Understanding Practical Dimensions of Aquifers and Ground Water

-- A Pre requisite for ensuring Source Sustainability

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Water Cycle

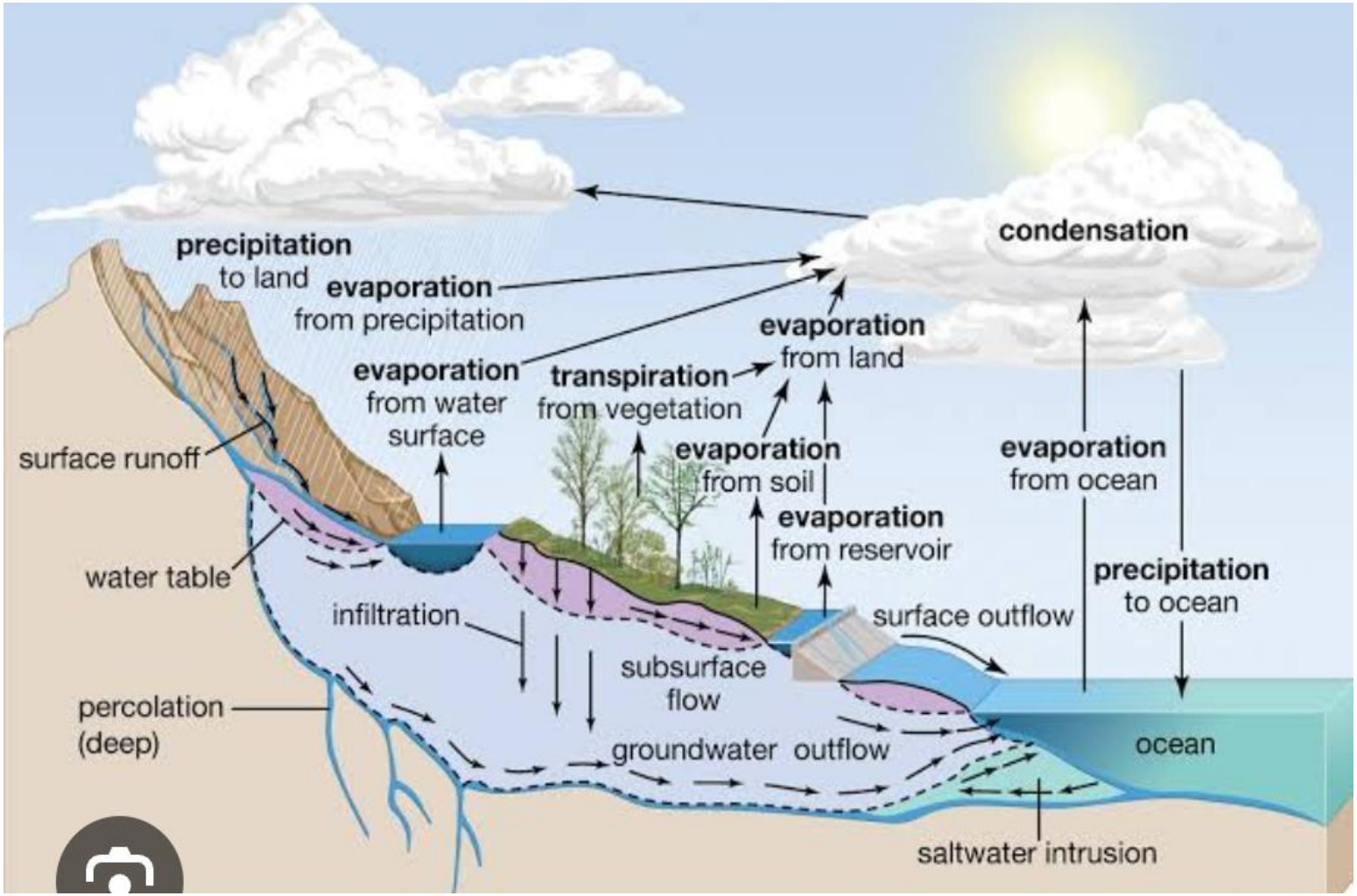
Main Processes

- Evaporation
- Condensation
- Precipitation
- Infiltration/Percolation
- Transpiration
- Run-off
- Storage

