Ethiopian TVET-System

Irrigation & Drainage Construction

Level II

Based on, March 2017G.C. Occupational Standard

Module Title: Designing basic water System Model

TTLM Code: EIS IDC2 TTLM 0920v2

This module includes the following Learning Guides

LG54. Investigate irrigation and drain water systems

LG Code: EIS IDC2 M13 0920 LO1-54

LG55: Apply basic scientific principles to the Operation of water system.

LG Code: EIS IDC2 M13 0920 LO1-55

LG56: Investigate safe and effective operations of irrigation and drain water system model

LG Code: EIS IDC2 M13 0920 LO1-56

LG57: Prepare detail design

LG Code: EIS IDC2 M13 092019 LO1-57

Instruction Sheet	Learning Guide -54: Investigate irrigation and drain Water systems

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

- Source of local water supply system and its characteristics.
- Water metering, allocation and water pricing systems
- Local irrigation water resource collection and distribution systems
- Characteristics of wastewater systems

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 –

- Determing and explaining source of local water supply system and its characteristics
- Verifying water metering and allocation system and related water pricing system
- Checking and explaining local irrigation water resource collection and distribution systems

Source of local water supply system and its characteristics are determined and explained.

Water metering and allocation system and related water pricing system are verified

Local irrigation water resource collection and distribution systems are checked and explained

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information "Sheet 1, Sheet 2, Sheet 3 and Sheet 4" in page 4, 14, 22 and 36 respectively.
4. Accomplish the "Self-check 1, Self-check 2, Self-check 3 and Self- check 4" -" in page 13, 21, 35 and 40 respectively
5. If you accomplish the self-checks, do operation sheet in page 41 and 42
6. LAP Test in page 43

Information Sheet -1	Determining and explaining source of local water supply system and its characteristics

1.1 Type of Water Source

1.1.1 Surface water

Surface water is water in a river, lake or fresh water wetland. Surface water is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, evapotranspiration and groundwater recharge.

A) Reservoir   B) Dam

C) Pond   D) River

Figure 1**:** Lakes, reservoirs, rivers, and rivers dammed to create reservoirs are the common example of surface water source (Source **Shirley Pauaso-Velera**)

1.1.2 Ground water

Groundwater is fresh water located in the subsurface pore space of soil and rocks. It is also water that is flowing within aquifers below the water table. The level of water below ground is called the water table. Groundwater can be extracted from wells or collected from springs.

Figure2: Hand dug well

Figure3: Rope pump well

Figure4: Spring water Source

Figure 5: The different type of water source that are used in water system model

(Source wilkpedia,327)

1.2 Characteristics of rain water source based system characteristics

In regions where rainfall is abundant and frequent, rainwater can be a good source of water supply for individual families and small communities. Rainwater can be collected in several ways:

- **Roof catchments:** Rainwater can be collected from house roofs made of tiles, slate, (corrugated) galvanized metal or equivalent. Pipes feed water from the roof and gutters into a collection tank where it can be stored until needed.

Figure 6: Rainwater is collected from the roof of this rural health post and stored in a covered, watertight Cistern. (Source Wikipedia)

- **Ground catchments:** These are systems that collect and store rain falling on an area of ground. The amount of rainwater that can be collected depends on whether the area is flat or sloping, and on the permeability of the top layer of the ground. These systems require space so are only appropriate in rural areas, where they can serve small villages and households for livestock and vegetable growing.
- **Sand dams:** In arid areas where there is a dry, sandy riverbed and the rain falls once or twice a year, a collection system known as a sand dam can be used to store water. A sand dam is a concrete wall (1 to 5 m high) built across a seasonal sandy riverbed. During the rainy season, a seasonal river forms and carries sand and silt downstream.

Figure 7: Rainwater storage ponds in Amhara Region.

Figure 8: A sand dam in Kenya used as source of rain water collection

1.3 Characteristics of ground water source-based system

Ground water source system includes:

1.3.1 Springs

Springs are formed when ground water appears at the ground surface for any reason as a current of flowing water. Springs can be found in different places often at slopes but sometimes also water may emerge under pressure at other places.

Types of springs:

- Depression spring: is a spring formed when the ground surface intersects the water table.
- Contact spring: is a spring created by a water bearing formation overlying an impervious formation that intersects the ground surface.
- Artesian spring: is a spring that results from the release of water under pressure from confined water bearing formation either through a fault or fissure reaching the ground surface. It is also known as fracture spring.

(a) Depression spring (b) Contact Spring

c) Bottled water are artesian Spring

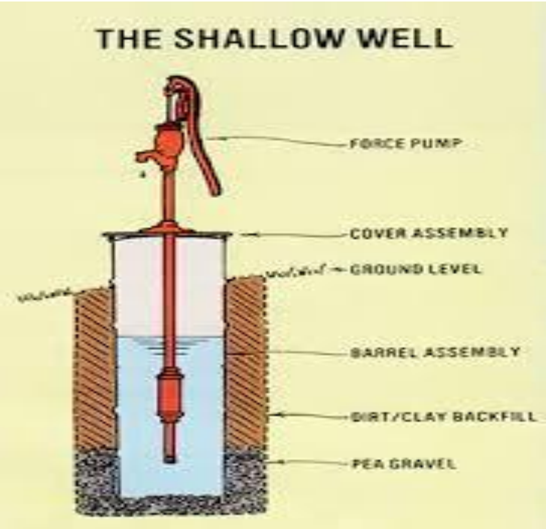
Figure9: The different type of springs (source YouTube)

In most cases this water will come from a confined water layer in the subsoil and therefore may be free from harmful bacteria and viruses. Spring protection may make this water source even more valuable, but a lot of care is needed not to build up water pressure in the system you construct as this may result in the water finding another outlet leaving the spring without water.

1.3.2 Wells Based System

Wells are artificial holes or pits vertically excavated for bringing ground water to the surface. well can be classified as shallow and deep well.

- **Shallow wells:** Shallow wells may be large diameter hand dug wells (diameter 1-4m) and depth ≤ 20m. Or machine drilled wells of small diameter (diameter 8-60cm) and depth ≤ 60m.



(A) Shallow well (B) Hand dug well

Figure10: Common type of shallow well (source Wikipedia)

- **Deep-wells:** Deep wells are most large, deep, high-capacity wells constructed by drilling rig. Construction can be accomplished by cable tool method or rotary method. Drilling rigs are capable of drilling wells 8 to 60cm in diameter and depth ≤ 600m.

(A) Deep well with Hand Pump (B) Deep well drilling

Figure 11: Different type of shallow well (source Wikipedia)

1.4 Characteristics of Surface water Source Based System

The quality and quantity of surface water varies from one place to another and over time, due to factors such as geology, climate and surrounding land use.

The variable quality of surface water means it has to be treated to make it safe for domestic consumption. The quantity of water in rivers and lakes obviously varies with rainfall and there can be wide fluctuations at different times of year. To ensure year-round supply, dams can be constructed to create reservoirs from which water can be extracted prior to treatment.

Figure12: Surface water collection for different use (YouTube)

1.5 Characteristics of Protected and unprotected water source

Unprotected sources are those with no barrier or other structure to protect the water from contamination. All surface water sources, such as lakes, rivers and streams or poorly constructed wells, are examples of unprotected sources.

A concrete cover should be fitted over the well casing, to prevent dust, insects, small animals and any other contaminants from falling in. The well, pump, pipework and associated structure should be regularly disinfected using chlorine solution to eliminate pathogens and ensure the water is safe to drink.

Figure13 Hand pump over a protected dug well. Note the concrete surround and the fence to keep out animals (source: SNV manual)

Figure14: Protected well with concrete surround and a lid. Note the black plastic bucket is suspended off the ground to keep it clean (source OWNP,M5)

Water from unprotected sources cannot be considered safe to drink unless it has been treated. The terms ‘improved’ and ‘unimproved’ are also used to describe water sources and are broadly equivalent to ‘protected’ and ‘unprotected’.

Figure 15: show common type of unprotected water Source

Water sources can be classified as protected or unprotected. Protected sources are covered by stonework, concrete or other materials that prevent the entry of physical, chemical and biological contaminants.

Self-Check -1	Written Test

Part I: Matching Type

Directions: Match column A to B and write your answer on the space provided. (1 pt. each)

Column A	Column B
----1. Water in a river, lake or fresh water wetland	A. Water
----2. Fresh water located in the subsurface pore space of soil	B. B. Rain
----3. Liquid water in the form of droplets that have condensed from	C. Surface
----4. Collected from house roofs made of tiles, slate, (corrugated)	D. Groundwat
----5. With no barrier or other structure to protect the water from	E. unprotected
----6. Cannot be considered safe to drink unless it has been treated	F. Protected
----7. Natural resources of water that are potentially useful	G. Roof
	H. Spring
	I. Dam

Part II: Multiple Choice parts (2 point)

8. One of the following is ground water source
   A. River C. Pond
   B. Lake D. Spring
9. One of the following is surface water source
   A. Hand dug well C. River
   B. Well with rope pump D. Spring

Note: **Satisfactory rating –** 5 points and above **Unsatisfactory -** below 5 points

You can ask you trainer for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ ID______________ Date: _______________

2.1 Introduction

There are several types of water meters in common use. The choice depends on the flow measurement method, the type of end user, the required flow rates, and accuracy requirements. In infromation-1 of this learning guide you have seen about; source of local water supply System and its Characteristics. Now, in information sheet-2 you will cover about, Water metering, allocation and water pricing systems and each part will be discussed as follow.

2.2 Water Metering System

2.2.1 Water metering

Water metering is the process of measuring water use. In many developed countries water meters are used to measure the volume of water used by residential and commercial buildings that are supplied with water by a public water supply system. Water meters can also be used at the water source, well, or throughout a water system to determine flow through a particular portion of the system. In most of the world water meters measure flow in cubic meters (m^3) or liters. There are two common approaches to flow measurement, displacement and velocity, each making use of a variety of technologies.

Figure 16: A typical residential water meter source From Wikipedia, the free encyclopedia

2.2.2 Displacement water meters

Positive Displacement flow meters are the only flow measuring technology to directly measure the volume of fluid that passes though the flow meter. It achieves this by trapping pockets of fluid between rotating components housed within a high precision chamber. This can be compared to repeatedly filling a beaker with fluid and pouring the contents downstream while counting the number of times the beaker is filled. This type of water meter is most often used in residential and small commercial applications and homes. Displacement meters are commonly referred to as Positive Displacement, or "PD" meters.

Figure 17: Positive displacement water meter

2.2.3 Velocity water meters

A velocity-type meter measures the velocity of flow through a meter of a known internal capacity. The speed of the flow can then be converted into volume of flow to determine the usage. There are several types of meters that measure water flow velocity, including jet meters (single-jet and multi-jet), turbine meters, propeller meters and ammeters. Most velocity-based meters have an adjustment vane for calibrating the meter to the required accuracy.

Figure 18: Different types water meter (Source YouTube)

2.3 Water allocation

One of the most serious issues of water management is the question how to allocate the water resources to guarantee sufficient amount of water for all demands. A Water Allocation is a volume of water that entitles the holder/customer to a percentage of that water based on the available water in the scheme dams, weirs or barrages. The percentage of water allocation available to the customer can be as high as 100 per cent or as low as 0 per cent, depending on the level of water storages.

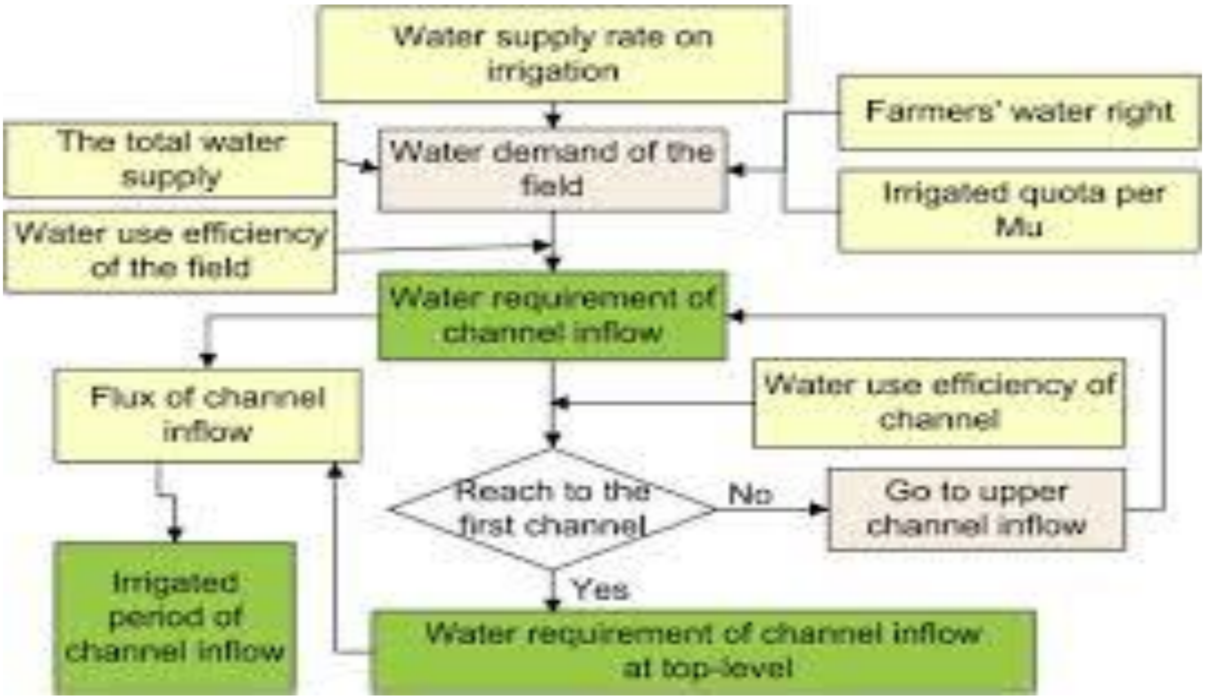


Figure 19: Irrigation water allocation example

The purpose of the allocation of water to different users is to match or balance the demand for water with its availability. There are various ways how to allocate water. These water allocation systems have evolved historically and continue to change. Hierarchies of water allocation systems in the U.S. and many other countries generally have the following components or features.

- The waters of international rivers and aquifers are allocated between nations based on international law
- Certain rights are reserved for military installations and other government owned lands and facilities.
- An administrative system that grants, limits, and modifies water rights and enforces the allocation of water resources may or may not include formal issuance of written permits to water right holders.
- Water users and water management entities implement various contracts and other for- mal agreements.
- Sharing of water resources may be governed by cultural traditions and informal agree

Figure 20: Drinking water supply allocation example

2.4 Water Pricing System

2.4.1 Cost Recovery requirement

A requirement to recover costs through water pricing is common in developed country, especially for urban water utilities. However, in some cases, innovative incentive pricing programs have a potential to promote economically efficient water use patterns and provide a revenue source to compensate for environmental damages.

2.4.2 Water price requirement

The urban water market and pricing have the following components:

- Cost of water supply: In most countries water pricing is based on average cost pricing or marginal cost pricing. The consumers are charged at a rate of per kiloliter of water consumed. This rate varies depending on the pricing structure in each city.

- Cost of maintenance of sewerage services: In most cities around the world, water boards are also responsible for maintaining the sewerage system and consumers are charged for this service.
- Cost of treatment of sewage water or wastewater discharged by households and industries: Most of the developed countries have introduced the “polluter pays principle” for the amount of water pollution load discharged by companies. Wastewater treatment charges are fully recovered from urban consumers of water.
- Service charge: in most cities, a minimum service charge is included in the water bill. The urban water authorities, usually known as Water Supply and Sewerage Boards, are responsible for the city’s water supply and sewage services.

Self-Check -2	Written Test

Direction: Write short and precise answers for the following questions and write your answer on the answer sheet.

1. What the points on which choice of water meter depends? {2pts}
2. Discuss the types of water meter? (3 pts)
3. What is water meter? (1 pts)

***Note:* Satisfactory rating –** 3 points and above **Unsatisfactory -** below 3 points

You can ask you trainer for the copy of the correct answers.

Score = ___________
Rating: ____________

Answer Sheet

Name: _________________________ ID_______ Date: __________

For Part I

1. _______ .
2. _______ .
3. ------------

3.1 Terms and definitions

- **Dam**: A dam is a hydraulic structure constructed across a river to store water on its upstream side. It is an impervious or fairly impervious barrier put across a natural stream so that a reservoir is formed.
- **Spillways and energy dissipaters**: Spillway is a channel that carries excess water over or around a dam or other obstruction. An energy dissipater is a device that is used to convert concentrated storm water runoff to sheet flow and is constructed at the end of all storm sewers or channels that outfall into a buffer.
- **Sluice and Outlet**: A sluice is an artificial channel for conducting water, with a valve or gate to regulate the flow. An outlet is a small structure which admits water from the distributing channel to a water course of field channel. Thus, an outlet is a sort of head regulator for the field channel delivering water to the irrigation fields.
- **Barrage**: An artificial obstruction placed in a river or water course to increase the depth of water.
- **Canal Head Regulator**: Any structure constructed to regulate the discharge, full supply level or velocity in a canal is known as a regulator work.
- **River Training Works**: Various measures adopted on a river to direct and guide the river flow, to train and regulate the river bed or to increase the low water depth are called River Training works. The purpose of the river training is to stabilize the channel along a certain alignment.
- **Cross regulator**: A regulator provided on the main channel at the downstream of the off take to head up the water level and to enable the off-taking channel to draw the required supply is called a Cross Regulator.

3.2 Irrigation water collection System

3.2.1 Direct Irrigation method

In this project water is directly diverted from the river into the canal by constructing a diversion structure like weir or barrage across the river with some poundage to take care of diurnal variations. It also effects in raising the river water level which is then able to flow into the off taking channel by gravity. The flow in the channel is usually controlled by a gated structure and this in combination with the diversion structure is also sometimes called the headwork's.

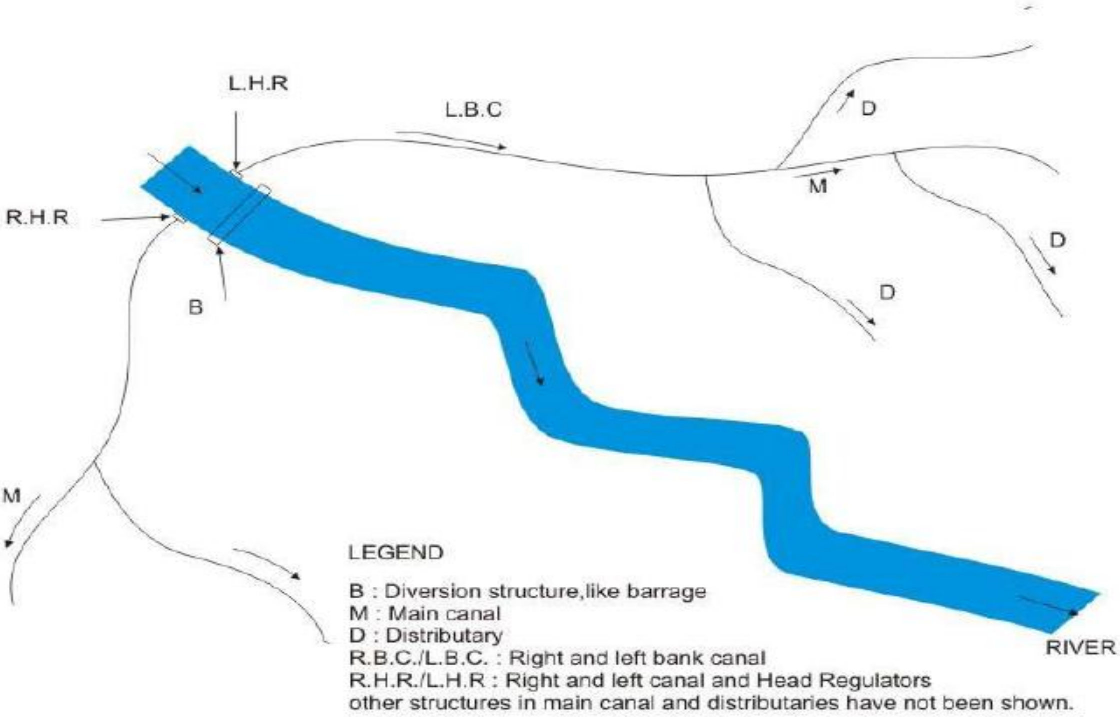


Figure 21: Example of direct irrigation water distribution method (Source: Irrigation Engineering Principles, Version 2 CE IIT, Kharagpur)

3.2.2 Storage Irrigation Method

For this type of irrigation schemes part of the excess water of a river during monsoon which otherwise would have passed down the river as a flood is stored in a reservoir or tank found at the upstream of a dam constructed across a river or stream. This stored water is then used for irrigation is adopted when the flow of river or stream is in excess of the requirements of irrigated crops during a certain part of the year but falls below requirements or is not available at all in the river during remaining part of the year. Since the construction site of a storage reservoir is possible in regions of undulating topography, it is usually practiced in non deltaic areas.

3.2.3 Combined Irrigation Method

In third type of scheme the storage head works or the dams has to be equipped with ancillary structure like outlet, sluice, spillway, log chutes, etc. The storage created by the dam behind the reservoir is substantial compared to that behind a barrage and may inundate a large tract of land, depending on the topography. The capacity of the reservoir is generally determined systematically by knowing possible withdrawal demands (in this case for irrigation) over the weeks and months of a year and corresponding expected inflows.

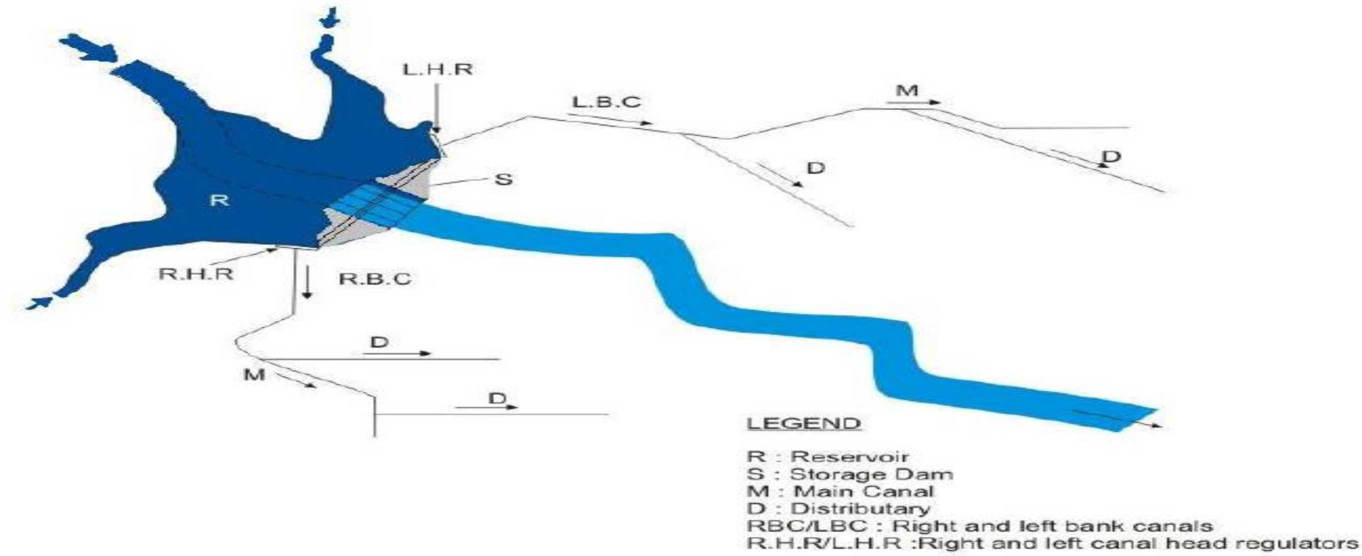


Figure 22: typical example of storage irrigation scheme (Source: Version 2 CE IIT, Kharagpur)

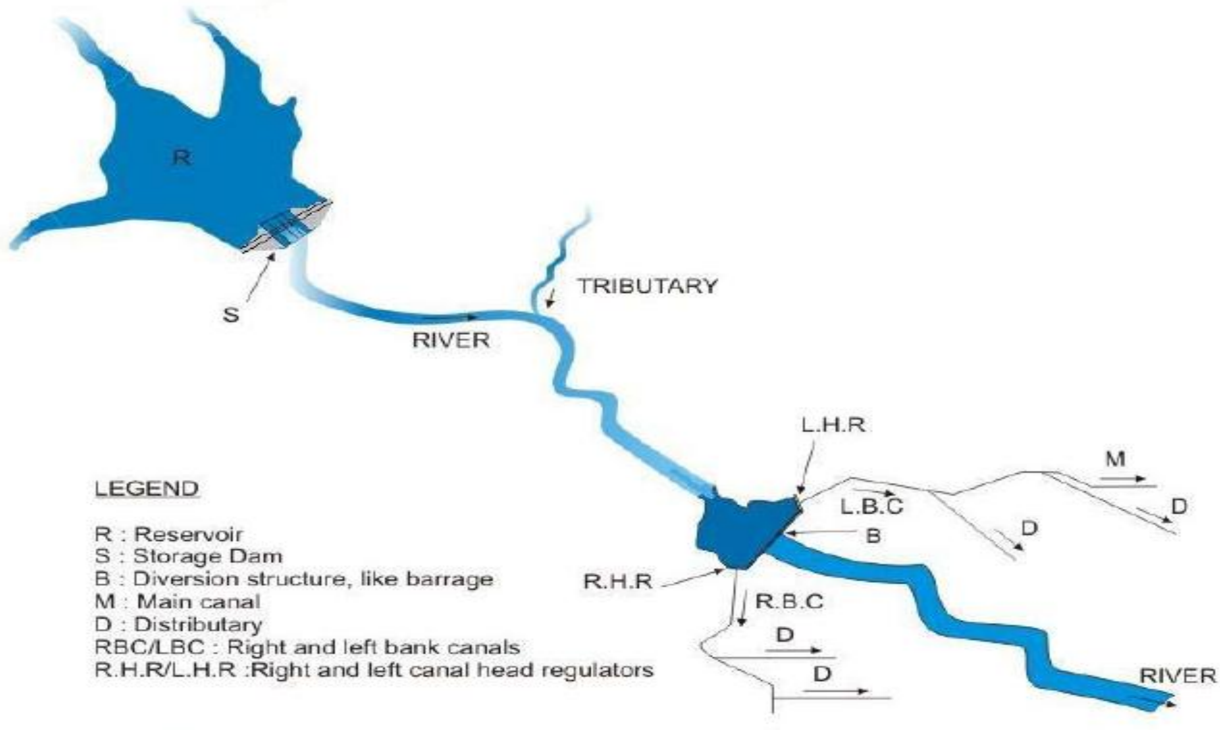


Figure 23: Typical layout of storage Irrigation scheme incorporating dam with barrage on its downstream (Source: Kharagpur)

3.3 Irrigation water distribution System

3.3.1 Methods of Field Water Application

Irrigation water conveyed to the head or upstream point of a field must be applied efficiently on the whole area such that the crops growing in the either fields gets water more or less uniformly. Another important parameter dictating the choice of the irrigation method is the type of soil. Sometimes water is applied not on the surface of the field but is used to moist the root zone of the plants from beneath the soil surface.

