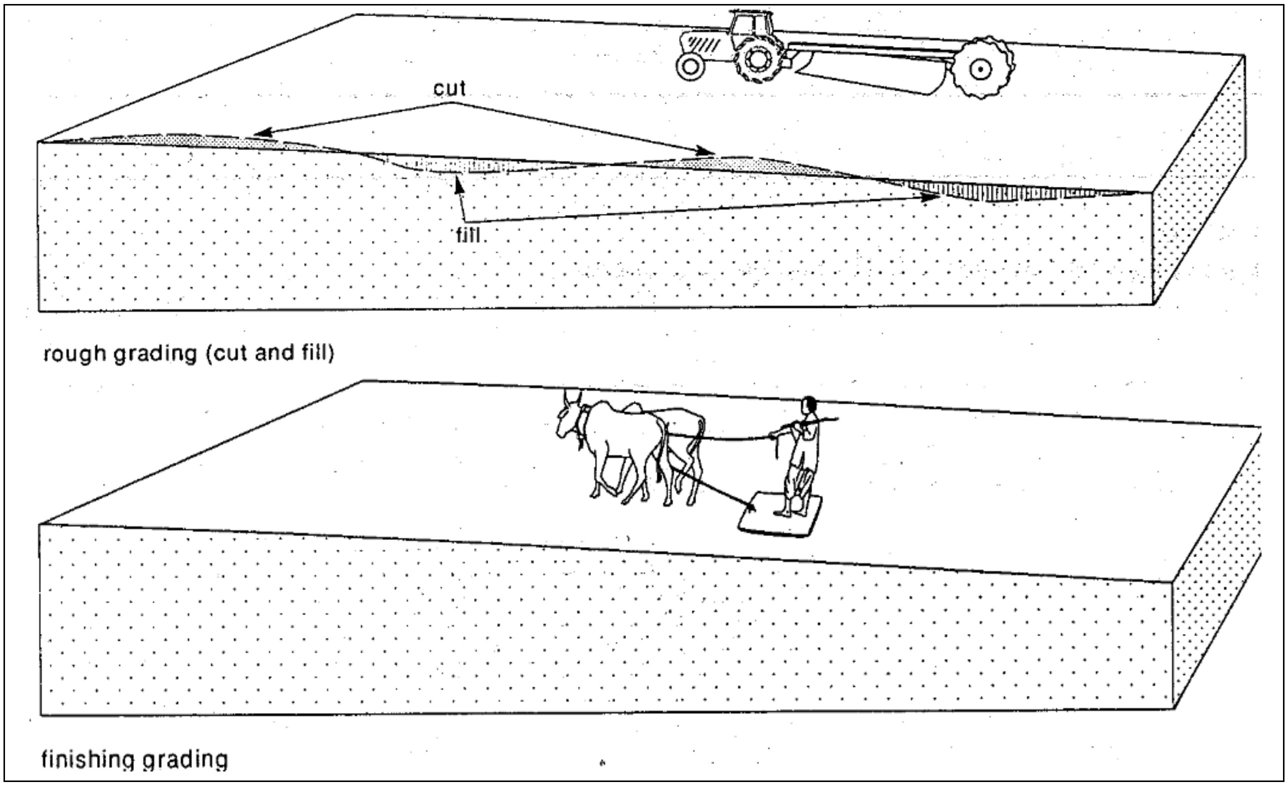


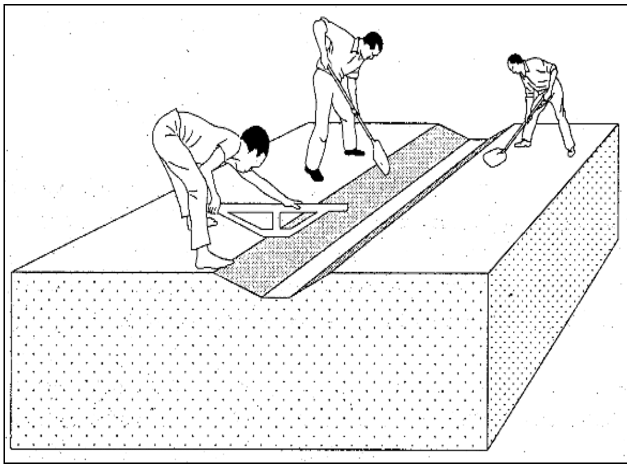
Figure_25. Steps in grading and planing operations

C. Field and collector drains

Construction of surface drains

Open surface drains can be constructed manually or mechanically (Figure 26). Care should be taken that the spoil from the drains does not block the inflow of runoff, but is deposited on the correct side of the ditch or is spread evenly over the adjacent fields.

Collector drains are usually constructed with different machinery than that used for field drains (i.e. excavators instead of land planes) (Figure 28). The soil is placed near the sides of the drain. Scrapers are needed when the excavated soil is to be transported some distance away.