Main Components

- Rainfall
- Surface Water
- Ground Water

Water Cycle


condensation
precipitation
to land
evaporation
from precipitation
evaporation
from land
evaporation
from water
surface
transpiration
from vegetation
surface runoff
evaporation
from soil
evaporation
from ocean
evaporation
from reservoir
water table
precipitation
to ocean
infiltration
surface outflow
subsurface
flow
percolation
(deep)
groundwater outflow
ocean
saltwater intrusion

Aquifer (underground water reservoirs)

- Aquifer is an underlying layer of permeable soil or rock in which groundwater is stored, throgh which groundwater flows and it provides sufficient/appreciable yields for various uses through pumping.

Types

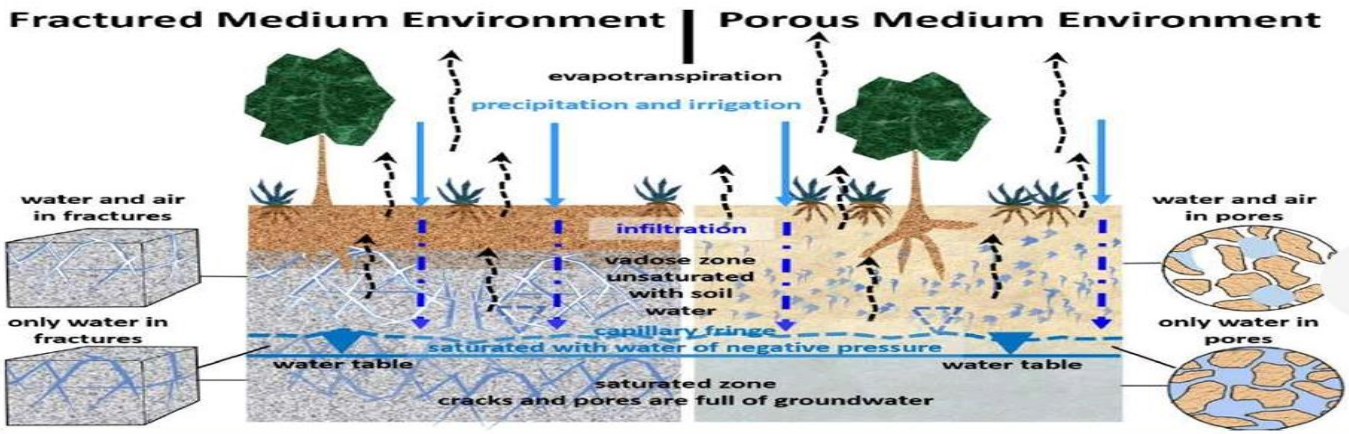
A) Alluvial Aquifers :

- Confined (Overlain & underlain by confining layer-clays)
- Unconfined (Not overlain, bottom is confining layer)
- Semiconfined (Leaky) – (overlain or underlain by semipervious layer)