Thus, in effective the type of irrigation methods can be broadly divided as under:

- Surface irrigation method
- Subsurface irrigation method

3.3.2 Surface Irrigation Methods

In this system of field water application, the water is applied directly to the soil from a channel located at the upper reach of the field. It is essential in these methods to construct designed water distribution systems to provide adequate control of water to the fields and proper land preparation to permit uniform distribution of water over the field.

Table 1: Advantage and disadvantage of Surface Irrigation

The Advantages of Drip Irrigation	Disadvantages of Drip Irrigation
Easiest and Cheapest	Dependent on Your Terrain
Best Utilization of Rain Water	Water logging

- **Flooding type of irrigation:** One of the surface irrigation methods is flooding method where the water is allowed to cover the surface of land in a continuous sheet of water with the depth of applied water just sufficient to allow the field to absorb the right amount of water needed to raise the soil moisture up to field capacity.

Figure 24: Wild flooding *(Source: garg)*

- **Border irrigation:** Borders are usually long uniformly graded strips of land separated by earth bunds (low ridges). The essential feature of the border irrigation is to provide an even surface over which the water can flow down the slope with a nearly uniform depth

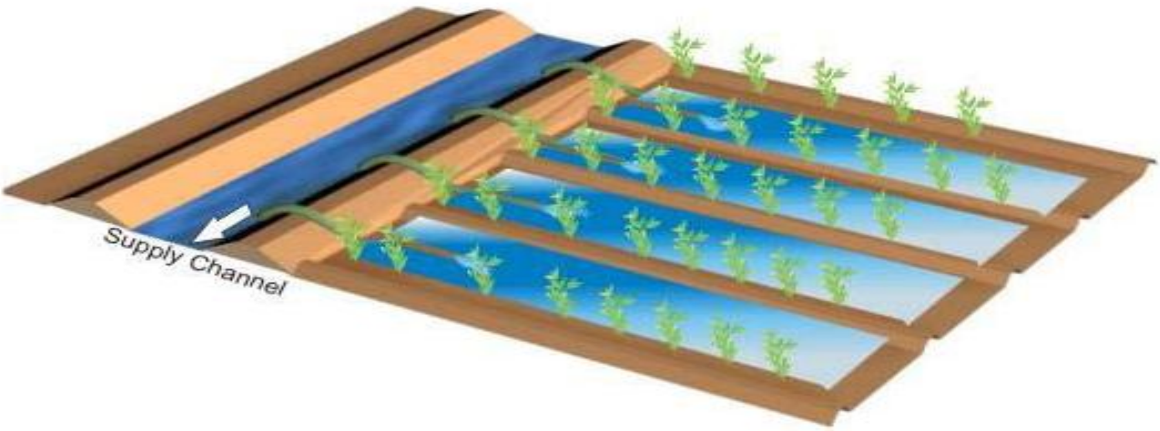


Figure 25: In border irrigation each strip is irrigated independently by turning in a stream of water at the upper end as shown in Figure *(Source: Kharagpur)*

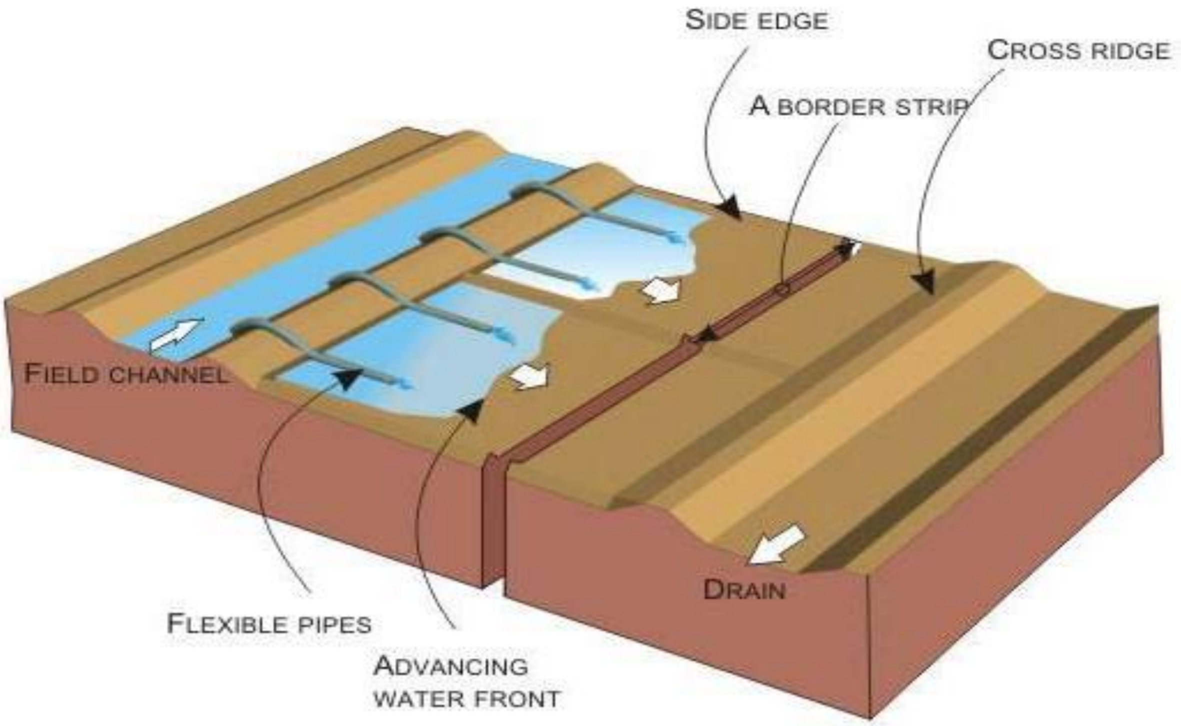


Figure 26: Water entering each border strip independently *(Source: Kharagpur)*

- **Basin Irrigation:** Basins are flat areas of land surrounded by low bunds. The bunds prevent the water from flowing to the adjacent fields. The basins are filled to desired depth and the water is retained until it infiltrates into the soil. Water may be maintained for considerable periods of time.

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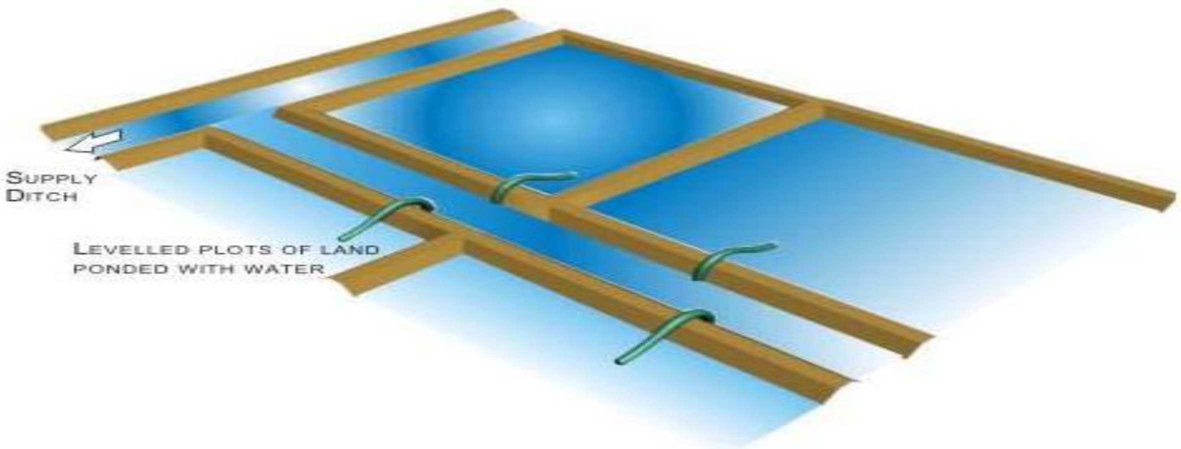


Figure 27: In Basin method, the land to be irrigated is divided into small plots or basins surrounded by checks, levees (low bunds); *(Source: Kharagpur)*

Sometimes, basin sizes are made larger to include two more trees in one basin. Water to the basins is supplied from a supply channel through small field channels conveyed the basins with the supply channel. Trees which can be irrigated successfully using the ring basin method include citrus and banana.

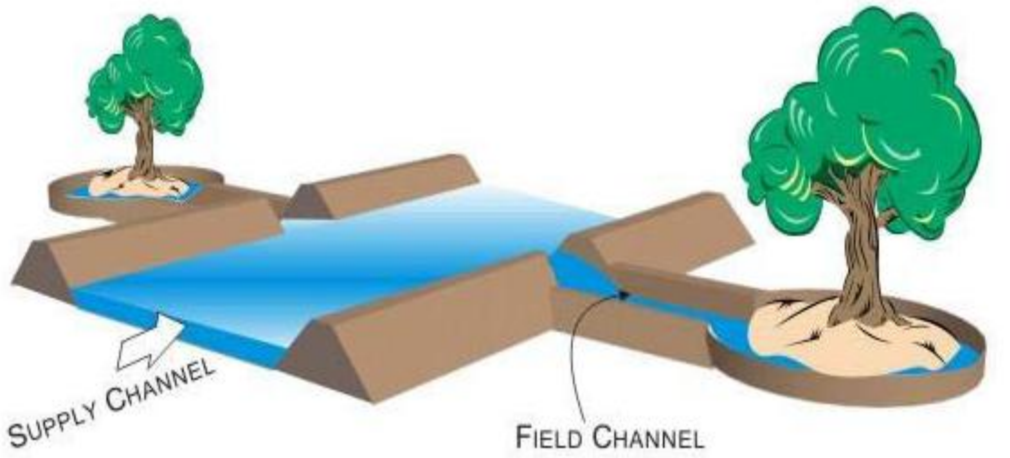
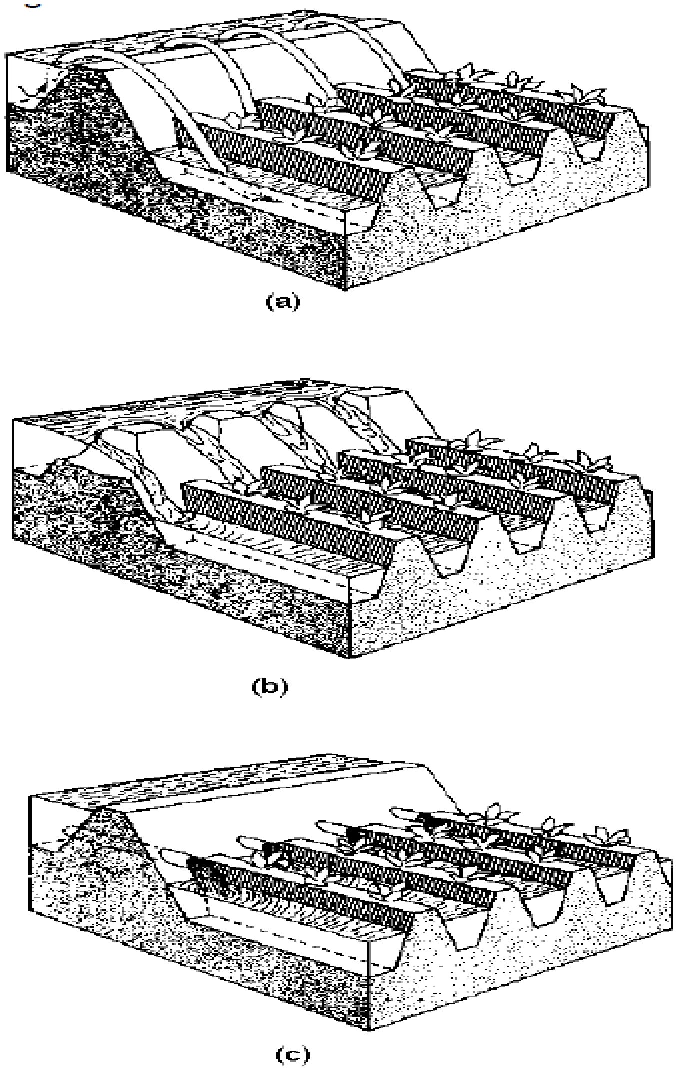


Figure 28: Common type of basin irrigation for trees and Banana *(source: FAO)*

- **Furrow Irrigation:** Furrows are small channels, which carry water down the land slope between the crop rows. Water infiltrates into the soil as it moves along the slope. The crop is usually grown on ridges between the furrows. is suitable for all row crops and for crops that cannot stand water for long periods, like 12 to 24 hours, as is generally encountered in the border or basin methods of irrigation. Furrows may be straight laid along the land slope, if the slope of the land is small (about 5 percent) for lands with larger slopes, the furrows can be laid along the contours.



- Using flexible pipes to siphons out water from field channel
- Using the breach method to apply water to the furrows
- Pipe outlet to deliver water to the furrows

Figure 29: Furrow irrigation method of applying water to the field (Source: FAO)

3.4 Sprinkler irrigation system

Sprinkler irrigation is a method of applying water which is similar to natural rainfall but spread uniformly over the land surface just when needed and at a rate less than the infiltration rate of the soil so as to avoid surface runoff from irrigation. The system of irrigation is suitable for undulating lands, with poor water availability, sandy or shallow soils, or where uniform application of water is desired.

Figure 30: Sprinkler irrigation System

While there are an incredible variety of different sprinkler types, at the end of the day they're all serving the same general purpose and can therefore be lumped together for the purposes of this blog post.

Figure 31: Sprinkler irrigation System

No land leveling is required as with the surface irrigation methods. Sprinklers are, however, not suitable for soils which easily form a crust. The water that is pumped through the pump pipe sprinkler system must be free of suspended sediments. As otherwise there would be chances of blockage of the sprinkler nozzles.

A typical sprinkler irrigation system consists of the following components:

- Pump unit
- Mainline and sometimes sub mainlines

- Laterals
- Sprinklers

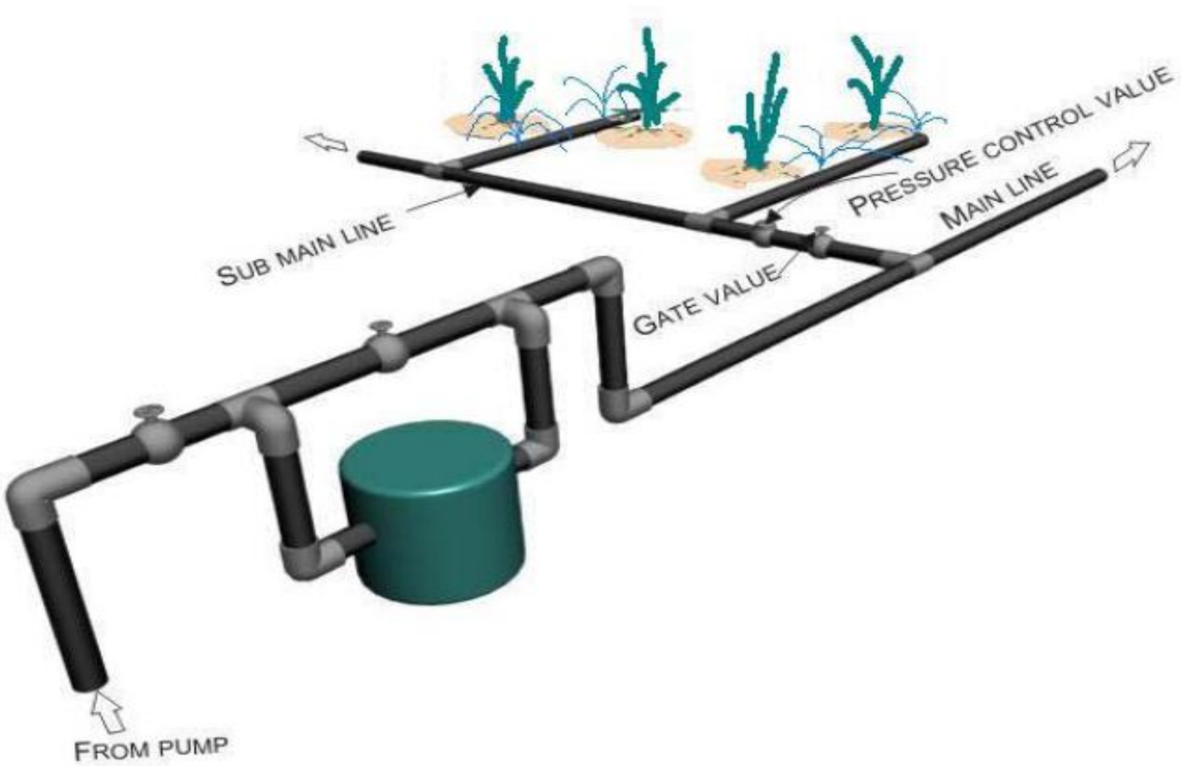


Figure 32: Shows a typical layout of a sprinkler irrigation system (Source Kharagpur)

Table 2: Advantage and disadvantage of Surface Irrigation

The Advantages of Drip Irrigation	Disadvantages of Drip Irrigation
Can Cover Large Areas	Expensive Upfront Cost
Can Be Used Anywhere	Susceptible to Wind

3.5 Drip irrigation system

Irrigation method that applies water to plants at a very low rate of application and without any pressure. The concept of the system is to target the roots of the crop rather than the entire land area the crops cover. Water is able to reach the deepest roots of the crop through capillaries and gravity

Figure 33: Drip irrigation method

Table 3: Advantage and disadvantage of Drip Irrigation

The Advantages of Drip Irrigation	Disadvantages of Drip Irrigation
Reduces Weed Growth	Requires Precise Installation
Efficient Water Usage	Requires Maintenance
Less Irrigation Water Needed	High Costs
Variation in Application Rates	waste
Avoid Over Irrigation	Clogging
High Yields	Not beneficial to Closely planted crop
No Water Logging	

Drip Irrigation System Components

- Pumping set: -Generates pressure to control the amount of water supplied
- Filters: Removes the impurities in the water
- Main Lines: -This is the distribution system for drip irrigation, commonly PVC pipes and polyethylene pipes used in the system. Pipes generally 65 mm in radius

- Sub Main: Connected to main line through a control valve. Distributes the water laterally through the field

Pumping set **Filters**

Figure-34: Pumping set and Filters of drip irrigation

Figure 35: Main and Sub main components of drip irrigation

- Drippers/emitters-Connected on the laterals in order to emit water in drops at a continuous flow rate, flow rates generally do not exceed 15 liters/hr

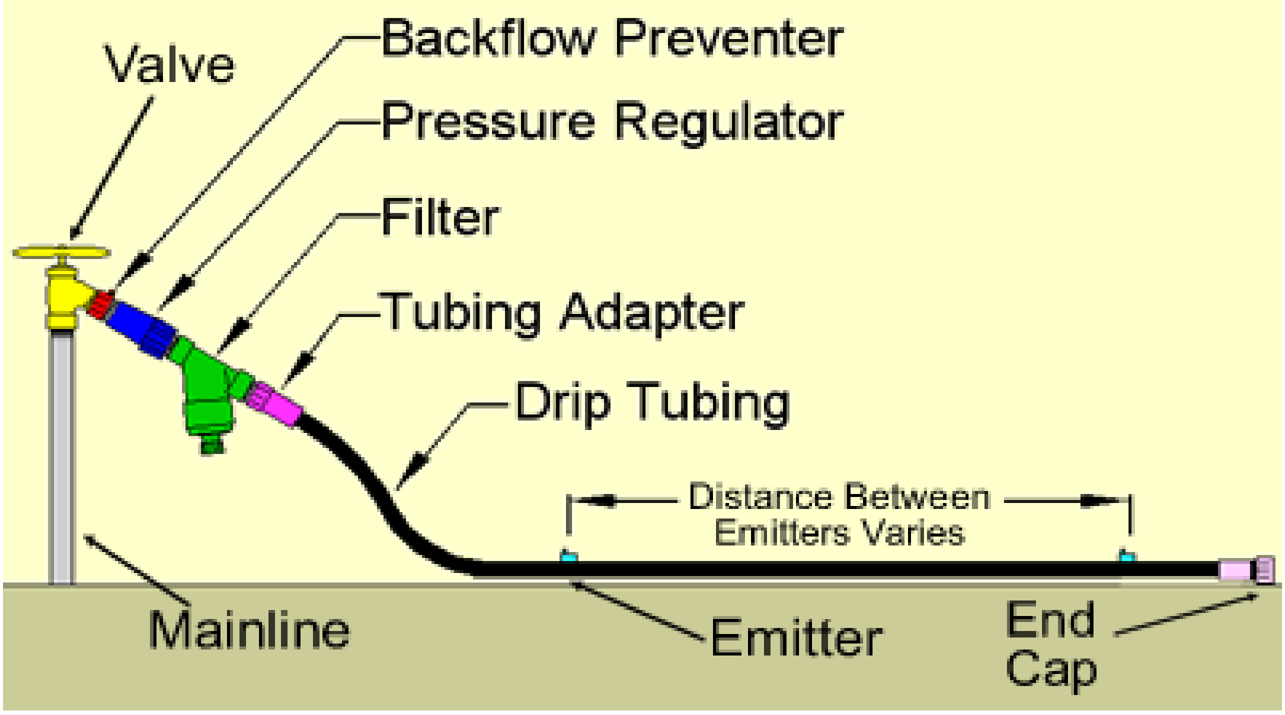


Figure 36: Dripper/emitter of drip irrigation (source NPTEL Volume 9)

Self-Check -3	Written Test

Part I: Matching Type (5 Points)

Directions: Match column A to B and write your answer on the space provided. (1 pt. each)

Column A	Column B
------1. Allowed to cover the surface of land in a continuous sheet	A. Sprinkler Irrigation System
------2. Water can flow down the slope with a nearly uniform depth	B. Furrow Irrigation
------3. The water is retained until it infiltrates into the soil	C. Basin Irrigation
------4. Water infiltrates into the soil as it moves along the slope	D. Border irrigation
------5. Similar to natural rainfall but spread uniformly over the land	E. Flooding type of irrigation
	F. Drip irrigation

Part II: Multiple Choice parts (1 point)

1. Irrigation method that applies water to plants at a very low rate of application and without any pressure (1 point)

A. Drip
B. Surface
C. Sprinkler
D. All

Name: _______________ ID______ Date:

Score = ___________

Rating: ____________

Answer Sheet

Note: **Satisfactory rating –** 3 points and above **Unsatisfactory -** below 3 points

You can ask you trainer for the copy of the correct answers.

