Heaven's Light is Our Guide

Rajshahi University of Engineering & Technology

Mithun Chakrabartty

Lecturer

Department of Civil Engineering

- Course code: CE 3221
- Course Title: Hydrology
- Credit: 3.00
- Contact hours/week: 3.00

Book List:

1. **A Text Book of Hydrology-** P. Jaya Rami Reddy
2. **Hydrology-** H.M. Raghunath
3. **Engineering Hydrology, 3E-** K Subramanya
4. **Ground Water, 2Edition-** H. M. Raghunath

SYLLABUS:

#part 1: Introduction:

Hydrologic cycle, meteorological aspects of Hydrology,precipitation, water losses, interception, evaporation, transpiration and infiltration.

Run off: Factors affecting run off, estimation of run off, stream flow, stream flow hydrograph, overland flow, flood rating, statistical methods in hydrology.

#part 2: Ground water:

Introduction, aquifer properties and ground water flow, well hydraulics, quality of ground water, ground water recharge, design, drilling and construction of water wells.

Hydrology:

New Latin *hydrologia,* from Latin *hydro- + -logia* -logy

-A science dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere.

-Hydrology is the science that encompasses the occurrence, distribution, movement and properties of the waters of the earth and their relationship with the environment within each phase of the hydrologic cycle.

What Hydrologists Do?

1. Hydrologists apply scientific knowledge and mathematical principles to solve water-related problems in society: problems of quantity, quality and availability.

2. They may be concerned with finding water supplies for cities or irrigated farms, or controlling river flooding or soil erosion. Or, they may work in environmental protection: preventing or cleaning up pollution or locating sites for safe disposal of hazardous wastes.

3. Persons trained in hydrology may have a wide variety of job titles. Scientists and engineers in hydrology may be involved in both field investigations and office work. In the field, they may collect basic data, oversee testing of water quality, direct field crews and work with equipment. Many jobs require travel, some abroad.

4. In the office, hydrologists do many things such as interpreting hydrologic data and performing analyses for determining possible water supplies.

5. Much of their work relies on computers for organizing, summarizing and analyzing masses of data, and for modeling studies such as the prediction of flooding and the consequences of reservoir releases or the effect of leaking underground oil storage tanks.

6. The work of hydrologists is as varied as the uses of water and may range from planning multimillion dollar interstate water projects to advising homeowners about backyard drainage problems.

Careers in Hydrology

1. Students who plan to become hydrologists need a strong emphasis in mathematics, statistics, geology, physics, computer science, chemistry and biology.

2. In addition, sufficient background in other subjects--economics, public finance, environmental law, government policy--is needed to communicate with experts in these fields and to understand the implications of their work on hydrology.

Thank You

For

Your Kind Attention

Heaven's Light is Our Guide

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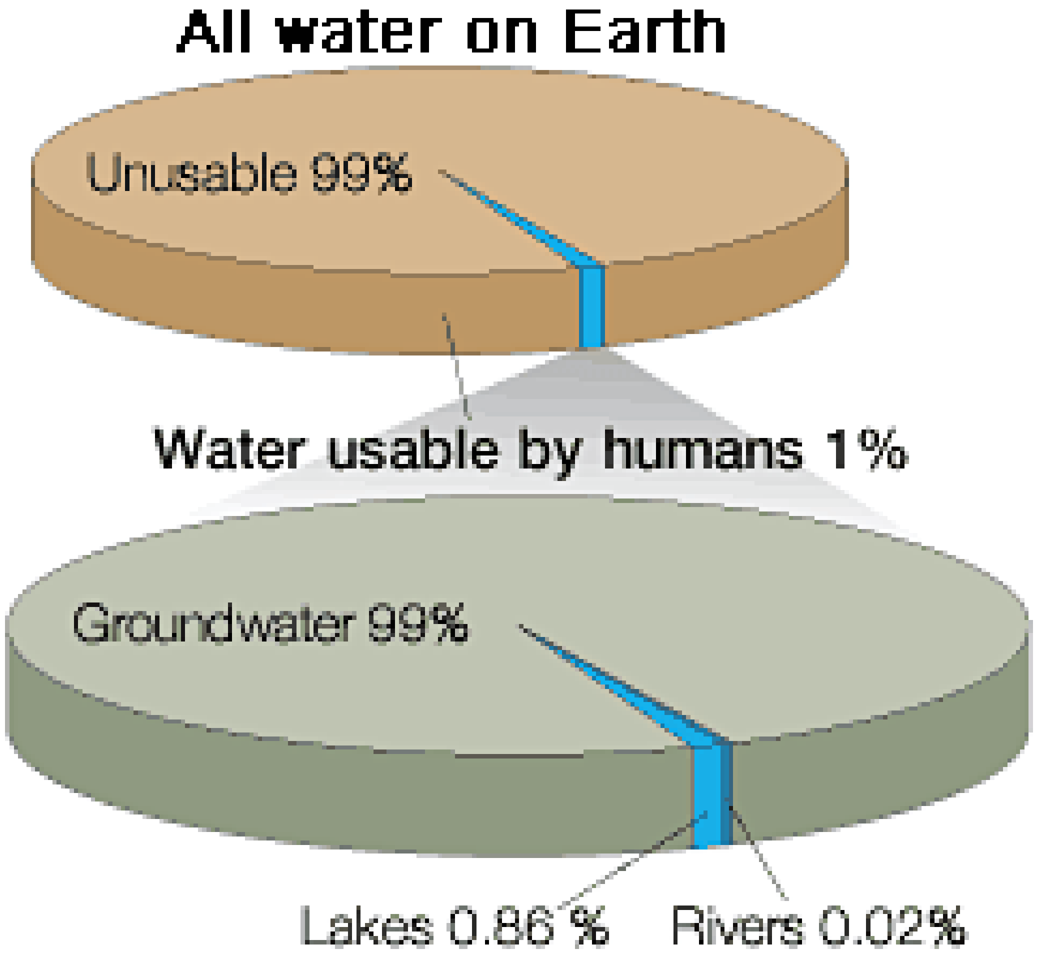
Lecturer

Department of Civil Engineering

Lecture-01
on
Ground Water

Introduction

- Over 70% of the earth's surface is covered in water.
- But of that water, just 1% is readily available for human use, and of that 1%, 99% of it is stored beneath our feet as groundwater.
- We all rely on groundwater in some way, so it's important that we understand this vital resource.



Introduction Cont…

Since the 1960's, groundwater has been used extensively as the main source of drinking and irrigation water supply. About 75 percent of cultivated land is irrigated by groundwater and the remaining 25 percent by surface water. Of the abstracted groundwater about 70-90 percent is used for agricultural purposes and the rest for drinking and other water supplies.

Table 1. Groundwater development by STW[1] and DTW[2] (BADC, 2005)

Year	No. of STW	No. of DTW	Year	No. of STW	No. of DTW
1985	133,800	15,300	1993	348,900	25,700
1988	186,400	23,500	1995	488,900	26,700
1989	217,900	23,300	1996	556,400	27,200
1991	270,300	21,500	1998	664,700	25,400
1992	309,300	25,500	2001	707,600	23,500
			2004	925,152	24,718

[1] STW = Shallow Tubewell, [2]DTW = Deep Tubewell

Introduction Cont…

Table 2. Status of irrigation in Bangladesh, 1995-1996 (WARPO, 2001)

Mode of irrigation	Type of equipment	No. of equipment in operation	Area irrigated ha	%
Groundwater	STW	556,400	1,937,700	57
	DSSTW[1]	19,300	64,600	2
	DTW	27,200	537,900	16
Surface Water	LLP[2]	60,700	577,200	17
	TRAD[3]	673,000	226,400	7
Others		161,800	50,100	1
Total			3,394,900	100

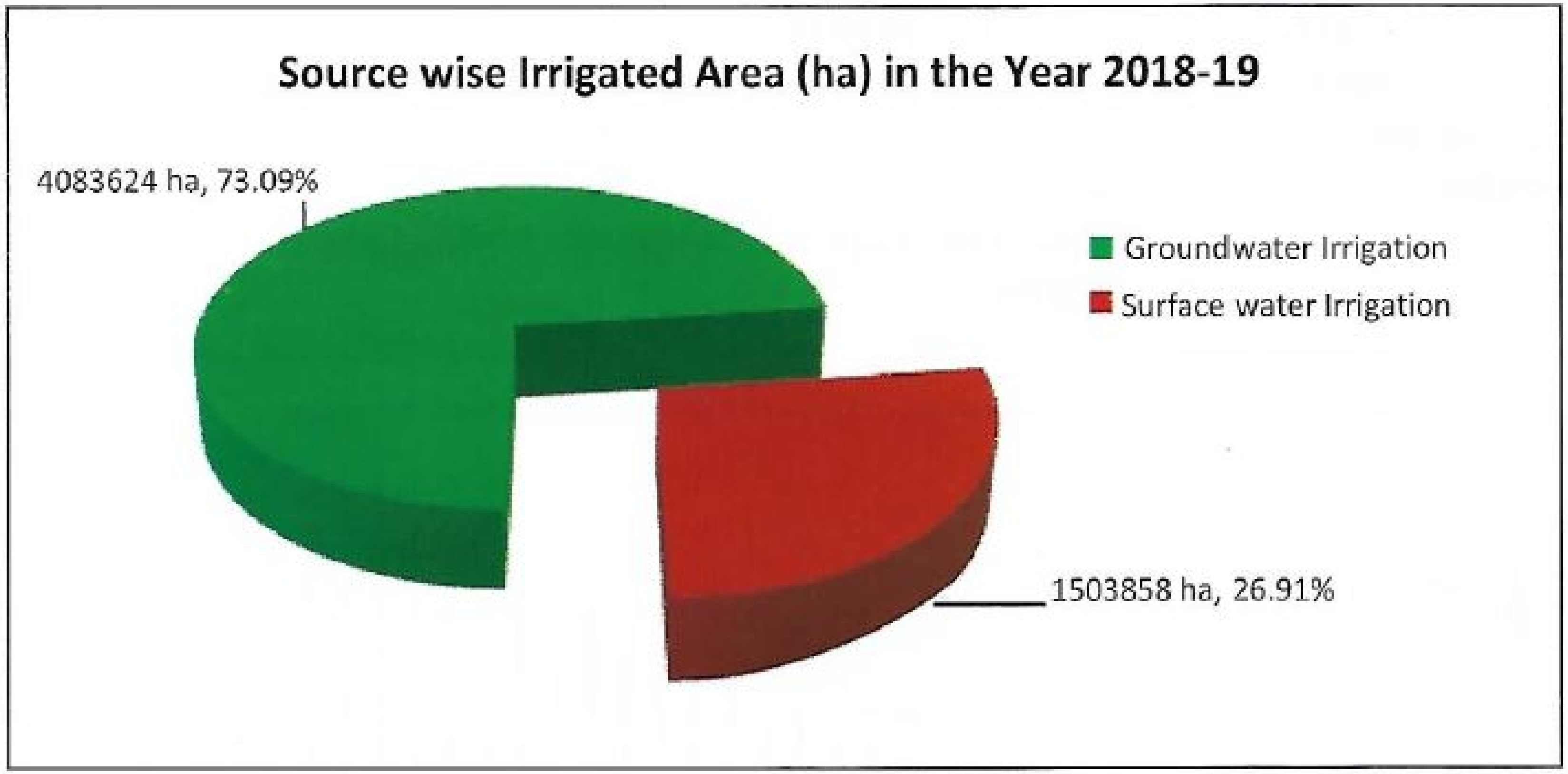
[1]DSSTW = Deep set shallow tubewell, LLP = Low lift pump TRAD = Treadle pump.

In the year **2018-19; 37,634 Nos.** Deep Tube Wells, **13,57,532 Nos.** Shallow Tube Wells and **1,87,188 Nos.** Low Lift Pumps are operated in Bangladesh to provide water for minor irrigation. About 73.09% of the total irrigated area is covered by groundwater and the remaining 26.91% area is covered by surface water.

Introduction Cont…

Table-1: Summary of Surface water and Ground water Irrigation by Different Modes during Rabi Season 2018-19

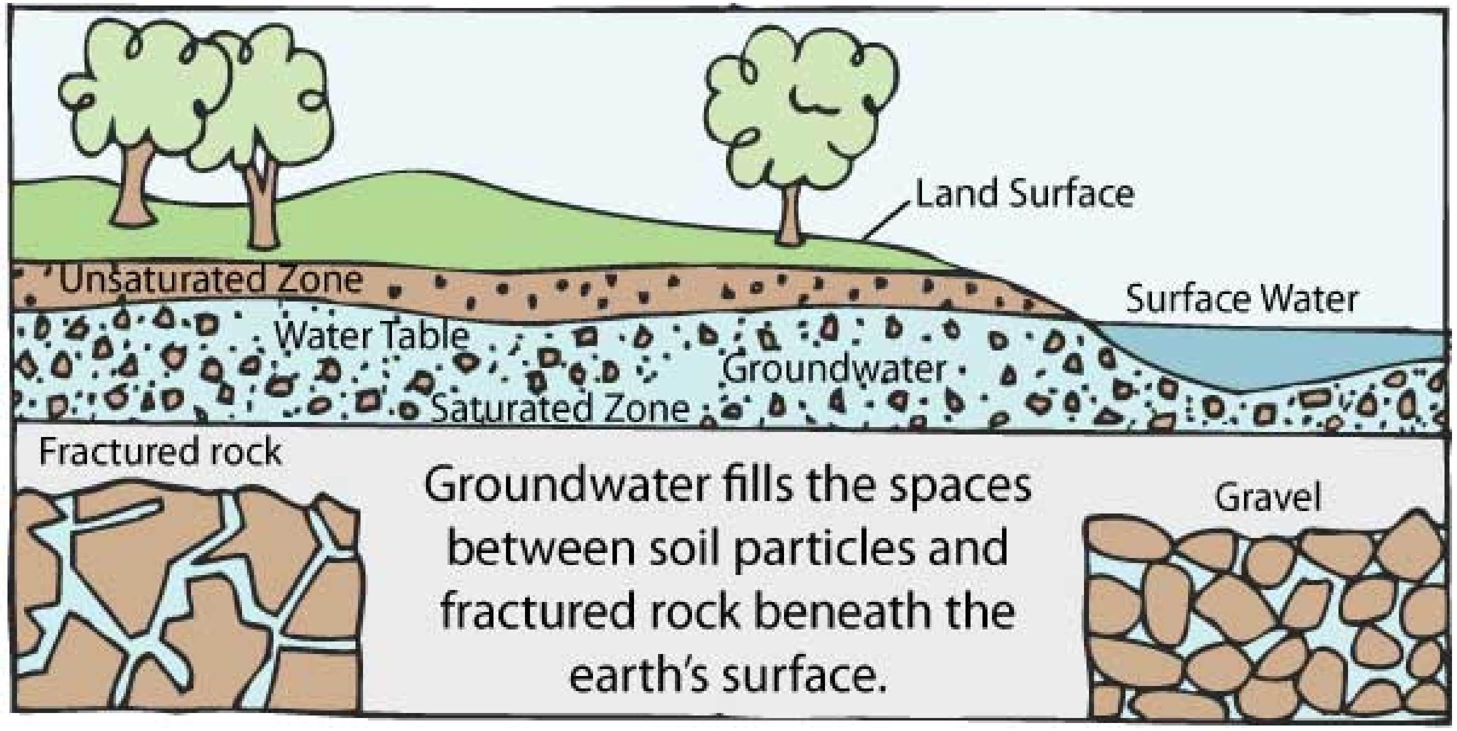
Sl. No.	Mode of irrigation	No. of Equipment	Area Irrigated	% of Surface water	% of Total Irrigated	Area Irrigated per Equipment
A.	**Surface water Irrigation by:**					
1	Low lift pump	187188				
2	Gravity flow					
3	Traditional method					
4	Solar Pump	2254				
	Sub Total	**189442**				
B.	**Groundwater Irrigation by:**					
1	Deep tube well	37634				
2	Shallow tube well	1357532				
3	Manual & Artesian well					
4	Solar Pump	533				
5	Dug Well	272				
	Sub Total	**1395971**				
	GRAND TOTAL	**1585413**	**5587482**		**100.00%**	



What is Groundwater?