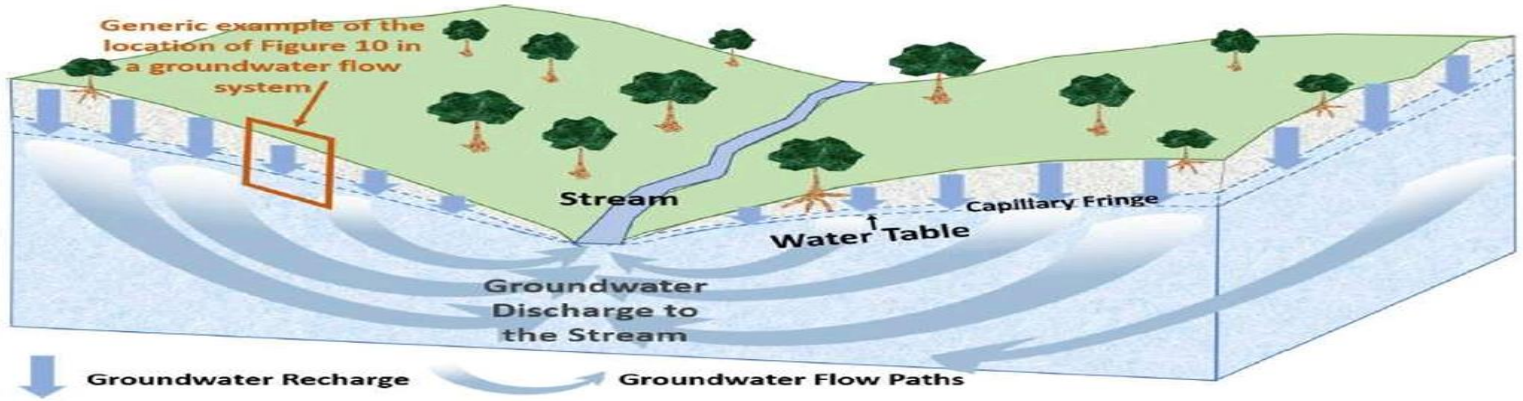
Aquifer Material :- Sand, gravel

B) Discontinuous Aquifers in Hard rock areas (localised pockets) :

- Fissured/Fractured aquifers
- Joints, weathered material as aquifers.
- (Sandstone, limestone, carbonate rock, igneous, metamorphic)



Schematic showing infiltration through the unsaturated zone to the capillary fringe and the water table, where it recharges the groundwater. Water in the unsaturated zone generally moves downward as infiltration (blue arrows) or upward as evapotranspiration (black arrows) thus flow is often envisioned as one-dimensional even though there are localized areas of lateral water movement



After water recharges the groundwater system, the sloping water table moves water laterally from hills to valleys where it seeps out into streams. The inset window places the one-dimensional flow of Figure 10 with in a broader spatial context

perched water table.