4.1 Definition of Wastewater

Wastewater is simply that part of the water supply to the community or to the industry which has been used for different purposes and has been mixed with solids either suspended or dissolved. Wastewater is 99.9% water and 0.1% solids. The main task in treating the wastewater is simply to remove most or all of this 0.1% of solids.

Figure 37: The effect of no waste management: paper, plastics and other solid waste litter the environment.

Figure 38: The effect of poor sanitation: liquid wastes are discharged into rivers and streams that may be used as a water source.

4.2 Type of liquid Waste water

Useful general classification of domestic liquid waste is as follows:

- Blackwater is wastewater that contains or consists of urine and faces. It contains pathogens (disease-causing agents).
- Grey water, or sullage, is wastewater from human washing and bathing, kitchen sinks, clothes washing, etc. It does not contain excreta.
- Storm water (or surface run-off or rainwater run-off) is wastewater that flows on the surface of the land to join streams. Note that this is considered as wastewater because it contains many different contaminants.
- Sewage is a combination of wastewater coming from any of the above sources and flows in underground sewers or open ditches.
- Excreta are a combination of urine and faeces.

Table 4: Type and source of waste water

Type of Wastewater	Source of wastewater
Gray water	Washing water from the kitchen, bathroom, laundry (without faeces and urine)
Black water	Water from flush toilet (faeces and urine with flush water)
Yellow water	Urine from separate toilets and urines
Brown water	Black water without urine or yellow water

4.3 Types of solid waste

There are different ways of classifying solid wastes according to the source of generation or the nature of the waste. Solid waste can be categorized as follows:

- Residential waste: from households and residential areas. This is sometimes called household waste. Garbage, rubbish, trash and refuse are other terms for residential waste.
- Commercial waste: from businesses such as food and drink establishments, shops, etc.
- Industrial waste: from various types of industrial processes, e.g. food processing, paper manufacture, manufacture of chemicals and metal processing.

- Institutional waste: from public and government institutions, e.g. offices, religious institutions, schools, universities, etc. This is similar to residential and commercial waste in composition.
- Municipal waste (or municipal solid waste) covers all the above wastes produced in an urban area. It is similar in composition to residential waste but excludes some industrial wastes.
- Healthcare waste: any solid waste produced in hospitals, clinics, health posts and other health facilities.
- Agricultural waste: waste that comes from farming.
- Waste from open areas: street sweepings, contents of roadside dustbins, ditches and other public places.
- Construction and demolition waste: from various types of building and demolition activities in urban areas.
- Electronic and electrical waste (e-waste): wastes generated from used electronic devices and household appliances.

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4.4 Wastewater characteristics

Wastewater has physical and chemical components, some of which may affect your selection of pipe materials or drainage system design.

- Wastewater has physical characteristics such as temperature, solids, odour and colour. In plumbing work the temperature and type of solids in the wastewater are important considerations.
- Wastewater at high temperature will affect some piping materials and treatment units such as septic tanks. You may have to consider the use of an arrestor to pre-treat the wastewater.
- Wastewater contains chemicals such as nitrogen, phosphorus and levels of dissolved oxygen as well as others that may affect its composition and pH rating. Highly acidic or alkaline
- wastewater is probably trade waste and will require pre-treatment before discharge to the sewer.
- The chemical properties of wastewater may also affect the pipe material. For example, AS/NZS 3500.2 states that copper should not be used to carry undiluted urine from urinals or the discharge from grease arrestors.
- Some establishments may also discharge toxic chemical substances in their wastewater, which will need pre-treatment.

4.5 Major sources of solid wastes in urban areas of Ethiopia

- Residential sources: from households and residential areas. These are the major sources of solid waste in almost all cities and towns in Ethiopia.
- Commercial sources: from businesses such as food and drink establishments, shops, banks, etc.
- Institutional sources: from public and government institutions e.g. offices, religious institutions, prisons, schools, universities, etc.
- Open areas: waste from street sweepings, roadside dustbins, ditches and other public places.
- Industrial sources: from various types of industrial processes.
- Health facilities: from hospitals and other health facilities.
- Construction and demolition: from various types of construction and demolition activities in urban areas such as the construction of apartments, the demolition of urban slums, etc.
- Agricultural sources: from farming — more common in peri-urban areas of small and medium towns of Ethiopia and in rural areas.
- Electronic and electrical waste (e-wastes): waste electronic devices (computers, phones, radios, etc.) and household appliances (cookers, washing machines, etc.).

Self-Check -4	Written Test

Write short and precise answers for the following questions and write your answer on the answer sheet provided.

1. What are the common types of waste? (3 pts)
2. Define waste water. (3 pts)
3. Mention at least two characteristics of waste water. (3 pts)
4. Write at least two sources of waste water. (3 pts)

Note: **Satisfactory rating –** 6 points and above **Unsatisfactory -** below 6 points

You can ask you trainer for the copy of the correct answers.

Score = ___________

Rating: ____________

Name: _________________ ID__________ Date: __________

Answer Sheet

For Part I

1. ____
2. ____
3. ____
4. ____

Operation Sheet 1	Procedures to identify source of local water supply system and its characteristics

Procedures for water source and its characteristics identification

Step 1- Visit the small village around your college

Step 2- Identify the existing water source

Steps3-Check the water collection system

Steps4-Use simple sketch to show your findings

Step 5- Explain your result

Operation Sheet 2	Procedures for local irrigation water resource collection and distribution systems

Drawing schematic drawing for water supply system

Step 1-Use millimeter paper

Step 2- Draw simple sketch of irrigation system Layout

Operation Sheet 3	Steps for water metering, allocation and water pricing systems

Procedures for measuring water with float method

Step 1 Select straight part of river

Step 2 M mark four page on the ground connect them with string

Step 3 Measure 10m distance

Step 4 Mark the second line with Point C and D

Step 5 Fill plastic bottle with water

Step 6 Let the plastic bottle from line

Step 7 Measure the time to reach at line CD

Step 8 Do this three times

Step 9 Take the average of them V=d/t

LAP Test	Practical Demonstration

Name: _______________________________ Date: _________________

Time started: _________________________ Time finished: _________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 7 hours.

Task 1. Identify water source and its characteristics in the given project area

Task 2. Drawing schematic drawing for water supply system using given millimeter paper

Task 3. Measure water discharge with float method

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

- Reviewing and exploring basic principles governing the natural flow of water in the area
- Ascertain and explain basic principles governing the distribution of water through channel and pipe networks.
- Using scientific principles in the design, construction and operation of a working model of a water system are used
- using scientific principles to measure the flow of water and manipulation

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 –

- Reviewing and exploring basic principles governing the natural flow of water in the area
- Ascertain and explain basic principles governing the distribution of water through channel and pipe networks.
- Using scientific principles in the design, construction and operation of a working model of a water system are used
- using scientific principles to measure the flow of water and manipulation

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 and Sheet 4” in page 45, 53, 60 and 66 respectively.
4. Accomplish the “Self-check 1, Self-check 2, Self-check 3 and Self- check 4” -” in page 52, 59, 65 and 72 respectively
5. If you accomplish the self-checks, do operation sheet in page 73
6. LAP Test in page 74

Information Sheet -1	Reviewing and exploring basic principles governing the natural flow of water in the area

1.1 Introduction

It is common for water resources engineers to design a water system involving flow of water from one place to another, usually passing a variety of structures on the way some of them meant for controlling the flow quantity. Rivers and artificial channels, like canals, convey water with a free surface, that is, the surface of water being exposed to air as opposed to flow of water in pipes. It is easy to visualize that for any such open channel flow, as they are called; the presence or absence of a hydraulic structure controls the position of the free surface of water. Knowing the mathematical description of flowing water, it is possible to compute the water surface profile, which is important for example in designing the height of the channel walls of the water conveying system.

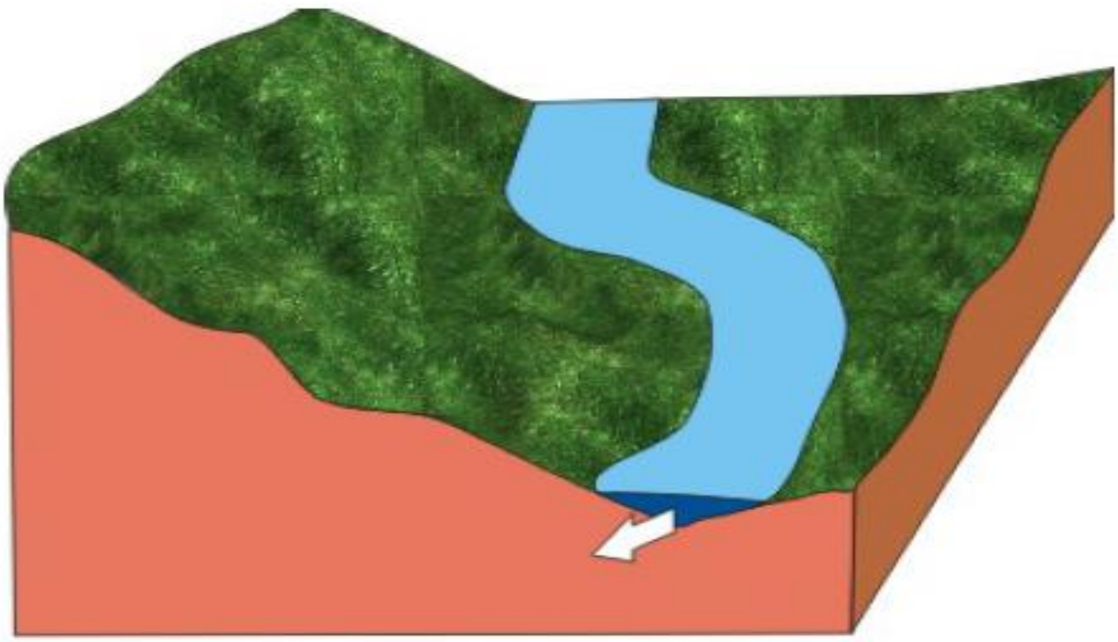


Figure 39: River flowing within its bank (Source, Flow Dynamics in Open Channels and Rivers, Version 2 CE IIT, Kharagpur)

1.2 Flow in natural rivers

When the water surface of the river just touches its banks, the discharge flowing through the river at this stage is called the “bank full discharge”. It is also sometimes called the “dominant discharge”. If the discharge in the river increases, the water will overflow the banks and would spill over to the adjacent land, called the flood plains.

Though the amount of discharge flowing through the river is of interest to the water resources engineer it cannot be measured directly by any instruments. Rather, an indirect method is used which requires knowledge of the velocity distribution in a river or an open channel. If we plot the velocity profile across a river, as shown in Figure 1-1, it would actually vary in three dimensions. Figure 1-3 shows the variation of velocity at the water surface.

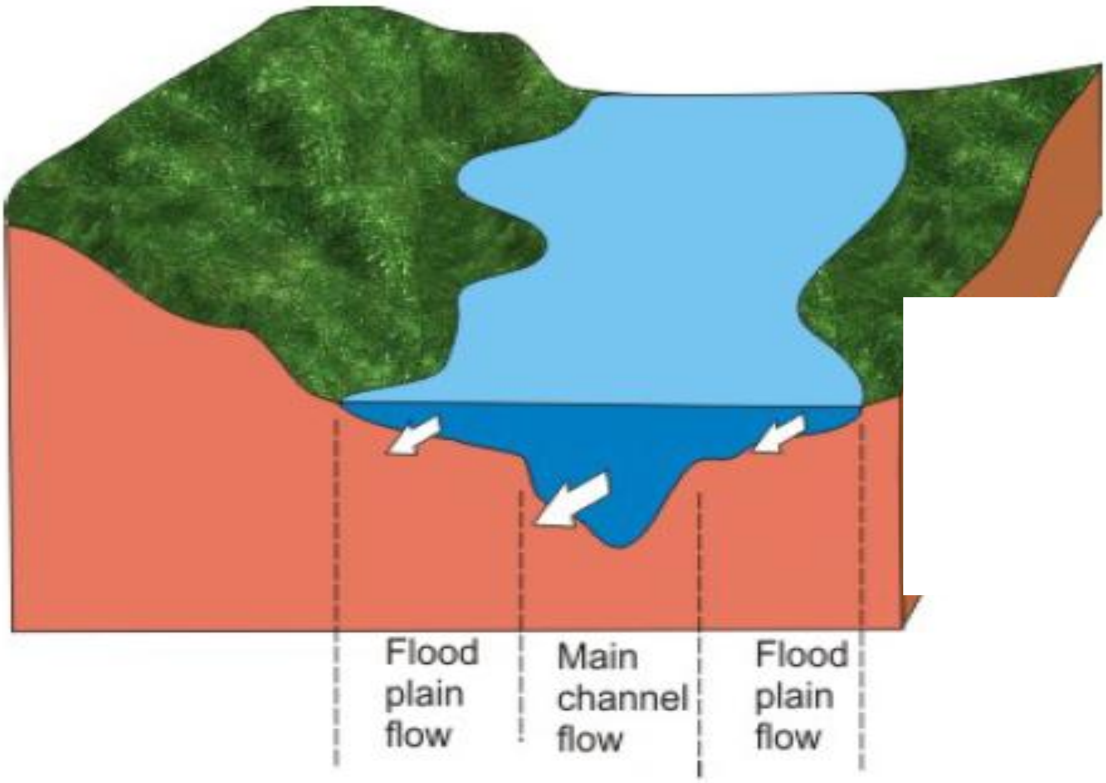


Figure 40: River flowing in its banaks during flood (Source, Flow Dynamics in Open Channels and Rivers, Version 2 CE IIT, Kharagpur)

1.3 Variation of discharge with river stage

The water level in a river is sometimes called the “stage” and as this varies, there is a proportional change in the total discharge conveyed. For each point of a river, the relation between stage and discharge is unique but a general form is found to be as shown in below.

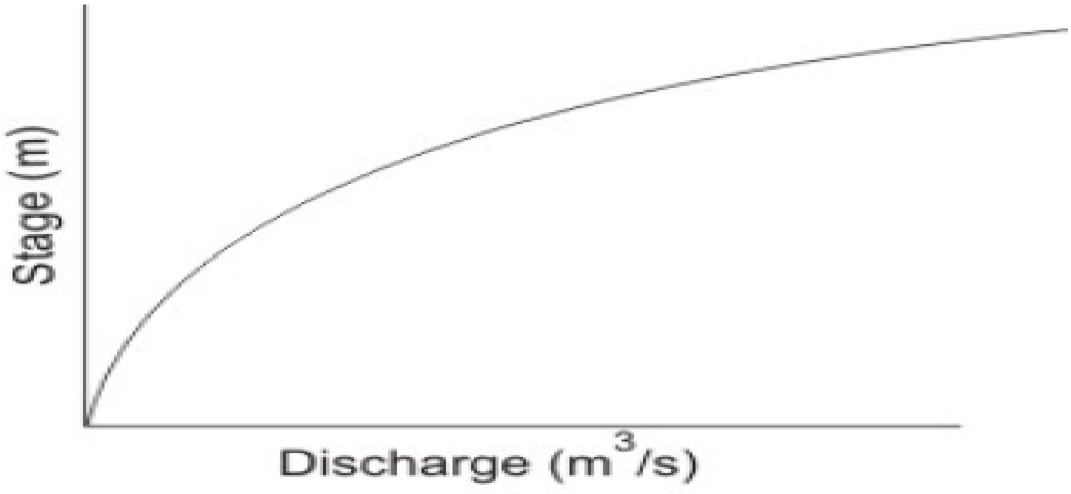


Figure 41: Stag*e discharge curve for river*

$$H = Z + h + \frac{V^2}{2g}$$

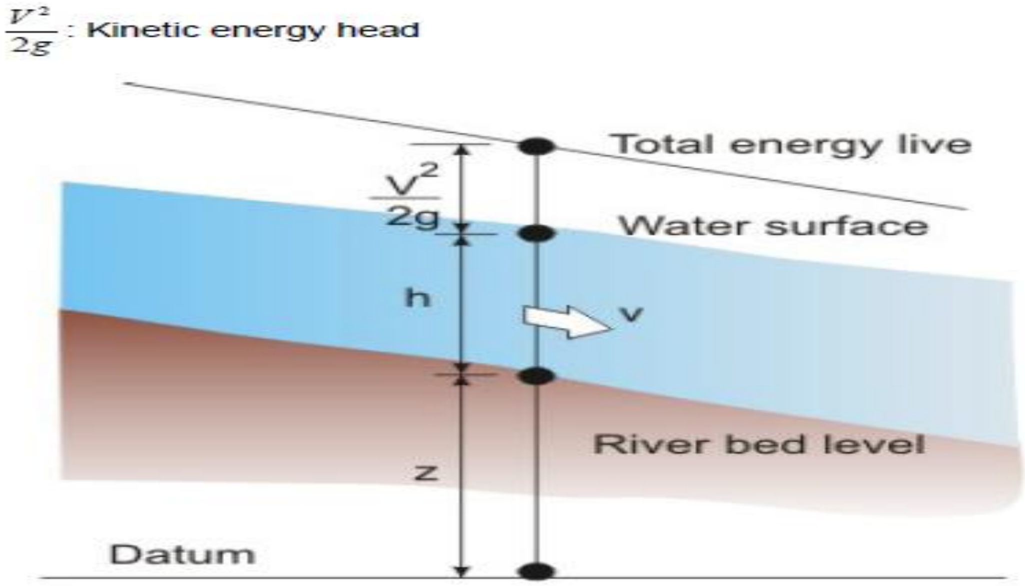


Figure 42: Variation of total energy along a river

Since the cross section, bed slope and flow resistance vary along a river length, the depth and velocity would vary correspondingly. However, if a short stretch of a river section is taken, then the variations in riverbed, water surface and the total energy may be considered as linear

1.4 Uniform flow in channels of simple cross section

For problems concerning the steady uniform flow in rivers and open channels, the Manning's equation is commonly used in India. The depth of water corresponding to a discharge in a channel or river under uniform flow conditions is called "normal depth". By combining the continuity equation with that of Manning's, one obtains Where the variables have been defined in the earlier sections. One may also write equation as follows

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

$$Q = K \sqrt{S}$$

Where K =nRA32, also called Conveyance, is often necessary to find out the normal depth of flow corresponding to a discharge Q, flowing in a channel for which equation may be rearranged as

$$A R^{2/3} = \frac{nQ}{S^{1/2}}$$

But a flow can have a free surface but not be an open-channel flow. Closed-conduit flows that consist of two immiscible fluid phases of differing density in contact with each other along some bounding surface are not open-channel flows, because they are nowhere in contact with open space, but they do have a freely deformable boundary within them. Such flows are free-surface flows but not open-channel flows (Figure 5-2), although they are usually called stratified flows, because the density difference between the two fluids gives rise to gravitational effects in the flow. On the other hand, open-channel flows are by their definition also free-surface flows.

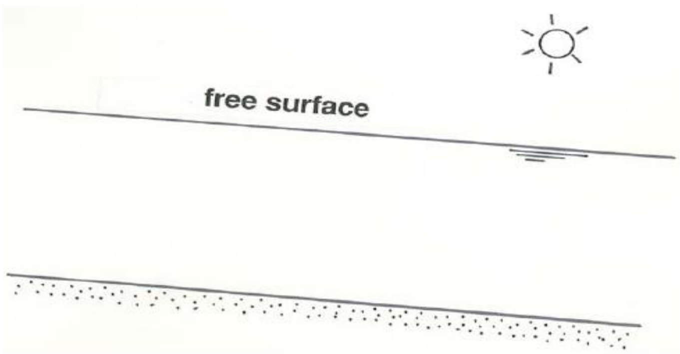


Figure 43: An Open channel flow

1.5 Uniform flow

Uniform flow serves as a good reference case from which to think about the effect of gravity on the free surface in an open-channel flow. Only if an open-channel flow can somehow be adjusted to be strictly uniform, in the sense that the water surface is planar and the flow depth is the same at all cross sections along the flow (Figure 5-5), can the effect of gravity in shaping the flow be ignored.

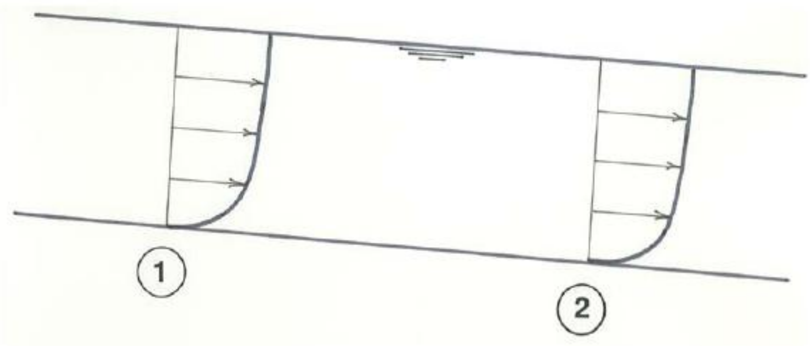


Figure 44: A uniform open channel flow

1.6 Energy in open channel

To address the two channel-transition problems posed earlier, we need to have a closer look at mechanical energy in an open-channel flow, and at how the partitioning of the various components of that mechanical energy, kinetic and potential, are changed at the transition in question. So, in the expanded Bernoulli equation the mechanical energy per unit volume of fluid moving along a streamline, v2/2 + p + ñgh, is constant. This can be written a little more conveniently for our purposes as energy per unit weight of fluid Ew. Because weight equals volume multiplied by ñg,

So in the expanded Bernoulli equation the mechanical energy per unit volume of fluid moving along a streamline, v2/2 + p + ρgh, is constant. This can be written a little more conveniently for our purposes as energy per unit weight of fluid Ew. Because weight equals volume multiplied by ρg,

$$E_w = \frac{v^2}{2g} + \frac{p}{\gamma} + h$$

1.7 The hydraulic jump

We still have not milked the positive-step example, as arranged in, for all the insight it affords. We made the implicit assumption that the flow coming from upstream had a combination of depth and velocity corresponding to the given q that was the outcome of the particular gentle channel

The answer is that commonly in situations like this the change from supercritical to subcritical is abrupt, in the form of what is called a hydraulic jump, rather than gradual.

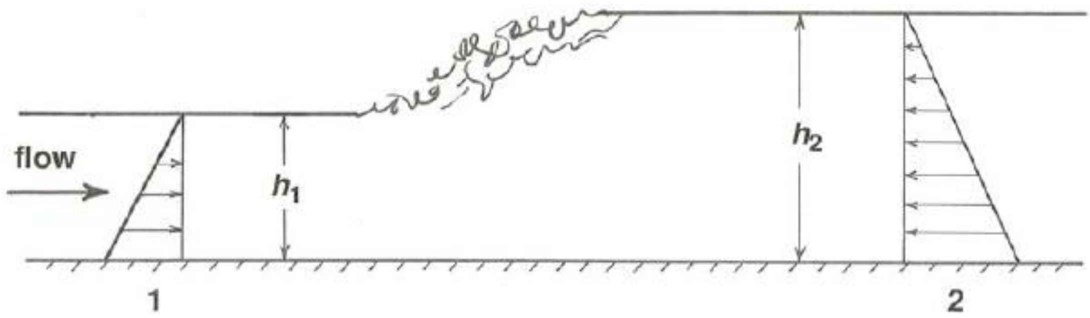


Figure 45: The hydraulic jump. The distribution of hydrostatic pressure is shown at section 1, upstream of the jump, and at section 2, downstream of the jump.

1.8 Water distribution system

The main purpose of water distribution network is to supply water to the users according to their demand with adequate pressure. Water distribution systems are composed of three major components: pumping stations, storage tanks and distribution piping. These systems are designed according to the loading conditions i.e., pressure and demand at nodal points. The loading conditions may include fire demands, peak daily demands or critical demands when the pipes are broken. A reliable design should consider all the loading conditions including the critical conditions. In this lecture we will discuss the simulation and optimization models for the design and analysis of water distribution networks.

1.9 Components of water distribution systems

Various components of water distribution systems are:

(i) Pipes: These are the principal elements in the system. The flow or velocity is usually described using Hazen– Williams equation

$$V = 1.318 C_{HW} R^{0.63} S_f^{0.54}$$

where *V* is the average flow velocity. *CHW* is the Hazen – Williams roughness coefficient, *R* is the hydraulic radius and *Sf* is the slope. In terms of head loss *hL*, the above equation can be expressed as,

$$h_L = \frac{KLQ^{1.852}}{C_{HW}^{1.852} D^{4.87}} = K_p Q^{1.852}$$

where L is the length of the pipe, D is the diameter and Q is the flow rate. Head loss can also be determined using Darcy – Weisbach equation as

$$h_L = f \frac{L}{D} \frac{V^2}{2g} = \frac{8fL}{\pi^2 g D^2} Q^2 = K_p Q^2$$

where f is the friction factor (determined from Moody's diagram) and g is the acceleration due to gravity.

