POLITEKNIK MALAYSIA
MERLIMAU

DCC50212 HYDROLOGY

TOPIC 1 : INTRODUCTION TO HYDROLOGY

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CIVIL ENGINEERING DEPARTMENT

#PoliteknikMerlimau #X4X
#PMMWarriors
ebook - topic 1

TOPIC 1 :

INTRODUCTION TO HYDROLOGY

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PREFACE

This e-book is written for students civil engineering that taking DCC50212 Hydrology courses, to assist them in understanding chapter topic one for introduction of hydrology.

This e-book has one chapters that cover concept of river basin and catchment area, hydrology cycle, climate change and calculation of water balance.

This e-book also contain worked examples and necessary information required for final examination.

I would like to express my gratitude to all students and members who have contributed in ensuring the compilation of this e-book possible. I also welcome any suggestions from readers to improve this e-book in any manner. May Allah bless us all on our effort, with mercy and acceptance.

Noorhaslizah binti Ahmad Rosli
Civil Engineering Department
Politeknik Merlimau Melaka
2023

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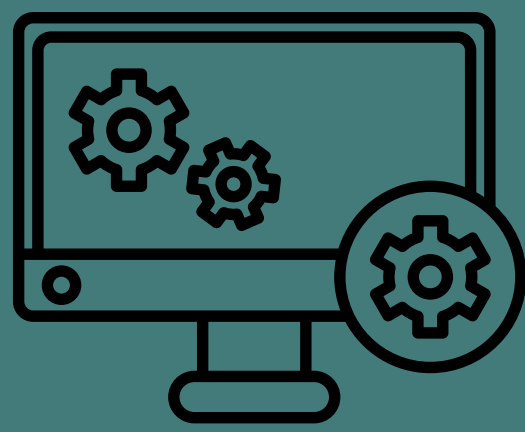


COURSE LEARNING OUTCOME

UPON COMPLETION OF THIS COURSE, STUDENTS SHOULD BE ABLE TO:

CLO1 : Apply basic concept of applied hydrology in Civil Engineering (C3 , PLO1)

COURSE SYLLABUS

TOPIC 1

1.0 INTRODUCTION TO HYDROLOGY

1.1 Explain the concept of river basin and catchment area

1.2 Discuss hydrology cycle with diagram

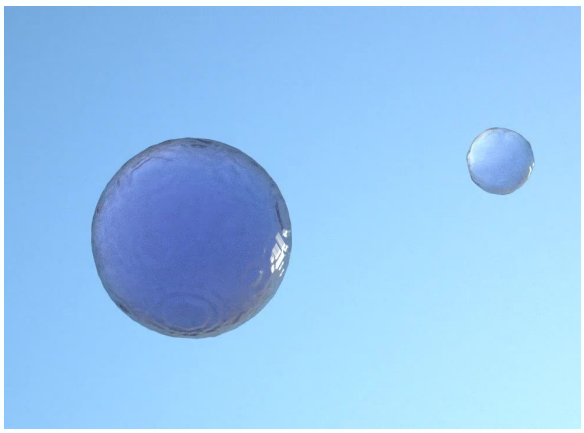
1.2.1 Explain the process involved in hydrologic cycle

a. Evaporation
b. Condensation
c. Precipitation
d. Surface Runoff
e. Infiltration
f. Underground water
g. Interception
h. Transpiration
i. Evapotranspiration

1.3 Discuss the climate change impact to the hydrological cycle

1.4 Calculate the water balance

WHAT IS THE HYDROLOGY ?



- A branch of scientific and engineering discipline that deals with the occurrence, distribution, movement, and properties of the waters of the earth.

- As a branch of earth science, it is concerned with the water in streams and lakes, rainfall and snowfall, snow and ice on the land, and water occurring below the earth's surface in the pores of the soil and rocks.

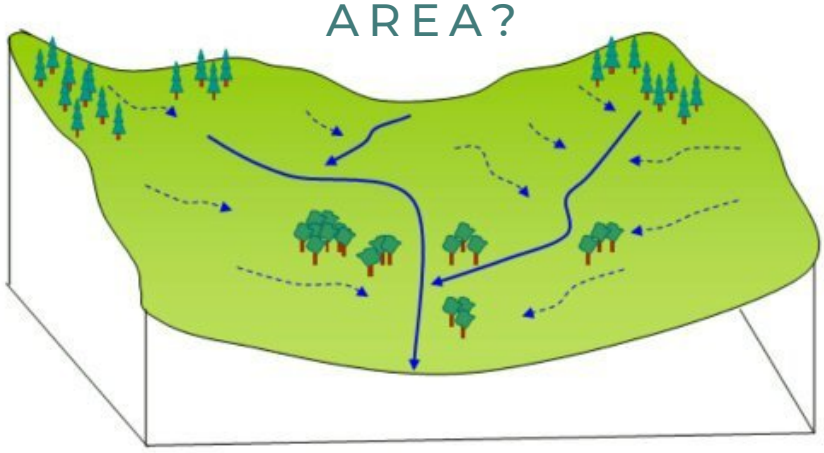
Engineering Hydrology
K Subramanya , 2008

CATCHMENT AREA

A portion of the earth's surface that collects runoff and concentrates it at its furthest downstream point, known as the catchment outlet.

The area of land draining into a stream or a water course at a given location is known as catchment area. It is also called as drainage area or drainage basin. In USA, it is known as watershed.

WHAT IS CATCHMENT AREA?



A catchment area.

Watershed – used for small catchment

Basin – used for large catchment

RIVER BASIN

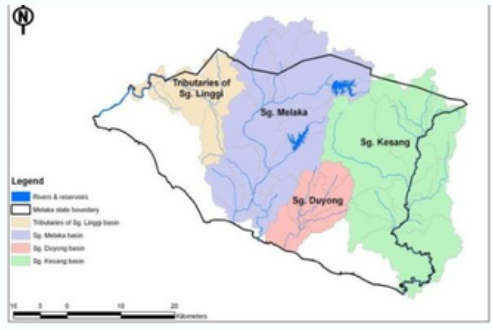
A river basin is the area of land over which surface run-off flows via streams, rivers, and lakes into the sea.

A river basin sends all the water that falls within it to a central river, and from there to the ocean.

Basins are divided into watersheds, or land areas that surround a small, river or lake.

A river basin drains all of the land around a major river.

A river basin is the portion of land drained by a river and its tributaries. It encompasses all of the land surface dissected and drained by many streams and creeks that flow downhill into one another.