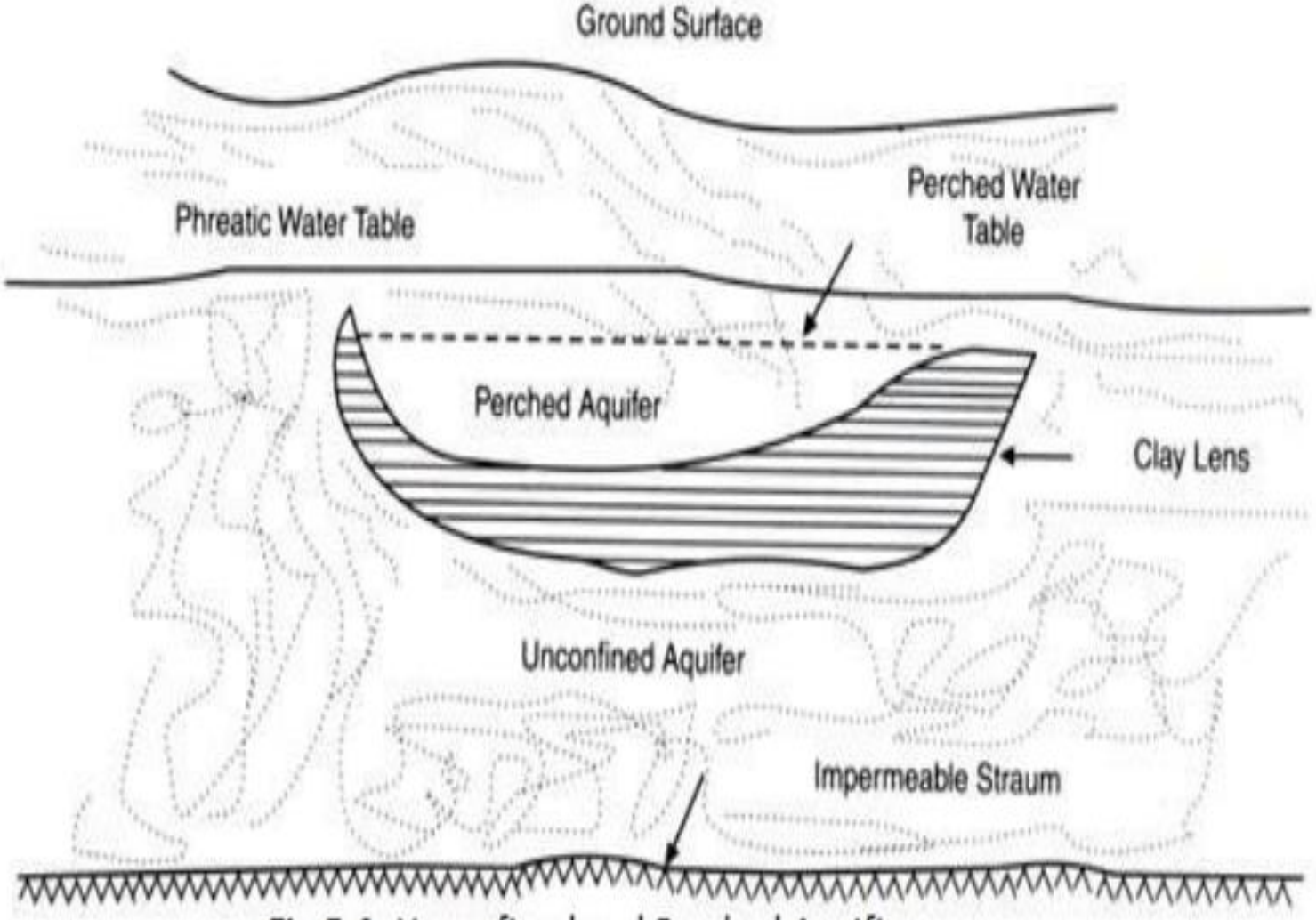


Fig 5.4- Unconfined and Perched Aquifier

Aquifer Characteristics

- Transmissivity (capacity to transmit water)

- Storativity (Volume of water released from storage)

- Specific yield

  (Ration of the volume of water that a sturated rock/soil will yield by gravity (%))

  (specific yield changes with fine/ medium/coarse sand)

An important parameter that signify ground water resource potential/availability

Understanding dynamics of Groundwater system

- Two main processes-

1. Time that takes water levels to respond changes in stress (like pumping) on groundwater system.
2. Time it takes the water to travel through groundwater system.

- ➢ Time frame of changes in water levels depends on how quickly the change in water level propogates after water is removed from storage.
- ➢ Time of travel of water flow- velocity and distance between recharge and discharge boundaries.

These two time scenarios vary in different GW systems.