Self-Check -1	Written Test

Part I: Description type

1. Write the difference between uniform and non-uniform flow. (2 pts)
2. What the points on which choice of water meter depends? (2 pts)
3. Discuss the types of water meter? (3 pts)
4. What is water meter? (2 pts)
5. How you determine energy in channel flow? (3 pts)
6. What is the use or purpose of hydraulic jump? (2 pts)

Note: **Satisfactory rating –** 7 points and above **Unsatisfactory -** below 7 points

You can ask you trainer for the copy of the correct answers.

Score = ___________

Rating: ____________

Name: _________________ ID__________ Date: _________________

Answer Sheet

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____

Information Sheet -2	Ascertain and explain basic principles governing the distribution of water through channel and pipe networks.

2.1 Basic Concepts and Properties of fluids

Mechanics is the oldest physical science that deals with both stationery and moving boundaries under the influence of forces. The branch of the mechanics that deals with bodies at rest is called statics while the branch that deals with bodies in motion is called dynamics.

Fluid Mechanics is the science that deals with behavior of fluids at rest (fluid statics) or in motion (fluid dynamics) and the interaction of fluids with solids or other fluids at the boundaries.

A substance in liquid / gas phase is referred as 'fluid'. Distinction between a solid & a fluid is made on the basis of substance's ability to resist an applied shear (tangential) stress that tends to change its shape. A solid can resist an applied shear by deforming its shape whereas a fluid deforms continuously under the influence of shear stress, no matter how small is its shape. In solids, stress is proportional to strain, but in fluids, stress is proportional to 'strain rate.'

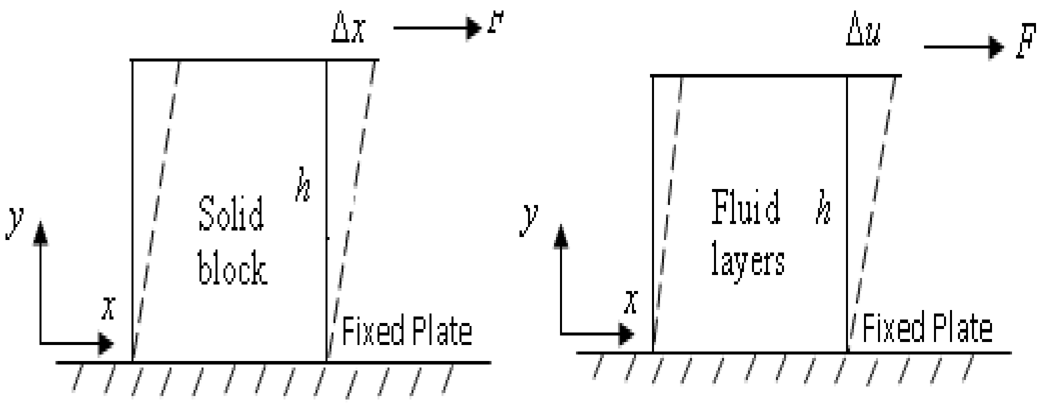


Figure 46: Illustration of solid and fluid deformation.

2.2 Basic Components of a Hydraulic System

Hydraulic systems are power-transmitting assemblies employing pressurized liquid as a fluid for transmitting energy from an energy-generating source to an energy-using point to accomplish useful work. Figure 47 shows a simple circuit of a hydraulic system with basic components.

Fluids are divided into liquids and gases. A liquid is hard to compress and as in the ancient saying 'Water takes the shape of the vessel containing it', it changes its shape according to the shape of its container with an upper free surface. Gas on the other hand is easy to compress, and fully expands to fill its container. There is thus no free surface. Consequently, an important characteristic of a fluid from the viewpoint of fluid mechanics is its compressibility. Another characteristic is its viscosity.

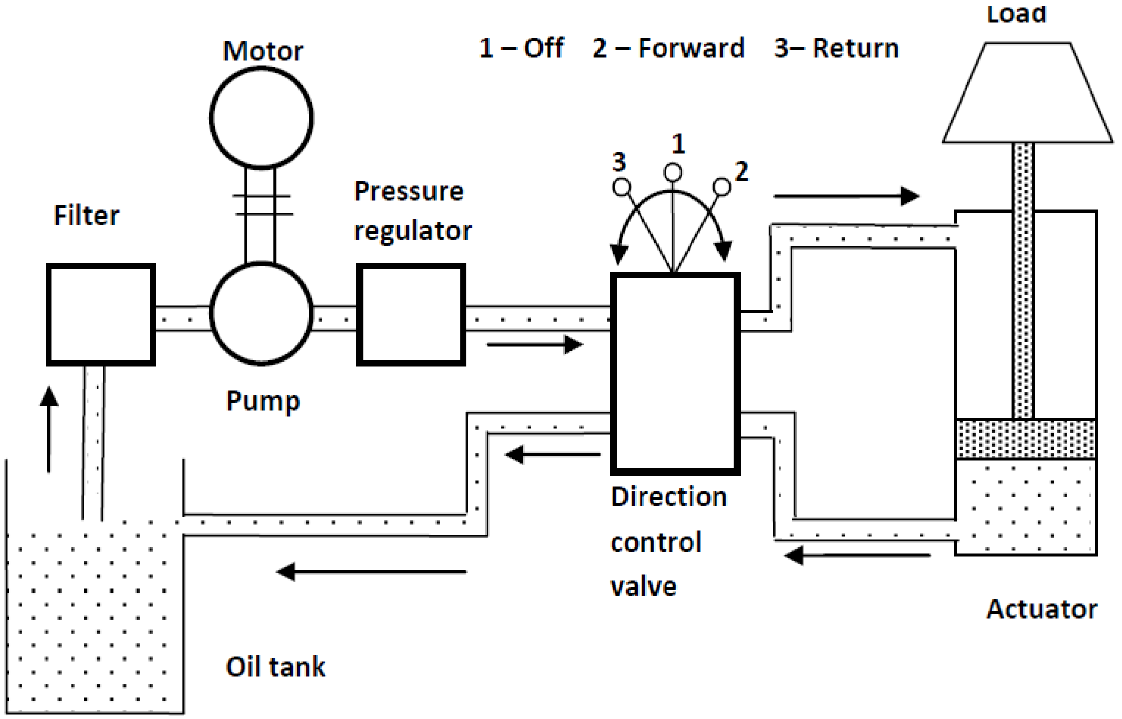


Figure 47: Components of a hydraulic system

Whereas a solid show its elasticity in tension, compression or shearing stress, a fluid does so only for compression. In other words, a fluid increases its pressure against compression, trying to retain its original volume. This characteristic is called compressibility. Furthermore, a fluid shows resistance whenever two layers slide over each other. This characteristic is called viscosity.

Table 5: Difference between Pipe Flow and Free Surface Flow (Source, Prof. B.S. Thandaveswara)

OPEN CHANNEL FLOW	Defines as a passage in which liquid flows with its upper surface exposed to atmosphere. The flow is due to gravity Flow conditions are greatly influenced by slope of the channel. Hydraulic grade line coincides with the water surface The maximum velocity occurs at a little distance below the water surface. The shape of the velocity profile is dependent on the channel roughness.
PIPE FLOW	A pipe is a closed conduit which is used for carrying fluids under pressure. The flow in a pipe is termed as pipe flow only when the fluid completely fills the cross section & there is no free surface of fluid. Hydraulic grade line does not coincide with the water surface. The maximum velocity occurring at the pipe centre. Velocity Distribution is symmetrical about the pipe axis.

2.3 Hydraulic grade line (HGL)

A curve drawn above the datum which has ordinates equal to the piezometric head at every point is called HGL or Hydraulic gradient.

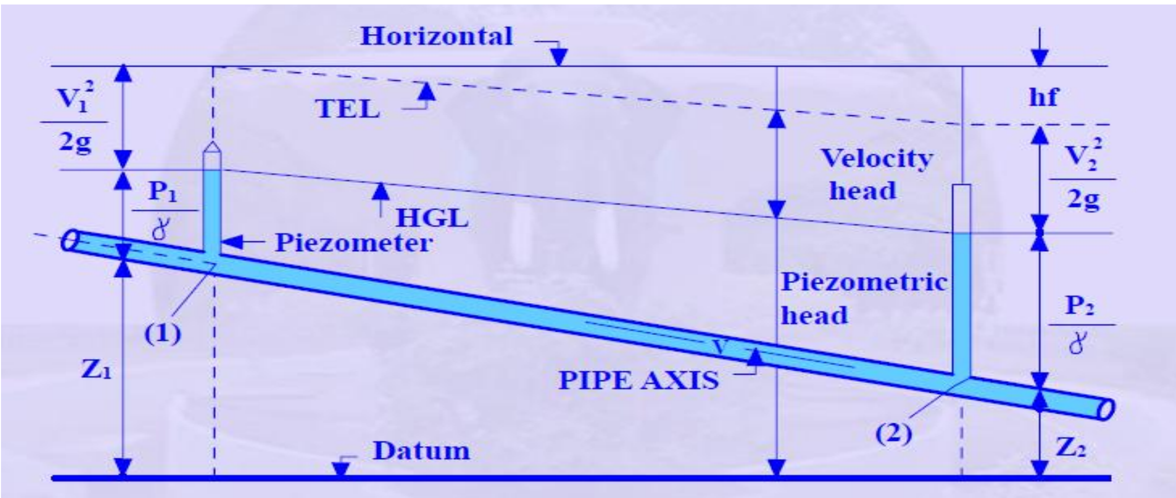
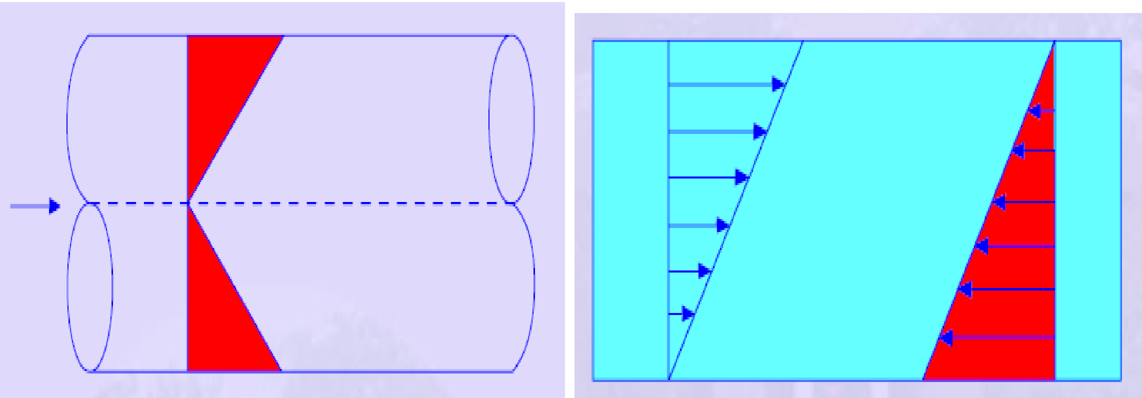


Figure 48: Hydraulic grade line HGL (Source, Prof. B.S. Thandaveswara)

- The vertical intercept between the datum and pipe axis is the elevation head.
- The datum and pressure gradient (HGL) is the piezometric head.
- The pipe axis and the HGL is the pressure head.
- HGL and TEL is the velocity head. Datum and TEL is the total head.

- The TEL always falls on the direction of flow because of loss of head. The HGL may rise or falls depending on the pressure variation in the pipe.

In a pipe of uniform section, the velocity head remains the same, if the rate of flow is constant. hence TEL and HGL are parallel if the pipe axis is horizontal. HGL is always below the TEL. At point where pressure is equal to the atmospheric pressure, HGL meets the pipe axis.



Shear stress distribution in pipe flow   Velocity distribution Shear stress distribution

Figure 49: Shear stress and Velocity distribution governing flow (Source, Prof. B.S. Thandaveswara)

2.4 Energy losses in hydraulic systems

2.4.1 Viscosity

Liquids such as water or petrol flow much easily than other liquids such as oil. The resistance to flow is essentially a measure of the viscosity of a fluid. The greater the viscosity of a fluid, the less readily it flows and the more is the energy required to move it. This energy is lost because it is dissipated as heat.

2.4.2 Laminar and Turbulent Flows

When speaking of fluid flow, one refers to the flow of an ideal fluid. Such a fluid is presumed to have no viscosity. This is an idealized situation that does not exist. When referring to the flow of a real fluid, the effects of viscosity are introduced into the problem. This results in the development of shear stresses between neighboring fluid particles when they move at different velocities. In the case of an ideal fluid flowing in a straight conduit, all the particles move in parallel lines with equal velocity. In the flow of a real fluid, the velocity adjacent to the wall is zero; it increases rapidly within a short distance from the wall and produces a velocity profile such as shown in figure below.

(a) (b)

Figure 2.6 Typical velocity profile: (a) Ideal fluid.(b) Real fluid

There are two types of flow in pipes:

2.4.3 Laminar flow

This is also known as streamline or viscous flow and is illustrated in figure 2.7 In streamline flow, the fluid appears to move by sliding of laminations of infinitesimal thickness relative to adjacent layers; that is, the particles move in definite and observable paths or streamlines. The flow characteristic of a viscous fluid is one in which viscosity plays a significant part.

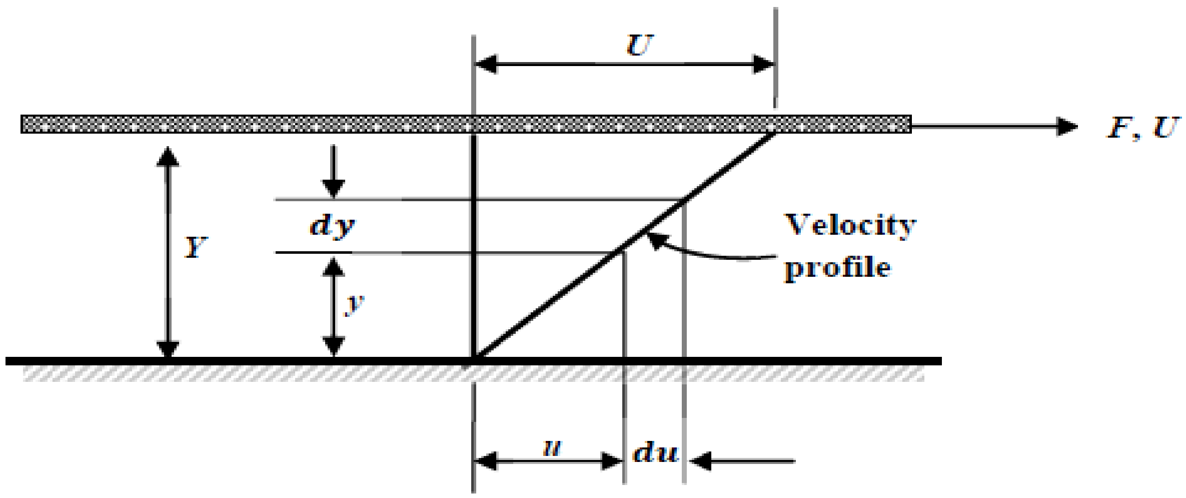


Figure 50: Laminar flow

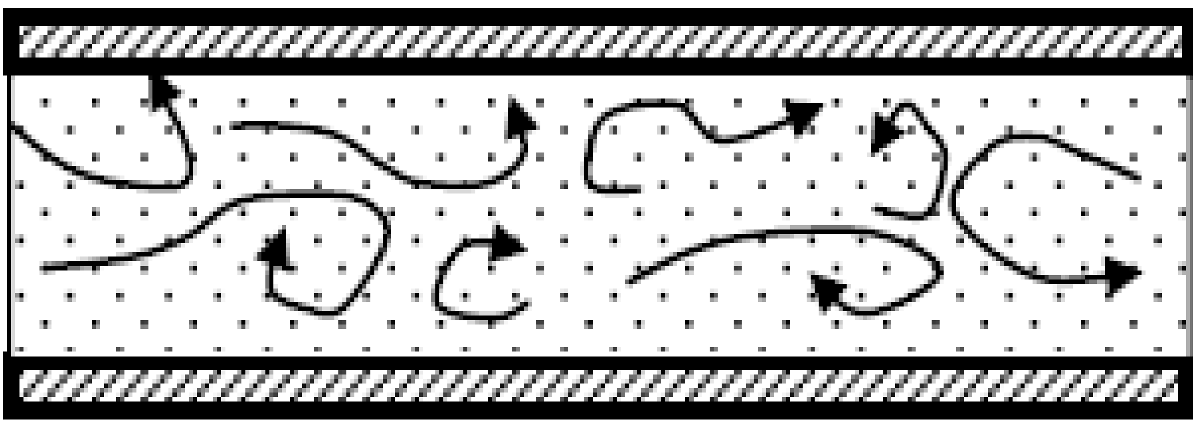


Figure 51: Turbulent flow

2.4.4 Turbulent flow

It is illustrated figure 2.8 It is characterized by a fluid flowing in random way. The movement of particles fluctuates up and down in a direction perpendicular as well as parallel to the mean flow direction. This mixing action generates turbulence due to the colliding fluid particles. This causes a considerably more resistance to flow and thus greater energy losses than those produced by laminar flow. A distinguishing characteristic of turbulence is its irregularity, there being no definite frequency, as in wave motion, and no observable pattern, as in the case of large eddies.

Self-Check -2	Written Test

Write short and precise answers for the following questions and write your answer on the answer sheet provided.

1. What is the use or purpose of hydraulic jump? (2 pts)
2. Define fluid mechanics. (3 pts)
3. Write the components of hydraulic system. (3 pts)
4. Write three differences between open channel flow and pipe flow. (3 pts)
5. Define hydraulic gradient. (3 pts)
6. Write the difference between laminar and turbulent flow (2 pts)
7. Define viscosity. (2 pts)

Note: **Satisfactory rating –** 9 points and above Unsatisfactory **-** below 9 points

You can ask you trainer for the copy of the correct answers.

Score = ____________

Rating: ____________

Name: _________________ ID_______________ Date: _______________

Answer Sheet

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____

3.1 Reynolds Number

In the flow of a fluid through a completely filled conduit, gravity does not affect the flow pattern. It is also obvious that capillarity is of no practical importance, and hence significant forces are inertial force and fluid friction due to viscosity. The same is true for an airplane traveling at speed below that at which compressibility of air is appreciable. Also, for a submarine submerged far enough so as not to produce waves on the surfaces, the only forces involved are those of friction and inertia.

Considering the ratio of inertial forces to viscous forces, the parameter obtained is called the Reynolds number, in honor of Osborne Reynolds, who presented this in a publication of his experimental work in 1882. He conducted a series of experiments to determine the conditions governing the transition from laminar flow to turbulent flow. Reynolds came to a significant conclusion that the nature of the flow depends on the dimensionless parameter, that is,

$$\mathrm{Re} = \frac{vD\rho}{\mu}$$

Where v is the fluid velocity is the inside diameter of the pipe, is the fluid density and is the absolute viscosity of the fluid.

- If Reis less than 2000, the flow is laminar.
- If Reis greater than 4000, the flow is turbulent.
- Reynolds number between 2000 and 4000 covers a critical zone between laminar and turbulent flow.

Energy losses occur in valves and fittings. Various types of fittings, such as bends, couplings, tees, elbows, filters, strainers, etc., are used in hydraulic systems. The nature of path through the valves and fittings determines the amount of energy losses. The more circuitous is the path, the greater are the losses. In many fluid power applications, energy losses due to flow in valves and fittings exceed those due to flow in pipes. Therefore, a proper selection of fitting is essential. In general, the smaller the size of pipe and fittings, the greater the losses.

Example 1

The kinematic viscosity of a hydraulic fluid is 0.0001 m^2/s. If it is flowing in a 30-mm diameter pipe at a velocity of 6 m/s, what is the Reynolds number? Is the flow laminar or turbulent?

Solution: From the definition of Reynolds number, we can write

$$\mathrm{Re} = \frac{vD\rho}{\mu} = \frac{vD}{\mu/\rho} = \frac{vD}{\nu} = \frac{6 \times 0.03}{0.0001} = 1800$$ <COMP: v and nu both being used>

Since Re is less than 2000, the flow is laminar.

3.2 Darcy–Weisbach Equation

If a fluid flows through a length of pipe and pressure is measured at two stations along the pipe, one finds that the pressure decreases in the direction of flow. This pressure decrease is mainly due to the friction of the fluid against the pipe wall. Friction is the main cause of energy losses in fluid power systems. The prediction of this friction loss is one of the important problems in fluid power. It is a very complicated problem and only in special cases, the friction factor is computed analytically.

Head losses in a long pipe in which the velocity distribution has become fully established or uniform along its length can be found by Darcy's equation as

$$H_L = f\left(\frac{L}{D}\right)\left(\frac{v^2}{2g}\right)$$

Where, f is the Darcy friction factor, L is the length of pipe (m), D is the inside diameter of the pipe (m), v is the average velocity (m/s) and g is the acceleration of gravity (m/s^2). The actual dependence of f on has to be determined experimentally. It should be apparent that friction factors determined do not apply near the entrance portion of a pipe where the flow changes fairly quickly from one cross-section to the next or to any other flow in which acceleration terms are not negligible. e R

3.3 Frictional Losses in Laminar Flow

Darcy's equation can be used to find head losses in pipes experiencing laminar flow by noting that for laminar flow, the friction factor equals the constant 64 divided by the Reynolds number:

$$f = \frac{64}{Re}$$

Substituting this into Darcy's equation gives the Hagen–Poiseuille equation:

$$H_L = \frac{64}{Re}\left(\frac{L}{D}\right)\left(\frac{v^2}{2g}\right)$$

Example -2

The kinematic viscosity of a hydraulic fluid is 0.0001 m^2/s. If it is flowing in a 20-mm diameter commercial steel pipe, find the friction factor in each case:

(a) The velocity is 2 m/s.

(b) The velocity is 10 m/s.

Solution:

(a) If the velocity is 2 m/s, then

$$Re = \frac{vD\rho}{\mu} = \frac{vD}{\mu/\rho} = \frac{vD}{\nu} = \frac{2\times 0.02}{0.0001} = 400$$

The flow is laminar. Now

$$f = \frac{64}{Re} = \frac{64}{400} = 0.16$$

(b) If the velocity is 10 m/s, then

$$Re = \frac{vD\rho}{\mu} = \frac{vD}{\mu/\rho} = \frac{vD}{\nu} = \frac{10\times 0.02}{0.0001} = 2000$$

The flow is laminar. Now

$$f = \frac{64}{Re} = \frac{64}{2000} = 0.032$$

Example 3

The kinematic viscosity of a hydraulic fluid is 0.0001 m2/s. If it is flowing in a 30-mm diameter pipe at a velocity of 6 m/s, find the head loss due to friction in units of bars for a 100-m smooth pipe. The oil has a specific gravity of 0.90.

Solution: We have

$$Re = \frac{vD\rho}{\mu} = \frac{vD}{\mu/\rho} = \frac{vD}{\nu} = \frac{6\times 0.03}{0.0001} = 1800$$

We can express the head loss in bar as

$$
\begin{aligned}
H_L &= \frac{64}{\text{Re}}\left(\frac{L}{D}\right)\left(\frac{v^2}{2g}\right) \\
&= \frac{64}{1800}\left(\frac{100}{0.030}\right)\left(\frac{6^2}{2\times 9.81}\right) \\
&= 217.5\ \text{m}
\end{aligned}
$$

Hence,

$$
\begin{aligned}
\Delta p &= \gamma H_L \\
&= 1000\ \text{kg/m}^3 \times 0.90 \times 9.81\ \text{m/s}^2 \times 217.5 \\
&= 1.92\ \text{MN/m}^2 \\
&= 1.92\ \text{MPa} \\
&= 19.2\ \text{bar}
\end{aligned}
$$

3.4 Frictional Losses in Turbulent Flow

Darcy's equation can be used to find head losses in pipes experiencing turbulent flow. However, the friction factor in turbulent flow is a function of Reynolds number and the relative roughness of the pipe.

