Heaven's Light is Our Guide

Rajshahi University of Engineering & Technology

Topic: **Design of Water Well**

Mithun Chakrabartty
Lecturer
Department of Civil Engineering

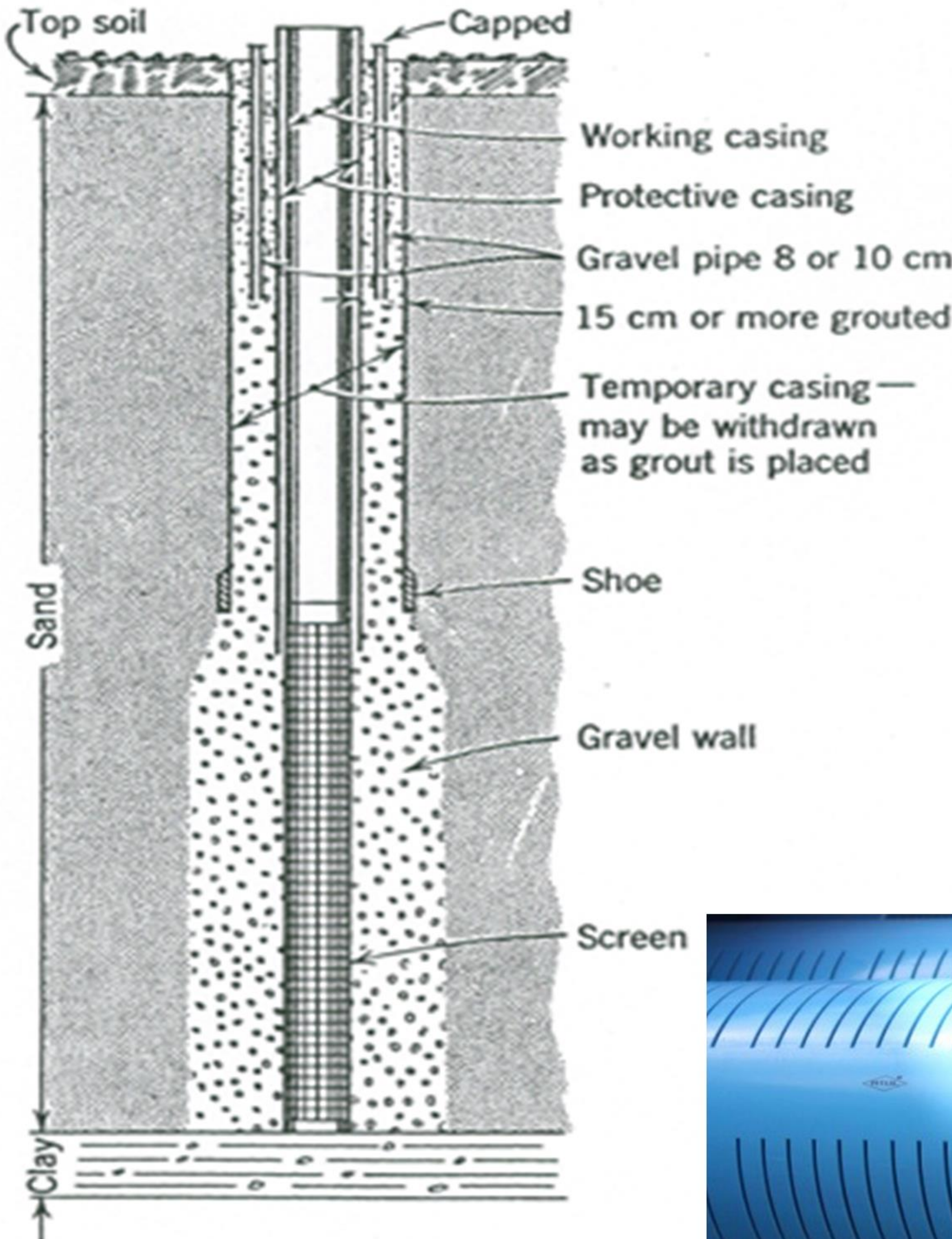
Introduction:

A water well has to be designed to get the optimum quantity of water economically from a given geological formation

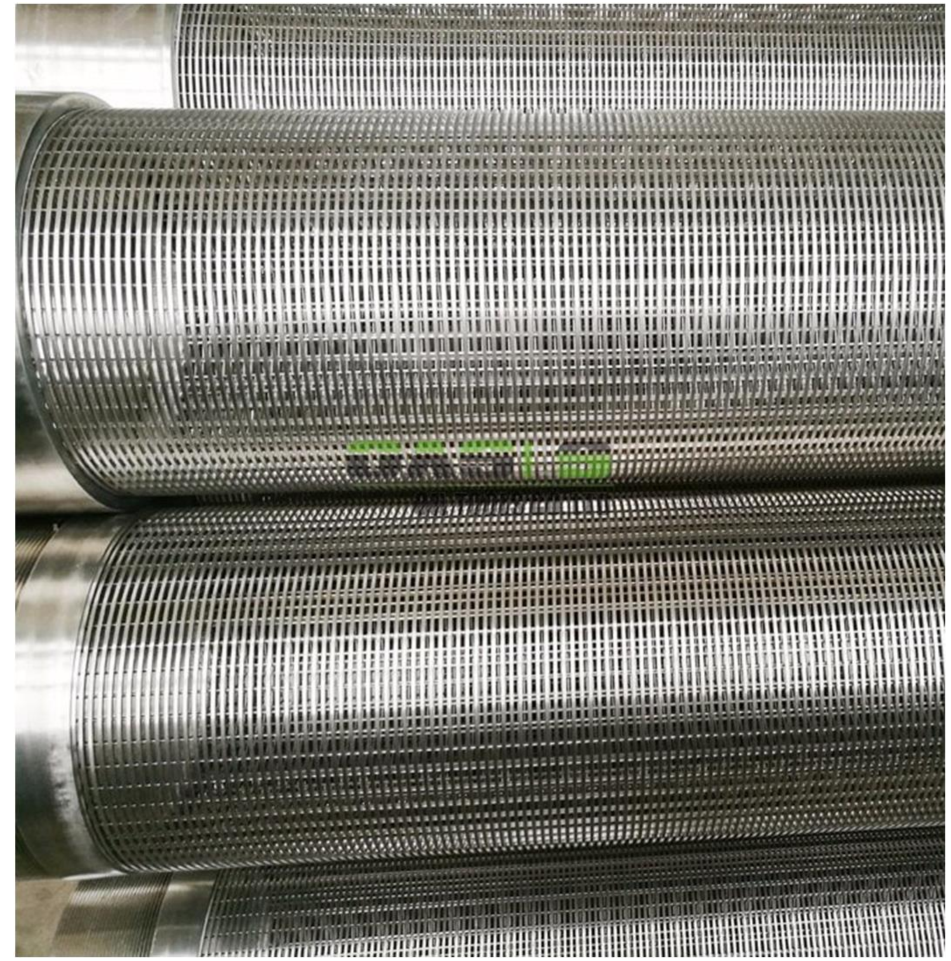
- The water requirements for the particular schemes –rural water supply , agricultural and industrial needs, has to be carefully determined
- The choice of open wells or bore wells (tube wells) and the method of well design depends upon-
  - -Topography
  - -Geological conditions of the underlying strata
  - -Depth of GW table
  - -Rainfall
  - -Climate
  - -The quantity of water required