SCHEMATIC SKETCH OF CATCHMENT OF RIVER

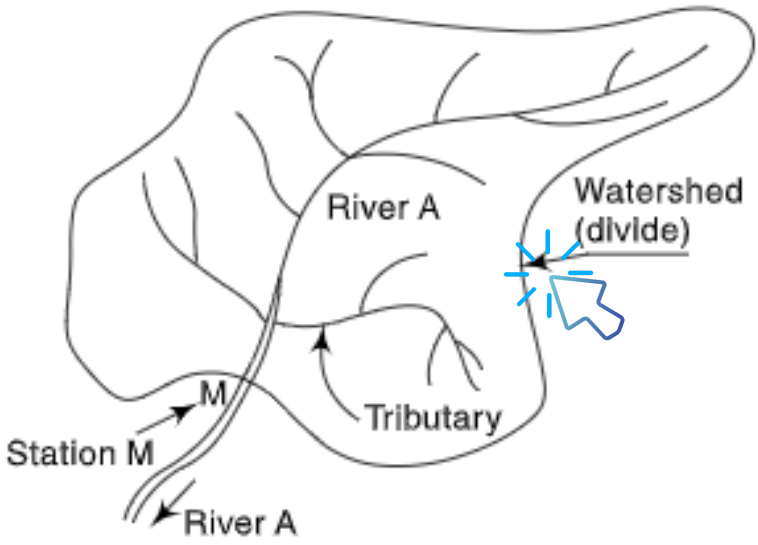
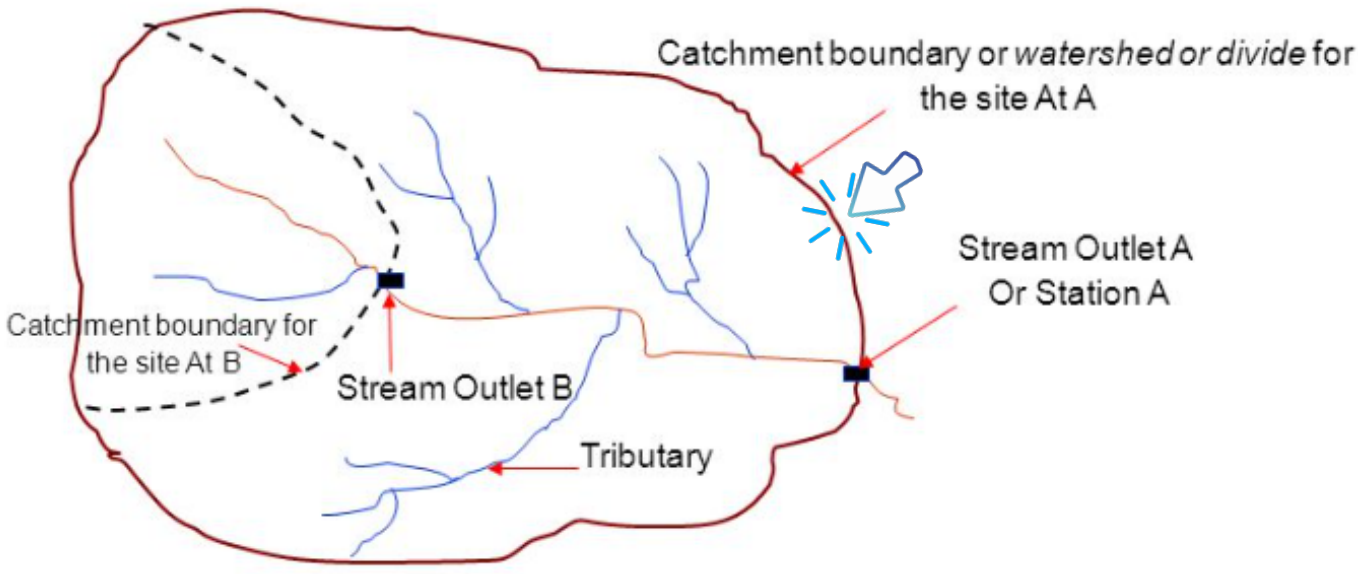
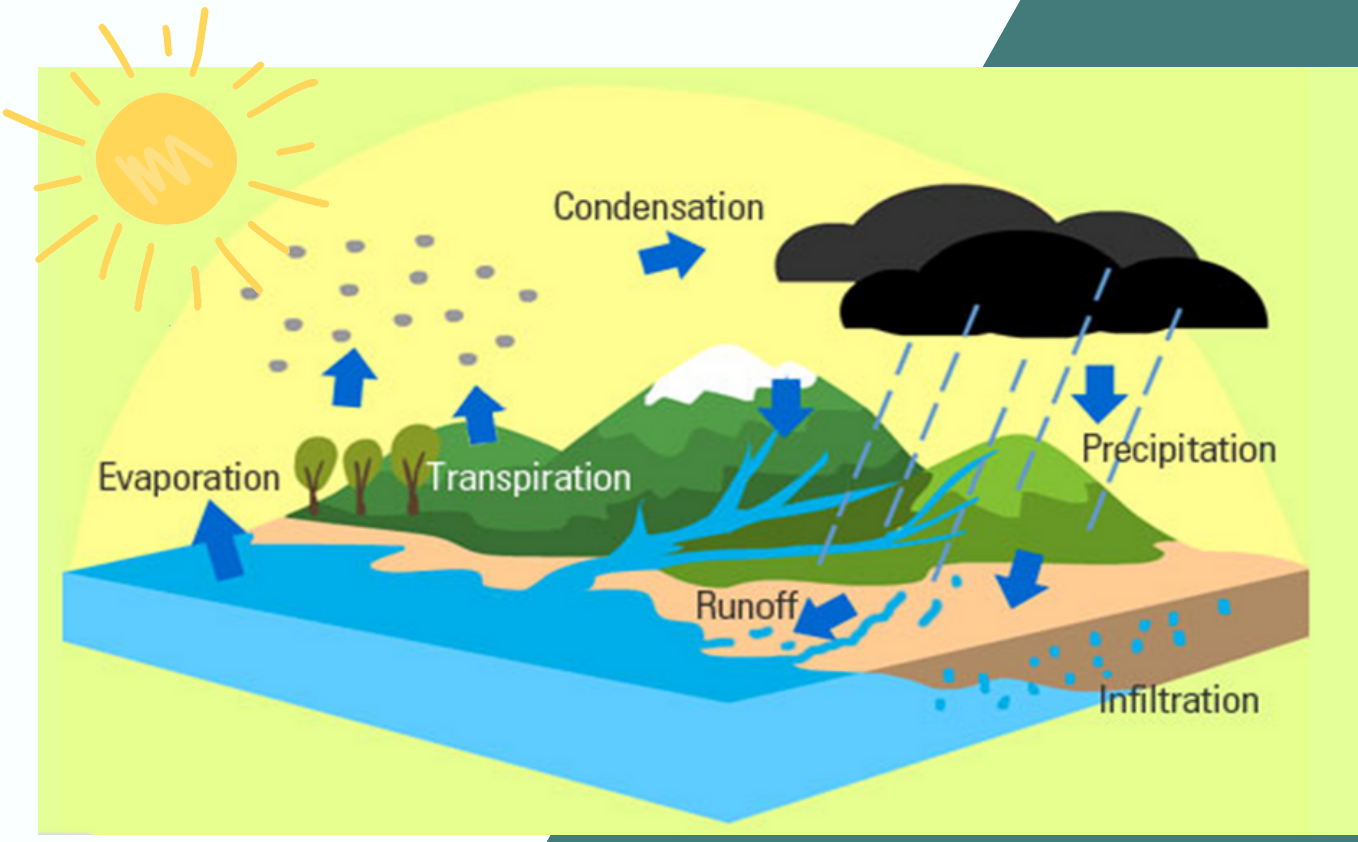


Fig. 1.3 Schematic Sketch of Catchment of River A at Station M



HYDROLOGY CYCLE

- A continuous process of water movement in various forms, phases and places between the atmosphere, the land, and the oceans.
- The actual process is very complex, containing many sub-cycles without any beginning or ending.
- In this respect, we may consider the oceans as the major sources of water, the atmosphere as the conveyer of water, and the land as the user of water.