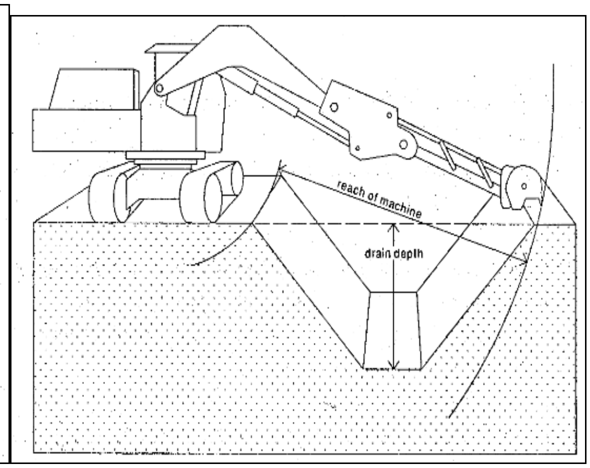


Figure_26. Construction of field drains Figure 19. Construction of collector drain with excavator

4.3. Checking the drainage system for configuration and capacity consistent with the drainage system plan

The field surface drains (furrows or shallow ditches) discharge into a network of open ditches or grassed waterways and larger watercourses. The main drainage system removes excess water to points outside the project area. Care must be taken to protect stretches where surface runoff collects and enters into field surface drains or where these drains enter larger ones. These are the points where gullies can start and where sediments enter into the main drainage system. At these transition points, provisions are needed to control erosion, even in flat lands.

The cross sections area of field drains, collector drains, main drain, grade and their side slopes should be checked against with the design plan to attain the capacity specified in drainage system plan.

4.4. Consulting the supervisor and taking remedial action when the drainage system operation does not meet the plan specifications.

A thorough check during construction is the most effective. All discrepancies can then be seen and corrections can still be made relatively easily. After construction the only way of correction is mostly by reconstructing the drain. The simplest and most practical control during construction is to check:

- The levels (starting level) using a levelling instrument
- The side slopes of open channels
- Alignment by verifying the start and end from the maps or design specifications;

- Horizontal straightness during construction by checking if the pegs have been properly placed.
- The bed grades of field and collector drains checked with a levelling instrument,

Information sheet # 5	**Unit**	**Assist Irrigation Drainage System Development**
	Module	**Assisting Irrigation Drainage System Development**
	LO#5	**Complete construction of surface drainage system**

5.1. Finishing earthworks

Backfilling and finishing

Backfilling and finishing of trenches should ensure a minimum of later land subsidence and preclude the occurrence of piping. The piping phenomenon may occur as a result of internal erosion of trench backfill by water flowing from the soil surface directly to the drains through the loose backfill material.

5.2. Restoring and removing waste material

After completing the installation works, make sure;

- ✓ All the trenches are filled in and the site is cleaned up properly.
- ✓ The site is must be restored and **waste material** removed from the site and disposed of in an environmentally aware and safe manner according to work procedures.

Disposal of waste materials

After installing irrigation and landscaping there is often range of unwanted waste material left behind that needs to be dealt with. Things such as matting, old pipe, envelopes, pots/tubes, soils, fertilizer, plastic wrapping, stakes, mulch, and plant debris. It is best practice when finished to leave a completely clean site free of rubbish.

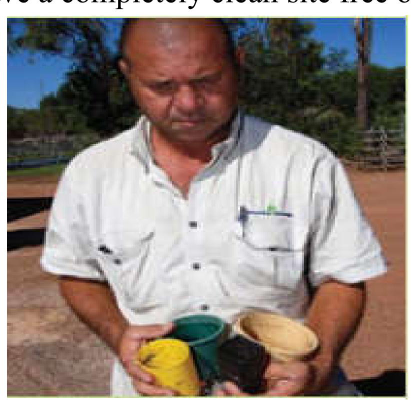


Figure _27: Disposing waste materials

Methods of waste disposal could include:

- Organic waste: mulch and composting.
- In organic wastes: plastic/ metal/paper based material may be recycled, reused or returned to manufacturer.

5.3. Cleaning, maintaining, storing tools, equipment and machinery

To make the next job easy and to prevent personal injury it is very important to keep tools in good condition. Follow the steps below each time the tool are used:

- Wash the mud and dirty off and oil any metal parts to prevent rusting. Steel wool and light oil will remove any surface rust.
- Keep tools, machinery sharp and in good working order. Bevel the back edge of a spade off with a bench grinder or a course sharpening stone.
- Replace any broken handles and parts. Never use bush sticks as handles as they often break causing injury.
- Sand and oil all wooden handles to avoid getting nasty splinters.
- Machines repair and services must be under taken according to the manufacturer and enterprises standards.

Figure_28: Cleaning tools

5.4. Maintaining a clean and safe work area.

In this activities tasks include throughout and on completion of work;

- Disabling unused tools, equipment and machinery and
- Storing neatly out of the way of installation and construction activities;
- Safely storing materials on site;
- Using signage and safety barriers during construction and removing them after activities are completed, and swiftly and efficiently removing and processing debris and waste from the work area.

5.5. Recording and reporting work outcomes

- Work outcomes are recorded or reported to the supervisor according to enterprise work procedures.

Self-Check 3	Written Test

Name: _________________________ Date: _______________

Directions: Answer all the questions listed below.

1. Describe the ways of disposing waste materials? (5 pts)
2. Write at least five tasks that would be under taken after completion of installing drainage system? (10pts)
3. What is the function of field drain? (5pts)

Note: satisfactory Rating-10 and above pts. Unsatisfactory Rating-below 10 pts.

You can ask your teacher for the copy of the correct answers

Lap Test	**Practical Demonstration**

Name: _______________________________________ Date: ____________

Time started:_____ Time finished:____

Instructions:

- You are required to perform the following activity:
  - Task_1: Selecting the necessary tools and equipments:
  - Task_2: Setting out trench location
  - Task_3: Setting out alignments and levels
  - ✓ Task_4: Excavating the trenches
  - ✓ Task_5: Check for any service lines that may intercept your drainage line.