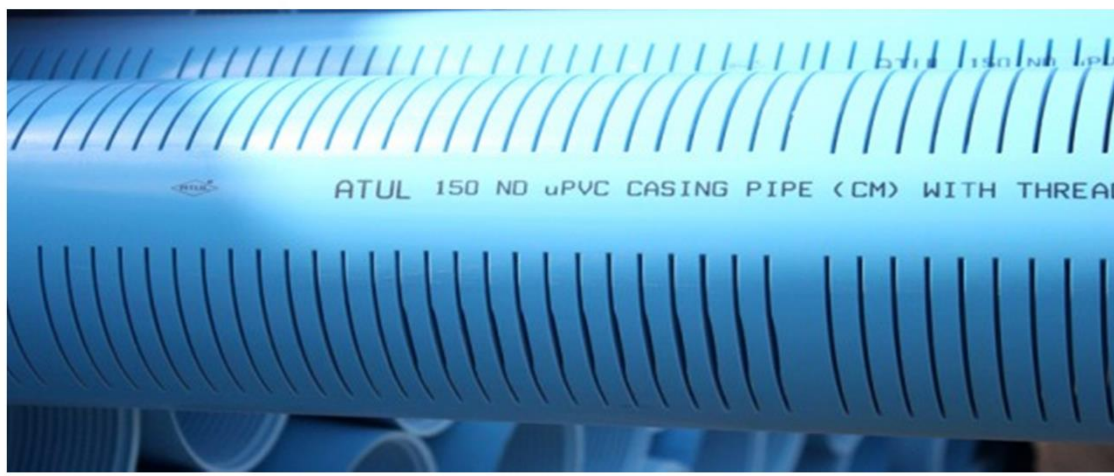
Introduction Cont…

- A water well design involves selection of proper dimensions like the diameter of the well and that of the casing, length and the location of the screen including slot size, shape and percentage of opening area.


Top soil
Capped
Working casing
Protective casing
Gravel pipe 8 or 10 cm
15 cm or more grouted
Temporary casing—
may be withdrawn
as grout is placed
Shoe
Sand
Gravel wall
Screen
Clay


www.oasiswellscreens.com



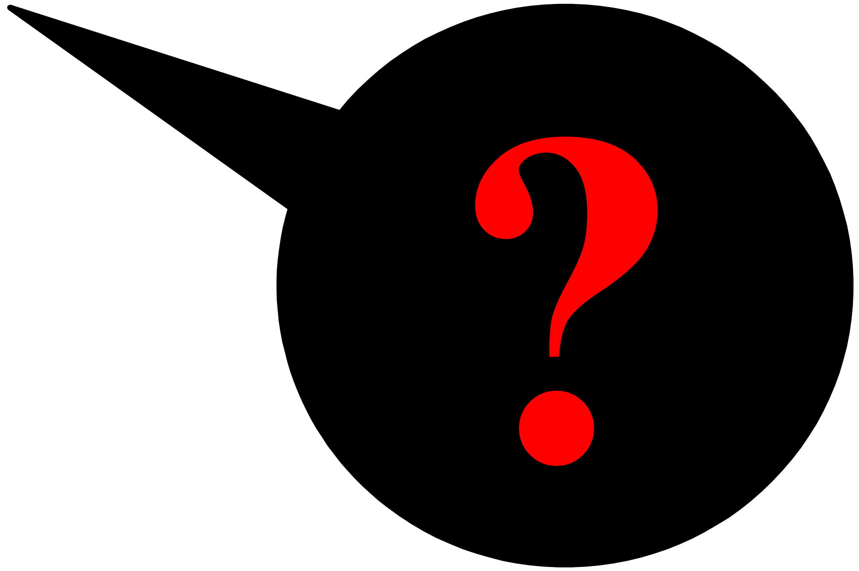

ATUL 150 ND uPVC CASING PIPE (CM) WITH THREAD

Well Diameter

The Size of the well diameter should be properly chosen since it significantly affects the cost of well construction.

The diameter must be chosen to give the desired percentage of open area in the screen (15 to 18%), so that the entrance velocities near the screen do not exceed 3 to 6 cm/sec, so as to reduce the well losses and hence the drawdown, to exclude the finest particles of sand from migrating near the slots and prevent incrustation and corrosion at the strainer slots.

Well Diameter



Is discharge increase proportionally with the increase of well diameter?

Depuit's equation

$$Q \alpha \frac{1}{\log 10 \frac{R}{r_w}}$$

For R=300 m, a 60 cm well yields only 25% more than a 15 cm well and 12% more than a 30 cm well, which shows that Drilling a large diameter well will not necessarily mean proportionally large yields.

Well Diameter

Anticipated well yield, lpm	Nominal size of pump bowl, cm	Size of well casing	
		Minimum, cm	Optimum, cm
400	10	12.5	15
400-600	12.5	15	20
600-1400	15	20	25
1400-2200	20	25	30
2200-3000	25	30	35
3000-4500	30	35	40
4500-6000	35	40	50
6000-10000	40	50	60

Well Depth

- The depth of a well and the number of aquifers it has to penetrate is usually determined from the lithological log of the area and confirmed from electrical resistivity and drilling time logs.

- An experienced driller can decide the depth at which drilling can be stopped after being advised by the hydrologist who analyses the samples collected during the drilling.

- The well is usually drilled up to bottom of the aquifer so that the full aquifer thickness is available, permitting greater well yield.

Design of well Screen

- Screen Length: In homogeneous artesian aquifer about 70 to 80% (3/4)of the aquifer thickness is screened. The screen should best be positioned at equal distance between the top and bottom of the aquifer.

- In case the non-homogeneous artesian aquifer, it is best to screen the most Permeable strata.

- Theory and experience have shown that screening the bottom one-third of the aquifer provides the optimum design.

- The principles of design in a non-homogeneous water table aquifer are the same as in the case of non-homogeneous artesian aquifer.

Design of slot Size

- The size of slots depends upon the gradation and size of the formation material
- In case of naturally developed wells the slot size is taken as 40 to 70% of the size of formation materials.
- If the slot size selected on this basis becomes smaller than 0.75mm, then it calls for an artificial gravel pack.
- Artificial gravel pack is required when the aquifer material is homogeneous with Uniformity co-efficient ($C_u = D_{60}/D_{10}$) less than 3.00 and effective grain Size (D_{10}) less than 0.25 mm.

Screen Diameter

After the length of the screen (depending upon the aquifer thickness) and the slot size (based on the size and gradation of the aquifer materials) have been selected, the screen diameter is determined so that the entrance velocities near the Screen will not exceed 3 to 6 cm/sec to prevent incrustation and corrosion and to minimize friction losses.
(Ref. Raghunath, 2007)

Selection of Screen

Selection of screen material depends on-

- Depth of aquifer
- Soil formation
- mineral content of water
- presence of bacterial slimes
- strength requirements

Selection of Screen

The Screen material should be resistant to incrustation and corrosion and should have strength to withstand the column load and collapse pressure.

The principle indicators of corrosive ground water are

- low pH
- Presence of dissolved oxygen
- CO_2> 50ppm (parts per million or mg/l)
- Cl> 500ppm

The principal indicators of incrustating ground water are

- total Hardness> 330 ppm
- total alkalinity> 300ppm
- iron content> 2 ppm
- pH> 8

Open wells Versus Borewells

In choosing the type of well the following factors have to be considered

1. Availability of space
2. Hydrological characteristics of the subsurface strata
3. Seasonal fluctuation of water levels
4. Cost of well construction including provision of water lifting appliances
5. Economics and ease of water lifting operation
6. Demand of water
7. Precipitation of the area

Open wells –Advantages

1. Storage capacity of water is available in the well itself

2. Do not require sophisticated equipment and skilled personnel for construction

3. Can be easily operated by installing a centrifugal pump at different Settings for low and high water levels

4. Can be revitalized by deepening by blasting or by putting a few Vertical bores at the bottom or horizontal or inclined bores on the sides to intercept the water bearing strata

Open wells -Disadvantages

1. Large space is required for the well and for excavated material lying on the surface like a big mound.
2. Construction is slow and laborious.
3. Subject to high fluctuations of water table during different seasons.
4. Susceptibility to dry up in years of drought.
5. High cost of construction as the depth increases in hard rock areas.
6. Deep seated aquifer cannot be economically trapped.
7. Uncertainty of tapping water of good quality.
8. Susceptibility for contamination or pollution unless sealed from surface water ingress.