Groundwater is the water found underground in the cracks and spaces in soil, sand and rock. It is stored in and moves slowly through geologic formations of soil, sand and rocks called aquifers.

The area where water fills the aquifer is called the saturated zone (or saturation zone). The top of this zone is called the water table. The water table may be located only a foot below the ground's surface or it can sit hundreds of feet down.



How much do we depend on groundwater?

- Groundwater supplies drinking water for 90% of the total BD Population.
- Groundwater helps grow our food. 70-90% of groundwater is used for irrigation to grow crops.
- Groundwater is an important component in many industrial processes.
- Groundwater is a source of recharge for lakes, rivers, and wetlands.

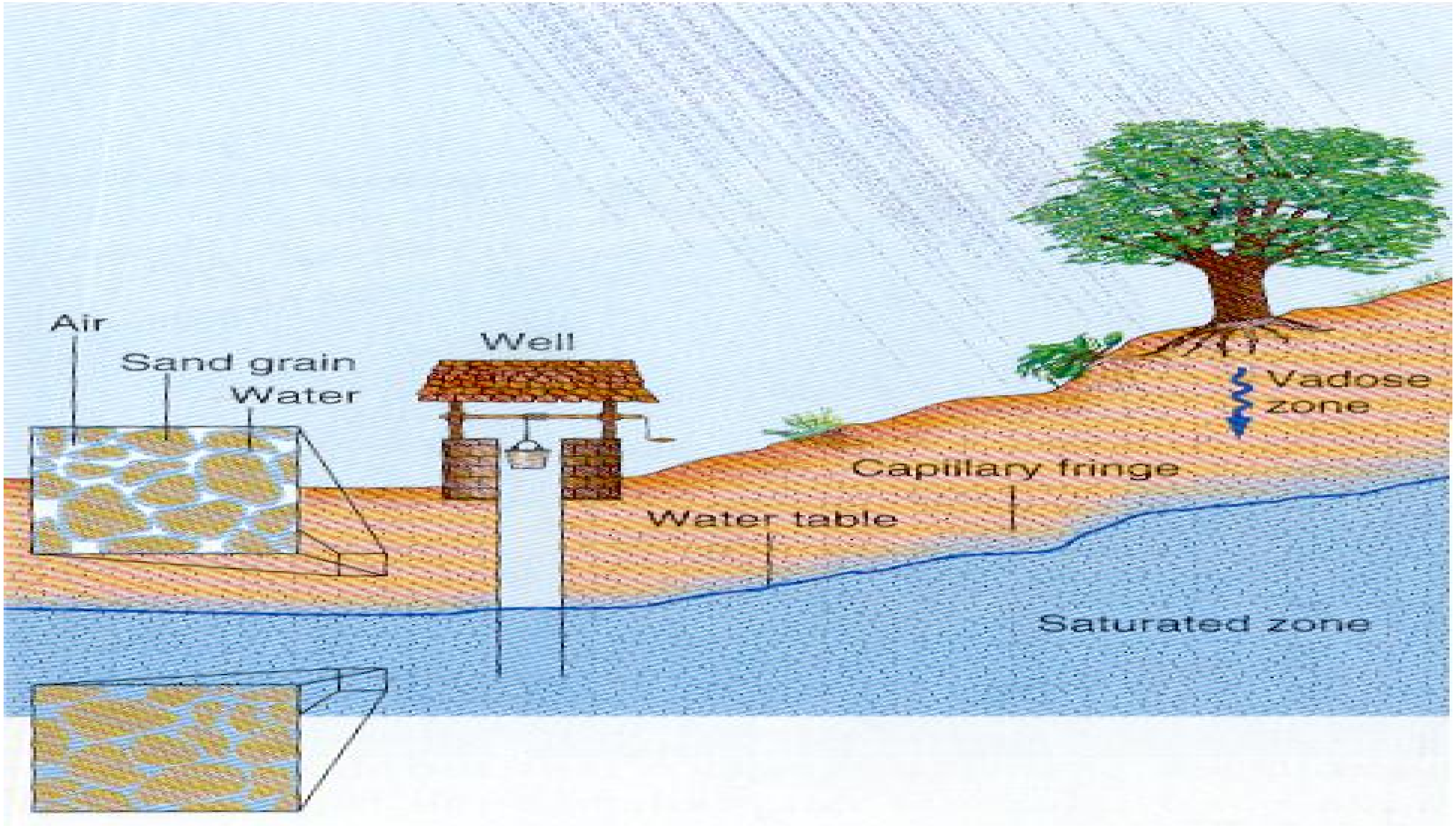
Advantages of Ground Water(GW) over surface water

01. GW is clean, colorless, and almost free from turbidities
02. GW is free from Pathogenic organism which causes disease
03. GW is rich with several minerals which are beneficial to health
04. For most cases GW needs no treatment
05. GW have uniform temperature in all most all the year
06. About 99% drinkable water is stored as ground water
07. GW is available for irrigation in dry season when surface water in not available
08. Ground water storage is free from atomic attack

The Water Table

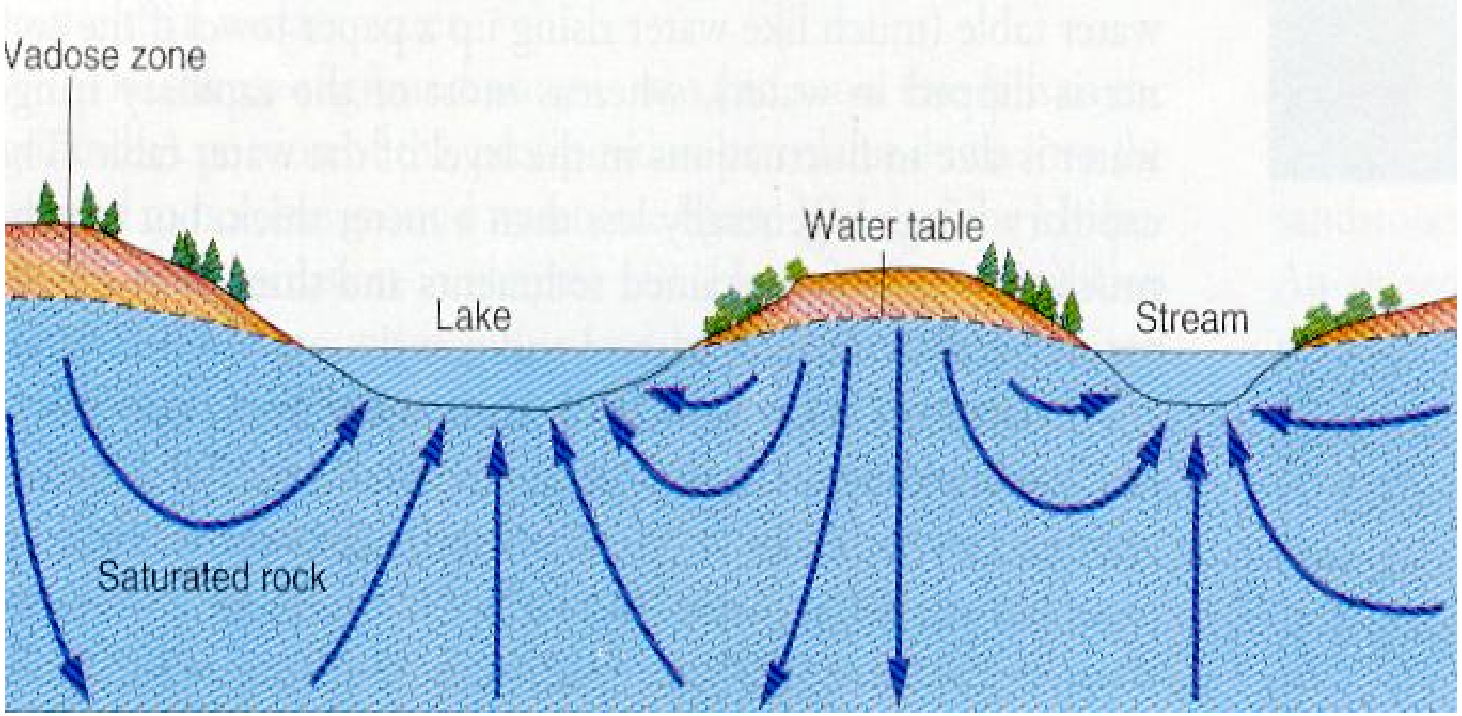
- **Saturated zone:** the subsurface zone in which all rock openings are filled with water
- **Water table:** the upper surface of the zone of saturation
- **Vadose zone:** a subsurface zone in which rock openings are generally unsaturated and filled partly with air and partly with water; above the saturated zone
- **Capillary fringe:** a transition zone with higher moisture content at the base of the vadose zone just above the water table

The Water Table Cont…



The Movement of Ground Water

- most ground water moves relatively slowly through rock underground
- because it moves in response to differences in water pressure and elevation, water within the upper part of the saturated zone tends to move downward following the slope of the water table



Movement of ground water beneath a sloping water table in uniformly permeable rock. Near the surface the ground water tends to flow parallel to the sloping water table

Movement of Ground Water (cont.)

Factors affecting the flow of ground water:

- **The slope of the water table** - the steeper the water table, the faster ground water moves
- **Permeability** - if rock pores are small and well connected, water moves slowly; when openings are large and poorly connected, the flow of water is more rapid

3. Pressure
4. Elevation
5. Soil Type
6. Degree of Saturation
7. Porosity
8. Precipitation
9. Vegetation

Definitions

Aquifer

An **aquifer** is an underg
rock fractures or uncons
which groundwater can
Example: Sand

Aquifer: Formations which contain groundwater and at the same time which are sufficiently permeable to transmit and yield water in usable quantities are called the aquifers.
The amount of water contained by the aquifer depends on the porosity of the aquifer formation while the amount of water that it can yield depends on its permeability.

Aquiclude

The opposite of an aqu
or sediment unit that d
be porous and capable
is so poor that it canno
Clay and **shale** are typi

Aquiclude: A geological formation which is saturated and which may contain large amount of water because of high porosity, but cannot transmit water as it is relatively impermeable is called Aquiclude.

Example: A clay layer

Definitions

Aquifuge

An aquifuge is an impermeable formation neither containing nor transmitting water.

Example: Solid Granite, Basalt

Aquitard

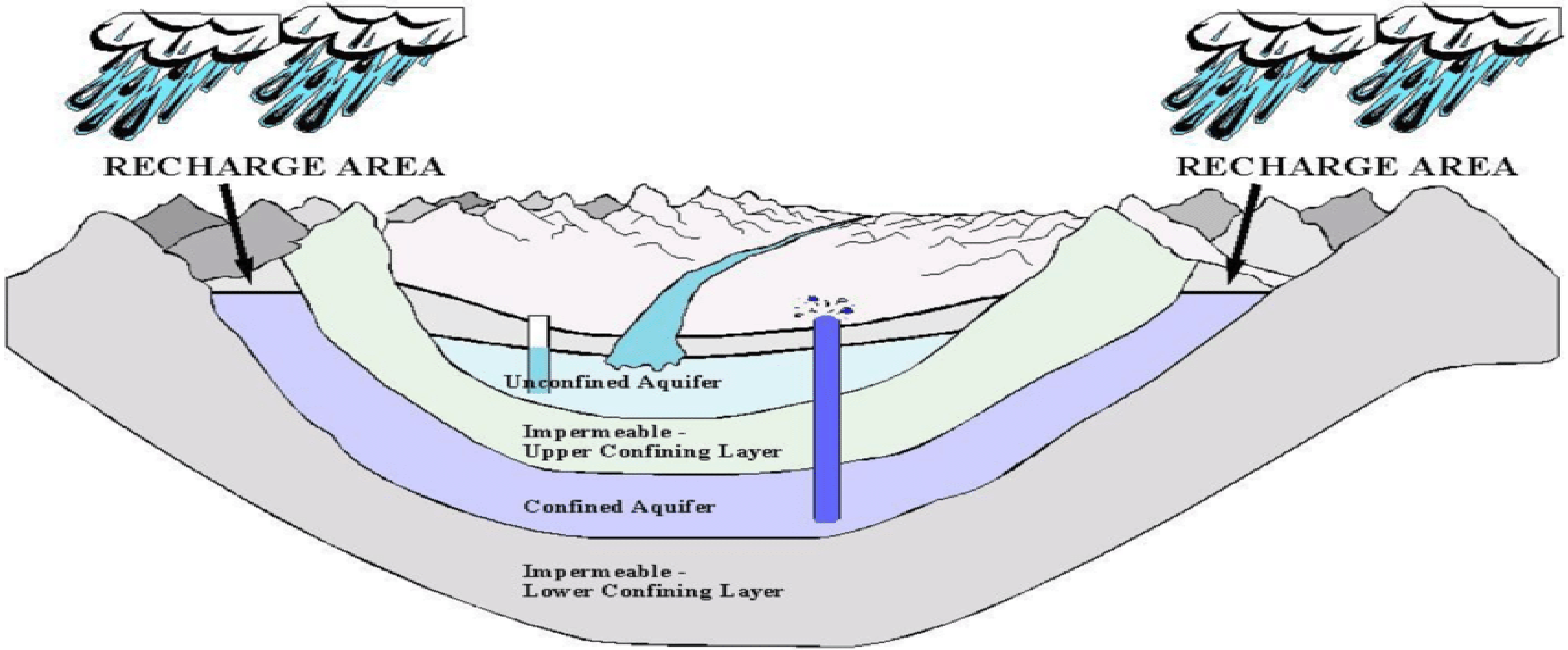
An *aquitard* is a geological unit that is permeable enough to transmit water in significant quantities when viewed over large areas and long periods, but its permeability is not sufficient to justify production wells being placed in it.

Example: Clay lenses interbedded with sand, Clays, loams, and shales are typical aquitards.