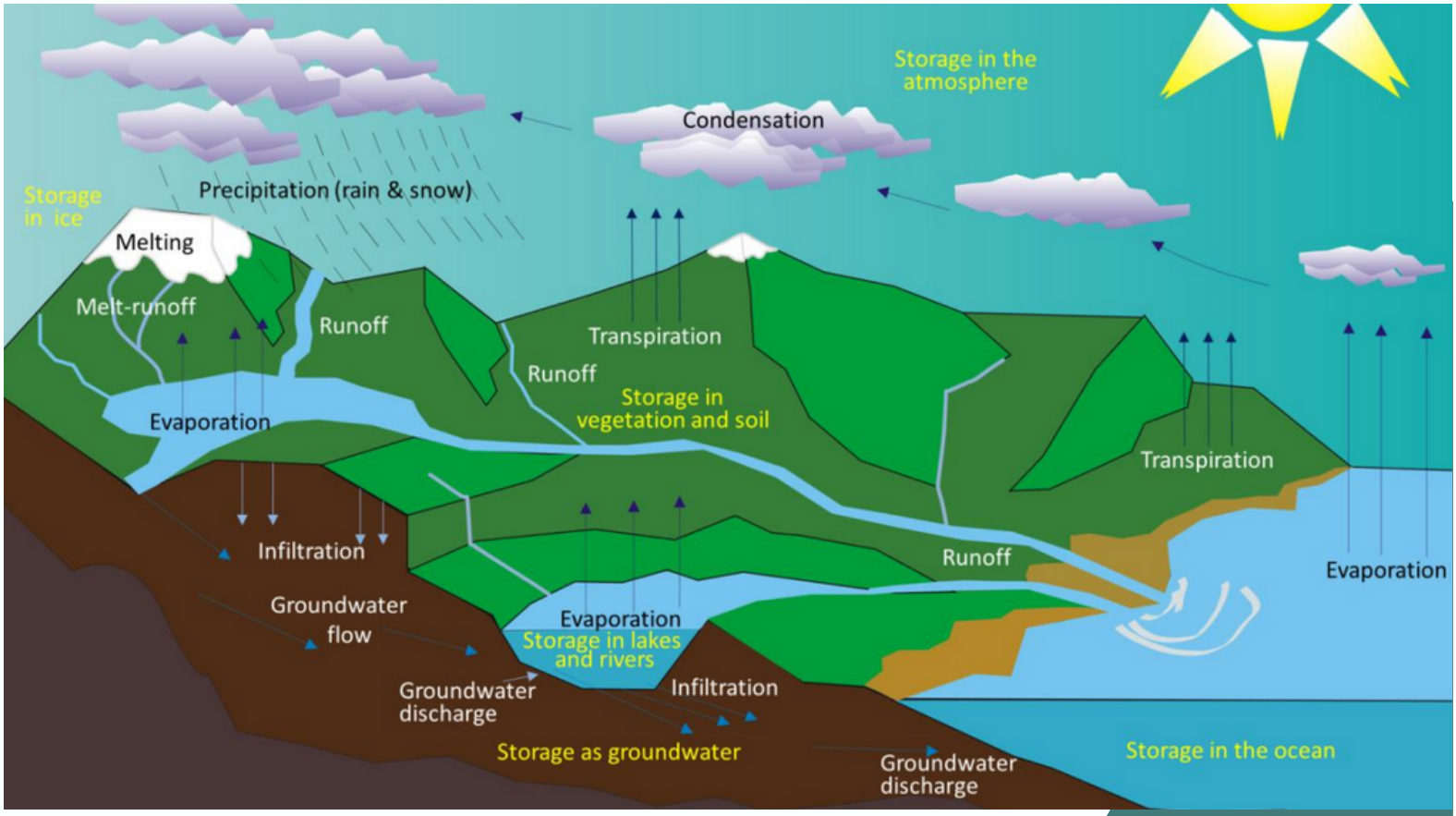


COMPONENTS OF HYDROLOGY CYCLE

- Process involved in hydrologic cycle:-

  a. Evaporation
  b. Condensation
  c. Precipitation
  d. Surface Runoff
  e. Infiltration
  f. Underground water
  g. Interception
  h. Transpiration
  i. Evapotranspiration

HOW THE HYDROLOGY CYCLE WORKS ?



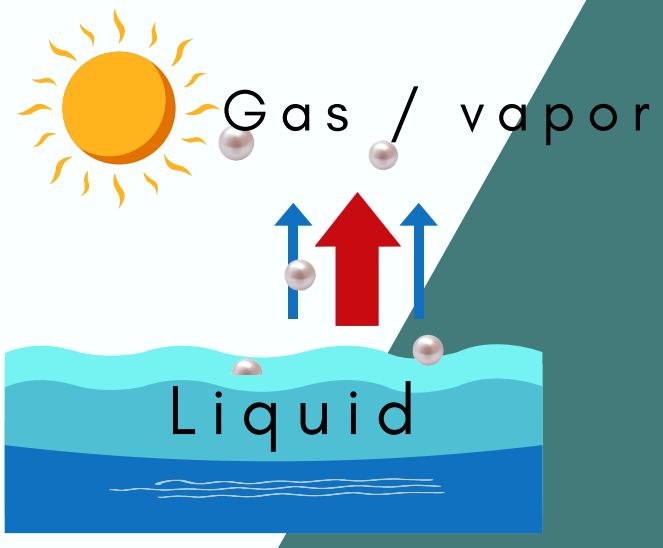
VIDEO LINK :

https://www.youtube.com/watch?v=ncORPosDrjI

https://www.youtube.com/watch?v=al-do-HGuIk

EVAPORATION

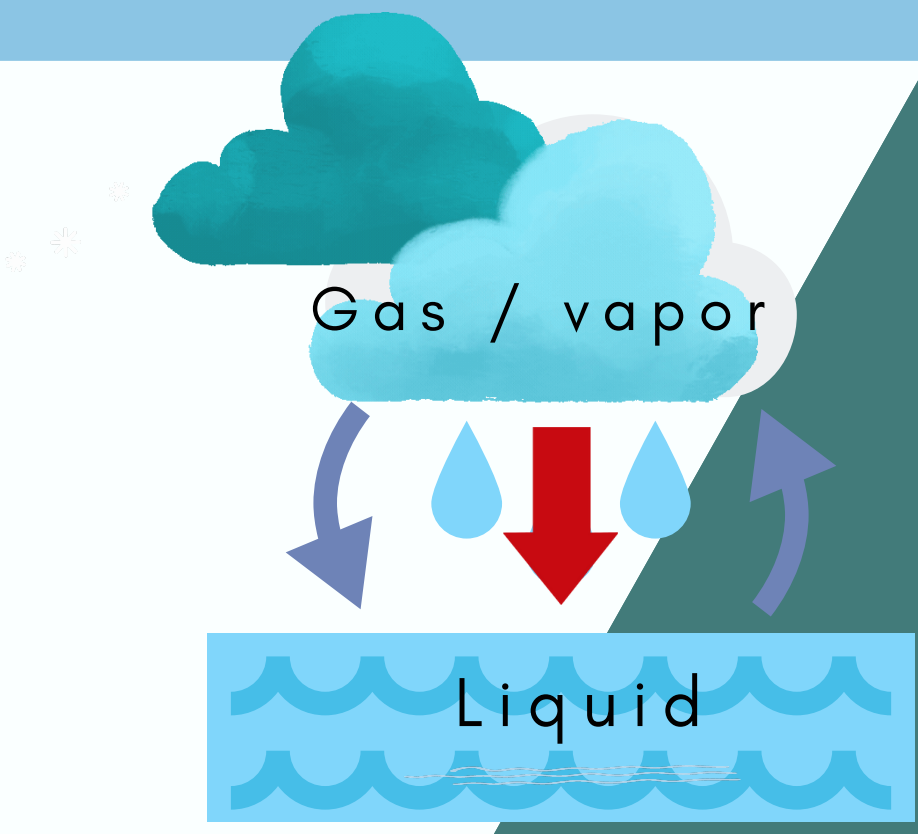
- Evaporation is the process in which water changes from a liquid to a gas or vapor.
- Evaporation occurs mainly as free water surface of ponds, lakes and seas.
- Increase with temperature.
- Oceans, seas, lakes, and rivers provide about 90% of the atmospheric moisture through evaporation process, with 10% more trough plants transpiration.
- The factors affecting evaporation are air and water temperature, relative humidity, wind velocity, sunshine and surface area (exposed).



https://www.youtube.com/watch?v=ncORPosDrjI

CONDENSATION

- Condensation is the phase change of water vapor into liquid.
- Cooling the air is the most common way for condensation to occur and create clouds.
- When air is saturated with water vapor, water vapor condenses into droplets of water, forming clouds.
- When the droplets gain enough mass, they will fall to the ground as rain or snow



https://www.youtube.com/watch?v=ncORPosDrjI

PRECIPITATION

- Precipitation is defined as the condensed water vapor that falls to the earth surface in any physical form.
- Process that occurs when any and all forms of water particles fall from the atmosphere and reach the ground.
- The usual forms of precipitation are rain, hail, freezing rain, snow or sleet.