Tube (bore) wells -Advantages

1. Do not require much space
2. Can be constructed quickly
3. Fairly sustained yield of water can be obtained even in years of scanty rainfall
4. Economic when deep –seated aquifers are encountered
5. Flowing artesian wells can sometimes be struck
6. Generally good quality of water is trapped

Tube (bore) wells -Disadvantages

1. Require costly and complicated drilling equipment and machinery
2. Required skilled workers and great care to drill and complete the tube wells
3. Installation of costly turbine or submersible pumps is required
4. Possibility of missing the fracture, fissures and joints in hard rock areas resulting in many dry holes
5. Installation can be hampered due to existence of hard rock in the bore.

Thank you

For

Taking the Stress

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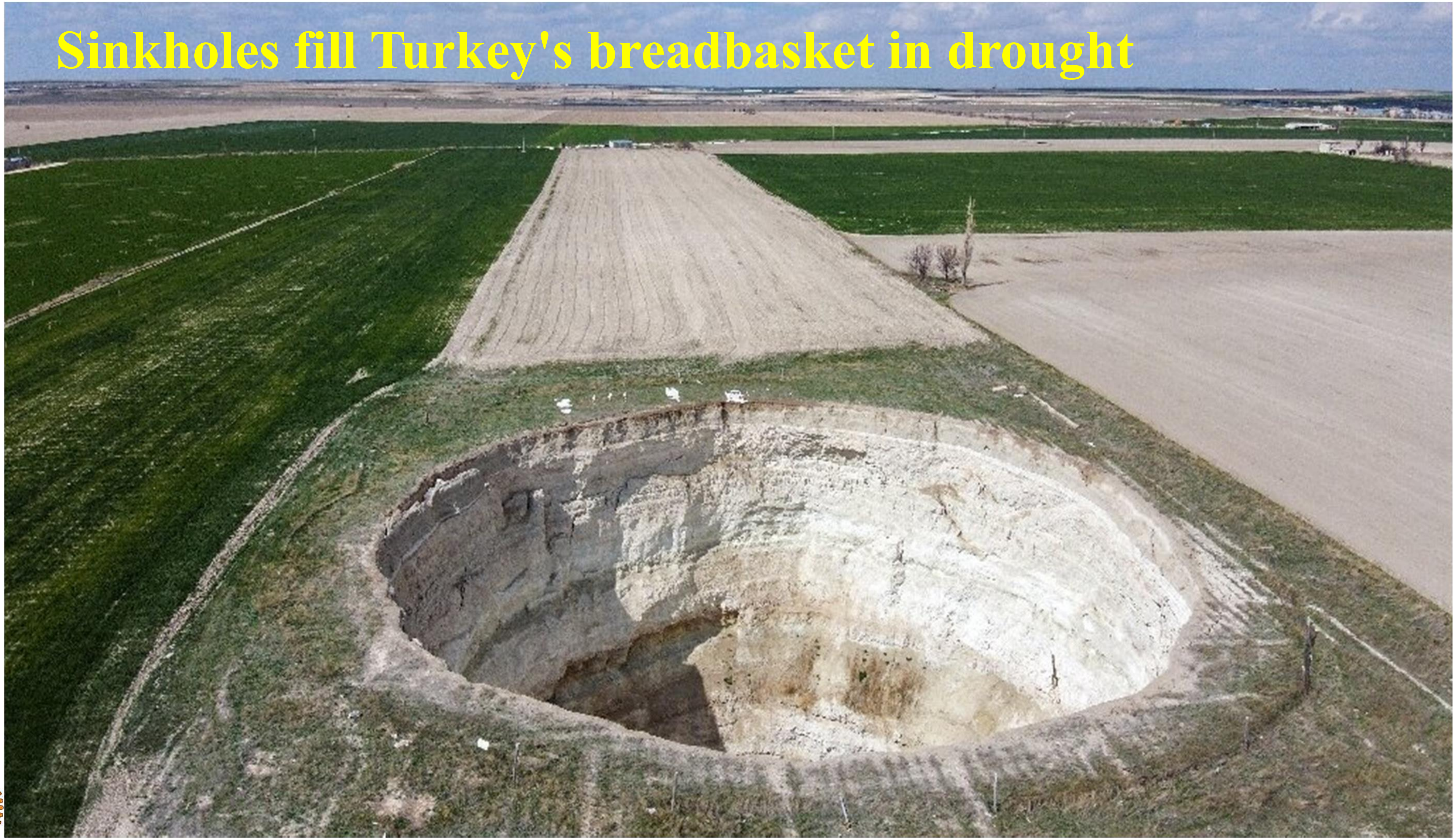
Mithun Chakrabartty
Lecturer
Department of Civil Engineering

LECTURE
ON
GROUND WATER RECHARGE


Sinkholes fill Turkey's breadbasket in drought

Large sinkhole opens up at Florida mobile home park, USA

Groundwater Recharge:

1. Developing of artificial underground reservoir by artificial recharging for storing water underground called recharging of underground water.
2. It is quite advantages as compared with dams, reservoirs etc.
3. Artificial recharging technique is under intensive research and is being increasingly used in France, Germany etc.

Why Artificial Recharge

- In most low rainfall areas of the country the availability of utilizable surface water is so low that people have to depend largely on ground water for agriculture and domestic use.
- So in order to improve the ground water situation it is necessary to artificially recharge the depleted ground water aquifers.

Identification of Areas for Recharge

- Where ground water levels are declining due to over-exploitation.
- Where substantial part of the aquifer has already been desaturated i.e. regeneration of water in wells and hand pumps is slow after some water has been drawn.
- Where availability of water from wells and hand pumps is inadequate during the lean months.
- Where ground water quality is poor and there is no alternative source of water.

Quality of Source Water

- Problems which arise as a result of recharge to ground water are mainly related to the quality of raw waters that are available for recharge and which generally require some sort of treatment before being used in recharge installations.
- A major requirement for waters that are to be used in recharge projects in that they need to be silt-free.

Advantages of Artificial Recharge

- To enhance the groundwater yield in depleted the aquifer due to urbanization.
- Conservation and storage of excess surface water for future requirements.
- To improve the quality of existing groundwater through dilution.
- To remove bacteriological and other impurities from sewage and waste water by natural filtration, so that water is suitable for re-use.
- To improve the structural characteristics of the soil underground.

Methods of Artificial Recharge

Artificial recharge is the process by which the ground water is augmented at rate much higher than those under natural condition of replenishment. The techniques of artificial recharge can be broadly categorized as follows:

Artificial Recharge Techniques

- **Direct**
  - Surface (spreading):
    - ✓ Flooding
    - ✓ Basin/ Percolation Tank
    - ✓ Stream Augmentation
    - ✓ Ditch & Furrow system
  - Sub-surface:
    - ✓ Recharge well
    - ✓ Recharge pit/ shaft
    - ✓ Dug well
- **Indirect**
  - Induced Recharge

Methods of artificial recharge

Spreading method

1. Flooding method
2. Basin method
3. Artificial channel method
4. Natural channel method
5. Khet-Talawadi/Field pit
6. Pond
7. Check dams

Injection method

- Wells
- Bores
- Galleries

Induced recharge method

METHODS OF RECHARGING:

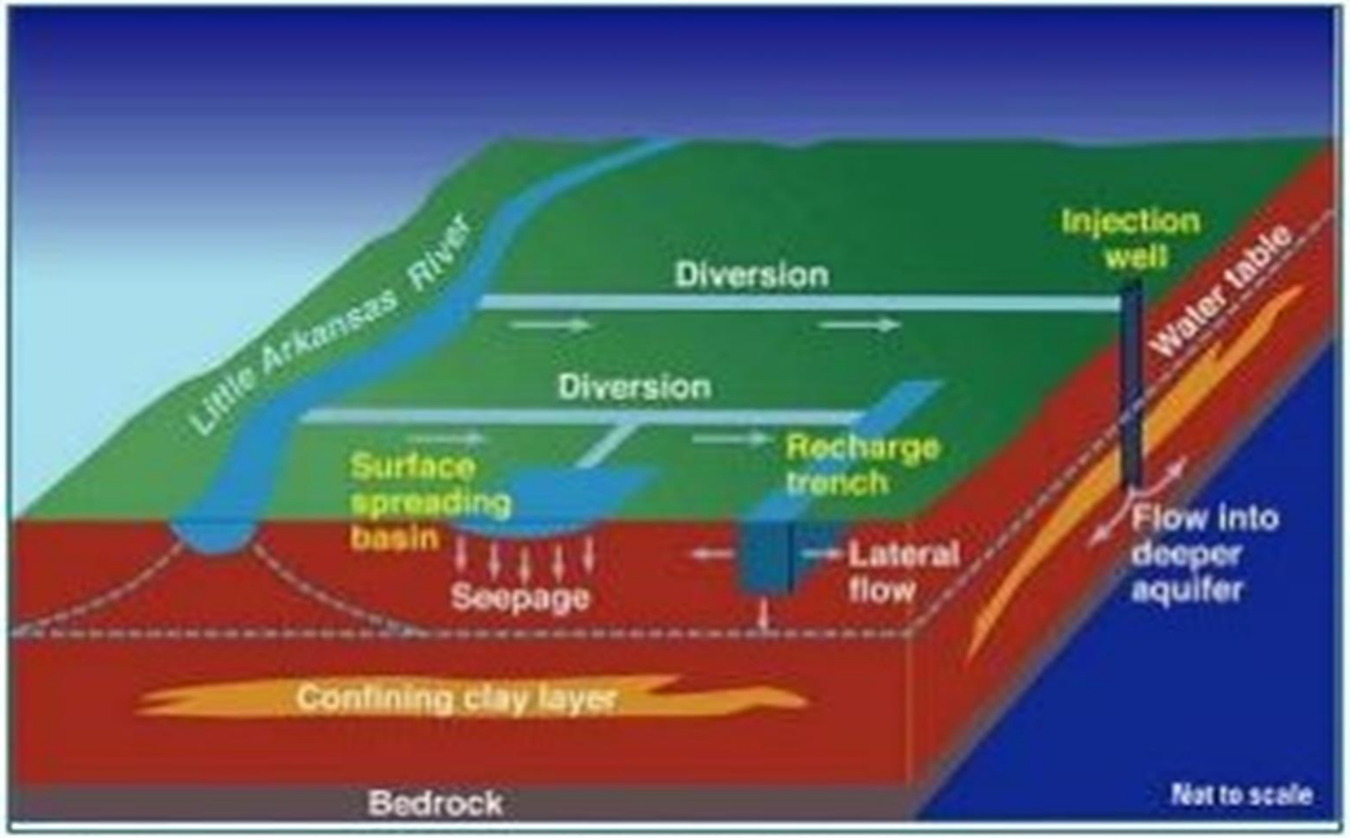
There are three methods of groundwater recharging:

1)Spreading method:

- In this method water is spreads over the surface of permeable open land and pits from where it is directly infiltrates to shallow aquifer.

- In this method water is stored in shallow ditches or spread over open area by constructing low earth dykes.
- Rate of recharging depends upon permeability of spreaded area and depth of water stored.
- Also some chemicals are added in soil to increase rate of recharging.

Surface (Spreading) Method



Source: www.indiawaterportal.org

Figure 1 : Surface Spreading Basin

- These methods are suitable where large area of basin is available and aquifers are unconfined without impervious layer above it.
- The rate of infiltration depend on nature of top soil if soil is sandy the infiltration will be higher then those of silty soil.
- The presence of solid suspension in water used for recharge clogs the soil pores leading to reduction in infiltration rate i.e. recharge rate.
- Water quality also affects the rate of infiltration. The various spreading methods are as below:-

1. Flooding

- This method is suitable for relatively flat topography.
- The water is spread as a thin sheet.
- It requires a system of distribution channel for the supply of water for flooding.
- Higher rate of vertical infiltration is obtained on areas with undisturbed vegetation and sandy soil covering.

2.Basin & Percolation Tanks

Fig. A percolation tank about to get dry towards beginning of summer. Location: Village: Ralegan Siddhi, District: Nagar, Maharashtra State.

Source: www.indiawaterportal.org

Figure 2 : Percolation Tank

- This is the most common method for artificial recharge.
- In this method, water is impounded in series of basins or percolation tank.
- The size of basin may depend upon the topography of area, in flatter area will have large basin.
- This method is applicable in alluvial area as well as hard rock formation.
- The efficiency and feasibility of this method is more in hard rock formation where the rocks are highly fractured and weathered.

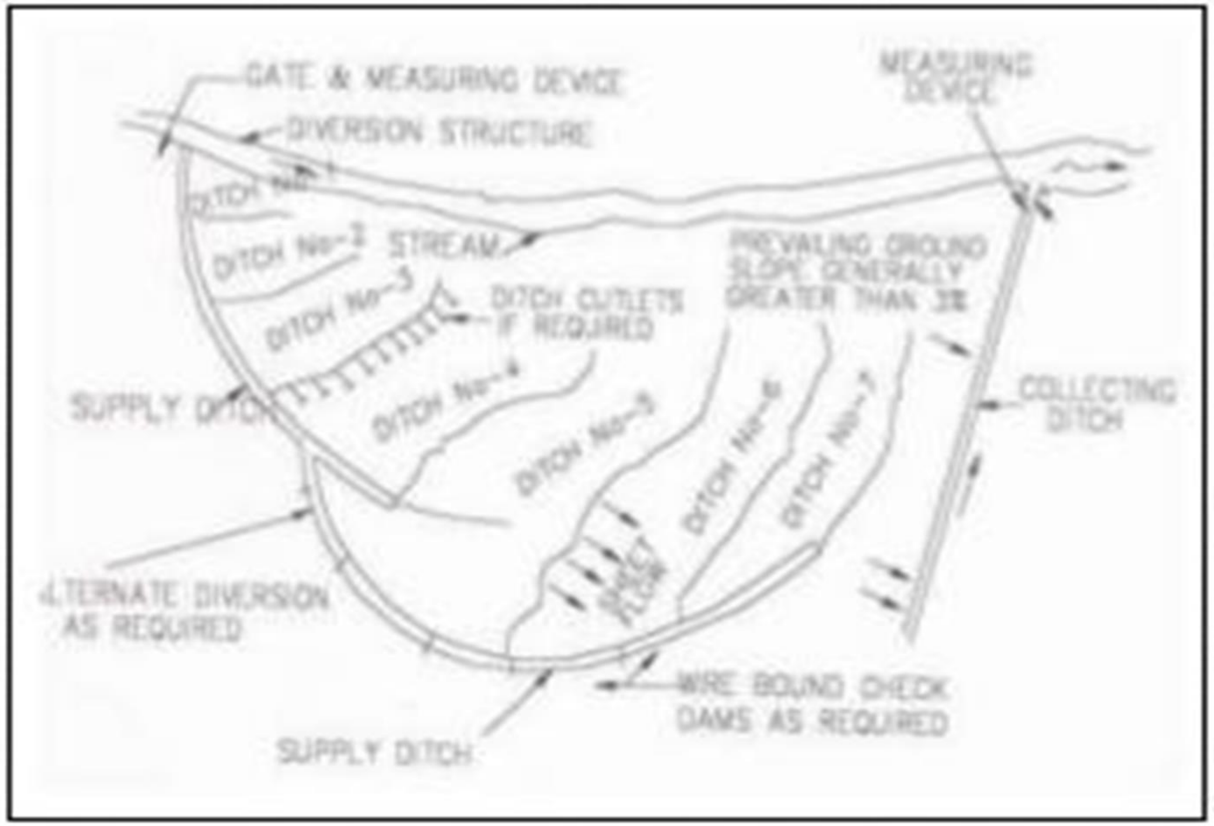
3. Stream Augmentation

Source: www.indiawaterportal.