Definitions

Confined Aquifer

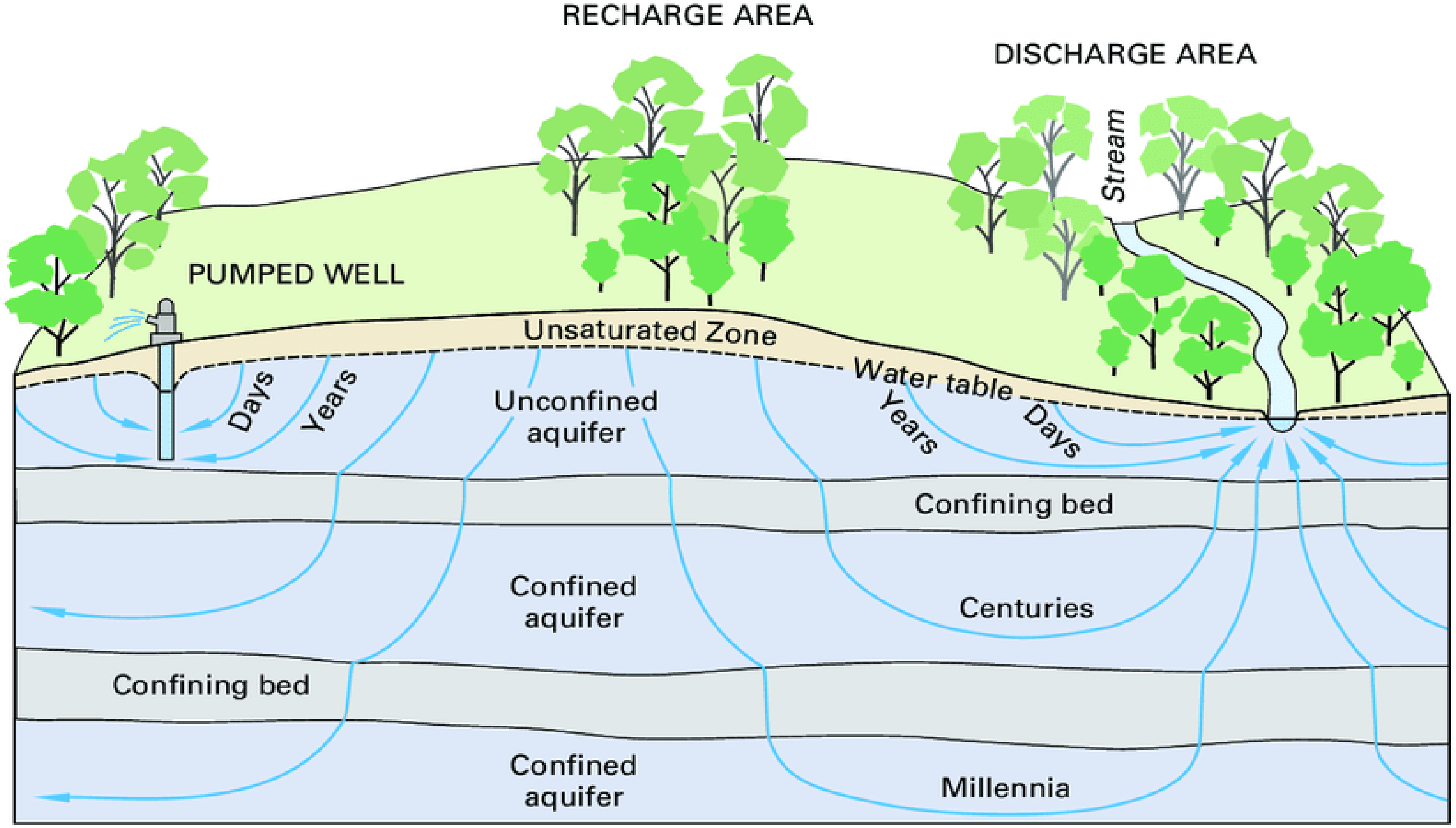
An aquifer that is bounded above and below by impermeable **rock** or sediment layers. There may or may not be enough pressure in the aquifer to make it an "artesian aquifer."



Definitions

Unconfined Aquifer

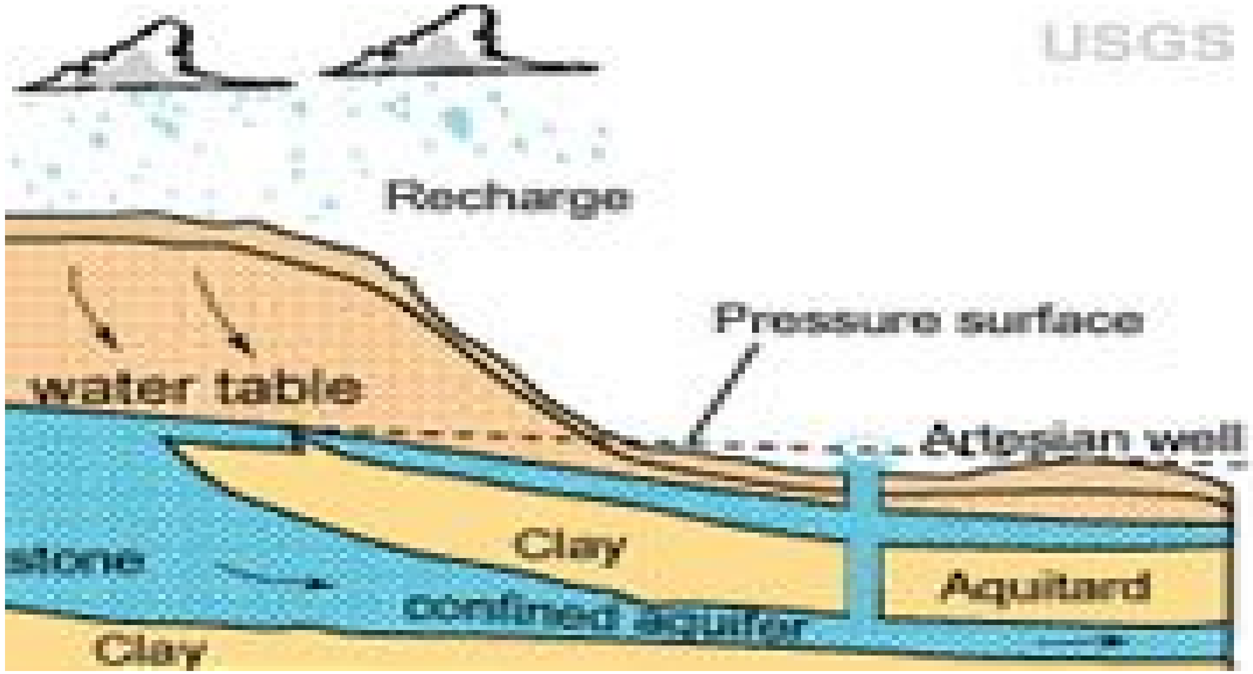
An aquifer that is not overlain by an impermeable **rock** unit. The water in this aquifer is under atmospheric pressure and is recharged by precipitation that falls on the land surface directly above the aquifer.



Definitions

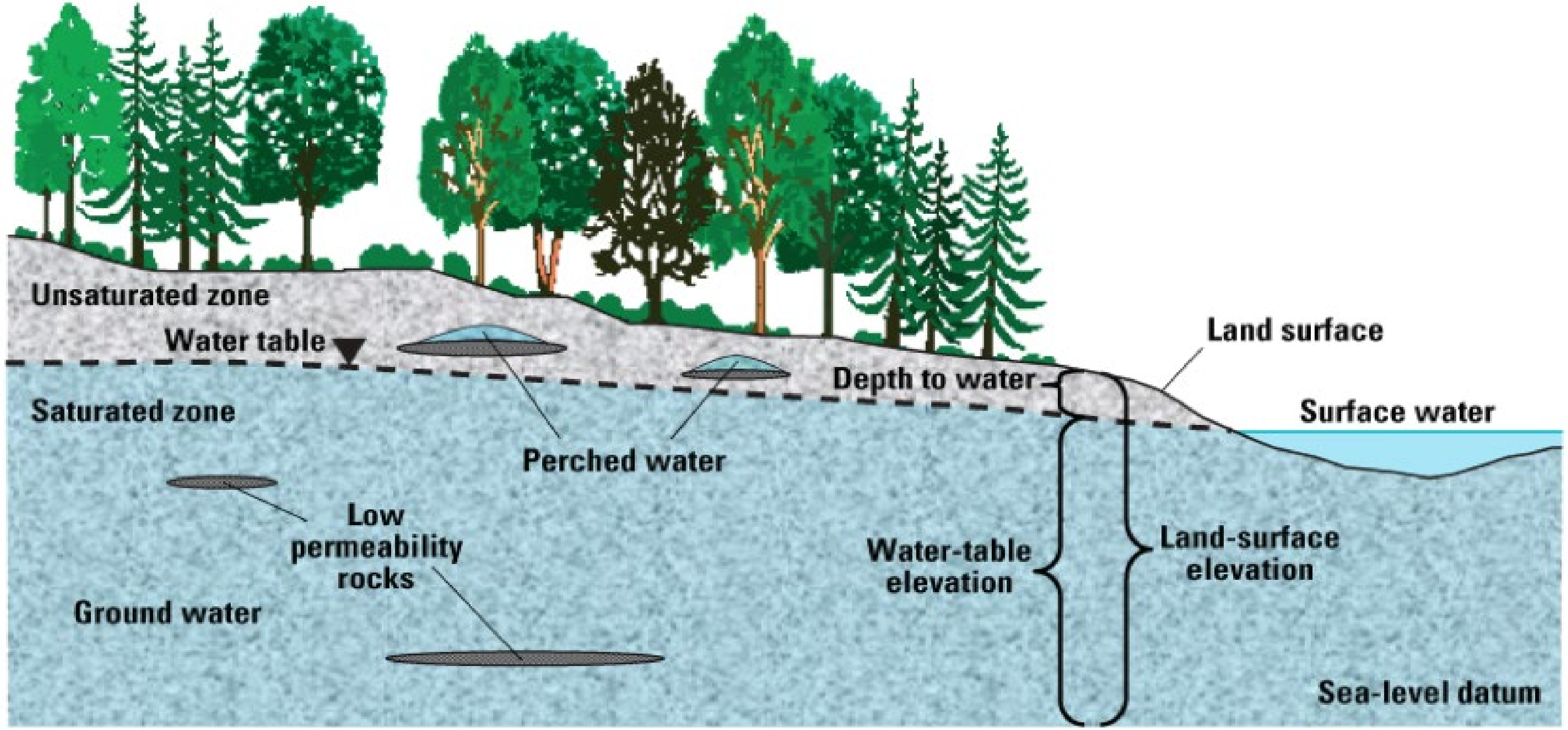
Artesian Aquifer/Confined Aquifer

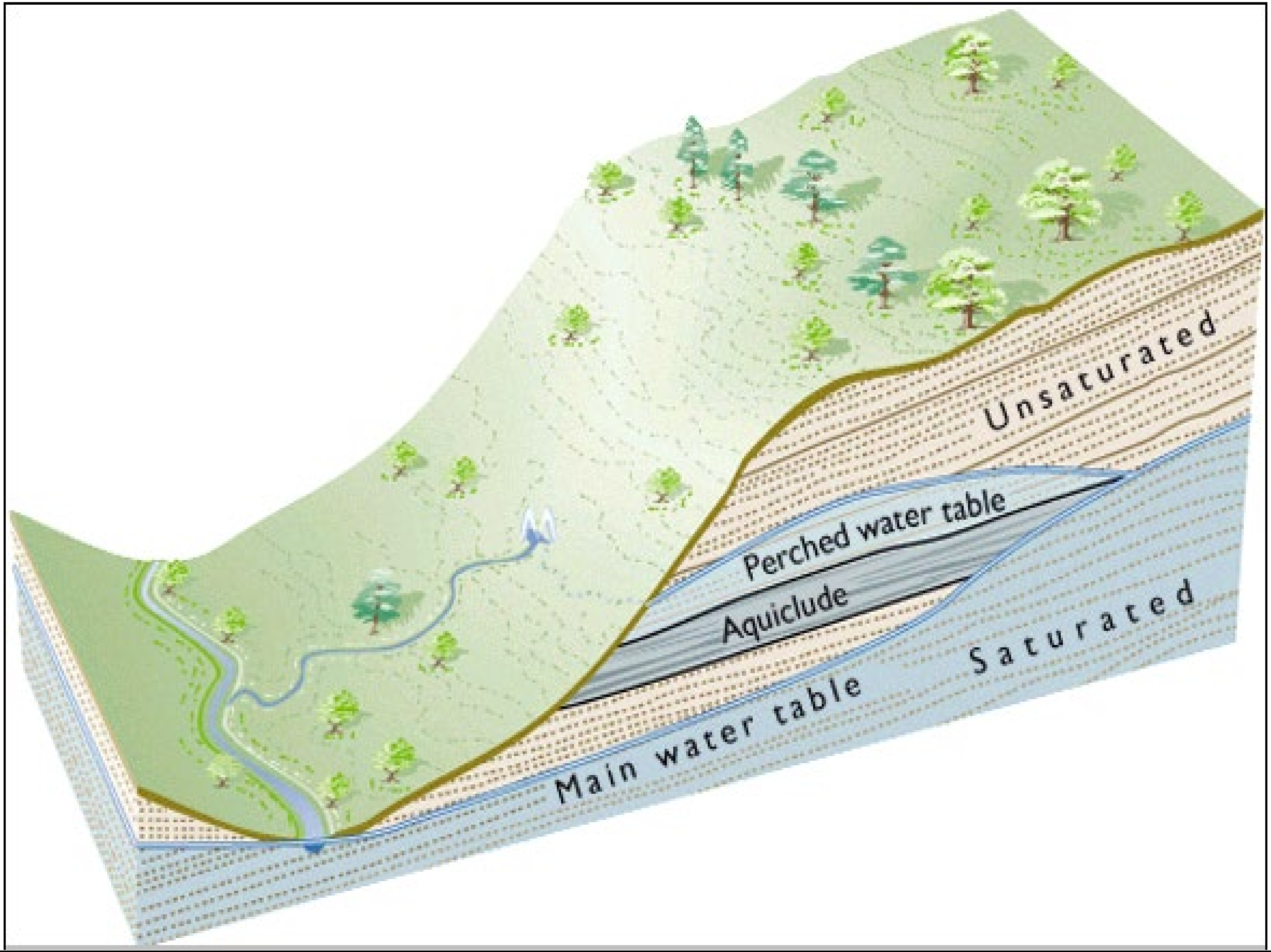
An aquifer that is bounded above and below by impermeable **rock** or sediment layers. The water in the aquifer is also under enough pressure that, when the aquifer is tapped by a well, the water rises up the well bore to a level that is above the top of the aquifer. The water may or may not flow onto the land surface.



Perched Aquifer

A **perched** water table (or **perched aquifer**) is an **aquifer** that occurs above the regional water table, in the vadose zone. This occurs when there is an impermeable layer of rock or sediment (aquiclude) or relatively impermeable layer (aquitard) above the main water table/**aquifer** but below the surface of the land.