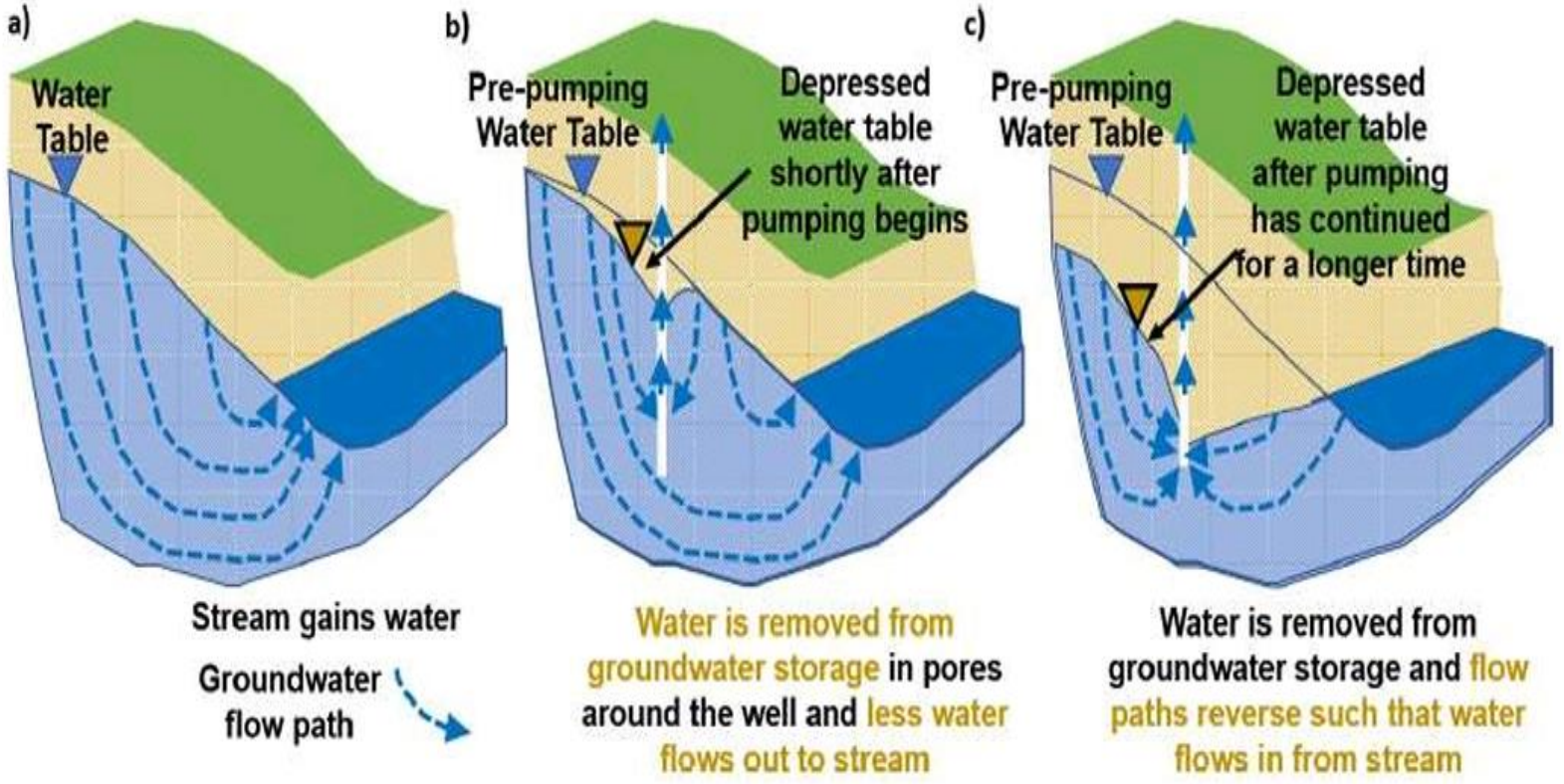
Understanding dynamics of Groundwater system

3. Volume of GW in storage decreases in response to withdrawals and that reflected as GWL declines.

- If water level declines (due to continuous exploitation) are sustained overtime

-- that would result into GW depletion -

--would lead to Aquifer damage/deterioration



Schematic showing that pumping water from a well near a stream depresses the water table:

a) before pumping;

b) b) shortly after pumping begins water comes from groundwater storage and less water flows toward the stream, decreasing flow in the stream; c) as pumping continues, the water table is depressed to the point that water flows from the stream to the well such that the stream discharge decreases further and the stream surface elevation is lowered.