Figure 3 : Check dam

- Seepage from natural streams or rivers is one of the most important source of recharge of the ground water reservoir.
- When total water supply available in a stream / river exceeds the rate of infiltration, the excess is lost as run off.
- This run off can be arrested through check bunds or widening the steam beds thus larger area is available to spread the river water increasing the infiltration.
- The site selected for check dam should have sufficient thickness of permeable bed or weathered formation to facilitate recharge of stored water within short span of time.
- The water stored in these structures is mostly confined to stream course and height is normally less than 2 m. To harness maximum run off, a series of such check dam may be constructed.

4. Ditch & Furrow System



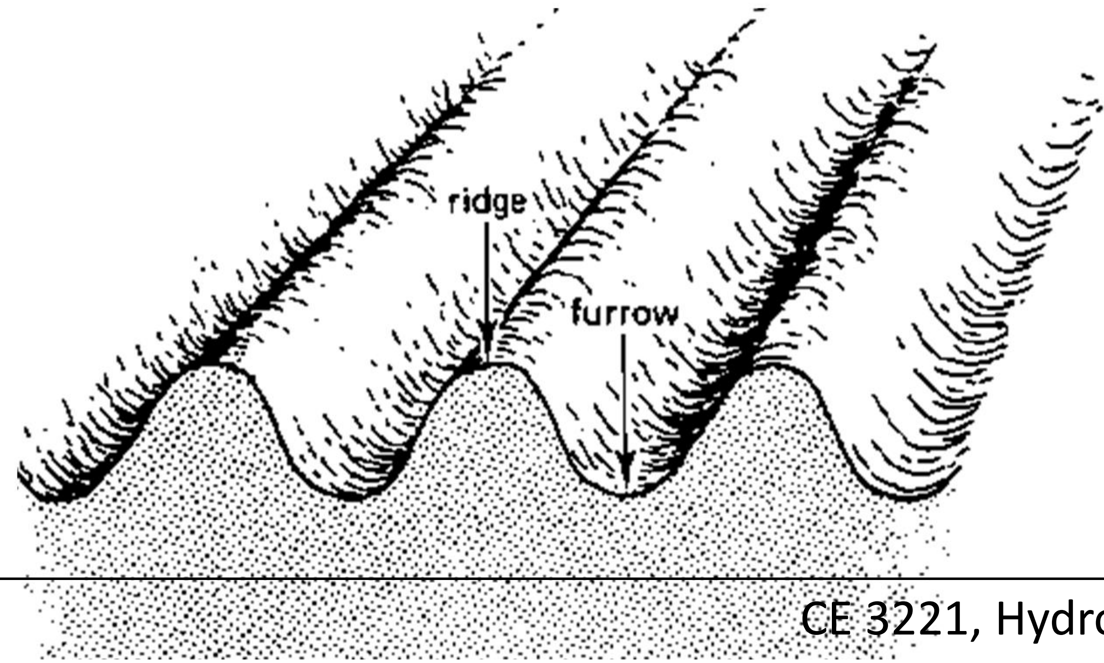
Source: megphed.gov.in

Figure 4 : Ditch and Furrow System

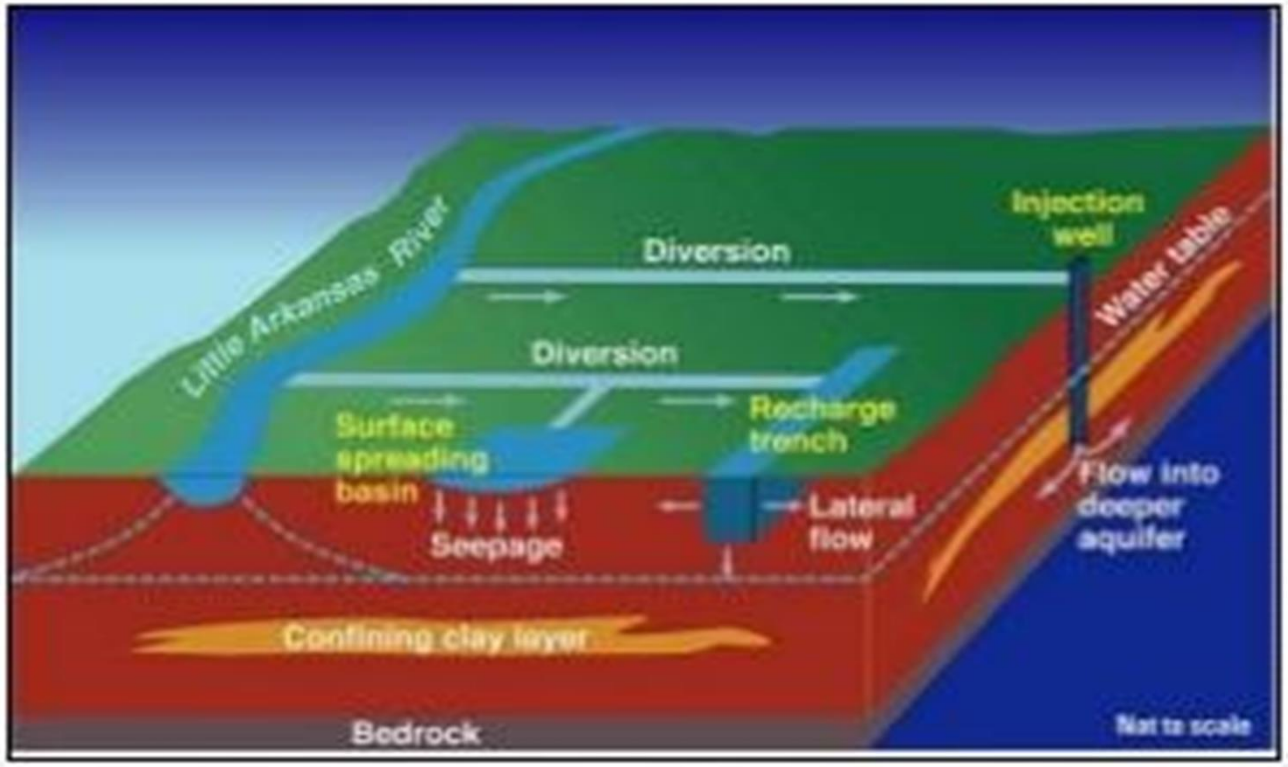
- In areas with irregular topography ditches or furrow provide maximum water contact area for recharge.
- This technique consists of a system of shallow flat bottomed and closely spaced ditches / furrow which are used to carry water from source like stream /canals and provide more percolation opportunity.
- This technique required less soil preparation and is less sensitive to silting.