Unsaturated
Perched water table
Aquiclude
Saturated
Main water table

Thank you
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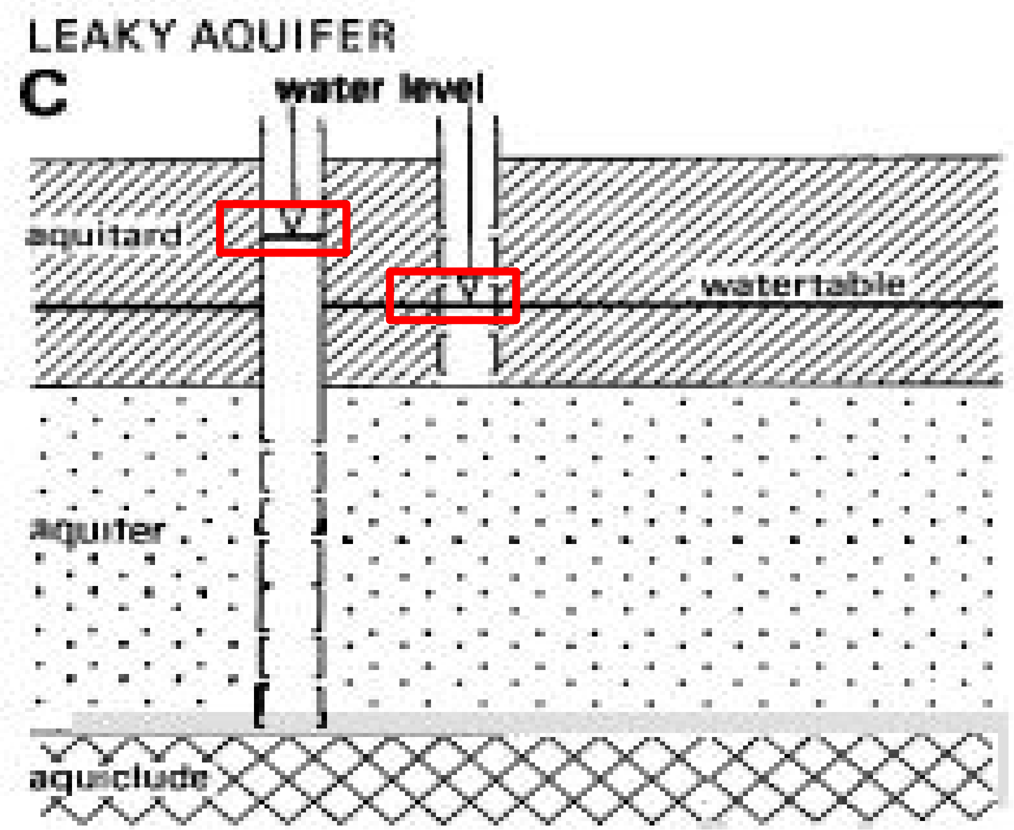
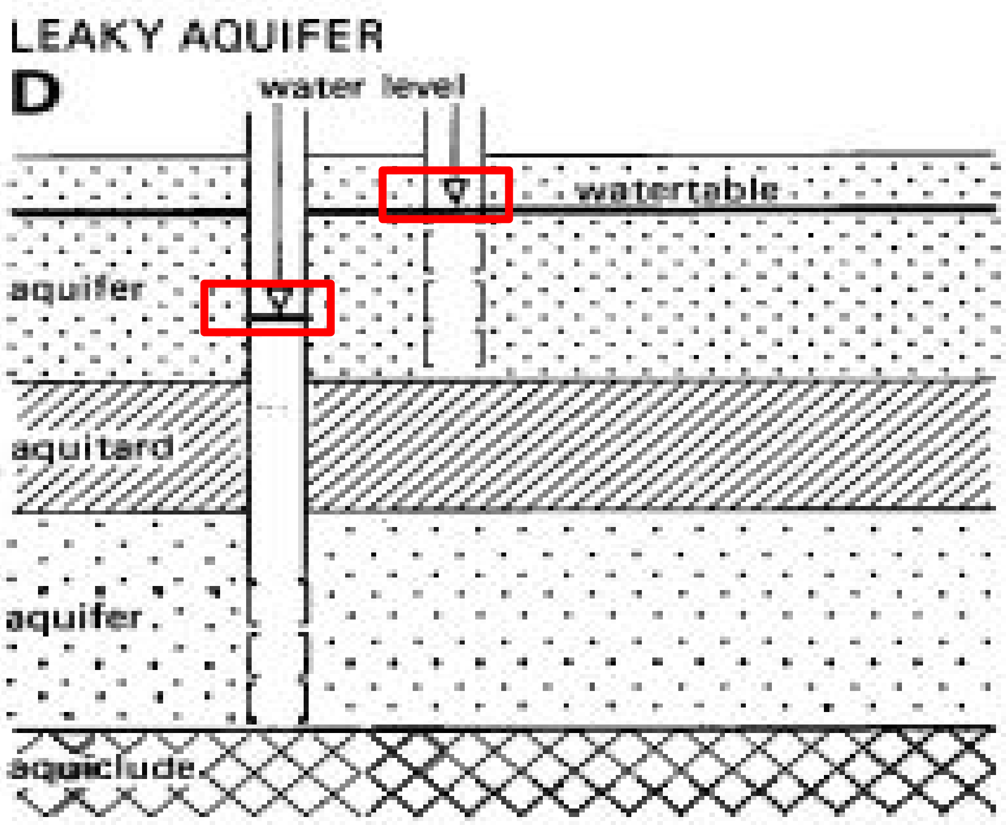
Lecture-03
on
Ground Water

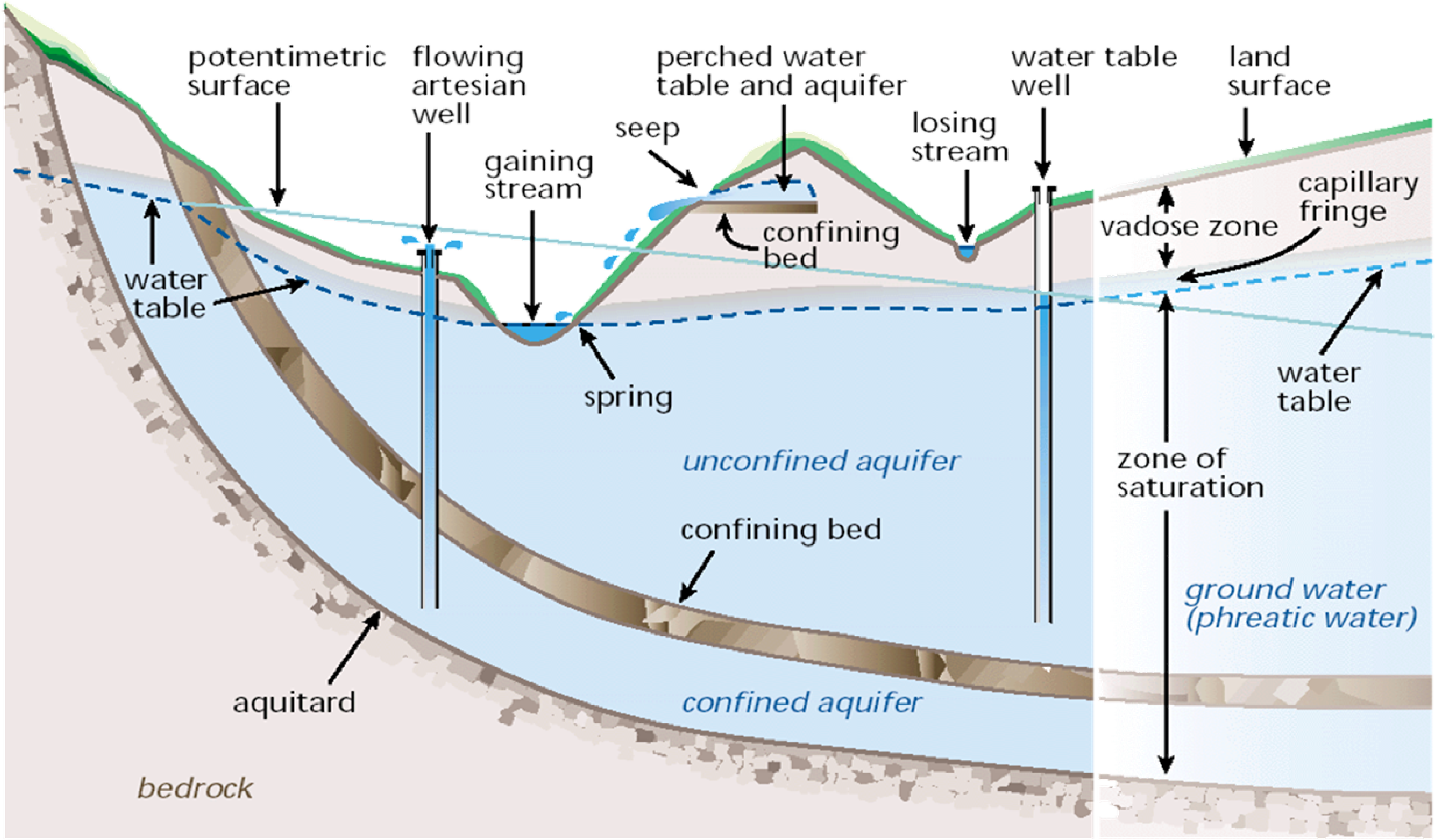
Leaky aquifer

A **leaky aquifer**, also known as a semi-confined **aquifer**, is an **aquifer** whose upper and lower boundaries are aquitards, or one boundary is an aquitard and the other is an aquiclude.