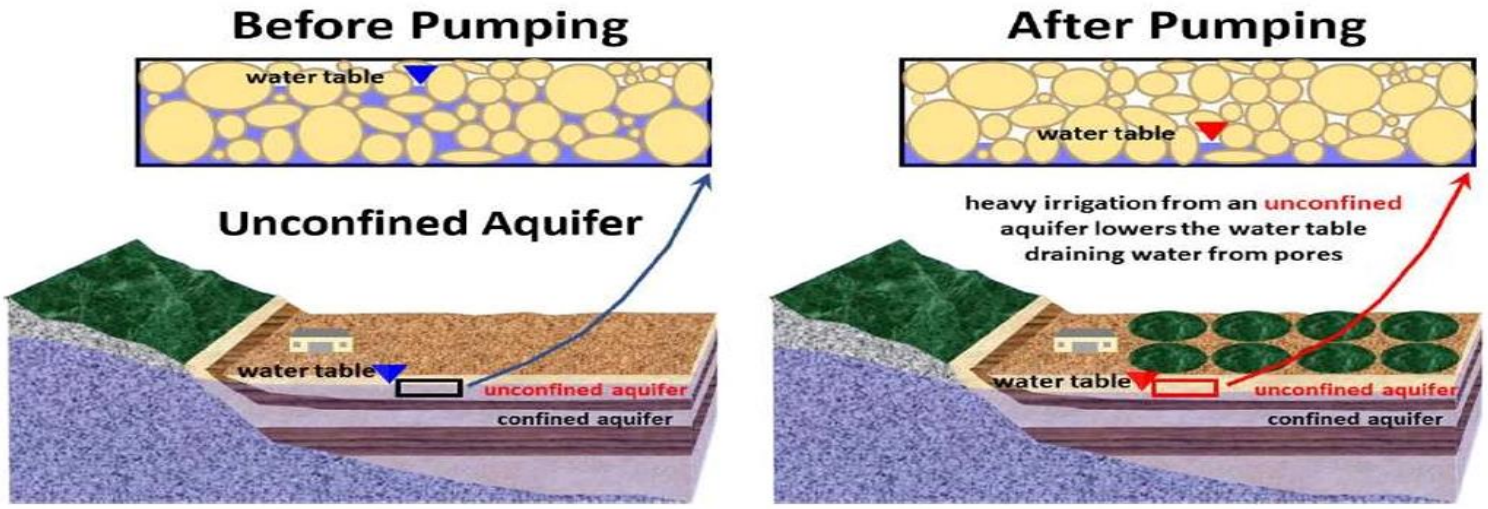
Ground moves slowly

GW moves continuously but slowly from areas of natural aquifer recharge to areas of aquifer discharge (springs, streams, wetlands).

G.W. residence times from decades to centuries and even in millennia

- Fossil water still held in storage-

In U.P., deep storages are >25 to 50 thousand years and even more.



Schematic showing the change in aquifer conditions before (left) and after (right) heavy pumping of an unconfined aquifer (pores drain)

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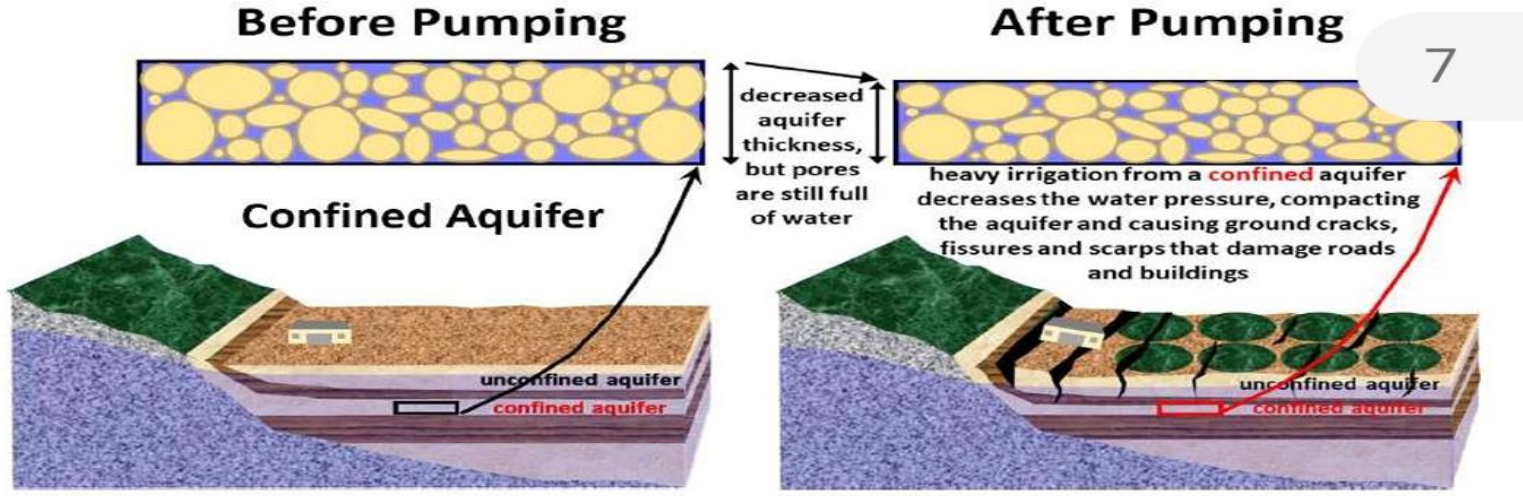