Furrow System

Furrow irrigation by opening the bank or dyke of the ditch



B.Sub-Surface Method

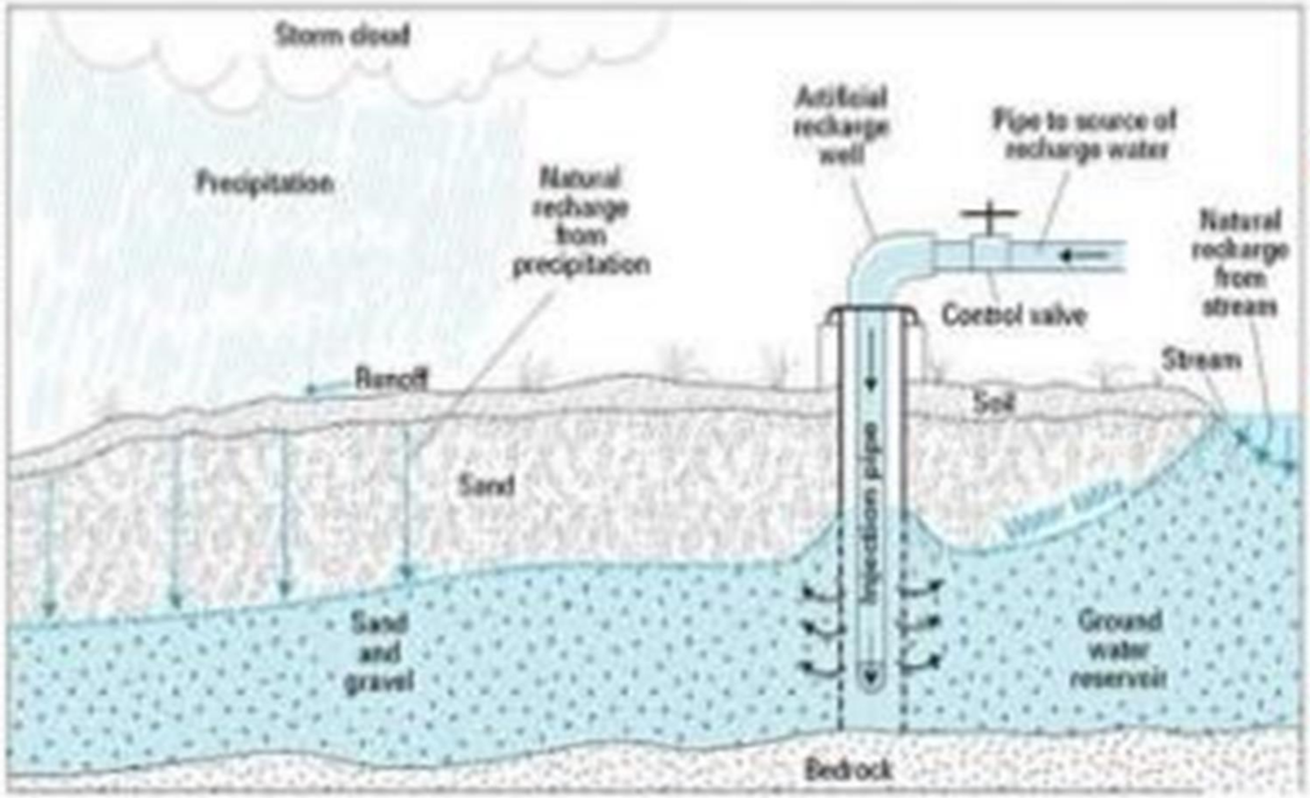


Source: www.indiawaterportal.org

Figure 5 : sub surface method

- In this method the structure lies below the surface and recharges ground water directly.
- The important structures commonly use are Recharge wells, Recharge shaft, Dug wells etc.

1.Recharge Well

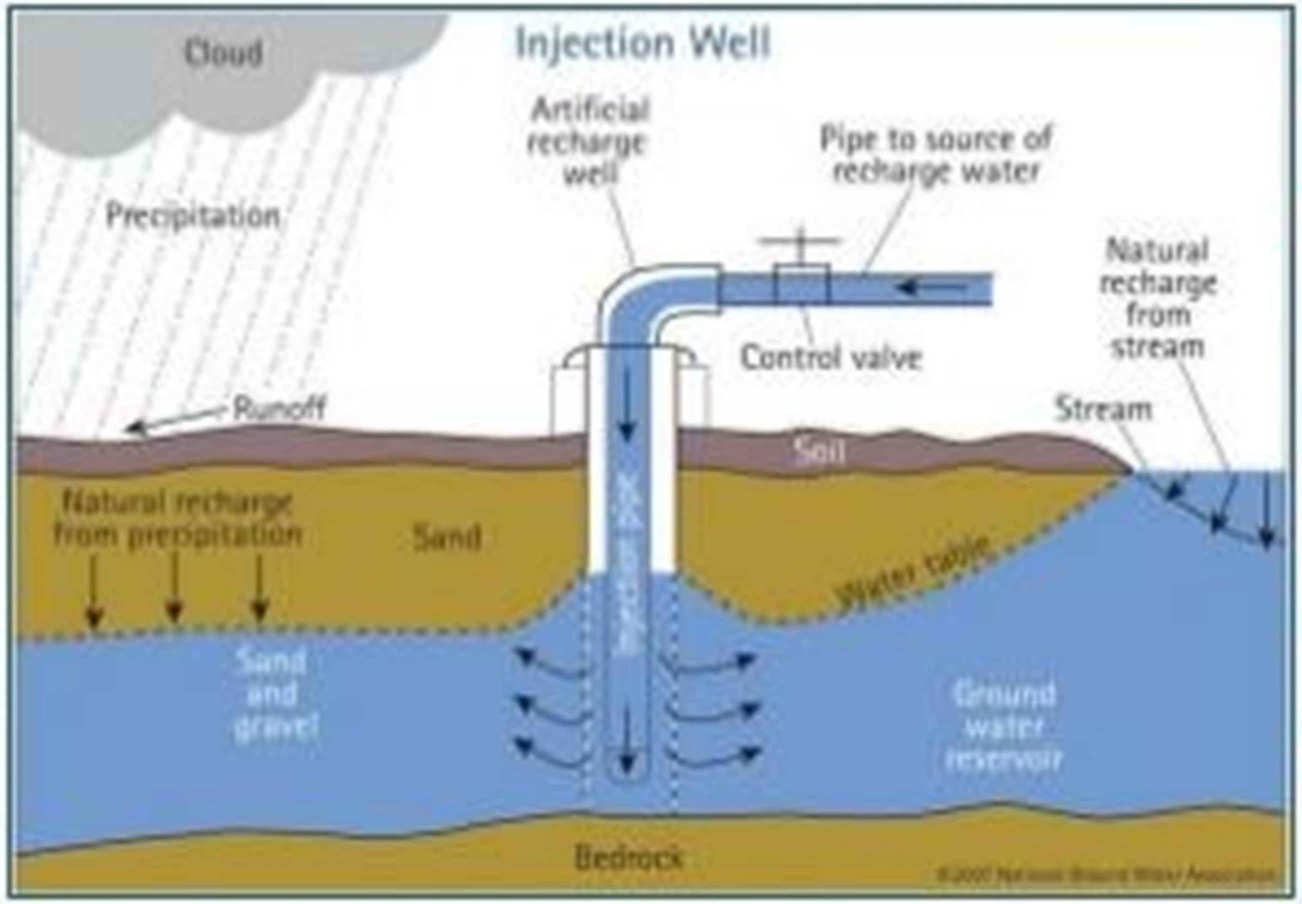


Source:www.ngwa.org

Figure 6 : Injection well

- Recharge wells can be of two types -
- (a) Injection well, where water is “pumped in” for recharge and
- (b) Recharge well, where water flows under gravity.