https://www.youtube.com/watch?v=ncORPosDrjI

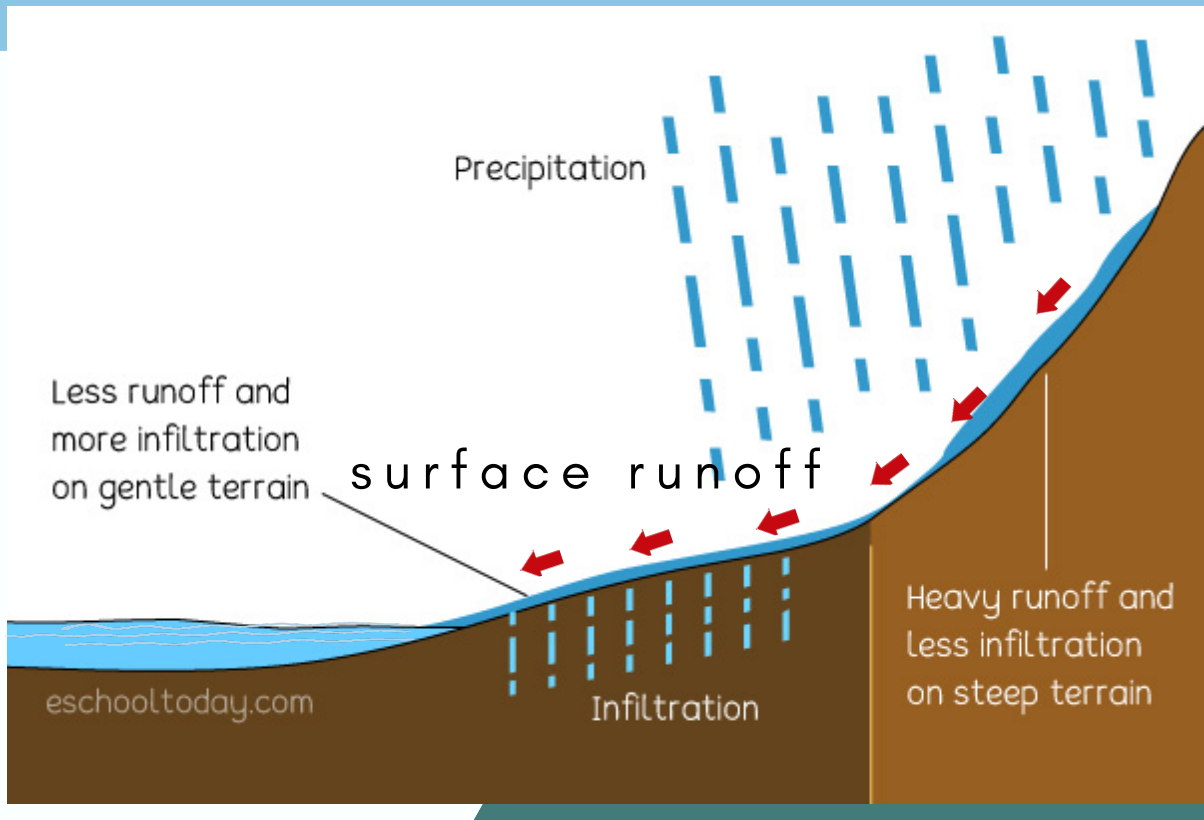
INTERCEPTION

- Interception is the process of interrupting the movement of water in the chain of transportation events leading to the streams.
- Interception refers to precipitation that does not reach the soil, but is instead intercepted by the leaves and branches of plants and the forest floor.

https://www.youtube.com/watch?v=ncORPosDrjI

SURFACE RUNOFF

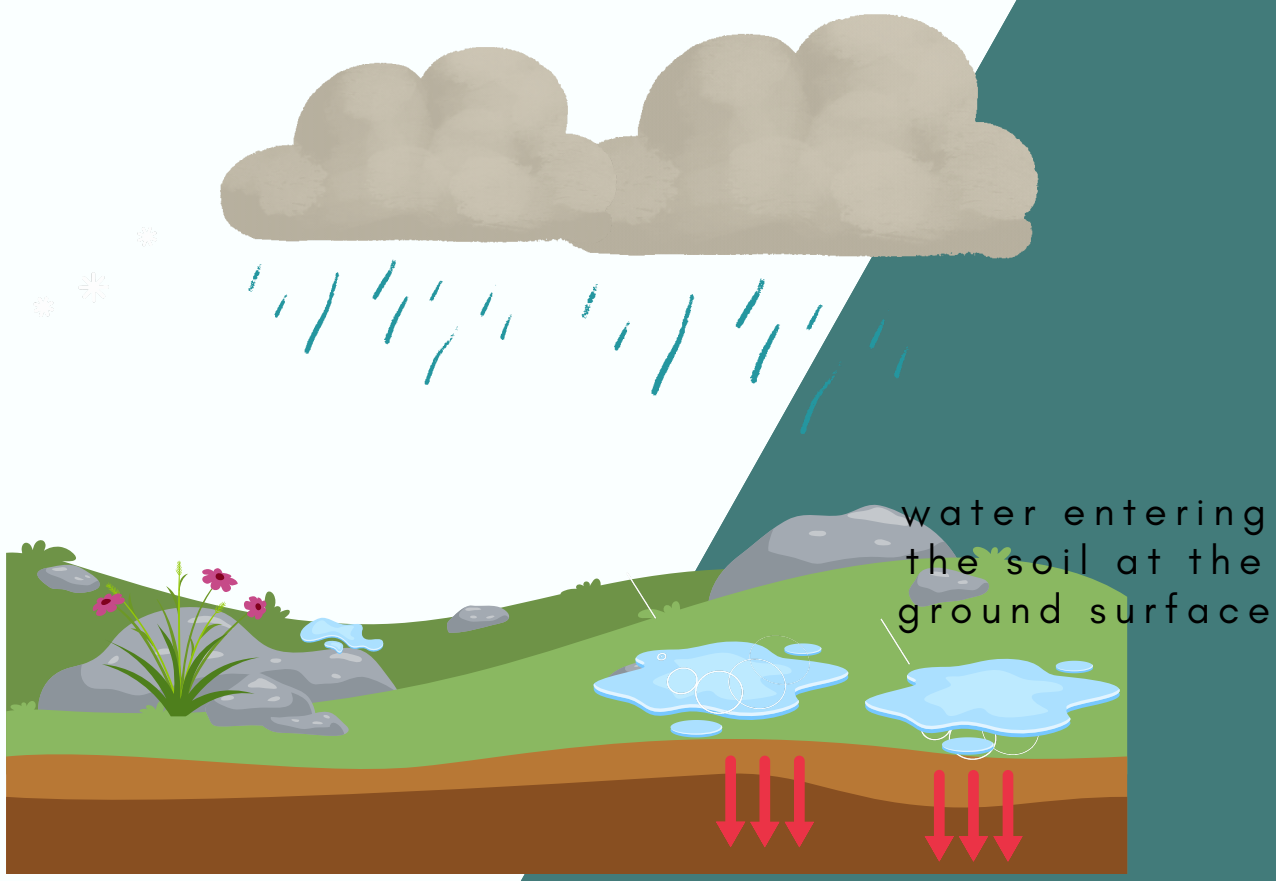
- Surface runoff is the water flow that occurs when the soil is infiltrated to its full capacity and excess water from rain, meltwater, or other sources flows over the land.
- Surface runoff is precipitation that did not get (infiltrated) absorbed into the soil or did not evaporate, and therefore, made its way from the ground surface into places that water is collected.



https://www.youtube.com/watch?v=ncORPosDrjI

INFILTRATION

- Infiltration is the process in which water on the ground surface enters the soil.
- Infiltration rate depends on the soil's characteristic, intensity and duration of rainfall, weather, initial moisture content, vegetal cover, land use, entrapped air and depth of the ground water table.