Schematic showing the change in aquifer conditions before (left) and after (right) heavy pumping of a confined aquifer (pores depressurize and geologic layers compact)

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GWL Response to Recharge

GW travels slowly horizontally 30-60 m/year in alluvial formations

- Vertical percolation rate relatively faster depending upon soil type.
- Studies suggest that GW levels respond slowly to the changes in weather, can take months or years once the aquifer is heavily/continuously pumped.
- Layer of unsaturated soil acts as a buffer between the atmosphere and aquifer.

GWL Response to Recharge

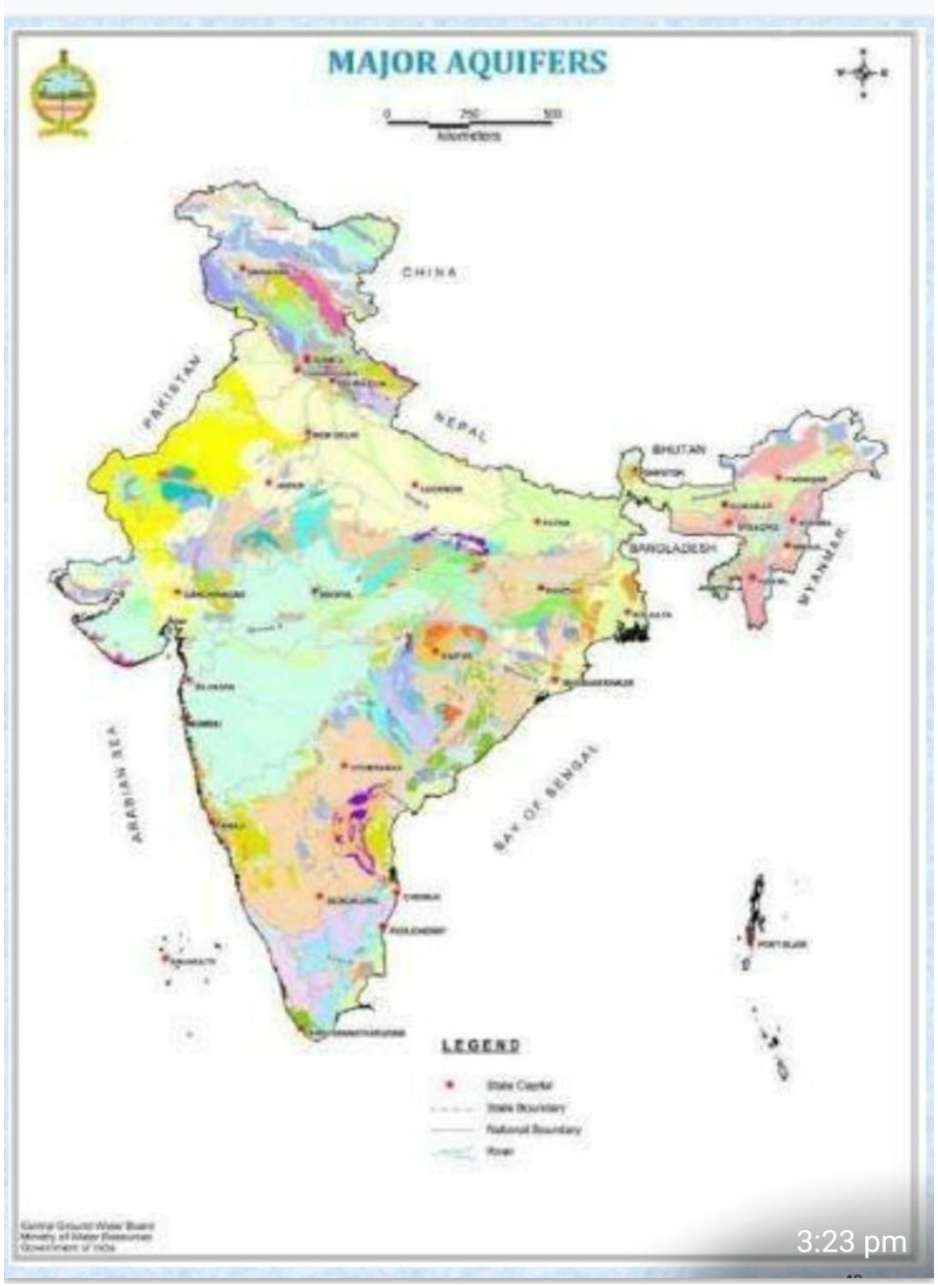
-When it rains, surface soil becomes wetter and S.W. bodies increase in volume, but it takes time to percolate to the aquifers.