The relative roughness of pipe is defined as the ratio of inside surface roughness to the diameter:

$$\text{Relative roughness} = \frac{\varepsilon}{D}$$

Table 6: Typical values of absolute roughness for various types of pipe

Type of Pipe	ε (mm)
Glass or plastic	Smooth
Drawn tube	0.0015
Wrought iron	0.046
Commercial steel	0.046
Asphalted cast iron	0.12
Galvanized iron	0.15
Cast iron	0.26
Riveted steel	1.8

3.5 Frictional Losses in Valves and Fittings

For many fluid power applications, the majority of the energy losses occur in valves and fittings in which there is a change in the cross-section of flow path and a change in the direction of the flow. Tests have shown that head losses in valves and fittings are proportional to the square of the velocity of the fluid:

$$H_L = K\left(\frac{v^2}{2g}\right)$$

Where K is called the loss coefficient of valve or fittings. K factors for commonly used valves are given in Table1.2.

Table 7: K factors for commonly used valves

Valve or Fitting		K Factor
Globe valve	Wide open	10
	1/2 open	12.5
Gate valve	Wide open	0.20
	3/4 open	0.90
	1/2 open	4.5
	1/4 open	24
Return bend		2.2
Standard tee		1.8
Standard elbow		0.90
45° elbow		0.42
90° elbow		0.75
Ball check valve		4
Union socket		0.04

For the hydraulic system shown in the below, the following data are given:

(a) A pump adds 2.984 kW to a fluid (pump hydraulic power = 2.984 kW).

(b) The elevation difference between stations 1 and 2 is 6.096 m.

(c) The pump flow rate is 0.00158m^3/s.

(d) The specific gravity of oil is 0.9.

(e) The kinematic viscosity of oil is 75 cS.

(f) The pipe diameter is 19.05 mm.

(g) Pipe lengths are as follows: 0.305, 1.22 and 4.88 m.

Find the pressure available at the inlet to the hydraulic motor. The pressure at the oil top surface level in the hydraulic tank is atmospheric (0 Pa gauge).

Self-Check -3	Written Test

Part I: True or False (1 Point each)

Directions: Write True if the statement is correct and False if the statement is incorrect and write your answer on the answer sheet provided. (2 pts each)

---------1. Reynolds number is the ratio of viscous forces to inertial force.

---------2. In the flow of a fluid through a completely filled conduit, gravity affects the flow pattern.

--------3. Friction is the main cause of energy losses in fluid power systems.

--------4. In the flow of a real fluid, the velocity adjacent to the wall is maximum.

--------5. A distinguishing characteristic of turbulence is its irregularity, no definite and no observable pattern.

Note: **Satisfactory rating –** 6 points and above **Unsatisfactory -** below 6 points

You can ask you trainer for the copy of the correct answers.

Score = ___________

Rating: ____________

Name: _________________ ID___________ Date: ____________

Answer Sheet

1. _________
2. _________
3. _________
4. _________
5. _________

4.1 Introduction

In order to harness the water potential of a river optimally, it is necessary to construct two types of hydraulic structures, as shown in Figure 52. These are:

- Storage structure, usually a dam, which acts like a reservoir for storing excess runoff of a river during periods of high flows (as during the monsoons) and releasing it according to a regulated schedule.
- Diversion structure, which may be a weir or a barrage that raises the water level of the river slightly, not for creating storage, but for allowing the water to get diverted through a canal situated at one or either of its banks. Since a diversion structure does not have enough storage, it is called a run-of-the river scheme. The diverted water passed through the canal may be used for irrigation, industry, domestic water needs or power generation.

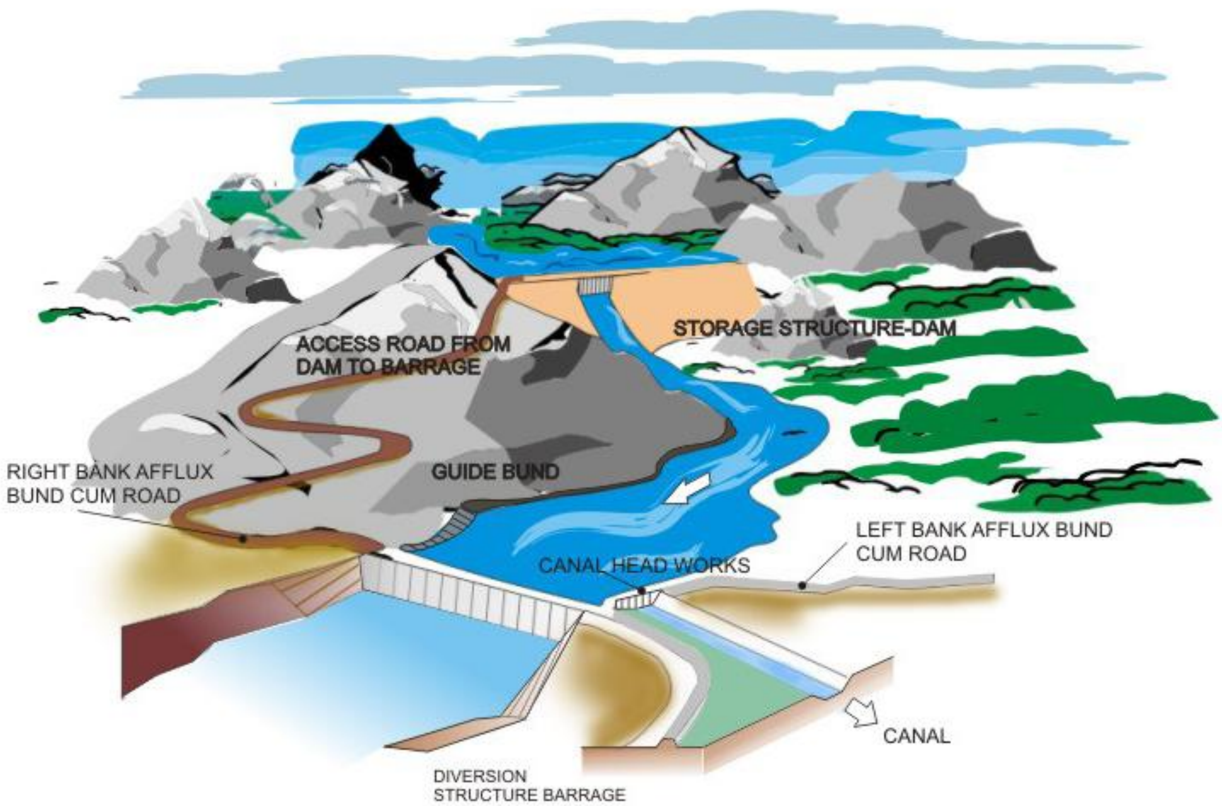


Figure 52: Structures for harnessing water resource potential of river

4.2 Steps for planning, layout, design, construction and operation of barrages

it is essential for the successful working of a barrage, or any hydraulic structure for that matter, depends on a proper selection of the location, alignment, layout, design and operation of the structure. Hence, the following aspects have to be carefully looked in to, which have been discussed in detail in the subsequent sections of this lesson:

- Site investigation and data collection
- Location and alignment selection of the barrage axis
- Planning, layout of the barrage and its appurtenant structures
- Hydraulic designs
- Structural designs
- River training works associated with barrages
- Head regulator for canal intake
- Instrumentation
- Construction
- Maintenance and operations.

4.3 Measuring Flow

Flow is the total volume of a fluid that flows past a fixed point in a river or stream over time. It is comparable to the speed at which a volume of fluid travels as seen in Figure One. Flow can be found for pipes, sewage systems, and household appliances. People use flow data for Micro hydro systems, waste-water information, settling rates, water table statistics, etc. Volumetric flow rates can be measured in various units such as:

- liters/sec (lps)
- cubic feet/sec (cfs)
- gallons/min (gpm)
- cubic meters/sec (cms)

There are numerous ways to measure flow rate which include:

- Bucket method
- Float method
- Weirs

- Current Meters

4.3.1 Bucket method

The Bucket method is a simple way to measure the flow rate using household items. It requires a stopwatch, a large bucket, and preferably two to three people. To measure the flow rate using the bucket method: Measure the volume of the bucket or container. Keep in mind that a typical 5-gallon bucket is often actually less than 5 gallons.

Find a location along the stream that has a waterfall. If none can be found, a waterfall can be constructed using a weir (see Figure Four). With a stopwatch, time how long it takes the waterfall to fill the bucket with water. Start the stopwatch simultaneously with the start of the bucket being filled and stop the stopwatch when the bucket fills. The bucket should not be filled by holding it below the surface of the stream because it is not the true flow rate.

Figure 53: an example of the Bucket Method

Record the time it takes to fill the bucket. Repeat steps two and three about six or seven times and take the average. It is a good idea to do a few trial runs before recording any data so that one can get a feel for the timing and measurements required. Only eliminate data if major problems arise such as debris from the stream interfering with the flow.

The flow rate is the volume of the bucket divided by the average time it took to fill the bucket.

Table 8: Bucket methods data for flow

Bucket Method Data for Flow

Trial Number	Time (seconds)	Bucket Volume (gallons)
1	13.2	5
2	14	5
3	14.5	5
4	13	5
5	13.4	5
6	13.1	5

$$Q = v/t$$

where $t = (13.2 + 14 + 14.5 + 13 + 13.4 + 13.1) sec/6 trials$

so t=13.5 seconds

and V=5 gallons

$$Q = 5 gallons/13.5 seconds$$

The flow rate Q= 0.37 gallons per second

or 22.2 gallons per minute

Here is an example using data found for the flow rate of the Jolly Giant Creek on Humboldt State University grounds: Using this data, the volumetric flow rate (Q) is equal to the volume of the bucket (V) divided by the average time (t).

where so t=13.5 seconds and V=5 gallons

The flow rate Q= 0.37 gallons per second

or 22.2 gallons per minute

4.3.2 Float method

The float method (also known as the cross-sectional method) is used to measure the flow rate for larger streams and rivers. It is found by multiplying a cross sectional area of the stream by the velocity of the water. To measure the flow rate using the float method:

Locate a spot in the stream that will act as the cross section of the stream. Using a meter stick, or some other means of measurement, measure the depth of the stream at equal intervals along the width of the stream (see Figure Three). Once this data is gathered, multiply each depth by the interval it was taken in and add all the amounts together. This calculation is the area of a cross section of the stream.

Decide on a length of the stream, typically longer than the width of the river, to send a floating object down (oranges work great).

Figure 54: finding the flow rate using a float and a meter stick.

4.3.3 Weirs

Weirs are small dams that can be used in measuring flow rate for small to medium sized streams (a few meters or wider). They allow overflow of the stream to pour over the top of the weir, creating a waterfall, as seen in Figure Four. Weirs increase the change in elevation making the stream flow more consistent which makes flow rate measurements more precise. However, it is very important that all the water in the stream be directed into the weir for it to accurately represent the stream flow. It is also important to keep sediment from building up behind the weir. Sharp crested weirs work best. There are many different types of weirs which include broad crested weirs, sharp crested weirs, combination weirs, V-notch weirs and minimum energy loss weirs.

Figure 55: An example of a V-notch weir

4.3.4 Meters

Meters are devices that measure the stream flow by directly measuring the current. There are many different types of meters by the most common is the Pygmy meter, the vortex meter, the flow probe, and the current meter: They are briefly described. Pygmy meter: a wheel is rotated by water flow and the rate of the rotation signifies the water velocity. It is primarily used in measuring discharge.

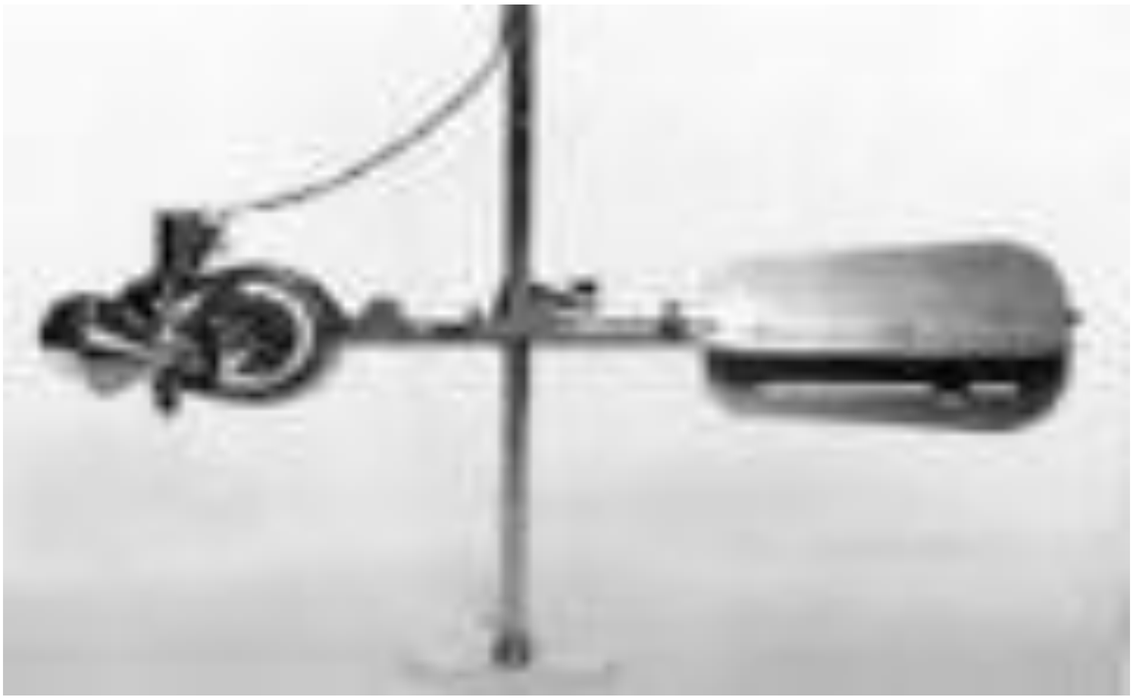


Figure 56: Current meter used for measuring flow

Self-Check -4	Written Test

Instructions: Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers. Write your answers in the sheet provided in the next page.

1. What are numerous ways to measure flow rate? (2pts)
2. How can you measure the flow rate by floating methods? (2 pts)
3. Write the types of flow rate measuring meters. (2 pts)
4. How can you measure the flow rate by bucket? (3 pts)
5. How can you measure the flow rate by weirs? (3 pts)

Note: **Satisfactory rating –** 6 points and above **Unsatisfactory -** below 6 points

You can ask you trainer for the copy of the correct answers.

Score = ___________

Rating: ____________

Answer Sheet

Name: ______________ ID___________ Date: ____________

1. ____
2. ____
3. ____
4. ____
5. ____

Operation Sheet 1	Apply Scientific Principles and Calculation

Using the information provided at exerice-1 apply scientific principles to measure the flow of water and manipulation.

Step 1: identify given information

Step 2: Calculate Velocity head at point 2

Step 3: Use Darcy Equation

Step 4: Apply Bernoulli theorem

Step 5: Solve for p2

LAP Test	**Practical Demonstration**

Name: _______________________________ Date: _________________

Time started: __________________________ Time finished: _________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 7 hours.

Task 1. Apply scientific principles

Instruction Sheet	arning Guide – 56: Investigate safe and effective operations of irrigation and drain water system model

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

- Potential risks to health due to inappropriate water systems
- Discussing with users about water system.
- Discussing with users about impact of irrigation and drain water
- Ways to use water wisely and dispose of wastewater safely
- Systems and equipment used in the workplace
- instructions, processes and precautions for water use
- Work procedures
- Typical problems in the workplace and actions and solutions
- Basic principles of teamwork in the workplace

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 –

- Determine and discuss Potential risks to health of inappropriately installed, managed or used water systems.
- Explain and discuss Wise use of water and conserve with the users.
- Explain the efficiency and environmental impact of irrigation and drain water management with the users

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3, Sheet 4 and Sheet 5” in page 76, 81, 84, 89 and 97 respectively.
4. Accomplish the “Self-check 1, Self-check 2, Self-check 3, Self-check 4 and Self- check 5” -” in page 80, 83, 88, 96 and 104 respectively
5. If you accomplish the self-checks, do operation sheet in page 105
6. LAP Test in page 106

1.1 Introduction

Irrigation water quality can affect food safety and health and has been identified as a possible source of pathogens in produce linked to disease outbreaks. Much irrigation water sources are subject to contamination from various sources in surrounding watersheds. A systems-based, watershed scale analysis is therefore necessary to comprehensively identify both sources of contamination and the conditions in the environment that facilitated or created that contamination, termed here ‘environmental antecedents.

1.2 Major irrigation activities affected the quality of water

Agricultural irrigation with wastewater is known to occur in many parts of the world, although the extent of the practice is a debatable point. A recent estimate is that worldwide 20 million ha of irrigated agriculture uses raw, treated, and/or partially diluted wastewater. One of the most economically feasible agricultural uses of reclaimed water is the irrigation of high-value horticultural crops, which typically have high returns per volume of water invested in. But this practice has been approached with trepidation, owing primarily to concerns about risks to human health via contamination of food with pathogenic microorganisms. It has been impossible to either allay or justify such concerns through traditional hypothesis testing science: infection rates are so low that the sample sizes needed for adequate statistical power render such studies impracticable. A more pragmatic approach, which has been gaining favor in recent years, is the application of probabilistic models. In the microbiological/human health context this methodology is referred to as quantitative microbial risk assessment (QMRA). It is a powerful tool for estimating order-of-magnitude risks associated with specific scenarios.

The risk of illness to consumers of vegetables irrigated with reclaimed water may be reduced to a negligibly small probability through the implementation of high-technology tertiary treatments and disinfection systems, such as activated carbon, reverse osmosis, membrane filtration, chlorination, ozonation, and UV radiation. However, such systems are often prohibitively expensive, particularly in developing nations, where only about 10% of wastewater undergoes treatment of any kind. Even in affluent nations, treatment costs are a key consideration in scheme development. An important first step in addressing the safety of horticultural reuse is to determine likely risks associated with a simple worst-case scenario: consumption of raw (uncooked and unpeeled) vegetables irrigated with no disinfected secondary treated effluent.

A sound understanding of such risks not only will be of significant value in managing low-technology reuse schemes but will form the basis of risk assessments for advanced reuse proposals.

QMRA models have been constructed for reclaimed-water irrigation of cucumber, lettuce, and food crops in general. Here, the first published QMRA models for enteric virus infection associated with the consumption of raw broccoli and cabbage irrigated with no disinfected secondary effluent are presented. Necessary data on the volume of irrigation water captured by these crops were lacking. Consequently, a field experiment was conducted to address this gap. We also present improved models for cucumber and lettuce. These suites of models represent the first variety-specific QMRAs to accommodate for variability in consumption behavior. To maximize the value of the models for decision making, a wide range of plausible scenarios were simulated. Problem with poor quality water are:

- Salinity from the water and soil
- Soil permeability
- Toxicity
- Physiological effect
- Nutritional effect
- Soil microbes
- And other Miscellaneous effect

Figure 58: Effect of runoff on water quality and human health

Figure59: Case and effect of poor water quality on human health

The model variables having the greatest impact on the risk of infection were identified using sensitivity analysis by asks the following questions.

- **Do you apply the right amount of water at the right time?** The first step in good irrigation management is to apply the right amount of water at the right time. Applying too much water is costly and increases runoff or leaching. Applying too little water reduces crop yields. Applying water at the wrong time can cause all three of these problems. You should develop an irrigation schedule based on four factors:

- ✓ soil moisture conditions and water-holding capacity
- ✓ plant needs
- ✓ weather conditions
- ✓ Water application rates.

- **Is your irrigation system well designed?** A poorly designed system can result in excessive or insufficient water application. Some signs of a poorly designed irrigation system are
    - ✓ uneven crop growth or color
    - ✓ runoff of irrigation water
    - ✓ surface pounding of water

  To avoid distributing water in uneven patterns, have your irrigation system professionally evaluated for efficiency and uniformity. For example, to surface-irrigate uniformly, water should be applied to the field surface for an approximately equal amount of time at all points. In a furrow irrigation system, water should advance from the top of the field to the end of the field in about ¼ of the total irrigation time set. For overhead irrigation systems, pressure and nozzle uniformity should be checked during regular maintenance (for more information on irrigation system efficiency). Consider using drip irrigation or a similar system that allows you to apply water only to the plant rooting zone. However, drip irrigation systems can be costly to establish and are not appropriate for all crops.
- **What is the action plan?** Now that you have assessed your management practices, you can take action to change practices that may be causing water pollution. For areas that you identified as high or moderate risk, decide what action you need to take and fill out the action Plan below.

Self-Check 1	Written Test

Directions: Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

1. What are the four base factors to develop an irrigation schedule? (5 pts)
2. What are the signs of a poorly designed irrigation system? (4 pts)
3. How can you avoid distributing water in uneven patterns? (6 pts)
4. What are the most problems come with pure quality of water? (5 pts)

Note: Satisfactory rating – 10 points Unsatisfactory - below 10 points

You can ask you teacher for the copy of the correct answers.

Score = ___________

Rating: ____________

Answer Sheet

Name: _________________________ ID: _________ Date: ______________

Short Answer Questions

1. ____

____

2. ____

____

3. ____

____

4. ____

____

____

2.1 Wise use of water

Water-wise landscaping focuses on working with nature and natural forces, such as rainfall, to create a pleasant, healthy landscape, while using less water from the local supply. Minimizing the need for watering in your landscape requires careful planning and common sense. Several principles for water-wise landscaping include choosing the best design and plants, preparing soils, planting properly and watering properly for efficient water use. We can discuss with the user by ask the following question

2.2 Wise watering on the farm

Wise Watering aims to assist irrigated enterprises to:

- Improve on-farm productivity and water use efficiency;
- Improve on-farm water management;
- Improve the profitability of irrigation; and
- Adopt practices which sustain land and water resources on- and off-farm

2.3 Improve Irrigation Management

There are many reasons why we have to think seriously about how we use water to produce our crops and earn a living. Some of these are the increasing competition for water, the increasing cost of water and recent changes in the allocation and use of water. Other reasons for improved irrigation and drainage management include:

- Improve your production per mega liter.
- Improved water use will grow better crops by giving them optimum soil moisture levels and reducing crop exposure to periods of water logging and drought.
- Reduce the cost of production.
- Improve our water use efficiency through applying the right amount of water at the right time. Improved water use efficiency means reducing the amount of water which is not used by the crop, minimizing system losses and reducing unnecessary pumping which all help to reduce the cost of producing a crop.
- Reduce pests and diseases: - Healthier crops and increased crop productivity all add up to more dollars in our pockets. Maintaining optimum soil moisture

will aid crop performance and fewer problems with maintaining the health of our crops. You may end up with surplus irrigation water. If we improve our irrigation efficiency it may provide us with surplus irrigation water which can be used for further cropping or provide an income through sale or lease of surplus water needs. This means more dollars.

- Reduce impacts on the environment; -Because we rely on water, we must safeguard it from deteriorating in quality. Reducing excess irrigation minimizes water logging, soil salinity, leaching of nutrients and chemicals, and the amount of saline groundwater seepage into our rivers and streams.
- Ensuring the long-term survival of our industry: - Improved irrigation management practices are the key to our long-term survival as an irrigation industry because the health of our rivers and land depends on best irrigation management practices.
- Get the Facts about Irrigation: - Check to make sure your system is working properly. Simple changes to your sprinkler system can save a lot of water and improve your landscape's health and appearance! Moving just one sprinkler head or changing a single nozzle could significantly reduce the amount of water you use and keep your landscape beautiful.

Self Check2	Written test

Directions: Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

1. What is the most important question to discuss with the water users about wise use of water? (5 pts)
2. What are the aims of Wise use of water to assist irrigated enterprises? (4 pts)
3. What are the reasons for improved irrigation and drainage management? (6 pts)
4. How to solve the problem of pure quality of water? (5 pts)

Note: Satisfactory rating – 10 points Unsatisfactory - below 10 points

You can ask you teacher for the copy of the correct answers.

Score = ___________

Rating: ____________

Name: _________________ID: ____________ Date: _________________

Short Answer Questions

1____

2____

3____

4. ____

3.1 Efficiency and environmental impact

The aim of irrigation is to provide a pasture or crop with the amount of water it requires for optimal growth. The efficiency of your irrigation depends on a number of factors that include:

- type of irrigation system
- application rate
- scheduling and
- the presence of a recycling system.

Irrigation efficiency can be greatly improved in most situations. Some changes will produce a large and direct improvement, while others rely on a series of indirect changes to produce a positive response. Three key areas aimed at improving irrigation efficiency are addressed in this document. These are

- Irrigation system design
- Improving irrigation efficiency and
- Irrigation scheduling.