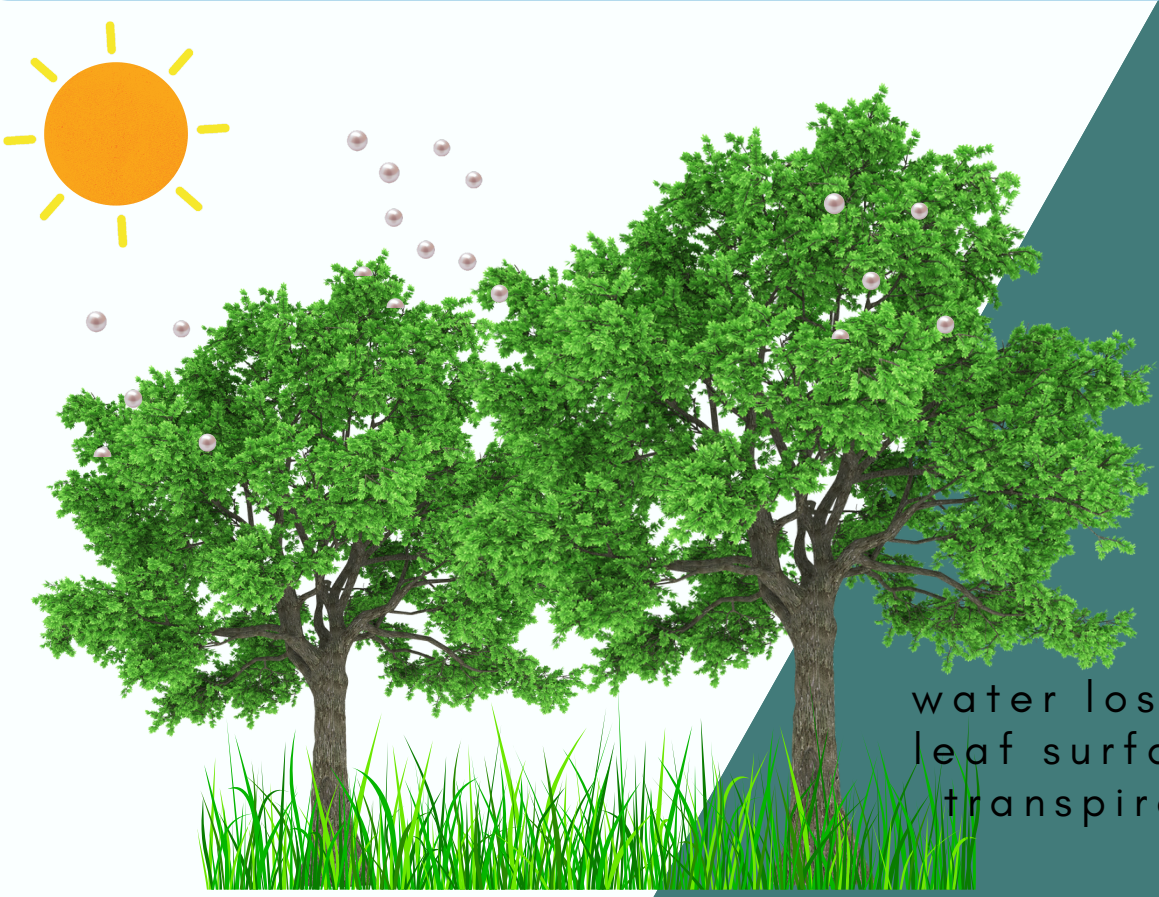


water entering the soil at the ground surface

https://www.youtube.com/watch?v=ncORPosDrjI

TRANSPIRATION

- Transpiration is the process in which water leaves the body of living plant and reaches the atmosphere as water vapour.
- The process in which the water vapor escapes from the living plant leaves and enters the atmosphere.
- Transpiration is essentially evaporation of water from plant