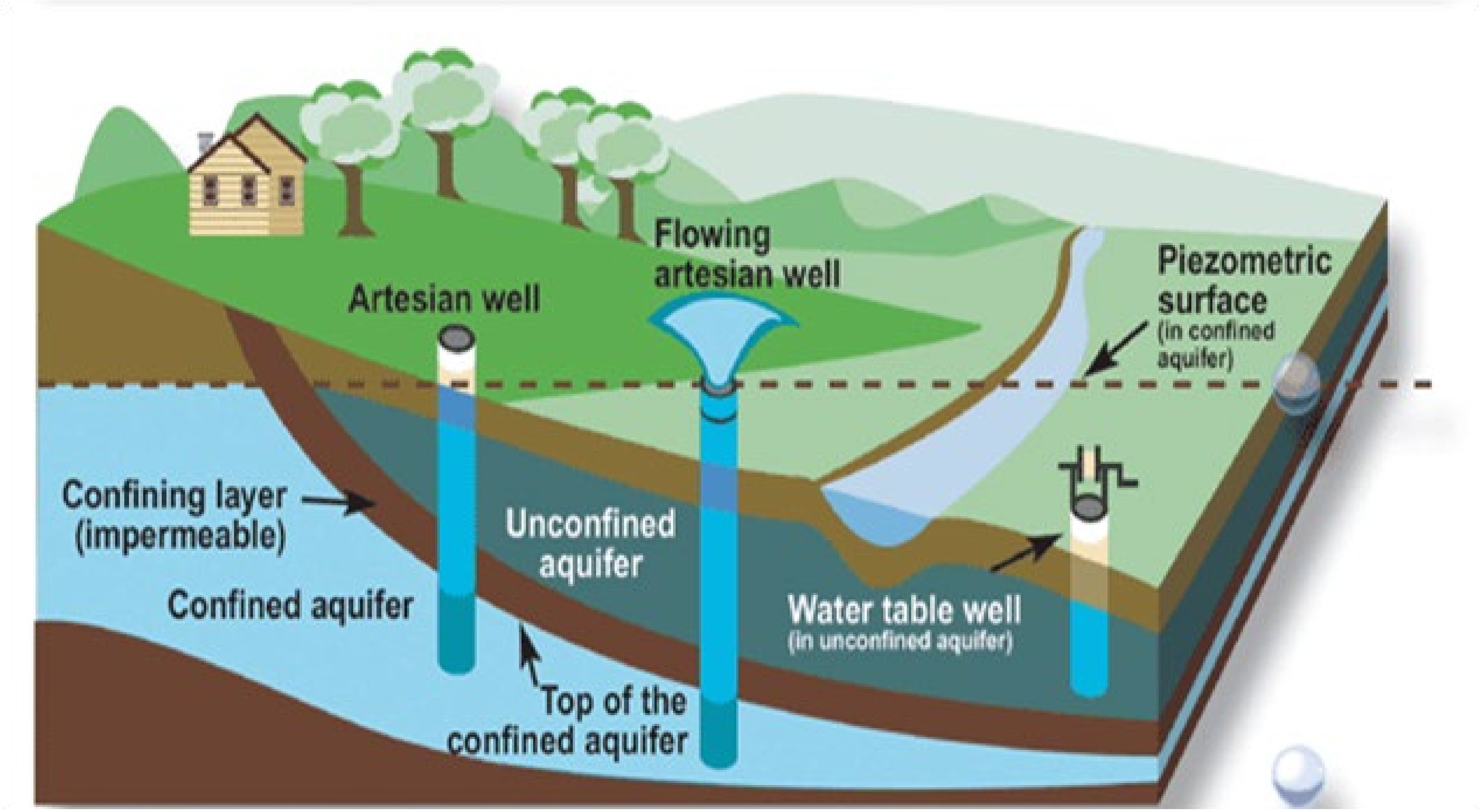




Definitions



Definitions

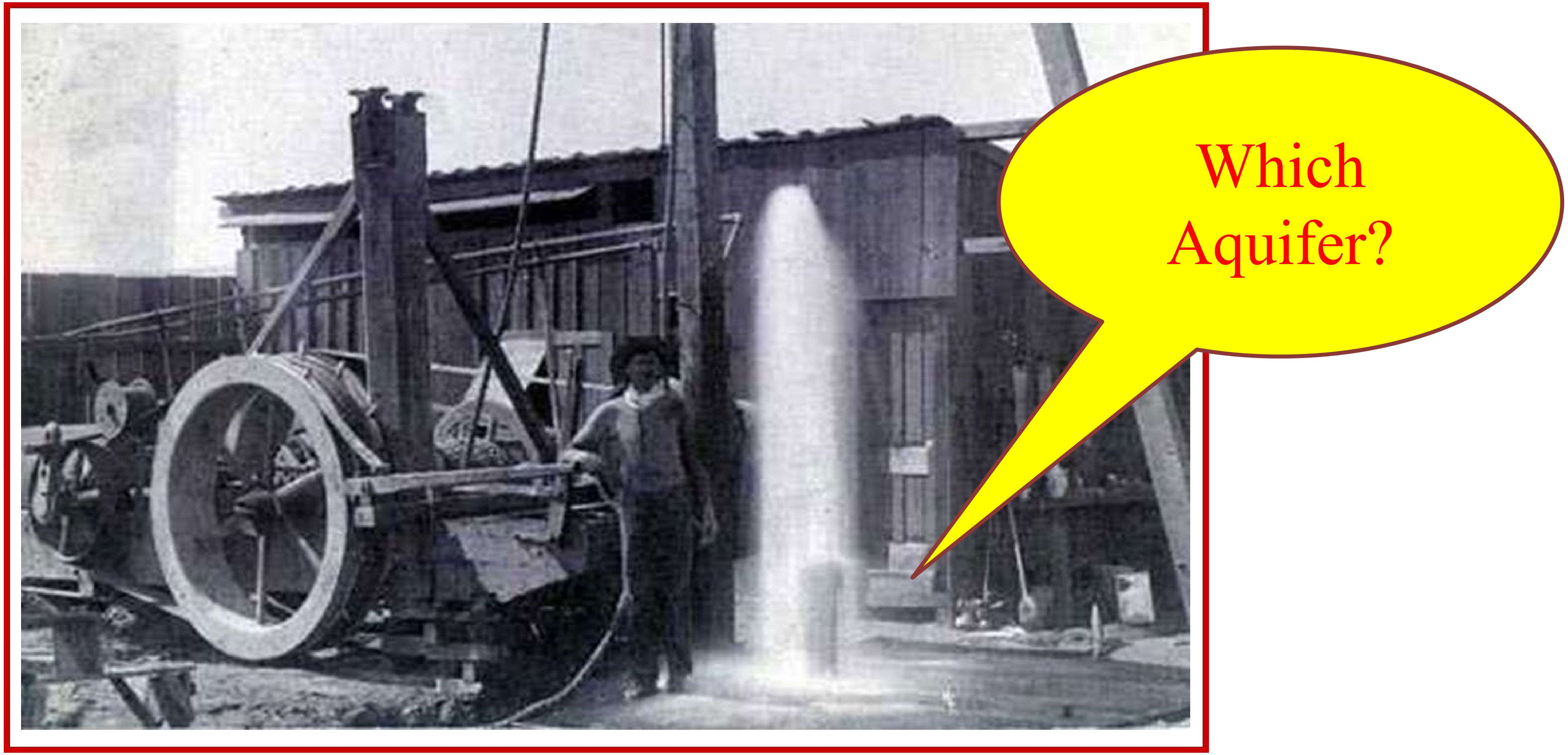


ASSIGNMENT

Q. What is Piezometric Surface ?

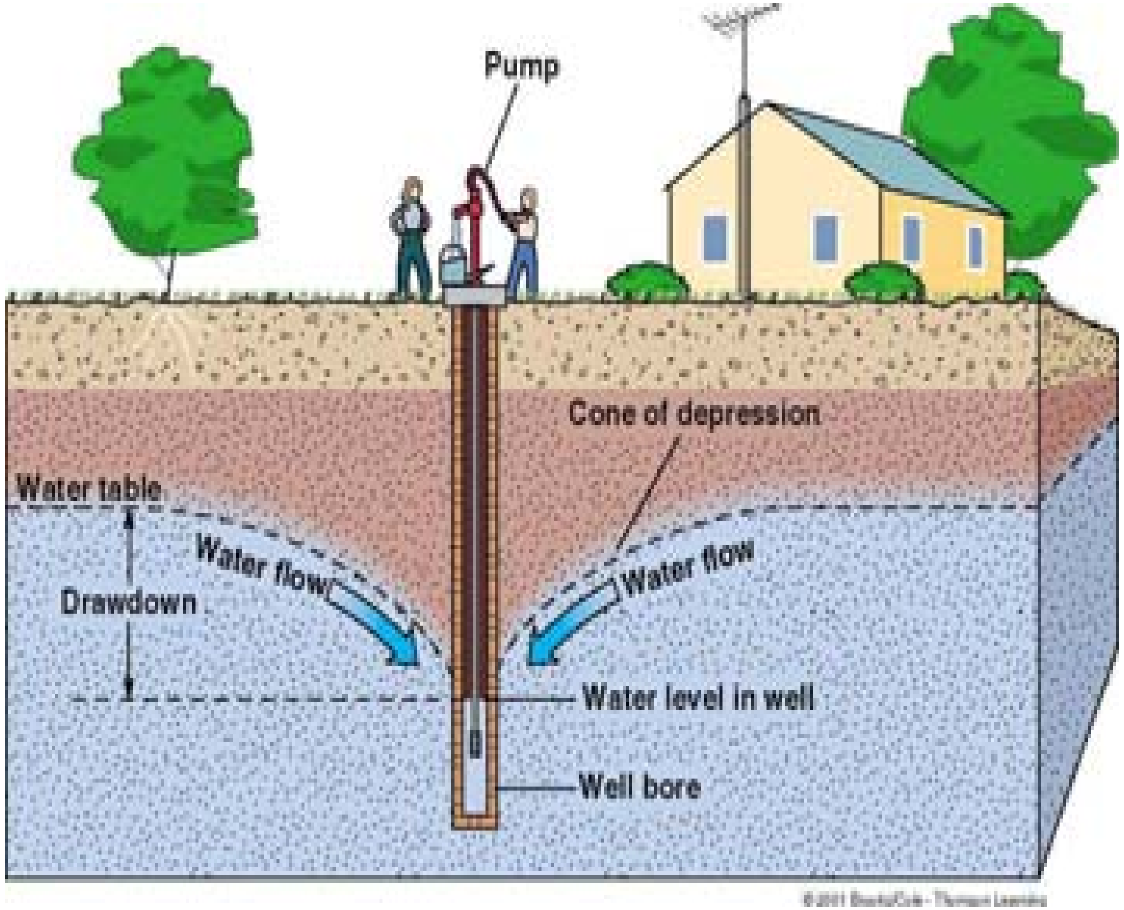
Piezometer surface: Piezometer surface is the surface obtained by connecting equilibrium water levels in the tubes or piezometer penetrating the confined aquifer.

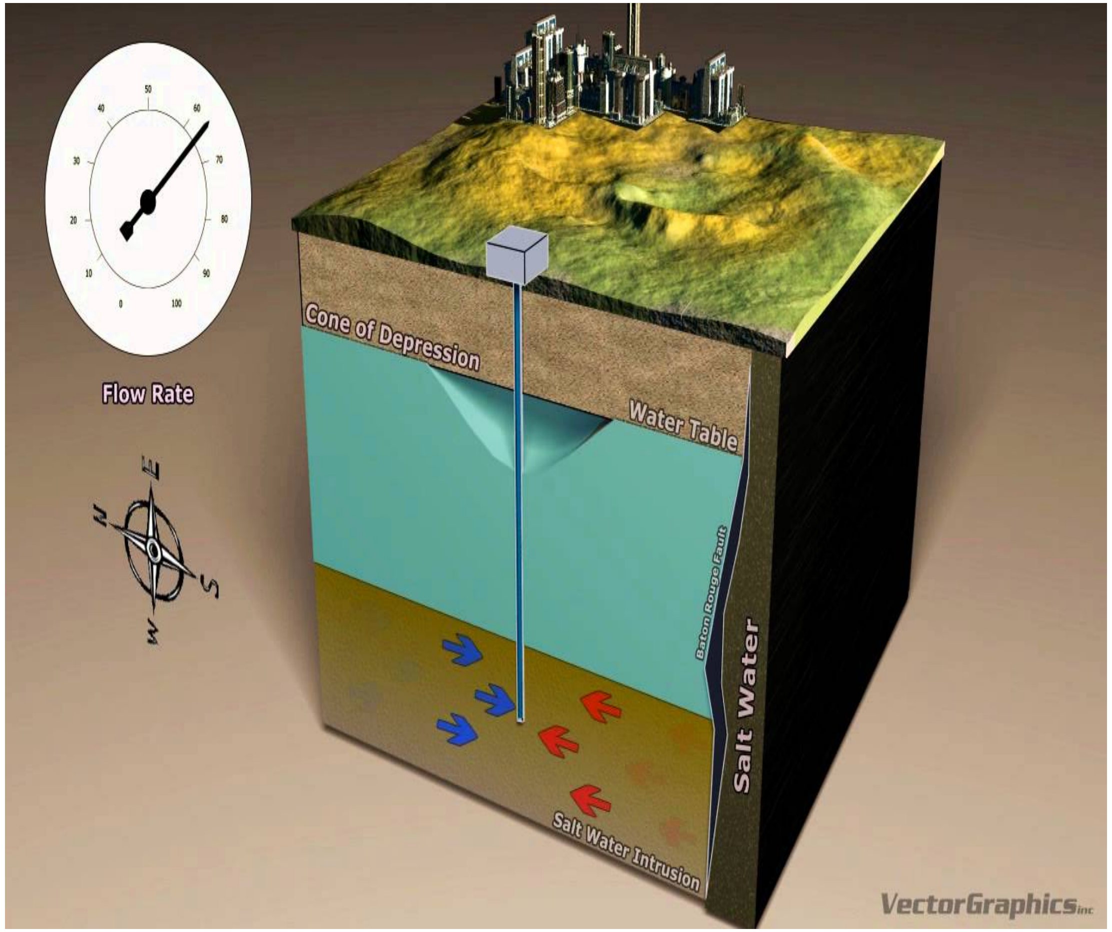
Definitions



Cone of Depression

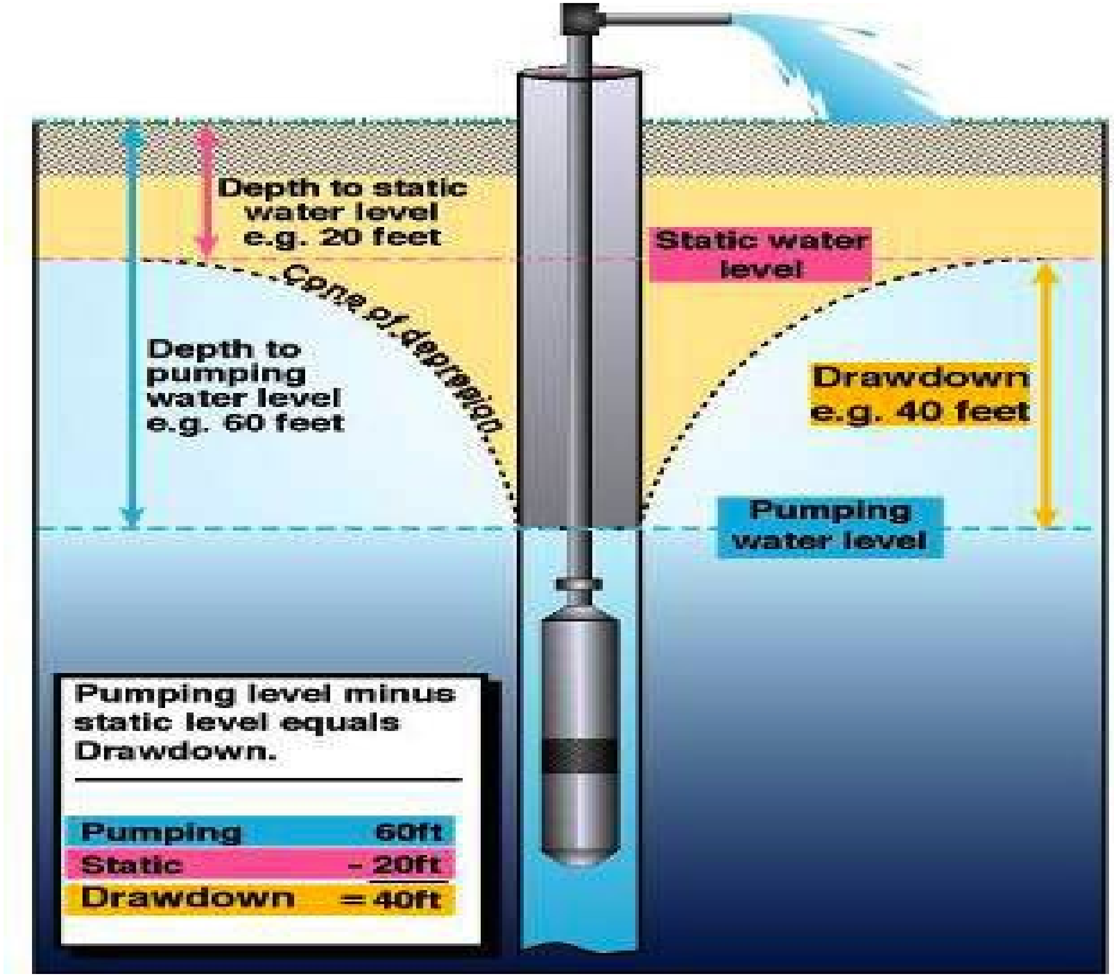
If water is pumped at a constant rate from the well, a gradient in the water table toward the well is created which results in a depressing form of water table. This is called cone of depression.