The cost of implementing efficient water use will vary according to individual farm designs and component costs. The presentation of case studies provides a meaningful assessment of what others have done and what it cost them. Environmental impacts of irrigation are the changes in quantity and quality of soil and water as a result of irrigation and the ensuing effects on natural and social conditions at the tail-end and downstream of the irrigation scheme. The impacts stem from the changed hydrological conditions owing to the installation and operation of the scheme. An irrigation scheme often draws water from the river and distributes it over the irrigated area. As a hydrological result it is found that:

- the downstream river discharge is reduced
- the evaporation in the scheme is increased
- the groundwater recharge in the scheme is increased
- the level of the water table rises
- the drainage flow is increased

These may be called direct effects. The effects there for on soil and water quality are indirect and complex, water logging and soil salinity are part of these, whereas the subsequent impacts on natural, ecological and socio-economic conditions is very intricate. Irrigation can also be done extracting groundwater by (tube) wells. As a hydrological result it is found that the level of the water descends. The effects may be water mining, land/soil subsidence, and, along the coast, saltwater intrusion. Irrigation projects can have large benefits, but the negative side effects are often overlooked. The lower the irrigation efficiency, the higher are the losses. Although fairly high irrigation efficiencies of 70% or more (i.e. losses of 30% or less) can be obtained with sophisticated techniques like sprinkler irrigation and drip irrigation, or by precision land leveling for surface irrigation, in practice the losses are commonly in the order of 40 to 60%.The effects of irrigation on water table, soil salinity and salinity of drainage and groundwater, and the effects of mitigation measures can be simulated and predicted using agro-hydro-salinity models.

Figure 60: Effect of irrigation on the environment

3.2 Irrigated Agriculture: Sources of Environmental Impact

The benefits of irrigation have resulted in lower food prices, higher employment and more rapid agricultural and economic development. The spread of irrigation has been a key factor behind the near tripling of global grain production since 1950. But irrigation and water resource development can also cause social and environmental problems. Irrigation represents an alteration of the natural conditions of the landscape by extracting water from an available source, adding water to fields where there was none or little before, and introducing man-made structures and features to extract, transfer and dispose of water. Irrigation projects and irrigated agriculture practices can impact the environment in a variety of ways. For this review we will distinguish the following sources of environmental impact:

- Construction of irrigation projects,
- Water supply and operation of irrigation projects, and
- Irrigated agriculture management practices.

The development of irrigation projects results in an alteration of the current condition of the landscape. Depending on the nature of the projects, many questions regarding environmental impact may arise. A few examples follow.

- What is the social impact of relocating inhabitants of a given area to accommodate a new irrigation project?
- What is the impact of the new project on wildlife, particularly endangered species, and on archeological patrimony?
- What is the impact of infrastructure associated with the construction and operation of the project (roads, power lines, canals, etc)?
- Will reclaimed and/or recycled construction materials be used, including aggregate, rebar, lumber, and asphalt?
- Will construction materials used be reclaimed and reused in future projects rather than being disposed of?
- o Are there alternative materials available to reduce hazardous and toxic materials use during construction?
- Does the construction plan provide for erosion and sediment control, does it minimize the disturbance of vegetation and soil, and does it include revegetation of disturbed areas?
- Does the project use existing structures to the extent possible and avoid sensitive habitats?

- Will seepage be minimized or eliminated by selecting canal and ditch materials that prevent Seepage?

Environmental impact derived from the water supply and the operation of irrigation projects. Irrigated agriculture depends on supplies from surface or ground water. The environmental impact of irrigation systems depends on the nature of the water source, the quality of the water, and how water is delivered to the irrigated land. Withdrawing ground-water may cause the land to subside, aquifers to become saline, or may accelerate other types of ground-water pollution. Withdrawing surface water implies changes to the natural hydrology of rivers and water streams, changes to water temperature, and other alterations to the natural conditions, sometimes deeply affecting the aquatic ecosystems associated with these water bodies.

Self Check3	Written test

Directions: Choose the best answer for the following question and encircle the answer (2ptseach)

1. The efficiency of irrigation affected by the following factors except?
   A. Type of irrigation system
   B. Application rate
   C. Scheduling and
   D. The presence of a recycling system
   E. None of the above
2. Which one of the following is case of environmental impact?
   A. Construction of irrigation projects,
   B. Water supply and operation of irrigation projects
   C. Irrigated agriculture management practices.
   D. All
3. One of the following is the result of poor irrigation system and impacted environment?
   A. the downstream river discharge is reduced
   B. the evaporation in the scheme is increased
   C. the groundwater recharge in the scheme is increased
   D. the drainage flow is increased
   E. all of the above

Answer Sheet

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

Note: **Satisfactory rating - 10 points** **Unsatisfactory - below 10 points**

4.1 Irrigation and drain water management

Operate the irrigation system so that the timing and amount of irrigation water applied match crop water needs. This will require, as a minimum:

- The accurate measurement of soil-water depletion volume and the volume of irrigation water applied, and
- Uniform application of water. When chemigation is used, include backflow preventers for wells; minimize the harmful amounts of chemigated waters that discharge from the edge of the field, and control deep percolation. In cases where chemigation is performed with furrow irrigation systems, a tail water management system may be needed.

The following limitations and special conditions apply:

- In some locations, irrigation return flows are subject to other water rights or are required to maintain stream flow. In these special cases, on-site reuse could be precluded and would not be considered part of the management measure for such locations. By increasing the water use efficiency, the discharge volume from the system will usually be reduced. While the total pollutant load may be reduced somewhat, there is the potential for an increase in the concentration of pollutants in the discharge. In these special cases, where living resources or human health may be adversely affected and where other management measures (nutrients and pesticides) do not reduce concentrations in the discharge, increasing water use efficiency would not be considered part of the management measure. In some irrigation districts, the time interval between the order for and the delivery of irrigation water to the farm may limit the irrigator's ability to achieve the maximum on-farm application efficiencies that are otherwise possible.
- In some locations, leaching is necessary to control salt in the soil profile. Leaching for salt control should be limited to the leaching requirement for the root zone. Where leakage from delivery systems or return flows supports wetlands or wildlife refuges, it may be preferable to modify the system to achieve a high level of efficiency and then divert the "saved water" to the wetland or wildlife refuge. This will improve the quality of water delivered to

wetlands or wildlife refuges by preventing the introduction of pollutants from irrigated lands to such diverted water.

- In some locations, sprinkler irrigation is used for frost or freeze protection, or for crop cooling. In these special cases, applications should be limited to the amount necessary for crop protection, and applied water should remain on-site by the following factors.

Return flows, runoff, and leachate from irrigated lands may transport the following types of pollutants:

- Sediment and particulate organic solids;
- Particulate-bound nutrients, chemicals, and metals, such as phosphorus, organic nitrogen, a portion of applied pesticides, and a portion of the metals applied with some organic wastes;
- Soluble nutrients, such as nitrogen, soluble phosphorus, a portion of the applied pesticides, soluble metals, salts, and many other major and minor nutrients; and
- Bacteria, viruses, and other microorganisms.

Transport of irrigation water from the source of supply to the irrigated field via open canals and laterals can be a source of water loss if the canals and laterals are not lined. Water is also transported through the lower ends of canals and laterals because of the flow-through requirements to maintain water levels in them. In many soils, unlined canals and laterals lose water via seepage in bottom and side walls.

Seepage water either moves into the ground water through infiltration or forms wet areas near the canal or lateral. This water will carry with it any soluble pollutants in the soil, thereby creating the potential for pollution of ground or surface water. Since irrigation is a consumptive use of water, any pollutants in the source waters that are not consumed by the crop (e.g., salts, pesticides, nutrients) can be concentrated in the soil, concentrated in the leach ate or seepage, or concentrated in the runoff or return flow from the system. Salts that concentrate in the soil profile must be removed for sustained crop production.

Application of this management measure will reduce the waste of irrigation water, improve the water use efficiency, and reduce the total pollutant discharge from an irrigation system.

Irrigation scheduling is the use of water management strategies to prevent over-application of water while minimizing yield loss due to water shortage or drought stress (Evans et al., 1991d). Irrigation scheduling will ensure that water is applied to the crop when needed and in the amount needed. Effective scheduling requires knowledge of the following factors:

- Soil properties;
- Soil-water relationships and status;
- Type of crop and its sensitivity to drought stress;
- The stage of crop development;
- The status of crop stress;
- The potential yield reduction if the crop remains in a stressed condition;
- Availability of a water supply; and
- Climatic factors such as rainfall and temperature.

Much of the above information can be found in Soil Conservation Service soil surveys and Extension Service literature. However, all information should be site-specific and verified in the field. There are three ways to determine when irrigation is needed:

- Measuring soil water;
- Estimating soil water using an accounting approach; and
- Measuring crop stress.

4.2 Systems and equipment used in the workplace

Soil water can be measured using a range of devices, including

- Tensiometers: - which measure soil water suction;
- Electrical resistance blocks (also called gypsum blocks or moisture blocks):- which measure electrical resistance that is related to soil water by a calibration curve;
- Neutron probes: - which directly measure soil water;
- Phene cells: - which are used to estimate soil water based on the relationship of heat conductance to soil water content;

- Wetting front detectors (WFD):- which used to indicate the amount of water applied in the field and
- Time domain reflectometers (TDR):- which can be used to estimate soil water based on the time it takes for an electromagnetic pulse to pass through the soil. The appropriate device for any given situation is a function of the acreage of irrigated land, soils, cost, and other site-specific factors.

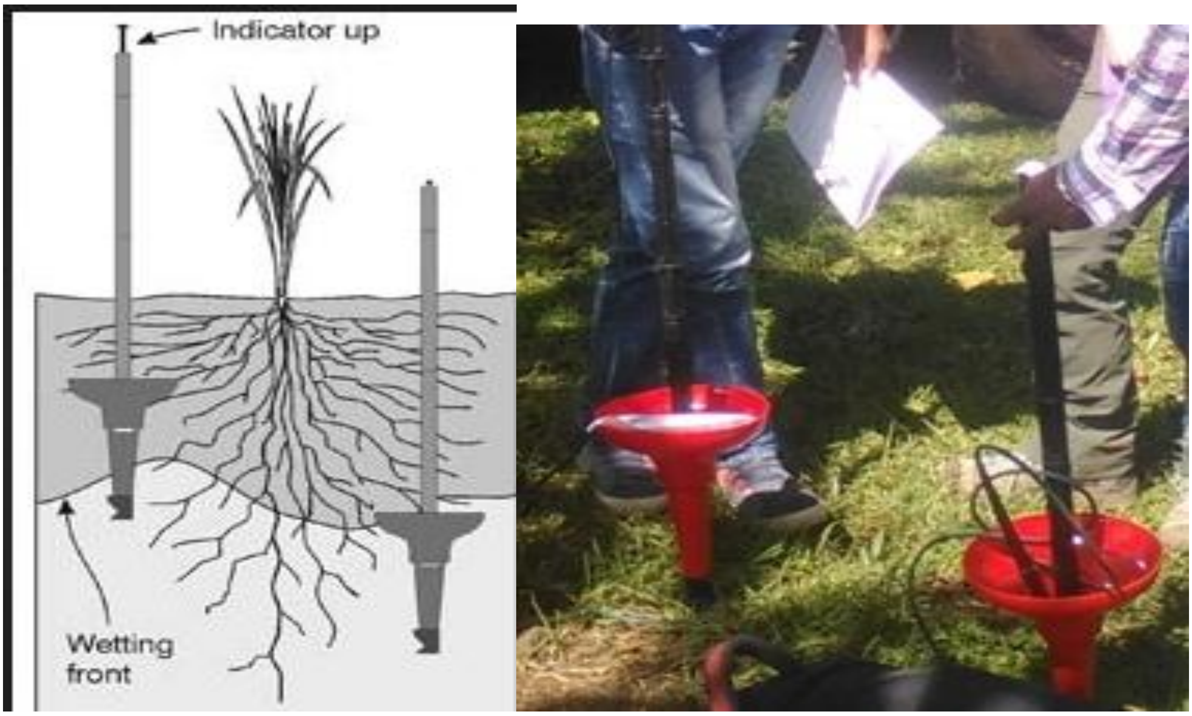


Figure61: WFD (wetting front detector)

Figure 62: TDR (time domain reflectometry) instruments

Figure 63: Electrical resistance blocks

The quantity of water applied can be measured by such devices as a totalizing flow meter that is installed in the delivery pipe. If water is supplied by ditch or canal, weirs or flumes in the ditch can be used to measure the rate of flow.

Deep percolation can be greatly reduced by limiting the amount of applied water to the amount that can be stored in the plant root zone. The deep percolation that is necessary for salt management can be accomplished with a sprinkler system by using longer sets or very slow pivot speeds or by applying water during the non-growing season.

Overall, five basic aspects of the irrigation system can be addressed:

- Irrigation scheduling;
- Efficient application of irrigation water;
- Efficient transport of irrigation water;
- Use of runoff or tail water; and
- Management of drainage water.

This management measure addresses irrigation scheduling, efficient application and the control of tail water when chemigation is used. The efficient transport of irrigation water, the use of runoff or tail water, and the management of drainage water are additional considerations.

Surface irrigation systems are usually designed to have a percentage (up to 30 percent) of the applied water lost as tail water. This tail water should be managed with a tail water recovery system, but such a system is not required as a component of this management measure unless chemigation is practiced. Tail water recovery systems usually include a system of ditches or berms to direct water from the end of the field to a small storage structure. Tail water is stored until it can be either pumped back to the head end of the field and reused or delivered to additional irrigated land. In some locations, there may be downstream water rights that are dependent upon tail water, or tail water may be used to maintain flow in streams.

These requirements may take legal precedence over the reuse of tail water.

Well-designed and managed irrigation systems remove runoff and leach ate efficiently; control deep percolation; and minimize erosion from applied water, thereby reducing adverse impacts on surface water and ground water. If a tail water recovery system is used, it should be designed to allow storm runoff to flow through the system without damage. Additional surface drainage structures such as filter strips, field drainage ditches, subsurface drains, and water table control may also be used to control runoff and leach ate if site conditions warrant their use.

Self-Check 4	Written Test

Directions: **Choose the best answer for the following question and encircle the answer** (2ptseach)

1. one of the following is an Effective scheduling requires knowledge factors:
   A. Soil properties;
   B. Soil-water relationships and status;
   C. Type of crop and its sensitivity to drought stress;
   D. The stage of crop development;
   E. The status of crop stress;
   F. All of the above.
2. a good irrigation system can be addressed the following points except:
   A. Irrigation scheduling;
   B. Efficient application of irrigation water;
   C. Efficient transport of irrigation water;
   D. Use of runoff or tail water;
   E. Management of drainage water.
   F. none of the above
3. One of the following is the result of poor irrigation water?
   A. Water contains Sediment and particulate organic solids;
   B. Water contains Particulate-bound nutrients, chemicals, and metals,
   C. Water contains Soluble nutrients, such pesticides, soluble salts, and many other major and minor nutrients; and
   D. Water contains Bacteria, viruses, and other microorganisms.
   E. all of the above

***Note:* Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Score = ___________

Rating: ____________

Name: _________________ ID: _______________ Date: _________________

5.1 Typical problems in the workplace and actions and solutions

The available information shows that irrigation efficiencies can be improved with scheduling that is based on knowledge of water needs and measurement of applied water. Improved irrigation efficiency can result in the reduction or elimination of runoff and return flows, as well as the control of deep percolation. Secondly, backflow preventers can be used to protect wells from chemicals used in chemigation. In addition, tail water prevention, or tail water management where necessary, is effective in reducing the discharge of soluble and particulate pollutants to receiving waters.

By reducing the volume of water applied to agricultural lands, pollutant loads are also reduced. Less interaction between irrigation water and agricultural land will generally result in less pollutant transport from the land and less leaching of pollutants to ground water. We have considered the following data to solve these problems.

Effectiveness Information: - Following is information on pollution reductions that can be expected from installation of the management practices outlined within this management measure. In a review of a wide range of agricultural control practices, determined that increased use of call periods, on-demand water ordering, irrigation scheduling, and flow measurement and control would all result in decreased losses of salts, sediment, and nutrients. Various alterations to existing furrow irrigation systems were also determined to be beneficial to water quality, as were tail water management and seepage control.

Properly designed sprinkler irrigation systems will have little runoff. Furrow irrigation and border check or border strip irrigation systems typically produce tail water, and tail water recovery systems may be needed to manage tail water losses. Tail water can be managed by applying the water to additional fields, by treating and releasing the tail water, or by reapplying the tail water to upslope cropland.

Irrigation Scheduling Practices: - Proper irrigation scheduling is a key element in irrigation water management. Irrigation scheduling should be based on knowing the daily water use of the crop, the water-holding capacity of the soil, and the lower limit of soil moisture for each crop and soil, and measuring the amount of water applied to the field. Also, natural precipitation should be considered and adjustments made in the scheduled irrigations.

Practices that may be used to accomplish proper irrigation scheduling are:

- **Irrigation water management:** - Determining and controlling the rate, amount, and timing of irrigation water in a planned and efficient manner.
  Management of the irrigation system should provide the control needed to minimize losses of water, and yields of sediment and sediment attached and dissolved substances, such as plant nutrients and herbicides, from the system. Poor management may allow the loss of dissolved substances from the irrigation system to surface or ground water. Good management may reduce saline percolation from geologic origins. Returns to the surface water system would increase downstream water temperature.

- **Water-measuring device: -** An irrigation water meter, flume, weir, or other water-measuring device installed in a pipeline or ditch.
  The measuring device must be installed between the point of diversion and water distribution system used on the field. The device should provide a means to measure the rate of flow. Total water volume used may then be calculated using rate of flow and time, or read directly, if a totalizing meter is used.
- **Soil and crop water use data: -** From soils information the available water-holding capacity of the soil can be determined along with the amount of water that the plant can extract from the soil before additional irrigation is needed.

Poor management may cause pollution of surface and ground water. Pesticide drift from chemigation may also be hazardous to vegetation, animals, and surface water resources. Appropriate safety equipment, operation and maintenance of the system is needed with chemigation to prevent accidental environmental pollution or backflows to water sources.

Practices for Efficient Irrigation Water Transport: - Irrigation water transportation systems that move water from the source of supply to the irrigation system should be designed and managed in a manner that minimizes evaporation, seepage, and flow-through water losses from canals and ditches. Delivery and timing need to be flexible enough to meet varying plant water needs throughout the growing season.

Transporting irrigation water from the source of supply to the field irrigation system can be a significant source of water loss and cause of degradation of both surface water and ground water. Losses during transmission include seepage from canals and ditches, evaporation from canals and ditches, and flow-through water. The primary water quality concern is the development of saline seeps below the canals and ditches and the discharge of saline waters. Another water quality concern is the potential for erosion caused by the discharge of flow-through water.

Practices for Drainage Water Management: - Drainage water from an irrigation system should be managed to reduce deep percolation, move tail water to the reuse system, reduce erosion, and help control adverse impacts on surface water and groundwater. A total drainage system should be an integral part of the planning and design of an efficient irrigation system. This may not be necessary for those soils that have sufficient natural drainage abilities. There are several practices to accomplish this:

- Filter strip: A strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and waste water.
- Surface drainage field ditch: A graded ditch for collecting excess water in a field. From erosive fields, this practice may increase the yields of sediment and sediment-attached substances to downstream water courses because of an increase in runoff. In other fields, the location of the ditches may cause a reduction in sheet and rill erosion and ephemeral gully erosion.
- Subsurface drain: A conduit, such as corrugated plastic tile, or pipe, installed beneath the ground surface to collect and/or convey drainage water.
- Water table control: Water table control through proper use of subsurface drains, water control structures, and water conveyance facilities for the efficient removal of drainage water and distribution of irrigation water.
- Controlled drainage: Control of surface and subsurface water through use of drainage facilities and water control structures.

The purpose is to conserve water and maintain optimum soil moisture to

- store and manage infiltrated rainfall for more efficient crop production;
- improve surface water quality by increasing infiltration, thereby reducing runoff, which may carry sediment and undesirable chemicals;
- reduce nitrates in the drainage water by enhancing conditions for denitrification;
- reduce subsidence and wind erosion of organic soils;
- hold water in channels in forest areas to act as ground fire breaks; and
- provide water for wildlife and a resting and feeding place for waterfowl.

5.2 Water quality concerns in drainage water management

There are several factors to consider when determining the opportunities for and constraints on the safe use, treatment and disposal of agricultural drainage water. Information and data desired at the site of drainage water production include: rate of drainage water production per unit area, chemical concentration of constituents of concern, and the rates of mass emission. Drainage water management requires additional information and data on drainage water quality and its suitability for the intended water uses as well as an understanding of environmental and health concerns. Upstream drainage water management affects the needs and water quality requirements of downstream water users.

In many regions of the world, municipalities and industries discharge wastewater into open drains initially intended for the conveyance of only agricultural drainage and storm water. In developing countries especially, municipal and industrial wastewater is often insufficiently treated before disposal into such open drains. The result is a risk that agricultural drainage water quality might be seriously contaminated with microbes, pathogens, toxic organics and trace elements including heavy metals.

Knowledge of the composition of the drainage effluent and the ability to predict changes in the composition as a result of changes in crop, irrigation or drainage water management practices are important in the planning and management of drainage water.

5.3 Factors affecting drainage water quality

Geology and hydrology: - The geology of the region plays an important role in drainage water quality. Through weathering processes, the types of rocks (both primary and sedimentary) in the upper and lower strata define the types and quantities of soluble constituents found in the irrigated area. The oceans have submerged many parts of the continents during a period in their geological history. The uplift of these submerged geological formations and receding seas have left marine evaporites and sedimentary rocks behind, high in sea salts including sodium, chloride, magnesium, sulphate and boron. These geological formations exist in varying thicknesses, depths and extents on the continents. Through hydrological processes, solutes can enter the upper stratum by irrigation or floodwater, upward groundwater flow in seepage zones, with rising groundwater levels, or capillary rise. Once the solutes are in the upper strata, they influence the quality of agricultural drainage water through farmers' irrigation and drainage water management. The following example shows how the geology and hydrology of an area influence the quality of agricultural drainage water. It also illustrates the relationship between geomorphology, water logging and salinization.

Drain water management strategies include source control, reuse, treatment, and evaporation ponds; questions of interest are efficient management, policy instruments, and sustainability. A high level of source control is indicated absent reuse due to the relatively high cost of evaporation ponds; this is accomplished largely through high uniformity/high cost irrigation systems. With reuse, the primary form of source control is reduction in land area devoted to freshwater production; the released land goes to reuse production. Reuse appears as an economically promising solution to the drainage problem. A high level of net returns is achieved while maintaining overall hydrologic balance in the system. Economic efficiency and hydrologic balance may be attained through pricing or market schemes. With pricing, growers are charged for deep percolations flows, while reuse and evaporation pond operators are paid for extractions. With markets, permit supply is generated by extractions from the water table, while permit demand is generated by deep percolation. Competitive equilibrium exists, is efficient, and implies hydrologic balance. The analysis suggests that a high level of agricultural production may be possible for some period of time while still maintaining environmental quality.

5.4 Basic principles of teamwork in the workplace

The best definition of teamwork in business involves a group of individuals working together to complete a task or a large goal. Teams are groups of people with complementary skills who are committed to a common purpose and hold themselves mutually accountable for its achievement.

Ideally, they develop a distinct identity and work together in a co-ordinate and mutually supportive way to fulfill their goal or purpose. Task effectiveness is the extent to which the team is successful in achieving its task-related objectives.

Figure 64 team group understanding

5.5 Characteristics of effective teamwork – the STAR team model

The STAR team model suggests that effective teamwork in the workplace happens when four elements (Strengths, Teamwork, Alignment and Results) are in place:

- Individuals flourish as they use and develop their Strengths
- People come together building relationships that result in effective Teamwork
- The team leader Aligns the team through effective communication of purpose, so that individual strengths combine with teamwork to deliver the teams results
- Together everyone achieves more as performance flows and Results that are meaningful and rewarding to the team are achieved

A different emphasis and focus for each of the STAR model elements is needed at different stages of the team's development.

For high performance, all three aspects of the STAR model are equally important, and the team balances the three areas of results, strengths and teamwork according to the situation. The team's impact spreads beyond its immediate context to influence other teams and the wider organization.

- The team finds new ways of working
- Team members initiate change
- The team sets fresh challenges
- Team members spreads good practice
- Team members coach and support each other and start to do so with other teams
- Team members take the lead more often in their area of expertise
- Connections are made across team, more widely across the organization and with customers which bring increasing value to what the team does.

5.6 Benefits of successful teams

- Improvements in participants' confidence, attitudes, motivation and personal satisfaction
- greater clarity in expressing ideas through group discussion
- better understanding by individuals of the nature of their contribution – and of the needs of other team members
- more efficient use of resources – especially time greater optimism – by focusing on positive outcomes and putting less weight on problems
- a wider range of ideas rather than individuals working in isolation
- More effective responses to changes – improved trust and communication help a team to adapt to new circumstances.