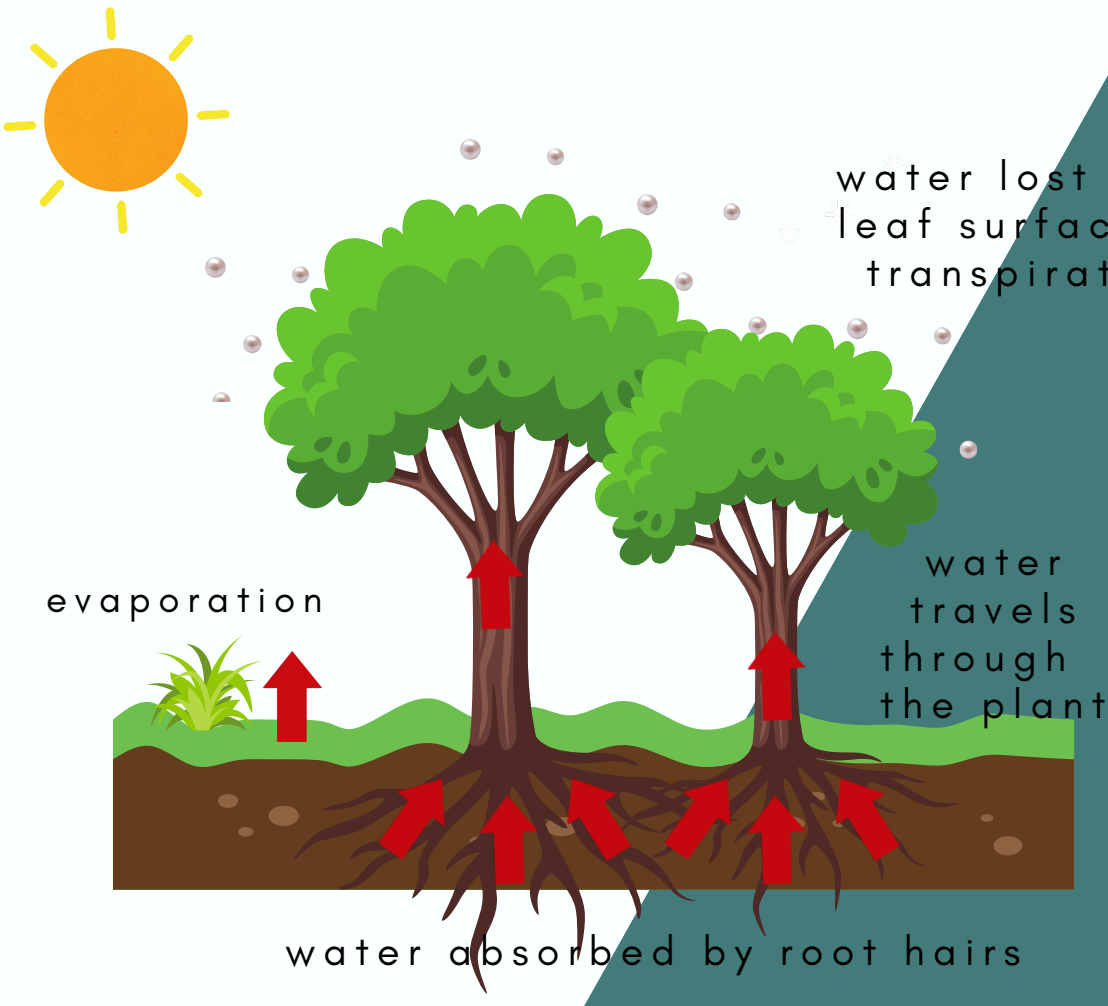


water lost from leaf surface by transpiration

https://www.youtube.com/watch?v=ncORPosDrjI

EVAPOTRANSPIRATION

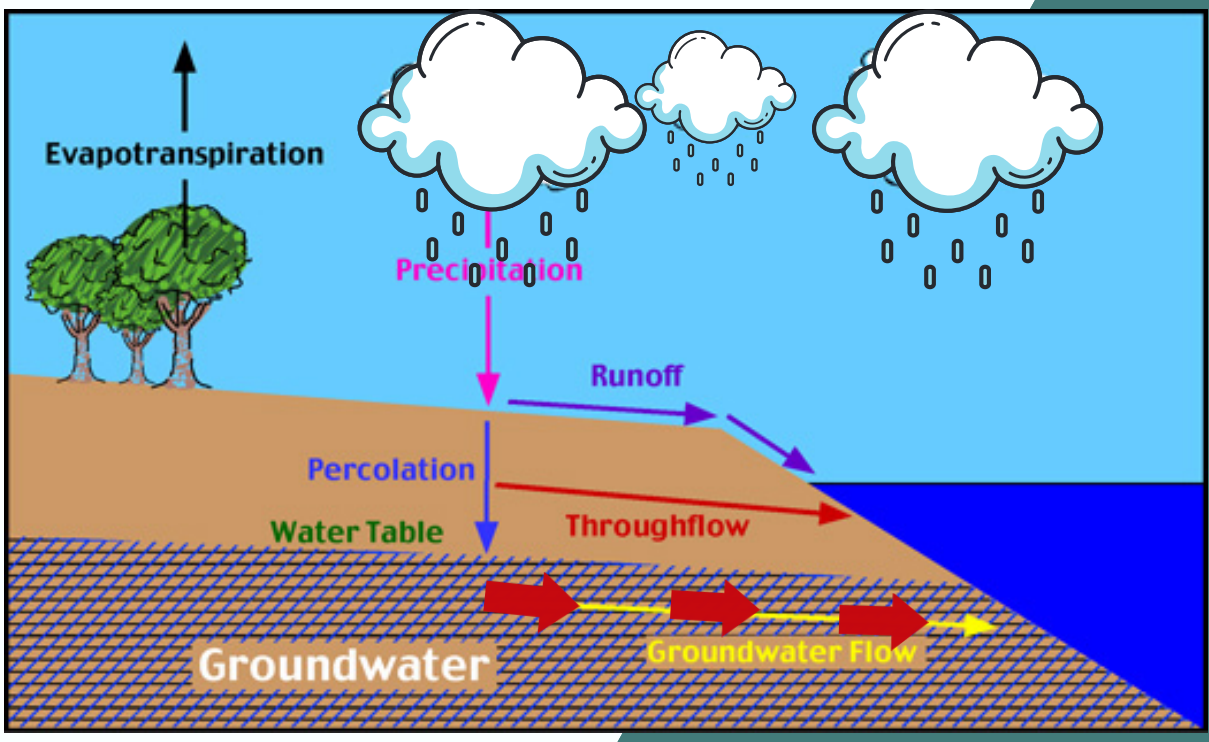
- Evapotranspiration is the sum of evaporation from the land surface plus transpiration from plants.
- The typical plant, including any found in a landscape, absorbs water from the soil through its roots.
- In general, evapotranspiration is the sum of evaporation and transpiration.



https://www.youtube.com/watch?v=ncORPosDrjI

GROUND WATER

- Groundwater is fresh water (from rain or melting ice and snow) that soaks into the soil and is stored in the tiny spaces (pores) between rocks and particles of soil
- Groundwater is water that exists underground in saturated zones beneath the land surface. The upper surface of the saturated zone is called the water table.



The movement of groundwater horizontally is called groundwater flow.

https://www.youtube.com/watch?v=ncORPosDrjI

FORMATIVE ASESSTMENT

TO DO!

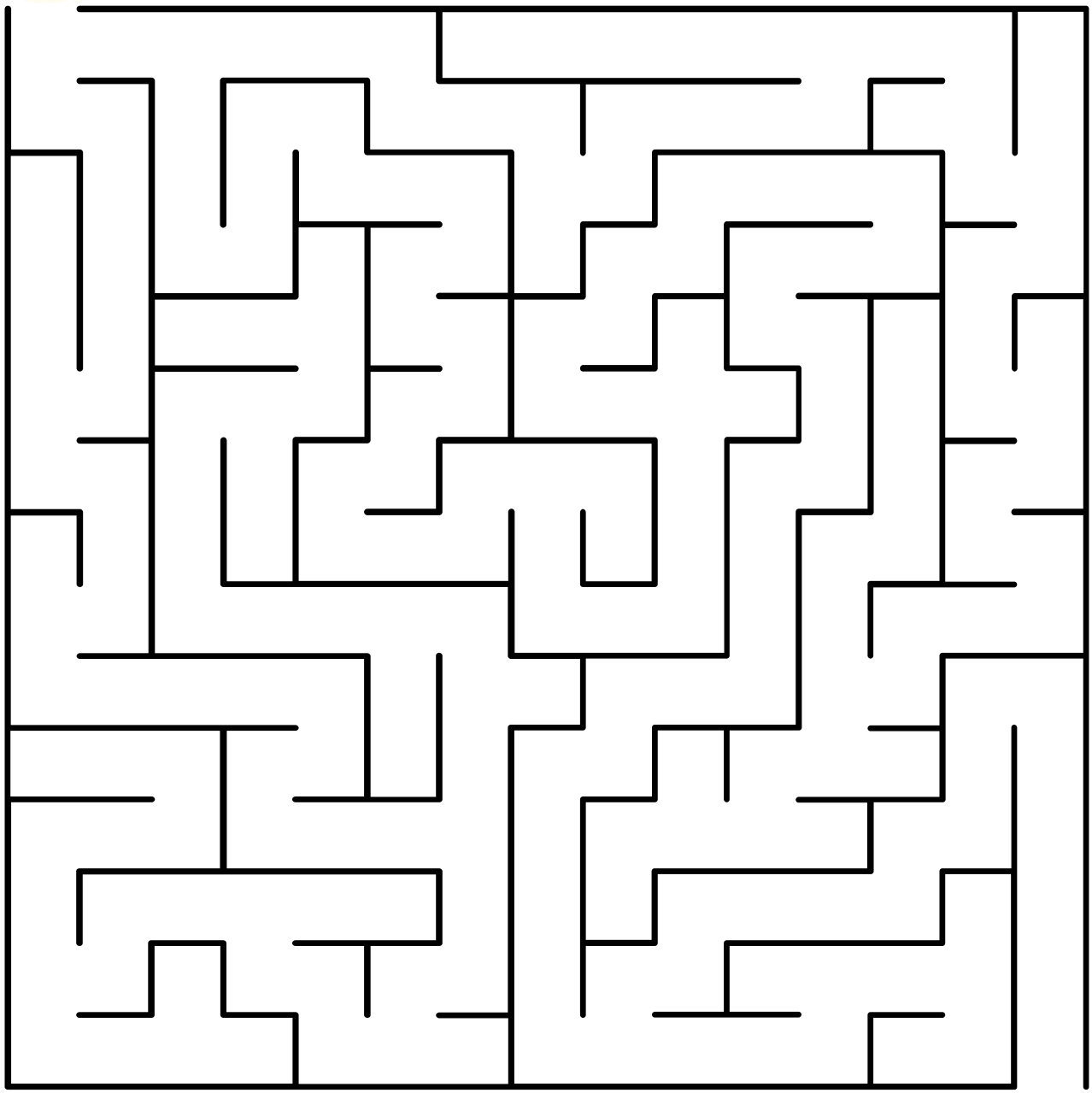
Sketch the diagram that includes the hydrology cycle process below:

a. Evaporation
b. Condensation
c. Precipitation
d. Surface Runoff
e. Infiltration
f. Underground water
g. Interception
h. Transpiration
i. Evapotranspiration

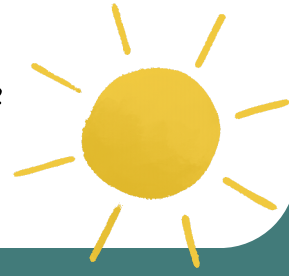
Stay Positive!

THE MISSING SUN!

This student is looking for a place with sun!
Can you help him find it?



Can you explain the function of the sun in the hydrological cycle process?



The Hydrology Cycle

WORD SEARCH

Can you find the words hidden in the puzzle?