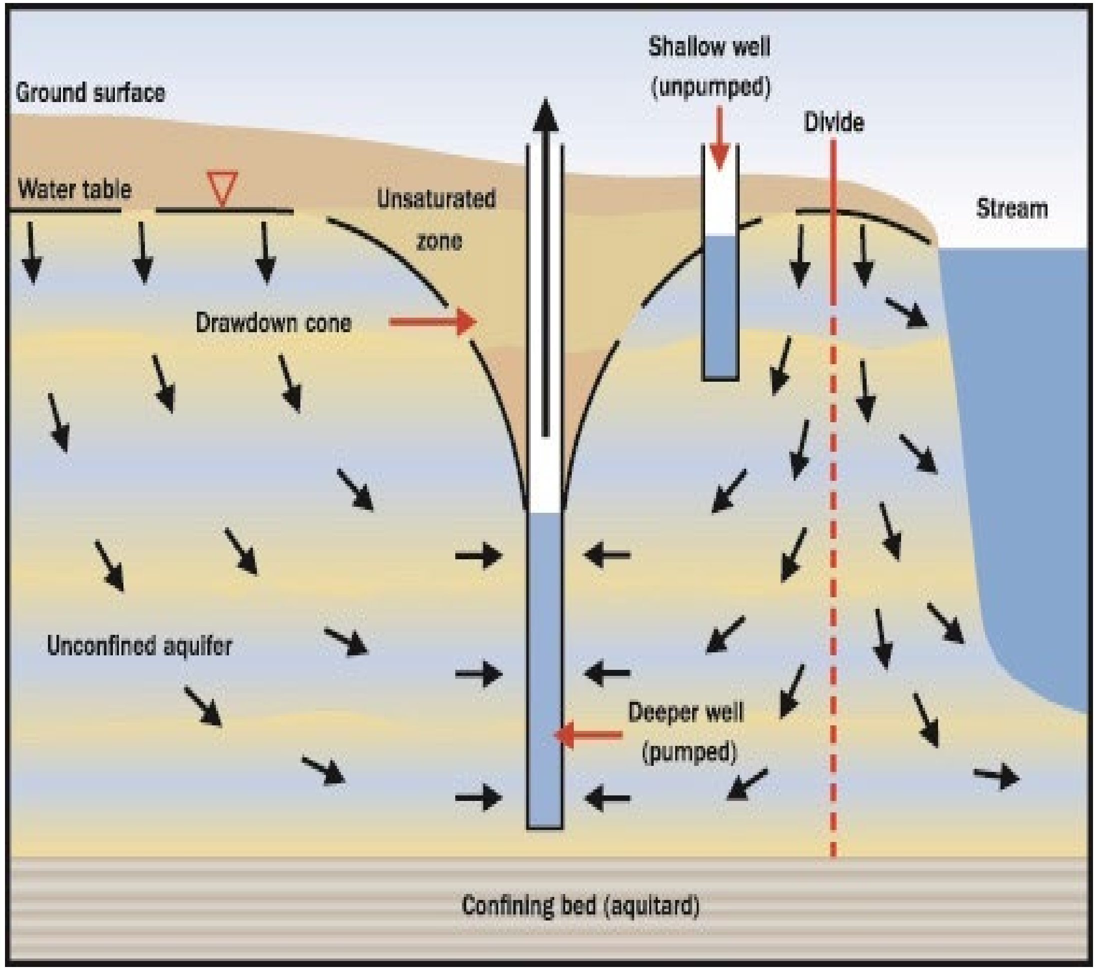




Drawdown

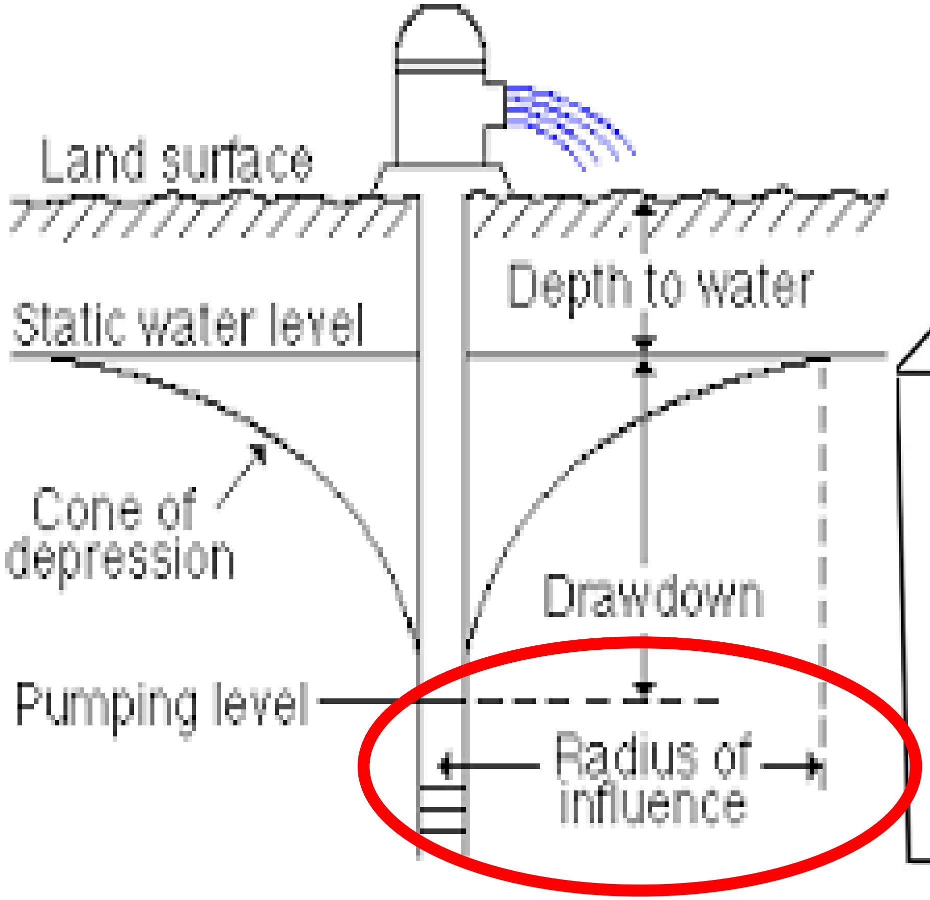
The decrease in water level at the well with respect to initial ground water table is called drawdown . It is donated by Sw.

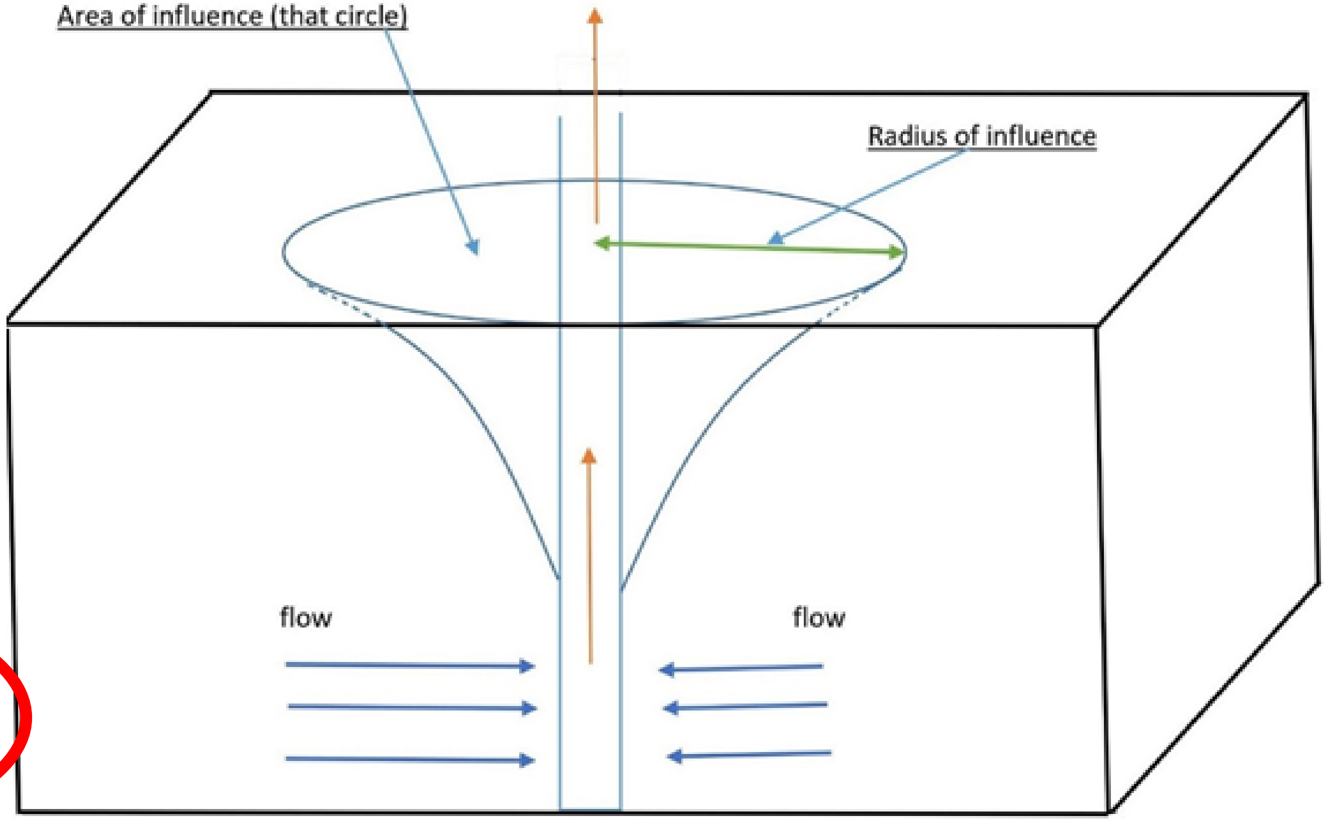




Radius of Influence

The radial distance from the center of a wellbore to the point where there is no lowering of the water table or potentiometric surface (the edge of the cone of depression)

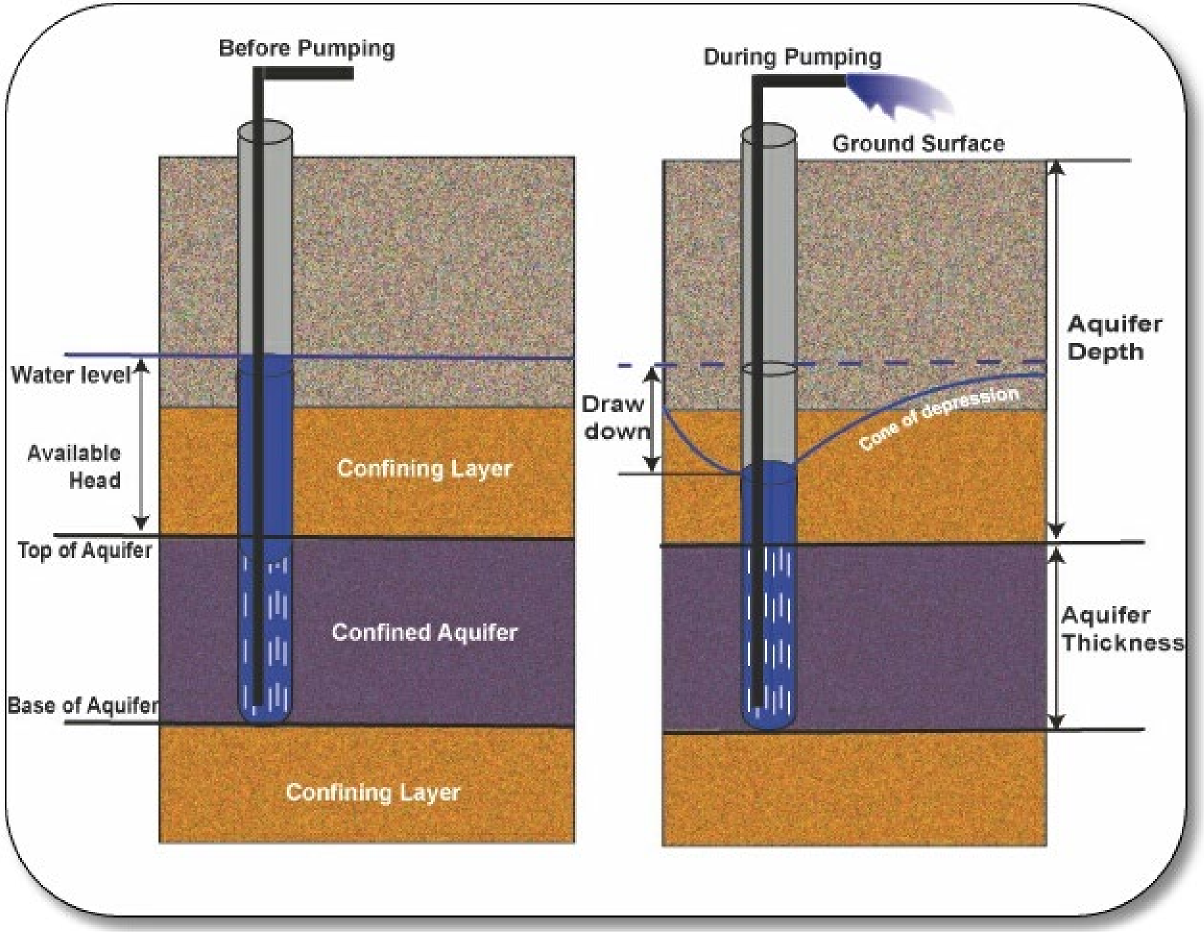




Safe Yield

Safe yield is defined as the maximum rate of withdrawal that can be sustained by an aquifer without causing an unacceptable decline in the hydraulic head or deterioration in water quality in the aquifer.

When setting the safe yield of an aquifer an attempt is being made to guide water resource managers regarding the volume of groundwater that can be abstracted sustainably over the long-term.



Specific Capacity

Definition

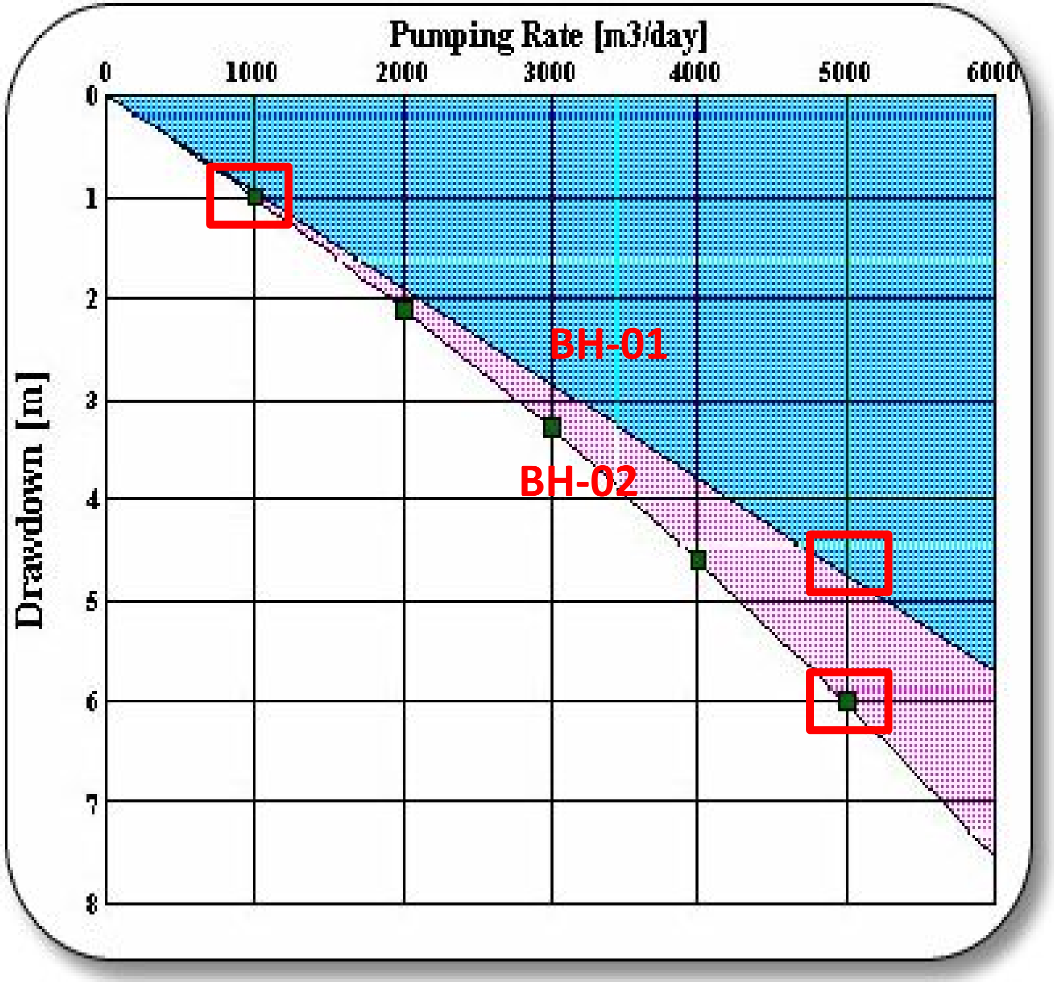
The rate of discharge from a borehole per unit of drawdown, usually expressed as lpm/m.

Description

Specific capacity is a measure of borehole performance and is calculated by dividing the yield of the borehole by drawdown induced by abstraction.

Why is specific capacity important?

Specific capacity is a measure borehole productivity and performance.



Specific Yield (S_y)

Formal definition

The ratio of the volume of water that drains by gravity to that of the total volume of the saturated porous medium.