Self-Check 5	Written Test

Name: ___________________________ Date: ________________

Directions: Choose the best answer for the following question and encircle the answer (2 pts each)

1. One of the following is factors affecting drainage system?
   A. Soil properties;
   B. Geological condition;
   C. Type of crop and its sensitivity to drought stress;
   D. Slope of the land;
   E. All of the above.

2. In irrigation system over irrigation is one of the problems for water loading and salt accumulation effect, so how to solve these problems?
   A. By applying proper drainage system after irrigation
   B. By irrigating proper amount of water
   C. By using different water measuring device
   D. By applying proper irrigation scheduling
   E. All of the above
   F. none of the above
3. Which one of the following is the important input data for irrigation scheduling?
   A. Soil data
   B. Climate data
   C. Plant data
   D. Water contains Bacteria, viruses, and other microorganisms.
   E. All of the above

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Score = ____________

Rating: _____________

Answer Sheet

Name: ___________________________ Date: ________________

Techniques for identifying water related problems:

Step 1- wears safety.

Step 2- identify hazards related to water conveyance system.

Step 3- select required tools and materials to collect data sample

Step 4- take water and other important samples.

Step 5- coding and preparing the data for analysis.

Step 6- analyze the sample and recorded the result.

Step 7- control the hazards applying suitable solution.

Step 7- document and report the result and inform the responsible organization.

LAP Test	Practical Demonstration

Name: _____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 7 hours.

Task 1. Identify water related problems

Instruction Sheet	Learning Guide-57: Prepare detail design

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

- Designing water system model by using appropriate materials.
- Design report, bill of quantity/cost estimate and tender documents
- Legislations and environmental protection in design details of water system model.
- Basic workplace reporting procedures
- communication skills
- listening, questioning and receiving feedback
- Working cooperatively and collaboratively with others to complete tasks

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 –

- Design the water system models considering specifications and standard by using materials.
- Prepare the design report, bill of quantity/cost estimate and tender documents.
- Consider appropriate legislation and environmental protection in design of water system model.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3, Sheet 4 and Sheet 5” in page 108, 121, 127, 134 and 137 respectively.
4. Accomplish the “Self-check 1, Self-check 2, Self-check 3, Self-check 4 and Self- check 5” -” in page 120, 126, 133, 136 and 141 respectively

Information Sheet-1	Designing water system model by using appropriate materials.

1.1 Important terms

When you are designing a water model you need to think about the following terms:

Supply needs: - the size and type of water system you design will depend on how many consumers need water and how much water is used.

Water source: the availability of water will have an impact on the type of system you design.

Barriers: the water model you design will need to account for difficult terrain like rocky ground or hills. These sorts of factors will affect the type of distribution network you choose.

Risks: what could possibly make the system fail and how will you guard against this happening?

1.2 Small scale water mode

This water model is designed to service one household. Rainwater is used as the water source and stored in a rainwater tank. The tank is raised, and gravity is used to move water through distribution pipes in one household. A pump isn't needed. Water must be maintained by the consumer to ensure it is fit for purpose. Water usually needs to be treated before drinking.

The particular model is for analyzing a water cycle in an industrial complex. It consists of three sub-models: water flow, water quality, and energy models.

The water flow model can handle various types of flow and storage, including tap water flow, reclaimed water flow, wastewater flow, treated water flow, reclaimed water flow, storage in factories, storage in a sewage treatment process, storage in a water reclamation plant, and storage in a water distribution reservoir.

The energy model computes the energy consumption of booster and circulation pumps and blowers for water distribution and water treatment on the basis of various computed flows.

The water quality model chiefly computes the quality of the treated wastewater flowing out of an activated sludge treatment process on the basis of the quality of the inflow to the process and an approximately formulated dynamic model of quality response.

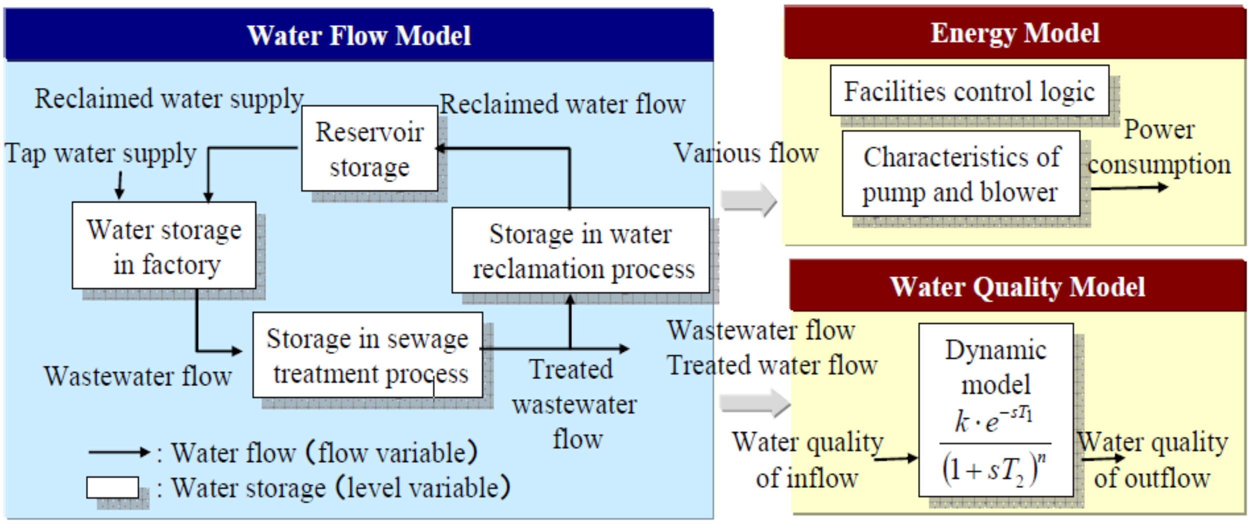


Figure 65: component of water model

1.3 Water Flow Model

A System Dynamics model for analyzing water flow and storage is shown in Fig. Tap and reclaimed water is supplied to factories in an industrial complex. After the supplied water is temporally stored in factories, it is discharged as wastewater into a sewer pipe. This delay is assumed to be approximately a first order lag system. A part of this wastewater evaporates or infiltrates underground. Wastewater is treated and purified in a settling basin, a primary sedimentation tank, an activated sludge treatment tank, and a final sedimentation tank. A part of

The treated wastewater is sent to a reclamation plant where it is further purified for reuse as reclaimed water, while the other part is discharged into an artificial river. Sand filtration and chemical precipitation are typically utilized in the water reclamation process

1.4 Drip Irrigation System Model Design

From an end user stand point drip irrigation systems not only provide water to the landscape more efficiently and effectively but also eliminate a lot of unwanted maintenance if installed properly.

As someone who installs drip systems regularly, we will explain the following crucial components.

- **Automated Zone Valve: -** This component is a given in drip irrigation systems, however, very few contractors know what the low-end flow is of the valves they install on a daily basis. For simplicity purposes and continued employment reasons we can tell you that a Jain valve can close with as low as 2 GPM. Most manufacturer's valves will close at about 3-4 GPM, because of this you are limited to larger zone design. Point source emitters and drip line put very little water out and therefore the hydraulics present closing complications when it comes time to shut the valve down. Always be sure to check the GPM flow spec on the valve you are going to use for your drip system to ensure the valve will shut down.

- **Pressure Regulation: -**Although manufacturer's offer pressure compensating emitters in drip line this does not mean that your system will not benefit from added pressure regulation at a valve level. Most contractors know that pressure compensation and pressure regulation are not the same thing, A pressure regulator will control pressure regardless of variations in flow, a pressure compensating emitter will distribute the exact same amount of water regardless of changes in pressure. Once the regulator is installed calculating drip line runs and flow capacity will be much easier.
- **Filtration for Drip Irrigation Systems: -** Filters are measured and specified by micron; micron is a unit of measurement used when measuring the spacing in fleece. In a typical clean water supply a 100-micron count filter will be just fine and require maintenance every year or two. When pulling from a lake or well you may want to consider a tighter weave and go up to a 150- or 200-micron count filter. Obviously based on this description you can see that the higher the number the tighter the concentration of weaves and thus more prone to catching debris. This can be a good thing or a bad thing, while you want to prevent clogged emitters you also don't want to add excessive maintenance. There are a lot of other components that make up a drip system
- **Main line, sub main line lateral and emitter (dripper):-** these is the other component of drip irrigation system used to convey filtered water from the filter to the plants.

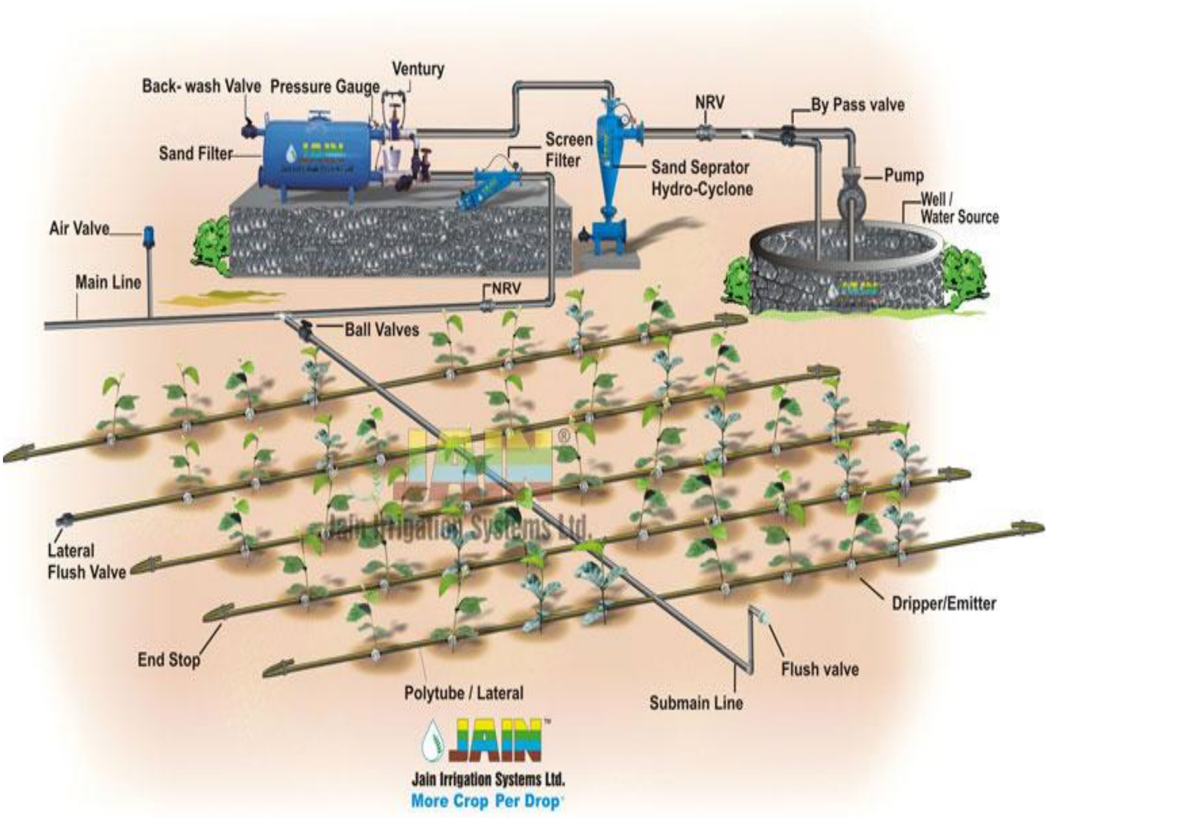


Figure 66: Drip irrigation system model designs

Figure 67: Automated Zone Valve component

Figure 68: Pressure Regulation

Figure 69: Filtration for Drip Irrigation Systems

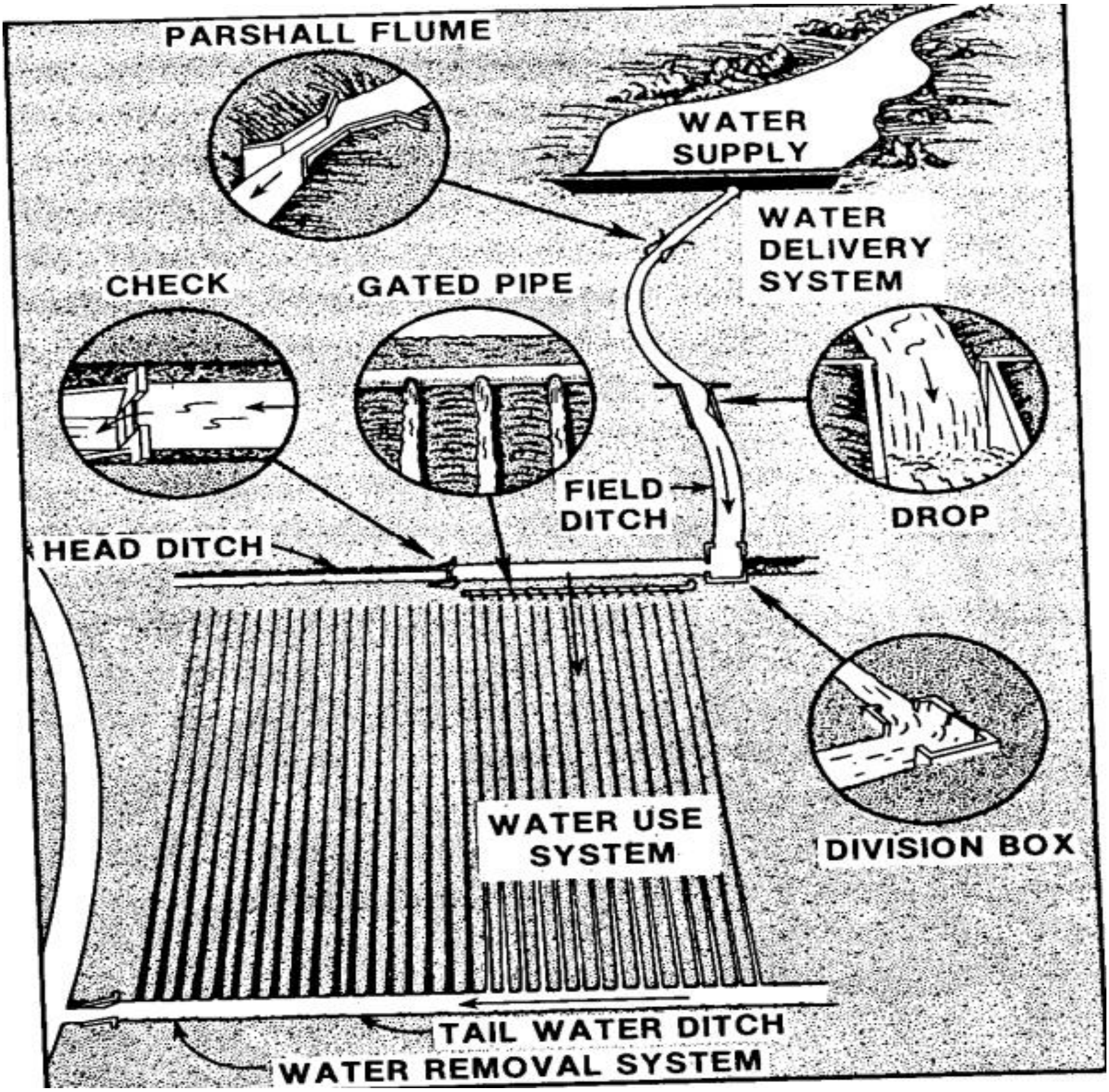


Figure 70: Component structures for irrigation water conveyance system

1.5 Pipe lines design for water supply project

- Gravity main: - It is designed to convey economically the safe yield of the spring to the newly constructed reservoir to be distributed by gravity.
- Economical size (D) of gravity main is determined by Lean formula as: -

$D = 0.97 * \sqrt{Q}$ to $1.22 * \sqrt{Q}$

Where, D= Pipe diameter in meter

Q= Discharge of spring in m3/sec.

- After obtaining pipe diameter, the velocity (V) of water flowing through the gravity main should be checked in order to be greater than the allowable velocity of 0.6 m/sec. To check this velocity, we have to use the formula: -

Q=AV,

$V=\frac{Q}{A}$ Where, $A=\frac{\pi D^2}{4}$

- Head loss in the pressure main

The head losses due to friction. It happens on every point of the carrier along the flow path and is accumulated Whenever the surface of one body slides over that of another, each body exerts a frictional force on the other, parallel to the surface. The force on each body is opposite to the direction of its motion relative to the other. Thus, when a block slides from left to right along the surface of a table, a frictional force to the left acts on the block and an equal force towards the right acts on the table.

Friction losses in pipes are depended by the following factors:

- The type of material that the pipe is made of (C).
- The condition of the pipe in relation to the degree of smoothness or roughness of the walls.
- The diameter of the pipe (D).
- The length of the pipe (L).
- The flow velocity (v).

Local losses (h_l) happen due to turbulence that is created because of sudden changes in the shape of flow like: changes in pipes diameter, stopper, bending, valve, pressure regulator, elbow, connection junction, etc. The head loss due to pipe friction should be calculated using Darcy Weisbach equation as: -

$$hf = \frac{fLV^2}{2gD}$$

Where, hf=head loss in meters

f=friction factor depends on the relative roughness of the pipe and is: -

$= 0.04(1+\frac{1}{35D})$ For old pipes and

$= 0.02(1+\frac{1}{35D})$ For new pipes

L=length of pipe in meter from cupping to reservoir.

v=velocity of flow through the pipe in m/sec.

g=acceleration due to gravity in m/sec.^{2}

D=diameter of pipe in meter

1.6 Factor affecting design period

The following factors should be kept in view while fixing the design period: -

- Fund available for the completion of the project. If more funds are available design period shall be large.
- Life of the pipe and other structural materials used in the irrigation and water supply scheme. Design period in no case should have more life than the components and material used in the scheme.
- As far as possible the design period should be nearly equal to the materials used in the irrigation and water supply works.
- Rate of interest on the loans taken to complete the project. If rate and interest is less it will be good to keep design period more. But if the interest rate is very high, the design period should be small.
- Anticipated expansion rate of the town.

1.7 Models design of drip irrigation system and pipe water supply projects

Example 1 Actual Water Requirement of the field**: -** the first step of drip irrigation design is to calculate the total water required by the area. Let's take an example, Suppose we have **1.2 ha** area and we are going to grow cotton crop in it at the spacing of **1.40m X 0.40m**. We are going to use inline dripper capacity of **2 LPH** (liter per hour). So first thing is how many plants is there in 1.2 ha area?

We can calculate it simply by, 1.2 X 10,000 = 12000 sq. meter now, = 12000 / 1.40 x 0.4 (Crop spacing) = 21429 plants in the field we are going to provide 2 liter water to each plant, so Total water requirement = 21429 x 2 (Total plants x dripper discharge) = 42,858 liter or 42.85 m3/hr. **so 1.20 ha are required 42.85 m3/hr. water to irrigate cotton crop.**

Example2 Based on the given data designs the necessary drip irrigation parameter?

Crop type = Mango

Selection 2 dripper of 8 lph capacity per plant

Spacing distance (5m X 5m)

Length of lateral = 50 m

Area= 1 ha (Assume square plot)

Pan evaporation = 8 mm/day

Pan coefficient = 0.7

Crop factor= 0.75

% wetted area= 60

Soil type= medium

Water source is well at the corner of the field (well depth) = 10m

Assume pump efficiency 70% and motor efficiency = 80%

Solution:

Step I: - Determination of Water Requirement of the crop (CWR):

CWR= Crop area X PE X PC X KC X % wetted area

= 5m X 5m X 8 X0.7X 0.75 X 0.6

= 63 lit /day/ plant

Step ii: - Selection of Dripper:

Selection 2 dripper of 8 lph capacity per plant

Total no of plants = $\frac{\text{Total area}}{\text{Plant area}}$

= 10,000/ 5 X 5 = 400

No of drippers = 400 X 2 = 800

Step iii: - Selection and Design of Lateral:

Flow rate of lateral = No of dripper on lateral X Discharge of drippers per plant.

No of dripper on lateral = $\frac{\text{Spacing between two drippers}}{\text{Length of Lateral}}$

No of dripper on lateral = $\frac{\text{Length of Lateral}}{\text{Spacing b/n plants}}$

50/5 = 10

Q of lateral = 10X 2 X8 = 160 lit/hr

Give the sub-main at the centre of the point

Length of lateral = 50 m

Diameter of lateral= 12 mm = 1.2 cm

Head loss in lateral by hazen William formula

ΔH= 1.526 X 104 X (Q/C) 1.852 X D -4.871 X LX F

Where, Q= Flow rate of lateral in m3 /hr

C= Hazen and William constant

D= Diameter of pipe in cm

L= Length of pipe in m

F= Outlet factor=0.39

∆H= 1.526 X 104 X (0.16/150) 1.852 X (1.2) -4.871 X 50 X 0.39

∆H= 0.38

∆ Head loss is less than 2 m, hence design is acceptable.

Step IV Selection and Design of Sub-main: Select 40 mm Sub- main.

Select 40 mm mainline

Flow rate of mainline= Flow rate of Sub main

Q= 6.4 m3 /hr

Diameter of mainline= 40mm=4cm.

Step V Head loss in Mainline, by F=100

H= 1.526 X 104 X (Q/C) 1.852 X D -4.871 X L X F

= 1.526 X 104 X (6.4/150) 1.852 X (4) -4.871 X 100

So, H= 2.58m

Selection Pump:

Total discharge,

Q=6.4 m3 /hr

Q= 6400 lph

Q = 6400 lps

$$\frac{}{60 \times 60} = 1.77 lps$$

Total head of pump = (Suction head+ delivery head) + operating pressure of drip irrigation system+ filter loss + fitting loss + mainline loss + ventury loss + elevation difference

Suction head + delivery head = 10

Operating pressure= 1 kg /cm2 or 10m

Filter loss = 2m for sand filter + 2m for screen filter

= 4m

Ventury loss = 5m

Fitting loss= 2m

Main line loss= 2.58

Elevation difference = 2m

So, Total head of pump = 10+10+4 + 2 +2.58 +5+2

= 35.5 m

H.P of pump = Q (lps) X H (m)

75 X 0.7 X 0.8

So, Pump efficiency and motor efficiency is given as 70% and 80% respectively.

HP= 1.49 hp

So, HP of Pump is 1.49 hp say 2 HP

Step VI: - Irrigation Time:

Irrigation Time = Peak water requirement per plant

Discharge of dripper per plant

= 63

____= 3.9 (say 4 hours)

2 X 8

So, Irrigation time required is 4 hrs.

Example3: - The East Belessa woreda water resources development office of North Gondar zone is going to construct gravity water supply scheme for Woyraye village of one of the kebeles The village is found at a maximum elevation of 1669 m a.s.l, The spring source is found at 1800 m a.s.l with 3 Km distance far from the village and have a yield of 0.9 litre/sec. Design the structure with appropriate parameters. Use all necessary materials are newly purchased.

Solutions

Available Data's are:-

- Spring discharge = 0.9Litre/sec = $0.9*10^{-3}m^3/sec$
- Reduced level at the spring eye = 1800 m.as.l
- Reduced level at proposed reservoir site = 1669 m.as.l

- Distance = 3Km = 3000 meter
- All materials are newly purchased
- Economical size (D) of gravity main is

$D = 0.97 * \sqrt{Q}$ to $1.22 * \sqrt{Q}$

$= 1.22 * \sqrt{0.9 * 10^{-3}}$ (To be on the safest side)

$= 0.0366\text{meters} = 1.441 \text{ inche} = 1.5 \text{ inche pipe}$

- After obtaining pipe diameter, the velocity (V) of water flowing through the gravity main should be checked in order to be greater than the allowable velocity of 0.6 m/sec. To check this velocity, we have to use the formula:-

  Q=AV,

  Where, $A = \frac{\pi D^2}{4} = \frac{\pi * 0.0366^2}{4} = 0.0011$ m^2

$$V = \frac{Q}{A} = \frac{0.9 * 10^{-3}}{0.0011} = 0.82 \text{m/sec}$$

Since, 0.82 m/sec > 0.6 m/sec, then Ok

- Head loss in the pressure main

  The head loss due to pipe friction should be calculated using Darcy Weisbach equation as:-

$$hf = \frac{fLV^2}{2gD} = \frac{fLV^2}{2gd}$$

$$f = 0.02\left(1 + \frac{1}{35D}\right), \text{since all materials are new}$$

$$= 0.02\left(1 + \frac{1}{35 * 0.0366}\right) = 0.0356$$

$$hf = \frac{fLV^2}{2gD} = \frac{0.0356 * 3000 * 0.82^2}{2 * 9.8 * 0.0366} = 100 \text{ meters}$$

- Let's consider 10% of h_f as minor loss = 0.1*100 = 10 meters
- Total head loss = 10m + 100m = 110 meters
- Available head = 1800m-1669m-2m(assumed water point height) = 129 meters
- Since the available head=129m is greater than the head loss=110m, water will reach safely to the village.