(a) Injection Well

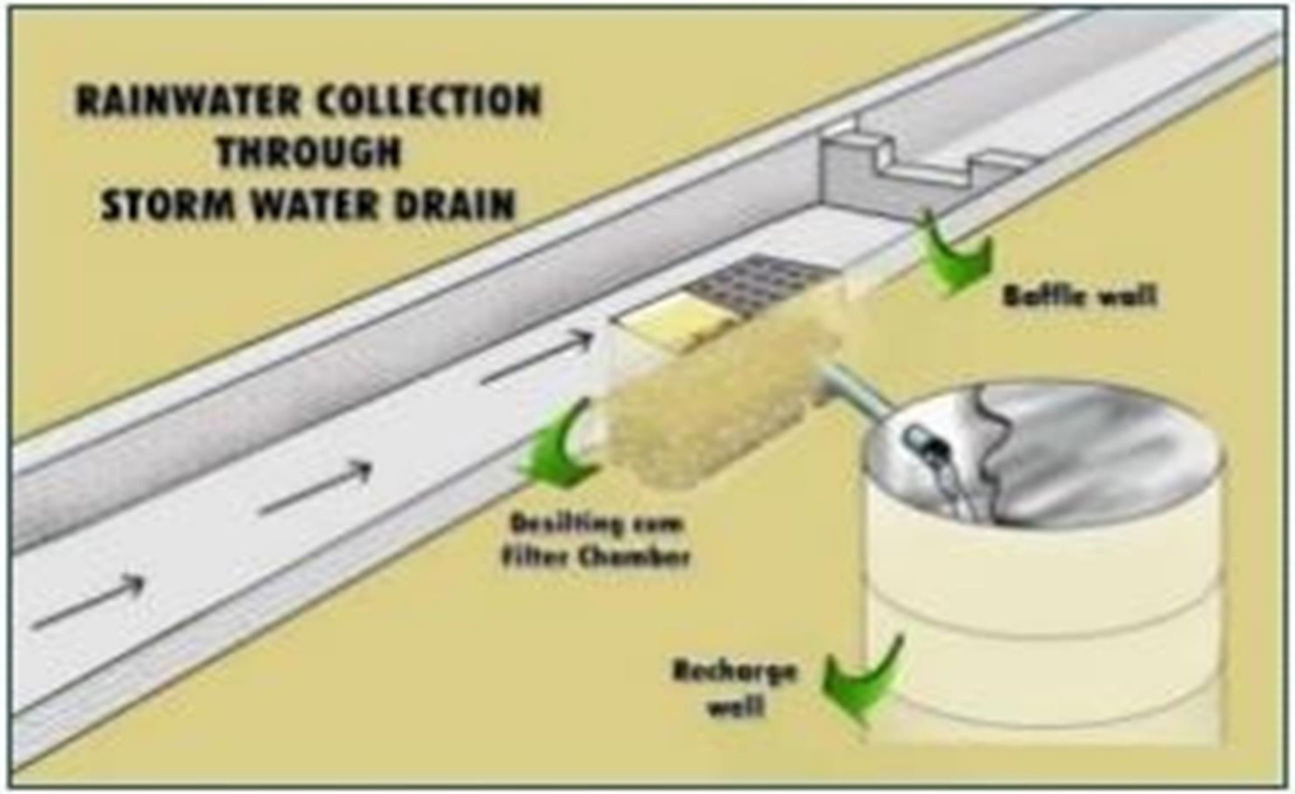


Source: www.ngwa.org

Figure (7) : Injection well

- The Injection wells are similar to a tube well.
- This technique is suitable for augmenting the ground water storage of deeper aquifers by "pumping in" treated surface water.
- These wells can be used as pumping wells during summers.
- The method is suitable to recharge single aquifer or multiple aquifers.
- The recharge through this technique is comparatively costlier and required specialized technique

(b) Recharge Well

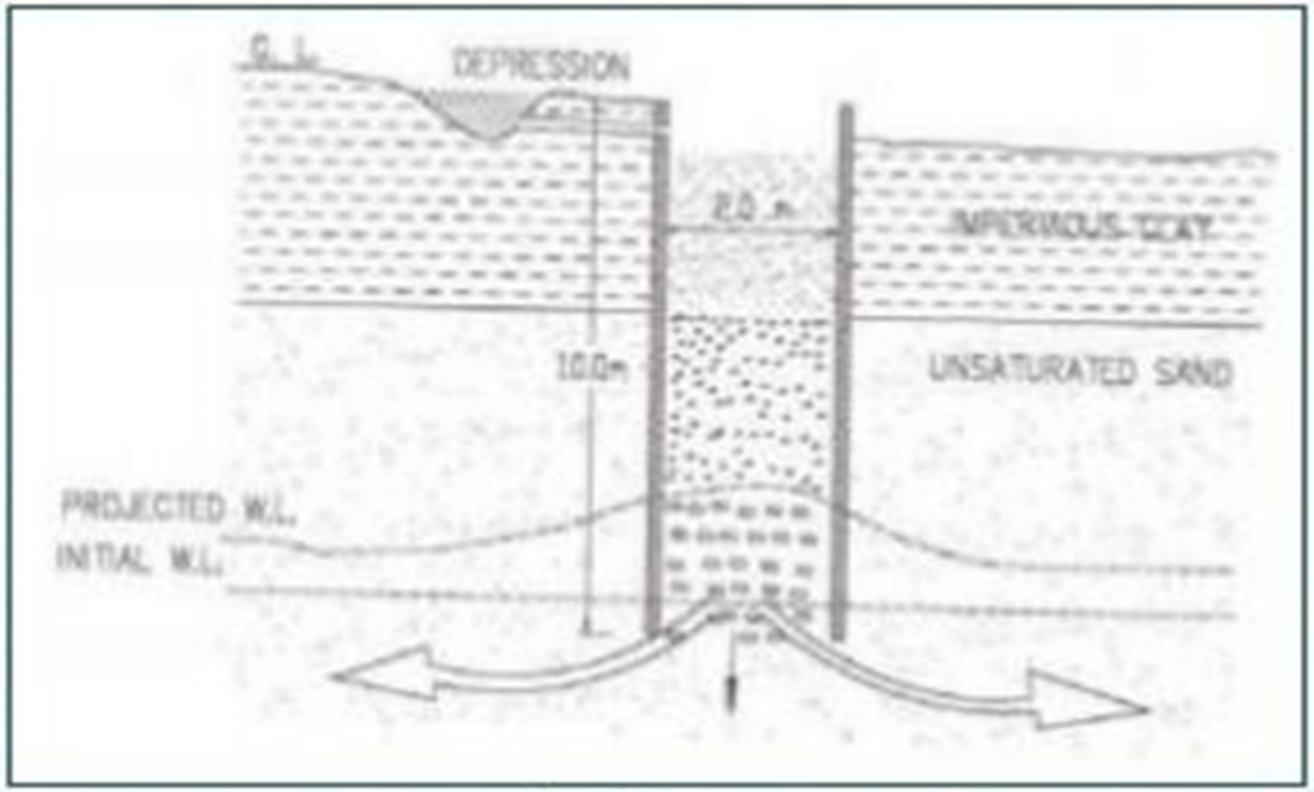


Source: www.indiawaterportal.org

Figure 8 : Simple Recharge well

- The recharge well for shallow water table aquifers up to 50 m are cost effective because recharge can take place under gravity flow only.
- These wells could be of two types, one is dry and another is wet.
- The dry types of wells have bottom of screen above the water table. In such wells excessive clogging is reported due to release of dissolved gasses as water leaves the well and on other hand redevelopment methods have not been found effective in dry type of wells.
- The wet type of wells are the wells in which screen is kept below water table. These wet type wells have been found more successful.