-Further, varied pattern of rains also effects in replenishing aquifers.

-And, in rice fields with increased saturation of subsurface soil, percolation rate gets reduced.

-In direct recharging, process of aquifer replenishment also decreases over the time due to over saturation of aquifers.

Topographic map of the Indian subcontinent


MAJOR AQUIFERS
0 250 500
kilometers
CHINA
PAKISTAN
NEPAL
BHUTAN
BANGLADESH
MYANMAR
ARABIAN SEA
BAY OF BENGAL
LEGEND
State Capital
State Boundary
National Boundary
River
Central Ground Water Board
Ministry of Water Resources
Government of India

Principal Aquifer Systems in India

1. Alluvium	2. Laterite
3. Basalt	4. Sandstone
5. Shale	6. Schist
7. Quartzite	8. Charnockite
9. Khondalite	10. Lime stone
11. Granite	12. Gneiss
13. Banded gneissic complex	14. Intrusive

S. No	Major Aquifer	S. No	Major Aquifer
1	Younger Alluvium	22	Shale or/ with limestone
2	Pebble Gravel	23	Miliolitic Limestone
3	Older Alluvium	24	Limestone/Dolomite
4	Aeolian Alluvium	25	Limestone -Dolomite
5	Coastal Alluvium	26	Limestone with Shale
6	Valley Fills	27	Marble
7	Glacial Deposits	28	Acid Rocks -Granite
8	Laterite	29	Acid Rocks -Pegmatite
9	Basalt Basic Rock	30	Schist
10	Basalt- Ultra Basics	31	Phyllite
11	Sandstone	32	Slate
12	Sandstone with Shale	33	Quartzite
13	Sandstone with shale/coal beds	34	Quartzite
14	Sandstone with clay	35	Charnockite
15	Sandstone/Conglomerate	36	Khondalite
16	Sandstone and Shale	37	Banded Gneissic Complex
17	Shale with Limestone	38	Gneiss - meta sedimentary
18	Shale with Sandstone	39	Gneiss Weathered/Massive
19	Shale, Limestone and Sandstone	40	Migmatite Gneiss
20	Shale	41	Intrusive-Dolerite
21	Shale/Shale with Limestone	42	Intrusive-Ultrabasic

(Source: CGWB)

Hydrogeological formations	Hydrogeological units	Area (sq km)	Lithology
Unconsolidated Formation	Bhabhar	1,400	Assorted sediments constituting boulder, cobbles, pebbles and sand
	Tarai	11,500	Alluvium (predominantly fine sediments with intercalation of clay or silt with sands)
	Central Ganga Plain	1,98,372	Alluvium (predominantly sand with intercalation of clay or silt)
	Marginal Alluvial Plain	8,688	Alluvium (sand with intercalation of clay or silt)
Consolidated formation (Hard Rock)	Southern Peninsular Area	21,750	Archean /Pre- Cambrian crystalline and Vindhyan sediments

(Source: CGWB)

Different Aquifer Groups in Central Ganga Plain

S. No.	Aquifer Group	Depth Range (mbgl)
1.	First aquifer	0-150
2.	Second aquifer	100 -210
3.	Third aquifer	225- 360
4.	Fourth aquifer	360 - 600 or beyond

(Mbgl denotes metre below ground level)

Thanks