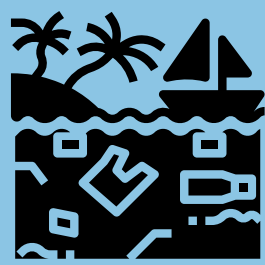
C R O P O S P H E R E A N P
O R E X O N P H E R E A S R
N A S L Y O L A Y E R I U E
D E O A A I T O S A U N U C
E V V Z L T E I T I S T V I
N A T E O A L N L A A E A P
S P R B O R D I O X I R E I
A O A W N I E H O G U C E T
T R M E S P S P H E R E U A
I A R O F S O N C H I P T T
O T H E R N O S P H E T E I
N I C Y N A E Y O C O I L O
R O A E U R C O U N N O U N
I N F I L T R A T I O N U N

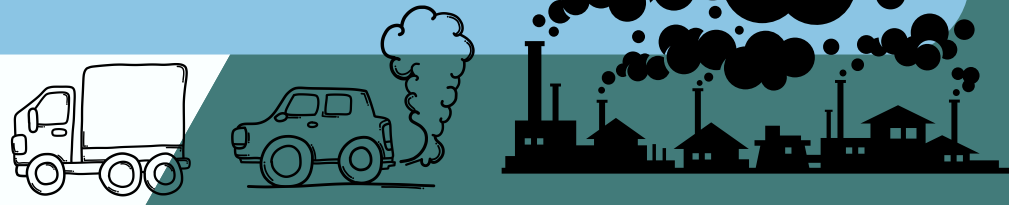
INTERCEPTION TRANSPIRATION EVAPORATION

PRECIPITATION INFILTRATION CONDENSATION

CLIMATE CHANGE

- Climate change is the change in the average weather patterns in a region over a long period of time. One component of climate change is global warming, the long-term heating of Earth due to greenhouse emissions.
- Climate change has also been connected with other damaging weather events such as more frequent and more intense hurricanes, floods, downpours, and winter storms.
- Causes of climate change:
  - Global warming
  - Rapid industrialization
  - Energy use
  - Transportation
  - Pollution
  - Deforestation
  - Agricultural practices
  - Consumer practices

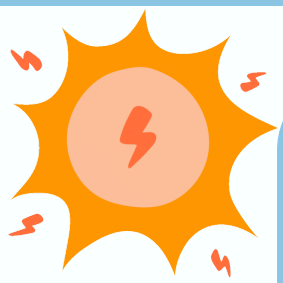




https://www.youtube.com/watch?v=ncORPosDrjI

IMPACT OF CLIMATE CHANGE

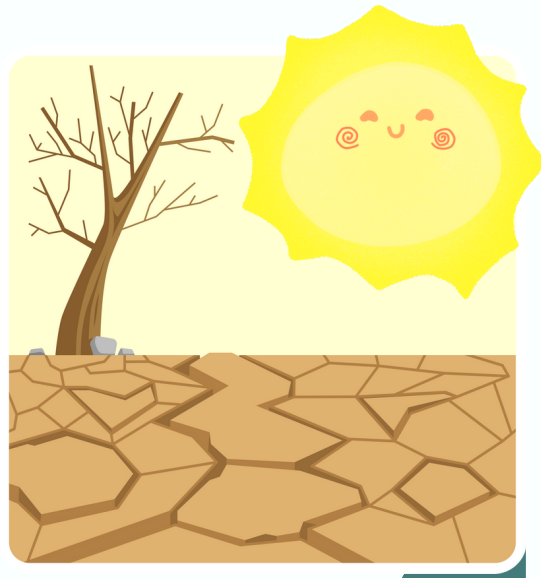
Rising sea level - warmer temperatures are heating up the ocean and and making ice and glaciers melt, causing the sea level to rise. This can flood coastal homes and communities.



Rising temperature - warmer temperatures are heating up the world. As greenhouse gas concentrations rise, so does the global surface temperature. Higher temperatures increase heat-related illnesses and make working outdoors more difficult. This drier, hotter climate also creates conditions that fuel more vicious wildfire seasons—with fires that spread faster and burn longer—putting millions of additional lives and homes at risk.

Flooding - in addition to coastal flooding caused by sea level rise, climate change influences the factors that result in inland and urban flooding: snowmelt and heavy rain.

Increased drought -
Climate change is changing water availability, making it scarcer in more regions. Global warming exacerbates water shortages in already water-stressed regions and is leading to an increased risk of agricultural droughts affecting crops, and ecological droughts increasing the vulnerability of ecosystems.



Extreme weather - Destructive storms have become more intense and more frequent in many regions. As temperatures rise, more moisture evaporates, which exacerbates extreme rainfall and flooding, causing more destructive storms. The frequency and extent of tropical storms is also affected by the warming ocean. Cyclones, hurricanes, and typhoons feed on warm waters at the ocean surface. Such storms often destroy homes and communities, causing deaths and huge economic losses.

https://www.youtube.com/watch?v=ncORPosDrjI

The effects of climate change in Malaysia

By DR MILTON LUM

THE DOCTOR SAYS

Tuesday, 05 Jul 2022

9:00 AM MYT

Megacities like Kuala Lumpur are prone to increased temperatures due to the UHI effect. — IZZRAFIQ ALIAS/The Star

On Apr 5 (2022), the United Nations (UN) Secretary-General described the latest report of the Intergovernmental Panel on Climate Change (IPCC) as "a litany of broken climate promises" and reminded the world that it is "on a fast track to climate disaster".

The Malaysian government has not been providing much information about the effects of climate change in the country.

Rain and floods

It also found an increase in the number of days classified as heavy rainfall (i.e. days with rainfall more than 20 millimetres).

The UN-reported research found that the maximum annual rainfall intensity has increased substantially, i.e. "the one-hour, three-hour and six-hour periods of rain between 2000 and 2007 have risen by 17%, 29% and 31%, respectively, compared with the period of 1970-1980".

Temperature up

According the banks' report, "Between 1970-2013, Peninsular Malaysia, Sabah and Sarawak experienced surface mean temperature increases of 0.14-0.25°C per decade. "Surface maximum temperatures increased by 0.17-0.22°C per decade during the same period, while surface minimum temperatures increased by 0.20-0.32°C per decade".

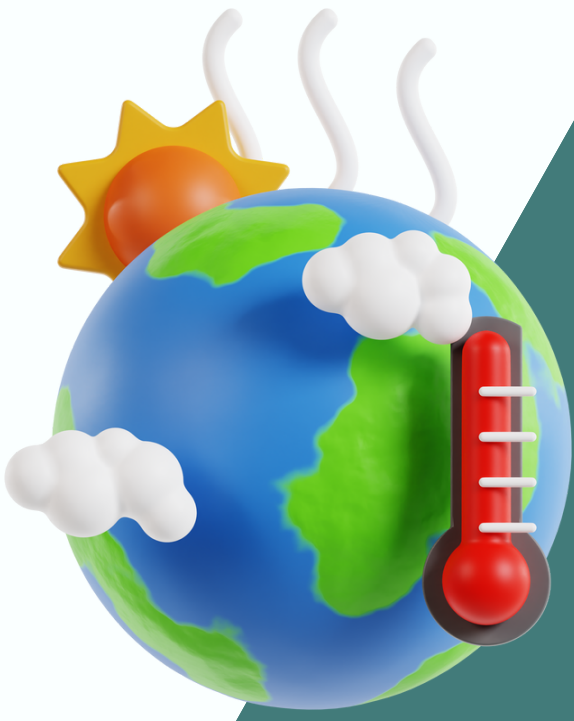
FORMATIVE ASESSTMENT

TO DO!

GROUP ACTIVITY

- Discuss the climate change impact to the hydrological cycle.

Create a mind map on the causes and effects of climate change related to hydrological cycle.



life is good

TO DO!

BUCKET FILLING

List the things that you can do to reduce climate change on our earth

WATER BALANCE

- The hydrologic equation is simply the statement of the law of conservation of matter and is given by:

Σ Inflows - Σ Outflows = ΔStorages

$$I - O = \Delta S$$
$$P - (ET + I + R + G) = \Delta S$$
$$P - ET - I - R - G = \Delta S$$

Where,

ΔS = change in storage
I = inflow (P)
O = outflow (ET,I,G,R)

REMEMBER! → hydrological cycle process

P = Precipitation
R = Surface Runoff
G = Underground Water
I = Infiltration
ET = Evapotranspiration

IMPORTANT

Do not forget

EXAMPLE 1

The drainage area of the James River at Scottsville, Virginia, is 11839 km2. If the mean annual runoff is determined to be 144.4 m3/s and the average annual rainfall is 1.08m, estimate the ET losses for the area. How does this compare with the lake evaporation of 1 m/yr measured at Richmond, Virginia?