2.Pits & Shafts

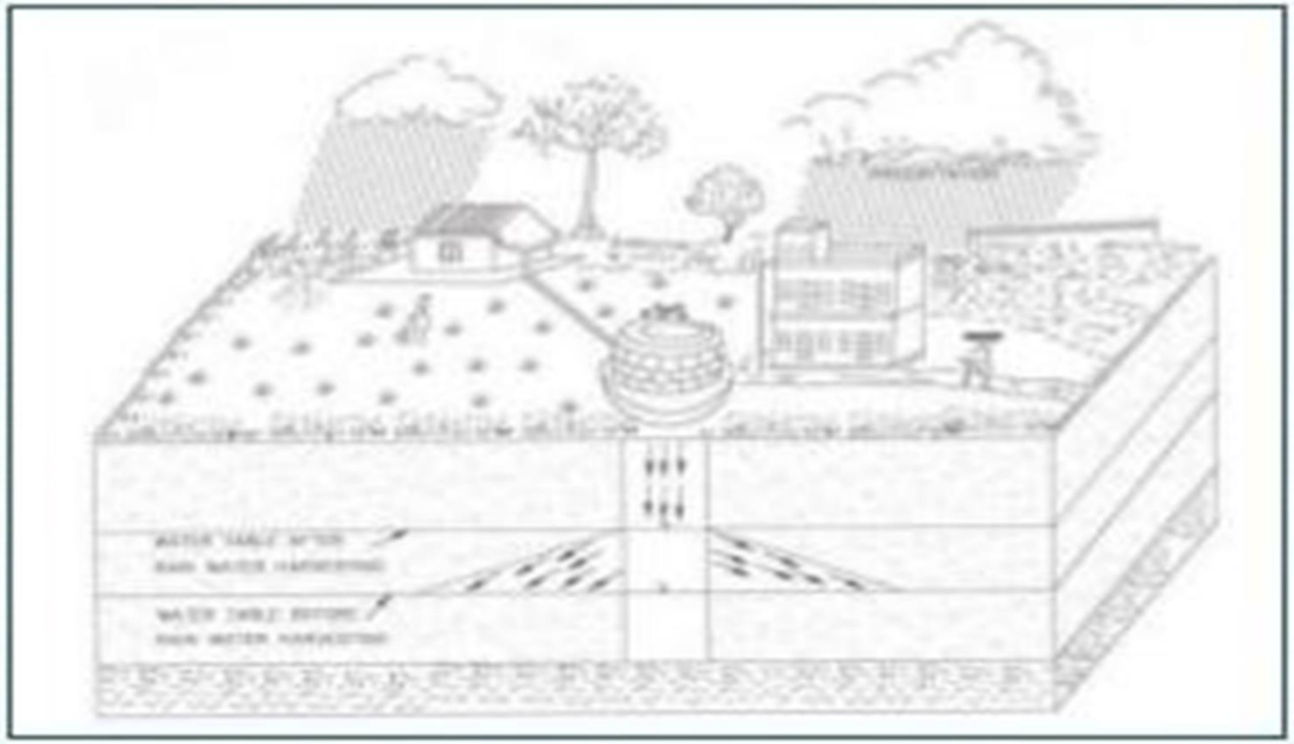


Source: megphed.gov.in

Figure(9) : Vertical recharge shaft

- In area where impervious layer is encountered at shallow depth the pits & shafts are suitable structure for artificial recharge.
- These structures are cost effective to recharge the aquifer directly.
- The diameter of shaft should normally be more than 2 m to accommodate more water.
- The advantage of shafts / pits structure is that they do not require large piece of land like percolation tank & other spreading method
- there are practically no losses of water in form of soil moisture and evaporation like other methods of spreading.

3. Dug Wells

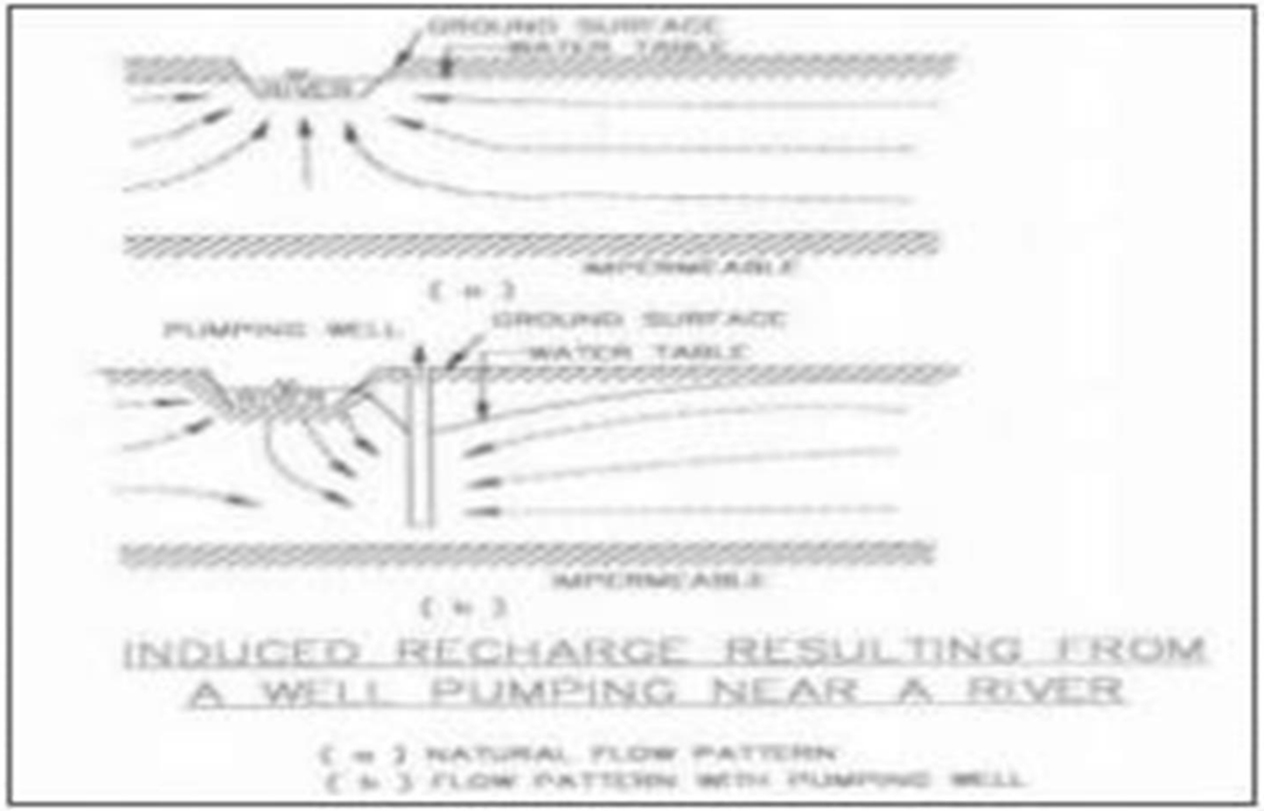


Source: megphed.gov.in

Figure (10) : Recharge through Dug Wells

- In alluvial as well as hard rock areas there are thousand of dug wells have either gone dry due to considerable decline of water levels.
- These dug wells can be used as recharge structure storm water and other surplus water from canal etc. can be diverted into these structures to directly recharge the dried aquifer.
- The water for recharge should be guided through a pipe to the bottom of well to avoid entrapment of bubbles in the aquifer.

C. Induced Recharge



Source: megphed.gov.in

Figure (11): Induced Recharge

- It is an indirect method of artificial recharge involving pumping from aquifer hydraulically connected with surface water such as perennial streams, unlined canal or lakes.
- The heavy pumping lowers the ground water level and cone of depression is created. Lowering of water levels induces the surface water to replenish the ground water.
- This method is effective where steam bed is connected to aquifer by sandy formation.

Conclusion

- Thus it can be concluded that artificial recharge give the reduction of runoff, increased availability of ground water especially in summer month, increase in irrigation, revival of springs, improvement in ground water quality. Yet even with full development of artificial recharge, ground availability would remain limited. Though ground water recharge scheme either naturally or artificially may not be the final answer, but they do call for the community effort and create the spirit of cooperation needed to subsequently manage sustainably ground water as a community resource.

REFERENCES

- 1.Http:\\megphed.gov.in\knowledge\RainwaterHarvest\Chapter9.pdf.
- 2. M.A.Sophocleous, "Combining the soil water balance and water-level fluctuation methods to estimate natural ground water recharge - practical aspects". Journal of hydrology, Vol.124, 229 (1991).
- 3.cgwb.gov.in/documents/Guide on Artificial Recharge.pdf

Thank You

For

Your Attention