Description

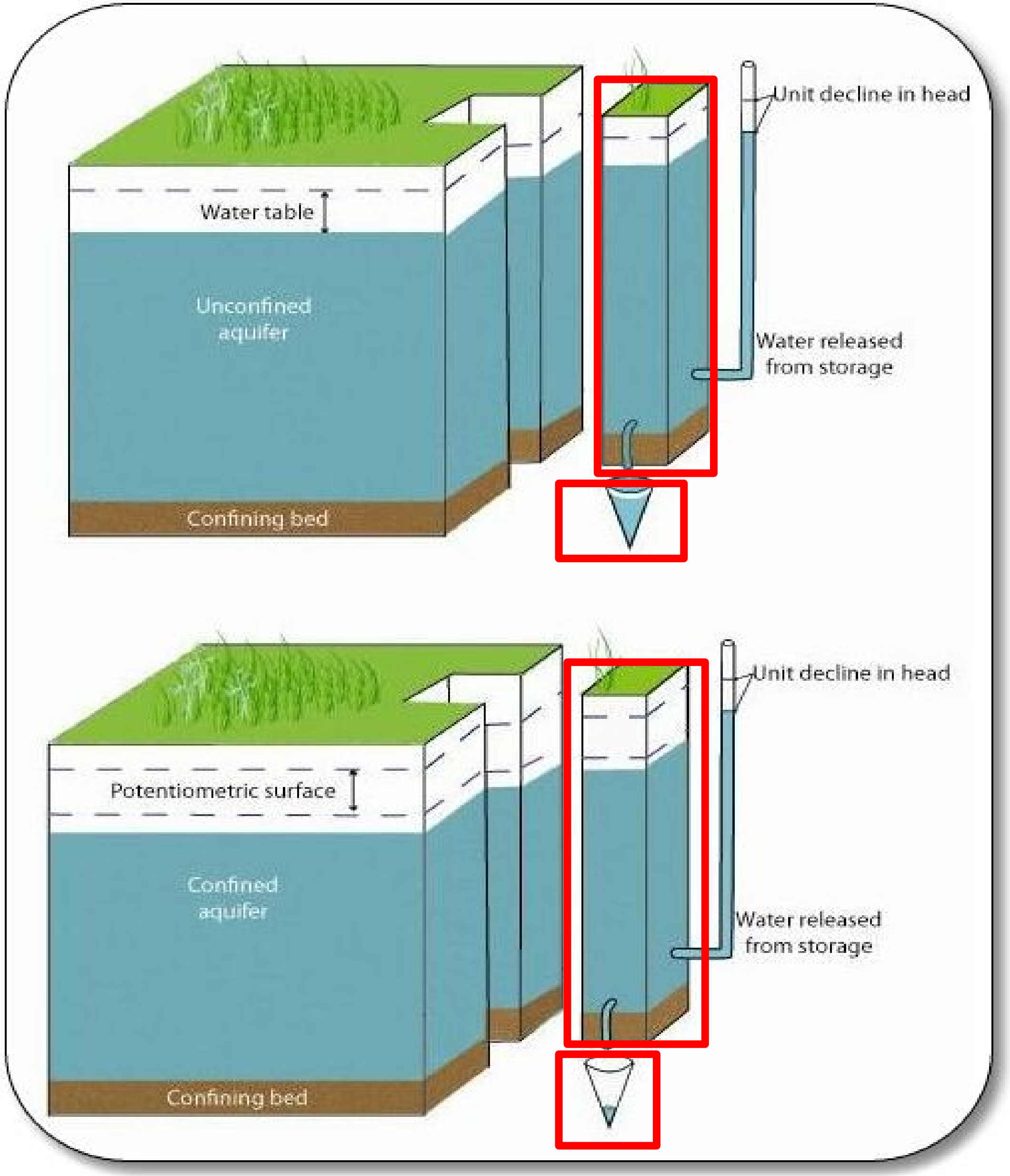
Specific yield is a ratio between 0 and 1 indicating the amount of water released due to drainage, from lowering the water table in an unconfined aquifer.

Thus, $Sy = (W_y / V) * 100$

Where, Wy is the volume of the yield water and V is the bulk volume of the soil or rock.

Why is specific yield important?

This is a measure of the water released from an unconfined aquifer.



Specific Retention (S_r)

Formal definition

The ratio of the volume of water that retain against gravity to that of the total volume of the saturated porous medium.

Thus, Sr = (Wr/ V) * 100

Where,

Wr is the volume of the retained water and V is the bulk volume of the soil or rock.

Since Wy and Wr constitutes the total volume of water in a saturated material it is apparent that the porosity will be equal to sum of the specific yield and the specific retention.

i.e. n=Sy + Sr

Why is specific yield important?

This is a measure of the water retained in an unconfined aquifer.

Storage Coefficient (S)

Definition

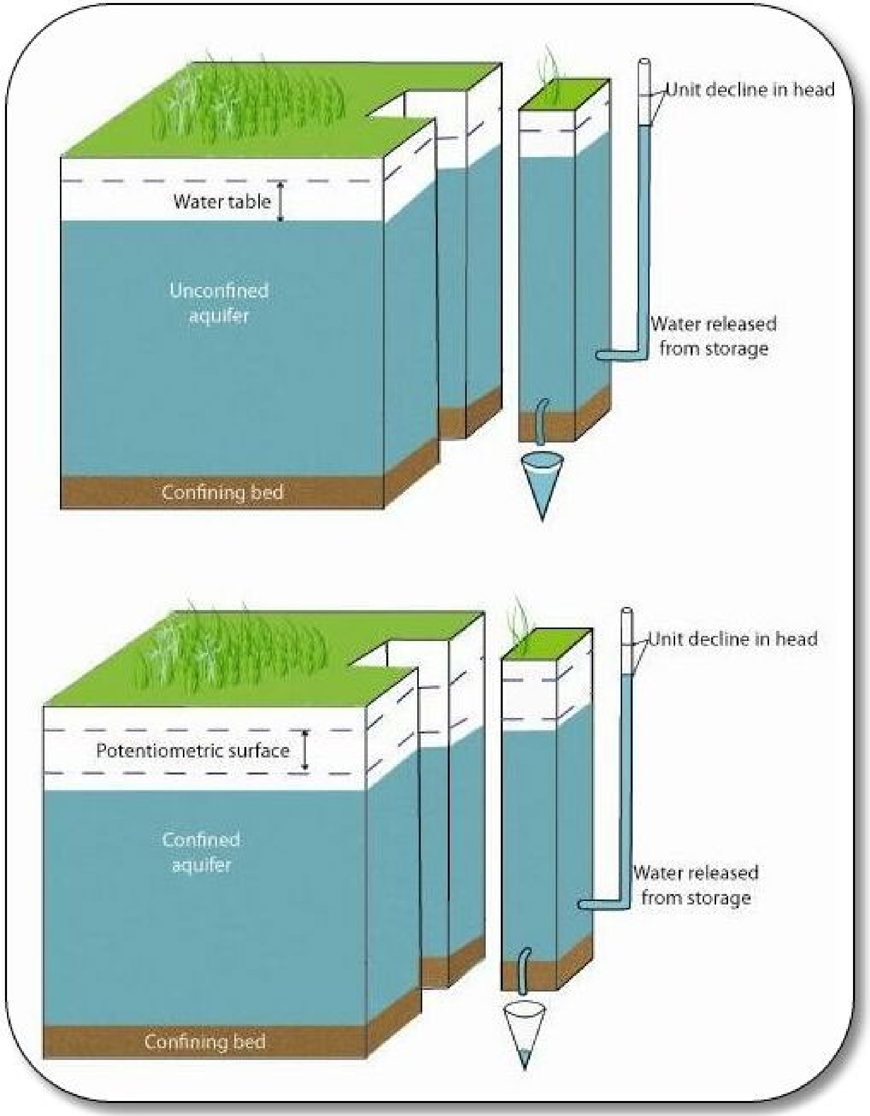
The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

Description

It is a volume of water per volume of aquifer released as a result of a change in head. For a confined aquifer, the storage coefficient is equal to the product of the specific storage and aquifer thickness.

Why is storage coefficient important?

This is a measure of the volume of water stored and released in an aquifer and is used to quantify the safe yield of an aquifer system.



Transmissivity (T)

Transmissivity is the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. It is expressed as the product of the average hydraulic conductivity and thickness of the saturated portion of an aquifer.

It is commonly measured in gallons per day per foot (gal/day/ft) and can be expressed as:

$$T = bK$$

b = saturation thickness of aquifer in feet

K = gal/day/ft

Description

Transmissivity is a measure of the ease with which groundwater flows in the subsurface.

Why is transmissivity important?

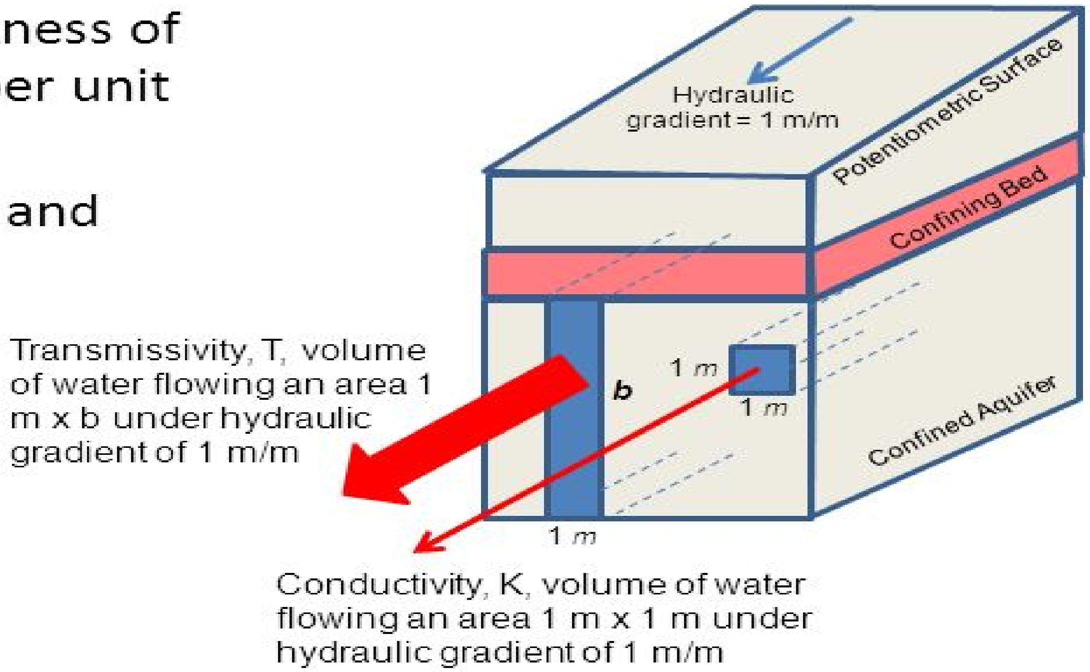
Transmissivity is used to calculate the yield of a borehole, determine the safe yield of an aquifer system and predict groundwater movement.

Aquifer Transmissivity

- Transmissivity (T)
  - Discharge through thickness of aquifer per unit width per unit head gradient
  - Product of conductivity and thickness

$$T = K b$$

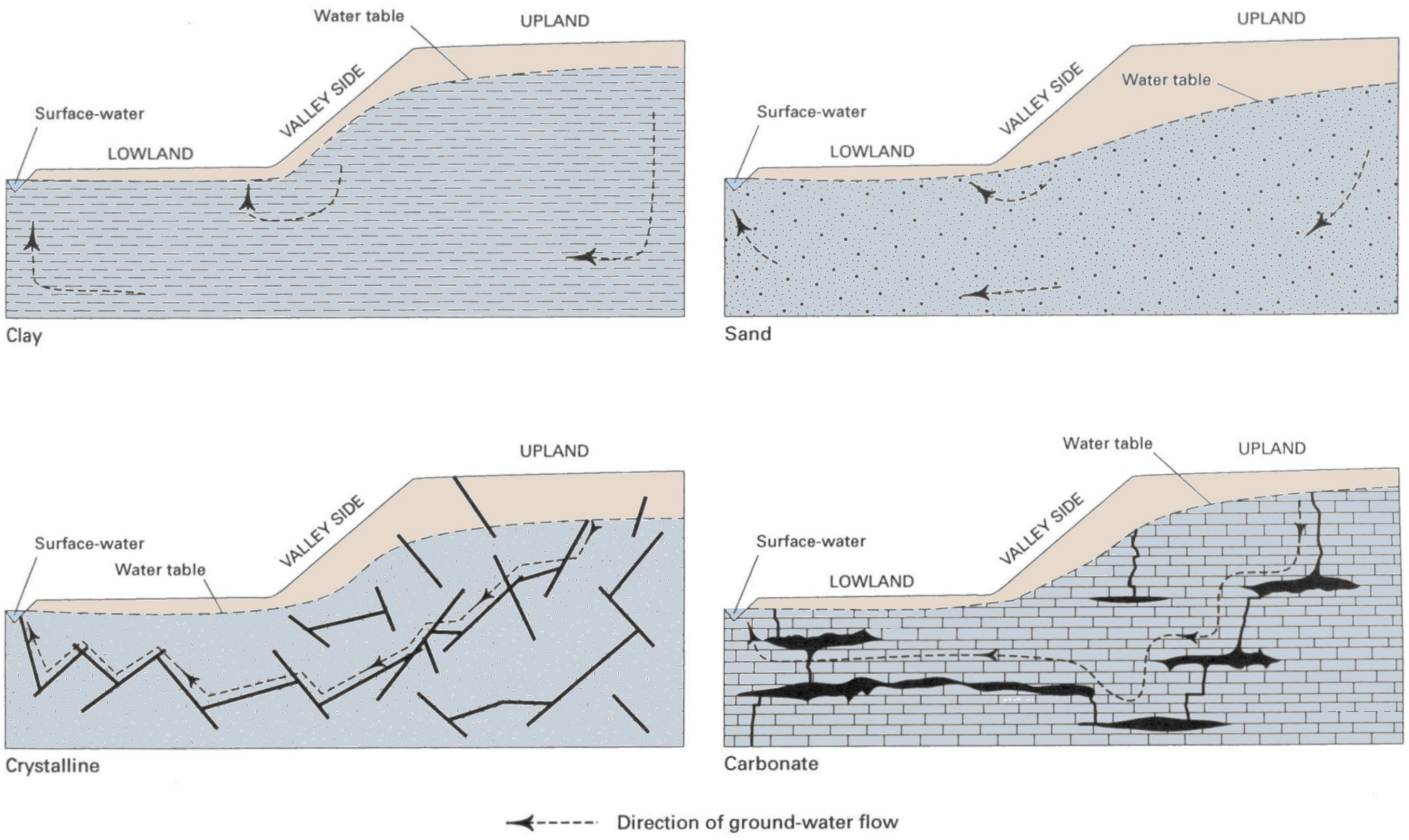
$$K(x,y) = \frac{1}{b} \int_0^b K(x,y,z)\,dz$$



Overdraft

Overdrafting is the process of extracting groundwater beyond the *safe yield* or equilibrium yield of the aquifer.