Self-Check 1	Written Test

Directions: Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

1 When you are designing a water model, what are the things that you think? (5 pts)

2 What is small scale water mode? (4 pts)

3 Why do we use work scheduling? (6 pts)

4 Draw water flow model. (5 pts)

5 Draw drip irrigation system model design. (5 pts)

***Note:* Satisfactory rating – 10 points** **Unsatisfactory - below 10 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

1. ____
2. ____
3. ____
4. ____
5. ____

Information Sheet 2	Design report, bill of quantity/cost estimate and tender documents

1.1 Design report

Design reports are written to introduce and document engineering and scientific designs. In general, these reports have two audiences. One audience includes other engineers and scientists interested in how the design works and how effective the design is. Another audience includes management interested in the application and effectiveness of the design. A commonly used organization for design reports:

- Summary,
- Introduction,
- Discussion,
- Conclusions, and
- Appendices.

1.1.1 Summary

The summary, sometimes labeled the abstract or executive summary, is a concise synopsis of the design itself, the motivation for having the design, and the design's effectiveness. The author should assume that the reader has some knowledge of the subject, but has not read the report. For that reason, the summary should provide enough background that it stands on its own. Note that if the summary is called an abstract, you are usually expected to target a technical audience in the summary. Likewise, if an executive summary is requested, you should target a management audience in the summary.

1.1.2 Introduction

The "Introduction" of a design report identifies the design problem, the objectives of the design, and the assumptions for the design, the design alternatives, and the selection of the design being reported. Also included for transition is a mapping of the entire report. Note that in longer reports, the selection of design is often a separate section.

1.1.3 Discussion

The discussion presents the design itself, the theory behind the design, the problems encountered (or anticipated) in producing the design, how those problems were (or could be) overcome, and the results of any tests on the design. Note that this part usually consists of two, three, or four main headings. In regards to the actual names of these headings, pay close attention to what your instructor requests. Also consider what would be a logical division for your particular design.

1.1.4 Conclusions

The "Conclusions" section summarizes the design and testing work completed and assesses how well the design meets the objectives presented in the "Introduction." Note that if the design does not meet the objectives, you should analyze why the design did not succeed and what could be modified to make the design a success. Besides summarizing the work and analyzing whether the objectives were met, the "Conclusions" section also gives a future perspective for how the design will be used in the future.

1.1.5 Appendices

In a design report, appendices often are included. One type of appendix that appears in design reports presents information that is too detailed to be placed into the report's text. For example, if you had a long table giving voltage-current measurements for an RLC circuit, you might place this tabular information in an appendix and include a graph of the data in the report's text. Another type of appendix that often appears in design reports presents tangential information that does not directly concern the design's objectives.

1.2 Bill of quantities (Cost estimation)

The Bill of Quantities (BOQ) is a descriptive list of each item of work, material or provision included in the project along with an estimate of the quantity required for each. The quantities and the description of the works are derived from the drawings and specifications. Blank columns should be provided in the table of the BOQ, for tenderers to fill in their unit prices (rates) against each item. The BOQ has the following advantages:

- It provides equal opportunity for all tenderers to enter a unit price or rate against each item. By summing up the total cost for each item, along with the quantities entered by the engineer, the total tender sum is thus derived on a basis common to all tenderers.

- It provides a basis for making progress payments, deriving costs for additional work and evaluating deductions which could arise as a result of deletion of some items from the contract. It can be used as reference for cases of adjudication.

During construction the actual quantity relating to each item is measured and entered into a blank bill, which is held for measurement and payment purposes. The payment is at the tender rate.

Table 9: Bill of quantity form (BOQ Form)

Project name: ____________________					
SNO	*Item description*	*Unit*	*Quantity (linked from takeoff sheet)*	*Unit price (birr/ unit)*	*Total Amount in Birr*
1	*Irrigation Canal construction*				
1.1	Excavation of soil	m^3	X	Y	X*Y
1.2	Masonry for 1:3 mix proportion	m^3	N	M	N*M
1.3	Plastering with 1:3 mix and 2 cm thickness	m2	z	B	Z*B
Sub total					R
2	Crossing flume				
2.1	Excavation				
2.2	Concrete				
2.3	Masonry				
Sub total					k
Total					R+K

For comparison, architect's designing a residential house use the metric of 8-12% of total construction costs for their fees. For commercial buildings from 5-15% to go from concept to blueprints. You can go well north of that (>20%) if you are building something of great significance, or working with the world's most highly recognized architectural companies. If Architecture, has reached a level of maturity that fees are pretty well defined as a proportion of total construction, irrespective of the function of the building, why can't the same argument be made for product design?

1.3 Tender document

Tender documents are prepared and sent out to potential tenderers to seek tenders (bids) as part of the procurement process at tender phase.

Tender documents that are provided to tenderers will consist of all or some of the following documents:

- **Cover letter: -** A formal letter inviting tenderers to submit a tender for the supply of contracting services. It will advise when and where the completed tender should be returned
- **Invitation to tender: -** This provides guidance on how the tender documents are to be completed.
- **Form of tender: -** The form of tender is a covering document prepared by the Client and signed by the tenderer to indicate that they understand the tender and accept the various terms and conditions of the contract, and other requirements of participating in the tender exercise.
- **Bill of quantities: -**This document is used as the basis of submitting the bid where all prices are entered for carrying out all works. The bill of quantities assists tenderers in producing an estimate of construction costs for their tender, and, as it means all tenderers will be pricing the same quantities (rather than taking off quantities from the construction drawings themselves). It also provides a fair and accurate system for tendering.
- **Design drawings (general layout plan, construction drawings):-** These are clear and concise detailed documents about the construction site, path construction and any related feature works. They are the essential ingredients for informing tenderers of exactly what is required to complete all works.

- **Specifications: -** This document sets out what needs to be achieved including policies, procedures or guidelines to be followed. It sets out the performance standards and the outcomes expected. It describes the materials and workmanship standards. They do not include cost, quantity or drawn information, and so need to be read alongside other tender documentation such as the terms and conditions of the contract, bill of quantities and construction drawings.
- **Quality requirements: -**A questionnaire about how the tenderer intends to provide the contracting service, including supporting evidence demonstrating relevant experience.
- **Tender evaluation criteria: -**This document advises how the tender submitted will be evaluated and the contract awarded.
- **Tender return label: -** This label states the time and date by which the tender must be returned.
- **Pre-construction information: -** The pre-construction information, which the Client must provide for all path construction projects, that is a legal requirement for notifiable projects only, should contain all the relevant information in the Clients possession or which they can easily obtain about the path construction project, that might influence the health and safety of path design and construction work, including any related feature works e.g. bridge construction and installation. Any information about environmental issues, e.g. contaminated land should also be included.

Pre-construction information may include:

- A description of the project and its programmed
- Information about the construction work
- Information about the site as a workplace
- Clients management and welfare arrangements
- The CDM planning period
- Any relevant information in any existing Health and Safety File
- Contact details for Client, Designer, CDM Co-ordinator (notifiable project only), Contractor or Principal Contractor (notifiable project only)
- Schedule of existing information
- Environmental restrictions and risks
- Design and construction hazards

Self-Check 2	Written Test

Directions: Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

1. What are commonly used organizations for design reports? (5 pts)
2. What is contract documentation? (4 pts)
3. What are the documents that make up the contract documentation? (6 pts)
4. What are the comprise of contract documents on design and build projects? (5 pts)
5. What is bill of quantity? (6 pts)

***Note:* Satisfactory rating - 13points** **Unsatisfactory - below 13 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

1. ____

____

2. ____

____

3. ____

3.1 Introductions

Construction practices that fail to control pollution can cause damage to Waterways and wetlands, kill fish, upset aquatic ecological systems and wildlife communities, and result in contamination of land and groundwater. The risk to the environment is particularly high when work is done near coastal areas, streams and creeks, or along a river valley. When construction occurs near built-up areas, poor practices may result in air and noise pollution which may cause annoyance and affect the health of neighboring communities.

Construction sites are constantly changing, and systems need to be in place to modify control measures to maintain their effectiveness. Therefore, frequent inspection and monitoring is required to continually check the effectiveness of measures.

The adoption of appropriate pollution controls during construction and land development activities is important not only to the environment but also the developer/builder.

- information how to avoid and minimize environmental impact, which is preferable
  to the less cost-effective option of controlling or treating discharges to the environment, or undertaking remedial action.
- information on the likely impact of construction activities on the environment and how this is to be assessed ·
- guidelines for undertaking risk assessment and management ·
- a clear statement of environmental performance objectives for each segment of
  the environment ·
- Suggested best practice environmental measures to meet the performance objectives based on available experience

The Guidelines provide contractors and developers with a framework within which due diligence obligations can be met and environmental damage can be avoided. The Guidelines are not prescriptive or detailed. Application will require tailoring them to particular site conditions and making adjustments if the measures listed are inappropriate to the site.

3.2 Major environmental protection activities

- Erosion and Sediment Control: - Without erosion and sediment protection measures, large amounts of soil can be lost from a building site and enter the storm water system. The storm water system drains directly into our waterways. Sediment in our waterways pollutes our creeks, lakes and rivers and has a major impact on water quality, aquatic plants and animals.
- Noise: - Construction and land development activities can generate levels of noise ranging from being a Nuisance to actually damaging people's health.
- Air Quality: -Mismanagement of air quality on site has the potential to result in detrimental effects on the health and amenity of neighbors and employees, reduced visibility on site, increased wear on machinery and equipment and complaints from neighbors.
- Spoil Management: - Placing contaminated material on your land can harm the environment by polluting waterways, destroying vegetation and contaminating land, and may leave you with an expensive clean-up bill.

3.3 Principles of Pollution Control

These guidelines will assist in determining the pollution control measures most appropriate for the commonly experienced situations in the ACT. The recommended approach is based on the following principles of pollution control.

- **Erosion and Sediment Control**
  - ✓ Plan erosion and sediment controls early in the land development process and incorporate the cost into the works program.
  - ✓ Install controls prior to commencement of earthworks and maintain until revegetation is fully established. Divert run-off from above the site to a stable disposal area.
  - ✓ Establish a stable drainage system through the site before other construction activities commence.
  - ✓ Minimize surface disturbance to retain the maximum area of natural vegetation cover.

- ✓ Install sediment control ponds and sediment traps to contain sediment on sites over 1ha.
- ✓ Chemically dose turbid water prior to discharge from the site.
- ✓ Maintain erosion and sediment control structures.
- ✓ Establish vegetation as soon as practical on all areas where soil has been exposed.

- **Noise:** Ensure all building work that generates noise is conducted within the time periods.
- **Air Quality:** Incorporate measures to limit affect on air quality by minimizing dust from construction activities and smoke from fires.
- **Spoil Management:** The EPA must be notified before disposing spoil off site or accepting soil on site. In some cases, an Environmental Authorization may be required. These guidelines have been produced to assist builders and developers meet their responsibilities under the *Environment Protection Act 1997* and the Environment Protection Regulation 2005. However, these guidelines are not mandatory and professional judgment should be used on the suitability of these guidelines for the known site conditions Information contained within these guidelines does not replace the need for site-specific evaluation, testing and design where it is judged necessary.

3.4 Legislation and policy management of particular activities

3.4.1 Land development – subdivision

Subdivisions require the most comprehensive design approach and use of most of the available recognized soil erosion control measures. The developer's design professional shall determine the control measures most appropriate for the site and for the nature of the works. Normally sediment control ponds and any critical al diversions will be the first priority of work and must be in place prior to commencement of general clearing, stripping, earthworks and hydraulic works. Large site areas should be divided into separate parts as a means of limiting the extent of exposed areas, and for implementing progressive stabilization on of works. We can consider the following points:

- Plan the development to fit the site.
  - ✓ Assess the physical characteristics of the site to determine how it can be developed with the smallest risk of environmental damage.

- ✓ Minimize land reshaping by using the existing topography wherever possible.
- Determine limits of land clearing and shaping.
  - ✓ Decide exactly which areas must be disturbed to accommodate the proposed construction and which areas can remain untouched.
  - ✓ Pay special attention to critical areas (for example, steep slopes, highly erodible soils, surface water borders, wetlands and the like).
  - ✓ Consider staged clearing and construction as an alternative e to mass clearing and construction
  - ✓ Fence off the areas which should remain undisturbed. Divide the site into natural drainage areas.
  - ✓ Determine how run-off will drain from the site.
  - ✓ Remember that it is more advantageous to control erosion at the source and prevent problems than to design perimeter controls to trap sediment.
  - ✓ Consider how erosion and sedimentation can be controlled in each small drainage area or sub catchment before looking at the entire site.
  - ✓ Identify stable and preferred water disposal areas.
- Select pollution control practices.
  - ✓ Determine erosion and sediment control measures appropriate for the site.
  - ✓ Include key dimensions and specification in construction details.
  - ✓ Liaise as necessary with the EPA and obtain agreement to the adequacy of the proposed measures.
  - ✓ Construct and maintain structural measures in accordance with standards and specifications set out this Guideline.
  - ✓ Incorporate measures to ensure all building work that generates noise takes place within the time periods detailed in Schedule 2 of the Environment Protection Regulation 2005.

3.4.2 Underground Utilities

Underground utilities are also a linear development that may cross a number of drains and watercourses and appropriate control measures need to be implemented. The following controls or specific principles apply to the installation of underground utilities.

- Excessive trench widths or depths shall be avoided. Limit construction equipment activity to disturbed areas.
- Wherever possible, spoil should be placed on the far side and uphill of the trench away from the storm water system.
- Stockpile topsoil separately (not greater than 2m high) from general excavated material.
- If the trench needs to be pumped dry, the discharge water should be chemically dosed before discharge if not of an acceptable standard.
- Run-off from works shall be passed through sediment controls.
- Where on-site controls are not practical, the storm water system, water channels or bodies of water shall be protected from sediment laden run-off.
- Where pipes are to be laid across a stream bed, stream diversions are required.
- For vehicular access across a watercourse or works crossing a watercourse temporary waterway crossing are required.
- Supervisory staff involved in excavation work shall ensure that their employees or contractors understand and follow the above requirements
- Maintain pollution control measures during construction and until full stabilization.
- Regularly remove any sediment from roads adjacent to the work area. Do not wash into the storm water system.

3.4.3 Channels and Floodways

Channels and floodways can be the most difficult works to control and stabilize. The design professional shall specify suitable pollution control measures for each site. The following general controls and principles apply to the construction of channels and floodways:

- Undertake pollution control works as first priority in order to stabilize against and ahead of upper catchment development.
- Use diversion structures to convey upstream run-off away from the site to a stable disposal area. Stabilize diversion works.
- Stockpile topsoil separately (not greater than 2m high) from other excavated material for respreadingover disturbed areas.
- Limit construction equipment activity and provide for limited access.

- Progressively construct works and stabilize with the aid of mulch, jute mesh, matting and turning immediately after construction.
- Use sediment traps and diversions to limit erosion potential See Section 4.9.
- Maintain all control measures during construction.

3.4.4 Ponds and Dams

Ponds and dams are generally constructed as initial infrastructure works; are generally located downstream of major urban development; and are designed to protect downstream water quality. The design professional shall specify suitable control measures for each site. The following general controls apply to the construction of dam and pond projects:

- Divert clean water away from disturbed area. Ensure it is diverted to a stabilized area.
- Direct discharge from basin excavation works into a pond such as a cofferdam and chemically dose before discharge if not of an acceptable standard.
- Disperse and slow discharge flow by using spreaders and/or other erosion and sediment controls.
- Divert run-off from embankment and spillway areas into a sediment control pond. Chemically dose before discharge if not of acceptable standard.
- Stockpile topsoil at the start of project (not higher than two m) and respreads over disturbed areas when works are complete.
- Stabilize downstream batter of embankment and spillway area immediately on completion.
- Maintain all control measures during construction and until stabilization.

Self-Check 3	Written Test

Directions: Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

1. What are the purpose and application of environmental guide line? (5 pts)
2. What are the major environmental protection activities and discuss each it? (4 pts)
3. Write the major principle of pollution control? (6 pts)
4. Write the Legislation and policy management of major environmental activities? (5 pts)
5. During construction of pond and dam projects what are the general controls points. (6 pts)

Note: **Satisfactory rating - 13points** **Unsatisfactory - below 13 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

1. ____
2. ____
3. ____
4. ____
5. ____

4.1 Design report procedures

Design reports are written to introduce and document engineering and scientific designs. In general, these reports have two audiences. One audience includes other engineers and scientists interested in how the design works and how effective the design is. Another audience includes management interested in the application and effectiveness of the design. A commonly used organization for design reports:

- **Summary:** The summary, sometimes labeled the abstract or executive summary, is a concise synopsis of the design itself, the motivation for having the design, and the design's effectiveness. The author should assume that the reader has some knowledge of the subject, but has not read the report. For that reason, the summary should provide enough background that it stands on its own. Note that if the summary is called an abstract, you are usually expected to target a technical audience in the summary. Likewise, if an executive summary is requested, you should target a management audience in the summary.
- **Introduction:** The "Introduction" of a design report identifies the design problem, the objectives of the design, and the assumptions for the design, the design alternatives, and the selection of the design being reported. Also included for transition is a mapping of the entire report. Note that in longer reports, the selection of design is often a separate section.
- **Discussion:** The discussion presents the design itself, the theory behind the design, the problems encountered (or anticipated) in producing the design, how those problems were (or could be) overcome, and the results of any tests on the design. Note that this part usually consists of two, three, or four main headings. In regards to the actual names of these headings, pay close attention to what your instructor requests. Also consider what would be a logical division for your particular design.
- **Conclusions:** The "Conclusions" section summarizes the design and testing work completed and assesses how well the design meets the objectives presented in the "Introduction." Note that if the design does not meet the objectives, you should analyze why the design did not succeed and what could be modified to make the design a success. Besides summarizing the work and analyzing whether the objectives were met, the "Conclusions"

section also gives a future perspective for how the design will be used in the future. For an example, see the following "Conclusions."

- **Appendices:** In a design report, appendices often are included. One type of appendix that appears in design reports presents information that is too detailed to be placed into the report's text. For example, if you had a long table giving voltage-current measurements for an RLC circuit, you might place this tabular information in an appendix and include a graph of the data in the report's text. Another type of appendix that often appears in design reports presents tangential information that does not directly concern the design's objectives.

Self-Check 4	Written Test

Directions: Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

1. What are the purpose and application of design report procedures? (5 pts)
2. From the deign report summery is the first procedures how to define these procedures? (4 pts)
3. From the deign report introduction is the second procedures how to define these procedures? (6 pts)
4. From the deign report discussion is the third procedures how to define these procedures? (5 pts)
5. What is the difference between summery and conclusion in design report component? (6 pts)

***Note:* Satisfactory rating - 13points** **Unsatisfactory - below 13 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

1. ____
2. ____
3. ____
4. ____
5. ____

5.1 Listening, questioning and receiving feedback

Effective Communication Skills contains the following elements:

- **Active Listening: -**Listening with the intent to truly understand your clients. Studies show that we are poor listeners and that effective active listening requires effort and training. Exercises for Active Listening:
  - Listen for and analyze main ideas in meetings
  - Focus on speaker's meaning, not words
  - Think ahead and speculate what the speaker might say
  - Test the validity of what the speaker is saying
  - Reflect on what your client has said
  - Use body language that agrees with what you are saying
  - Seek verification that you have understood the client correctly
- **Feedback: -**Confirm your perceptions of the message through offering and requesting feedback. Feedback demonstrates active listening and empathy while eliminating the risk of misinterpretations. Two types of feedback:1. Paraphrasing 2. Summarizing
- **Effective Questioning: -** Your clients will not always provide you with all of the information you need. Asking the right questions will allow you to better serve your clients. There are several techniques you can use to get the answers you need:
  - ✓ Open-Ended Questions
  - ✓ Closed-Ended Questions
  - ✓ Leading Questions
  - ✓ Indirect Questions
  - ✓ Follow-Up (Secondary) Questions Pauses

5.2 Working cooperatively and collaboratively with others to complete tasks

5.2.1 Elements of Successful Collaboration

The idea of collaboration seems easy enough – just work together. But there's more to it than that. If you need to work with others on a project, make sure you include all of these elements of a successful collaboration:

- Clear definitions and agreements on the roles of partners in the collaborative process.

- Open communication within teams to share the information necessary to carry out tasks.
- Consensus about goals and methods for completing projects or tasks. Don't move forward until all members are in agreement.
- Recognition of, and respect for, the contribution of all collaborators. It's important to give credit where credit is due.
- Identification of obstacles and addressing problems cooperatively as they occur. Teamwork is essential at all times.
- Group goals are placed above personal satisfaction and/or recognition. It's crucial to put the desired project results at the forefront – this isn't about the individual goals.
- Willingness to apologize for missteps and ability to forgive others for mistakes. Holding a grudge or sabotaging the efforts of other team members just can't happen. The following are examples of Collaboration Skills
    - ✓ Actively listening to the concerns of team members
    - ✓ Agreeing on roles that capitalize on individual strengths
    - ✓ Analyzing problems without assigning blame
    - ✓ Assessing the strengths and weaknesses of partners
    - ✓ Brainstorming solutions to problems
    - ✓ Building consensus about goals and processes for group projects
    - ✓ Compromising when necessary to move the group forward
    - ✓ Defining mutually acceptable roles
    - ✓ Delegating tasks with open discussion
    - ✓ Displaying a willingness to find solutions to problems
    - ✓ Drawing consensus around goals and processes
    - ✓ Facilitating group discussion
    - ✓ Following through with commitments in a reliable manner
    - ✓ Forgiving others when they come up short
    - ✓ Giving credit to others for contributions
    - ✓ Interviewing clients to determine their needs and preferences
    - ✓ Identifying obstacles to success
    - ✓ Investing the required time and energy to complete tasks
    - ✓ Taking a leadership role
    - ✓ Listening to the concerns of team members

Five ways to lead a high performing team and collaborate with them most effectively:

- **Get everyone on the same page: -** The most important thing you can do to collaborate is to get people to work with you on the same goals. If everyone is distracted by working on their own projects, nothing gets done. As a member of the team, or the team leader, you need to sit everyone down and discuss your short and long-term goals, how you're going to hit them and dictate who does what work.
- **Set expectations: -** Everyone on the team needs to know what they have to do and when they have to do it by. They should know how much work is expected of them and the amount of hours they should put into it. They should also know what part of the project they need to be working on and who they can count on for support and resources. Leaders need to connect their team's goals to the overall strategic plan of the company. It's important to also align the individual expectations with the shared expectations of the team. You also need to establish program metrics and timelines with the team and share progress updates so that people know when things are accomplished and can focus on other aspects of the project. Reporting is important so don't forget to update your boss or the executives on your status so you can show steady improvement.
- **Use tech tools**: - As you know from being on this site, Quick Base is a cloud-based platform to easily build your own business process applications that can help you collaborate better in teams, no coding required. Quick Base allows you to set reminders, alerts and notifications to match your team needs. Google Docs is a free and easy to use way to share Microsoft Word and Excel files, edit them and see who is accessing them. However, if you're using spreadsheets for online collaboration, you may want to assess if they are slowing you down or worse, causing manual errors.

- **Be open about everything: -**If something isn't going right or you aren't getting along with a team member, you need to be upfront with it. The more you hold back the more it will impede collaboration between the team. People love transparency because it makes them feel like they are part of a team.
- **Hold effective team meetings; -** Most teams **meetings catching** up about personal things. Before you start a meeting, have a reason for it. Then, tell each individual team member what they need to bring to each meeting and set an agenda. This way, you can measure the success of a meeting. Don't feel like the meeting has to be an hour or two hours – make it more about the tasks at hand because the more time people spend in the meeting, the less time they have to do work.

https://www.quickbase.com/blog/the-5-best-ways-to-collaborate-with-your-team

Self-Check 5	Written Test

Directions: Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

1. List the common elements of Effective Communication Skills and discuss each it? (5 pts)
2. If you need to work with others on a project, what are the elements of a successful collaboration? (5 pts)
3. List at least five Examples of Collaboration Skills? (5 pts)
4. What are the five ways to lead a high performing team and collaborate with them most effectively? (5 pts)
5. List at least three types of questioning in good communication skill? (6 pts)

Note: **Satisfactory rating - 13points Unsatisfactory - below 13 points**

Score = ___________

Rating: ____________

Answer Sheet

Name: _________________________ Date: _______________

Short Answer Questions

1. ____
2. ____
3. ____
4. ____
5. ____

No Reference????