Assuming that $\Delta S = 0$,
and Runoff is converted from m^3 to m/yr as follows

$$\Sigma \text{ Inflows} - \Sigma \text{ Outflows} = \Delta \text{Storages}$$

$$I - O = \Delta S$$

$$P - ET - I - R - G = \Delta S$$

$$R = 144.4m^3/s \quad P = 1.08m \quad ET = ??$$

$$R = 144.4\frac{m^3}{s} \times \frac{365day}{1\,yr} \times \frac{24hr}{1day} \times \frac{60minutes}{1hr} \times \frac{60s}{1minutes}$$

$$R = \frac{144.4 \times (365 \times 24 \times 60 \times 60)m^3}{11839km^2}$$

$$R = \frac{(144.4 \times 31536000)m^3}{11839 \times 10^6 m^2}$$

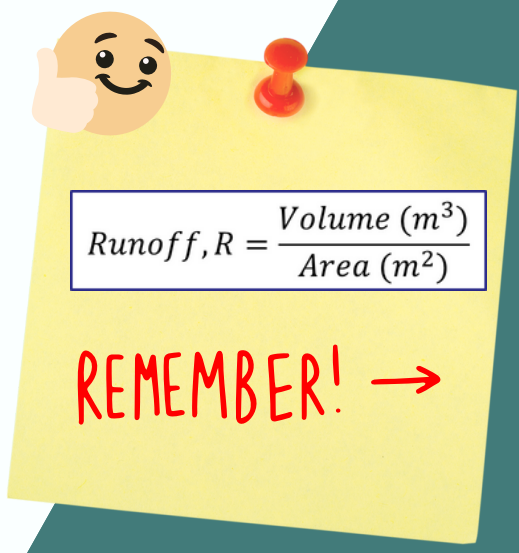
$$R = 0.38\text{m}$$

$$P - R - ET = \Delta S$$

$$ET = P - R$$

$$ET = 1.08 - 0.38$$

$$ET = 0.7m$$



EXAMPLE 2

In 2 months, Sungai Melaka is predicted to receive about 360 mm rainfall. Evaporation is approximately 87 mm and infiltration to sub layer predicted is 50 mm. What is the volume of runoff in m3 if the catchment area is 80 km2.

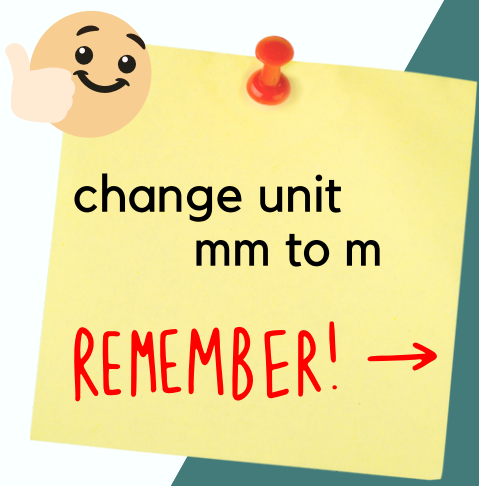
$$\Sigma \text{ Inflows} - \Sigma \text{ Outflows} = \Delta \text{Storages}$$

$$I - O = \Delta S$$

$$P - ET - I - R - G = \Delta S$$

$$P = 360mm \quad E = 87mm \quad I = 50mm \quad R = ??$$

$$P - R - E - I = \Delta S$$
$$R = P - E - I$$
$$R = 0.36 - 0.087 - 0.050$$
$$R = 0.223m$$



$$R = \frac{Volume\ (m^3)}{Area\ (m^2)}$$
$$VR = R \times A$$
$$VR = 0.223\ m^2 \times (80 \times 10^6) m^2$$
$$= 17.84 \times 10^6\ m^3$$

EXAMPLE 3

Based on the observation, the water flow rate that entering Malim Reservoir in a certain season is 360 m3/. If outflow from the reservoir including infiltration and evaporation loses is 255 m3/s. Calculate the change in storage for 21 days.

Σ Inflows - Σ Outflows = ΔStorages

Inflow $= 360 m^3/s$ Outflow $= 255 m^3/s$

$$Inflow = 360 \frac{m^3}{s} \times \frac{21 day}{1\ yr} \times \frac{24 hr}{1 day} \times \frac{60 minutes}{1 hr} \times \frac{60 s}{1 minutes}$$

$=$

$= \quad m^3$

$$Outflow = 255 \frac{m^3}{s} \times \frac{21 day}{1\ yr} \times \frac{24 hr}{1 day} \times \frac{60 minutes}{1 hr} \times \frac{60 s}{1 minutes}$$

$=$

$= \quad m^3$

$$\Delta\ Storage = \sum Inflow - \sum Outflow$$

$= \quad m^3 - \quad m^3$

$= 190 \times 10^6\ m^3$

FORMATIVE ASESSTMENT

TO DO!

QUESTION 1

In six month, Lui watersheds are expected to receive rainfall of 350mm. Evaporation estimated at 100 mm and diffusion into the subsurface is estimated at 40 mm. Estimate the volume runoff directly in cubic meters to be stored in reservoirs that are available if the basin area is 85 km^2.
[Ans: $17.85 \times 10^6 m^3$]

QUESTION 2

In a watershed that is 3.5 km^2, the volume of annual precipitation was 5,000 m^3 and the volume of water that was evaporated was 400 m^3. Estimate the volume of annual runoff (m^3). Assume that storage and groundwater flux are negligible. **[Ans: 4600 m^3]**

QUESTION 3

Based on observation, the water flow rate that entering Malim Reservoir in a certain season is 350 m^3/s. If the outflow from the reservoir including infiltration and evaporation loses is 265 m^3/s, calculate the change in storage for 14 days.
[Ans:102.816 x 106m^3]

QUESTION 4

The Lake capacity storage in the beginning of June 2016 is $25 \times 10^6 m^3$. During this time, the recorded inflow and outflow of the lake is $10\, m^3/s$ and $15.5 m^3/s$ respectively. A month later, the lake received a rainfall of 100 cm and the evaporation from the lake was estimated to be 40 cm. The average surface area of the lake was $30 km^2$. Calculate the changes of storage and its new storage of the lake (in m^3) at the end of July 2016. Assuming there is no contribution to or from the groundwater storage .
[Ans:-10.987×10^6 m^3 ; $14.013 \times 10^6 m^3$]

wonderful

FORMATIVE ASESSTMENT

TO DO!

QUESTION 5

The water storage in a river at a particular time is 20 000 m^3. At that time, the recorded inflow and outflow are 10 m^3/s and 15 m^3/s respectively. One hour later, the inflow and outflow were recorded as 15 m^3/s and 16 m^3/s respectively. Calculate the change of storage and the new storage of water in the river.

[Ans: -10800 m^3 ; 9200m^3]

QUESTION 6

The annual evaporation from a lake is found to be 125cm. If the lake's surface area is 12 km^2. What is the daily evaporation rate in centimeters?

[Ans: 0.34cm/day]

QUESTION 7

If the mean annual runoff of a drainage basin of 10 000 km^2 is 140 m^3 and the average annual precipitation is 105 cm, estimate the ET losses for the area in 1 year. **[Ans: 61 cm / year]**

Stay Positive!

THANKYOU

see you next topic

THE END!!!

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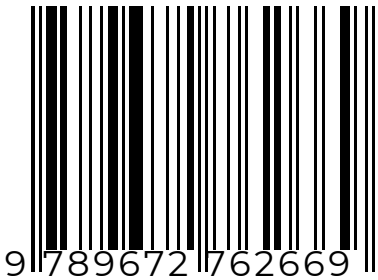

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