Ground Water Movement Directions

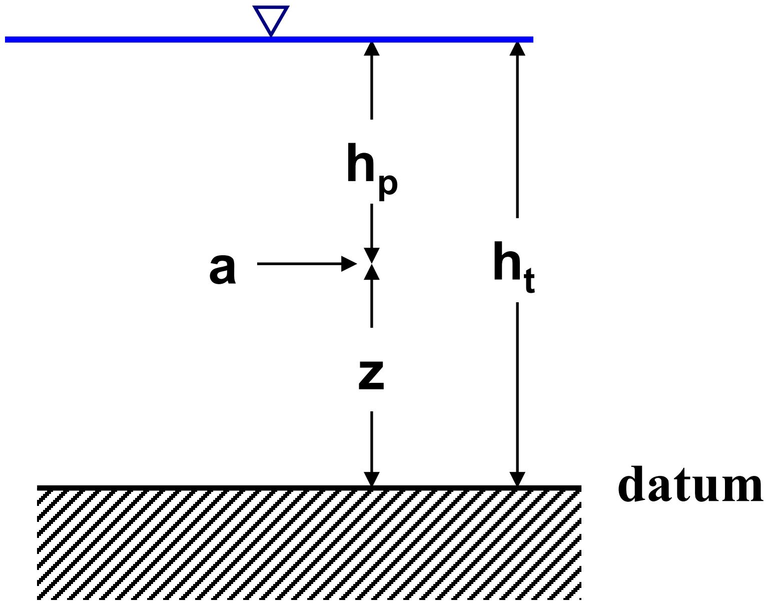


Hydraulic Head

Pressure:

$$P = \rho g h_p$$

Where:
r **= density of water (kg m^{-3})**
g **= gravitational acceleration (m s^{-2})**
h_p = pressure head



Total hydraulic head (h_t):

$$h_t = z + h_p$$

Where:
z **= elevation**
h_p = pressure head

Darcy's Law

Darcy's Law defines groundwater flow:

$$Q = k_v A \frac{dh_t}{dx}$$

where:

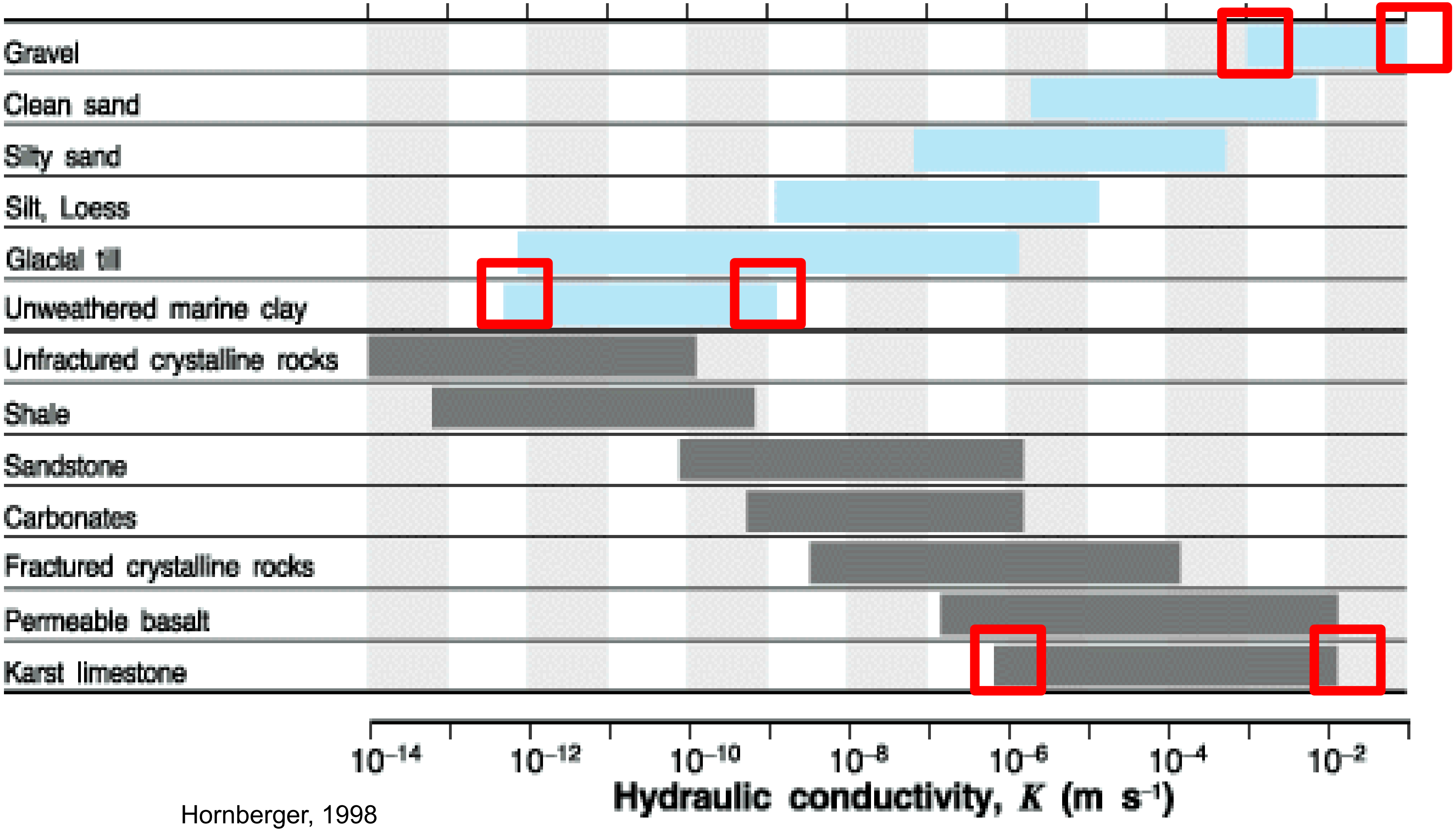
Q is discharge ($L^3\ T^{-1}$)

k_v is the hydraulic conductivity ($L\ T^{-1}$)

A is area of flow (L^2), and

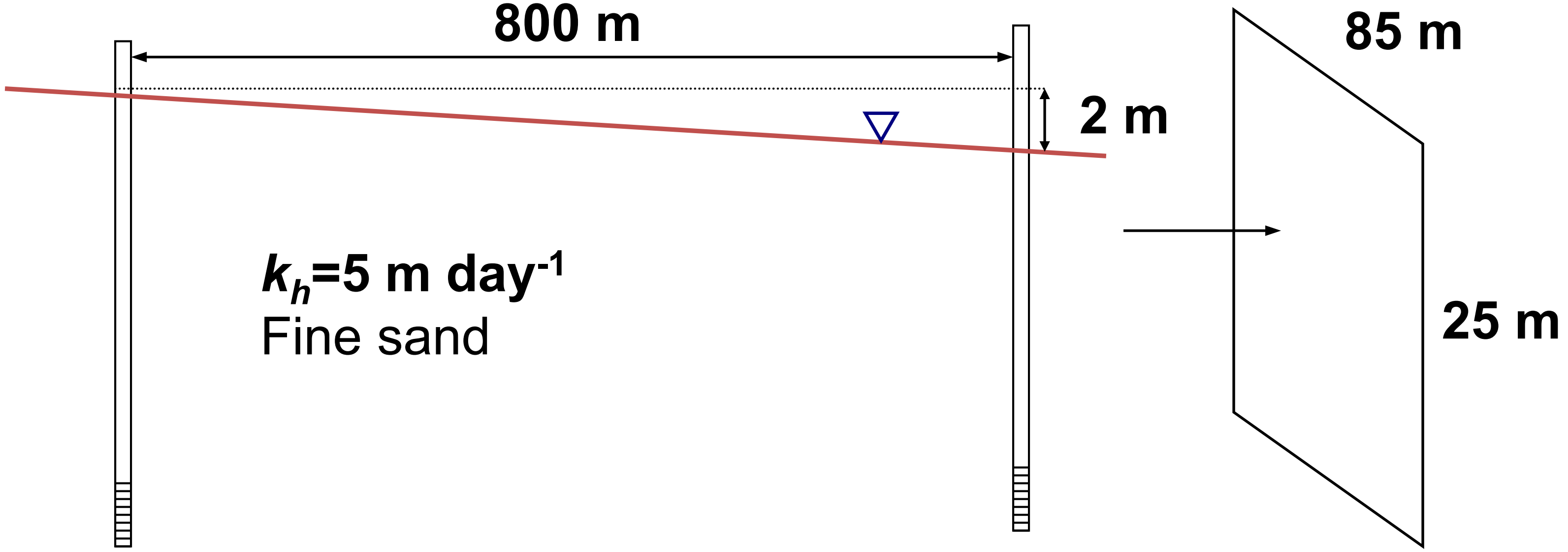
dh_t/dx is the gradient of pressure, or head

Hydraulic Conductivity (k_v)



Hornberger, 1998

Example



$$Solution: Q = k_v A \frac{dh_t}{dx} = \left(5\,\tfrac{\text{m}}{\text{day}}\right)\left(25\text{ m} \times 85\text{ m}\right)\left(\frac{2.0\text{ m}}{800\text{ m}}\right) = 26.6\,\tfrac{\text{m}^3}{\text{day}}$$

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Heaven's Light is Our Guide

Rajshahi University of Engineering & Technology

Topic: Design of Water Well

Mithun Chakrabartty
Lecturer
Department of Civil Engineering

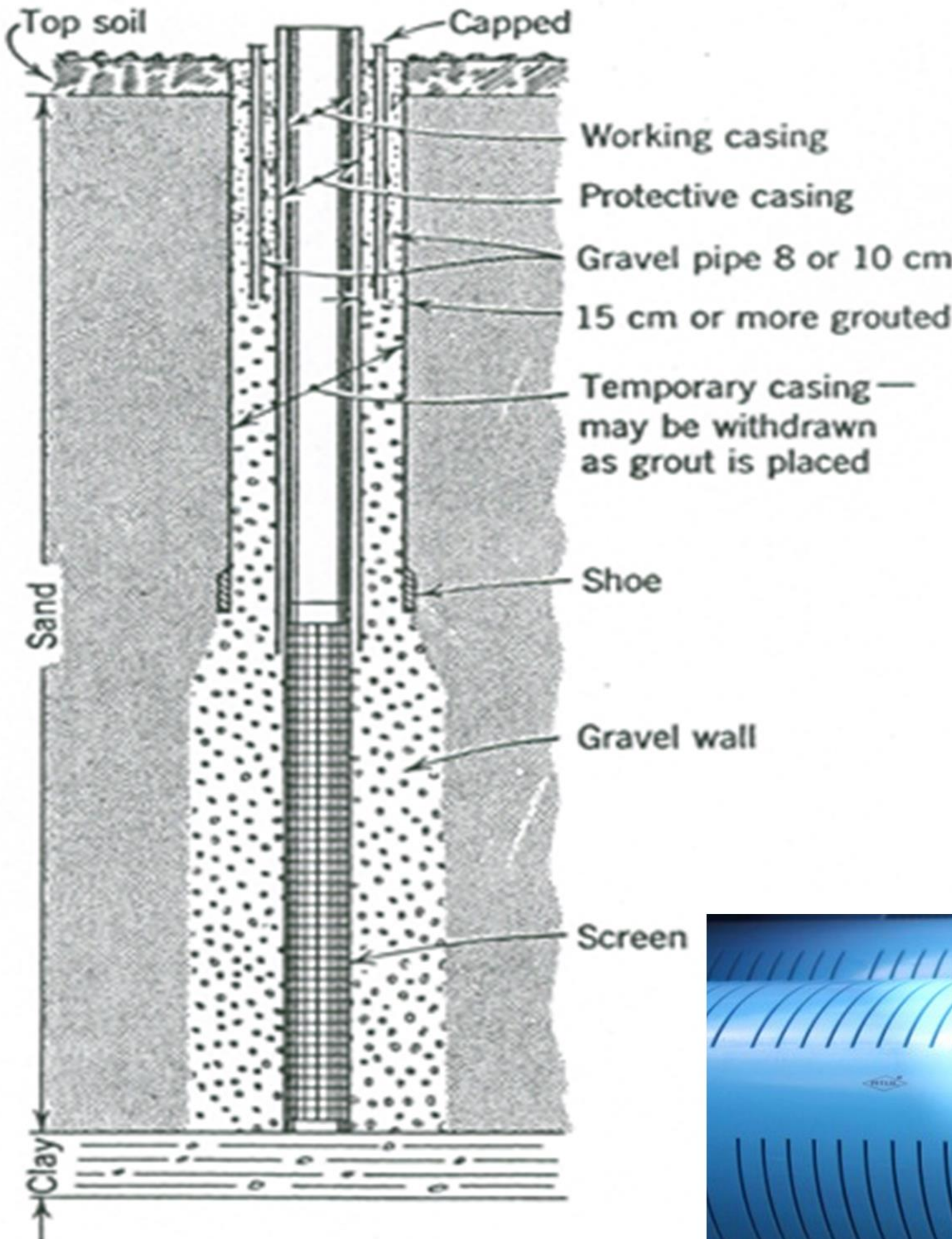
Introduction:

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

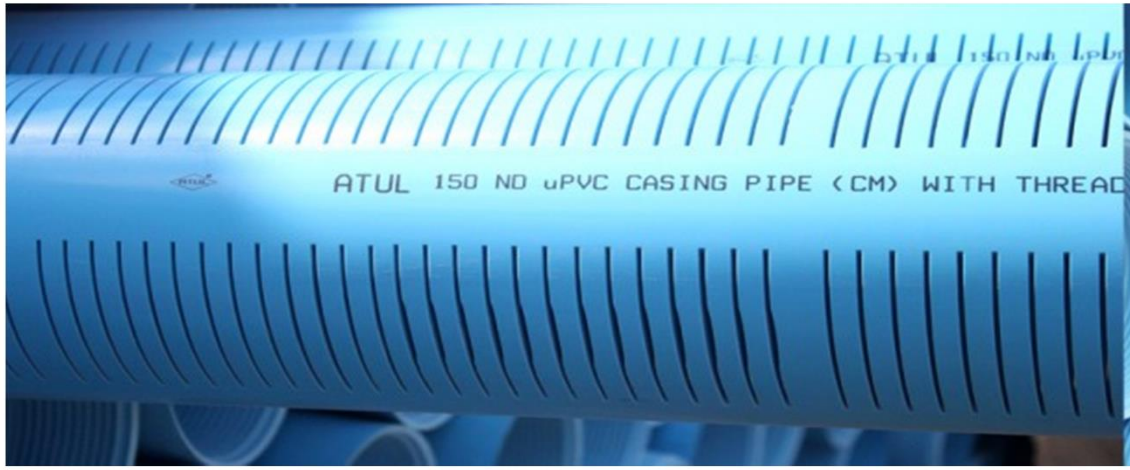
- The water requirements for the particular schemes –rural water supply , agricultural and industrial needs, has to be carefully determined
- The choice of open wells or bore wells (tube wells) and the method of well design depends upon-
  - -Topography
  - -Geological conditions of the underlying strata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

$$Q \alpha \frac{1}{log10 \frac{R}{r_w}}$$

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.

Topic: Design of Water Well

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

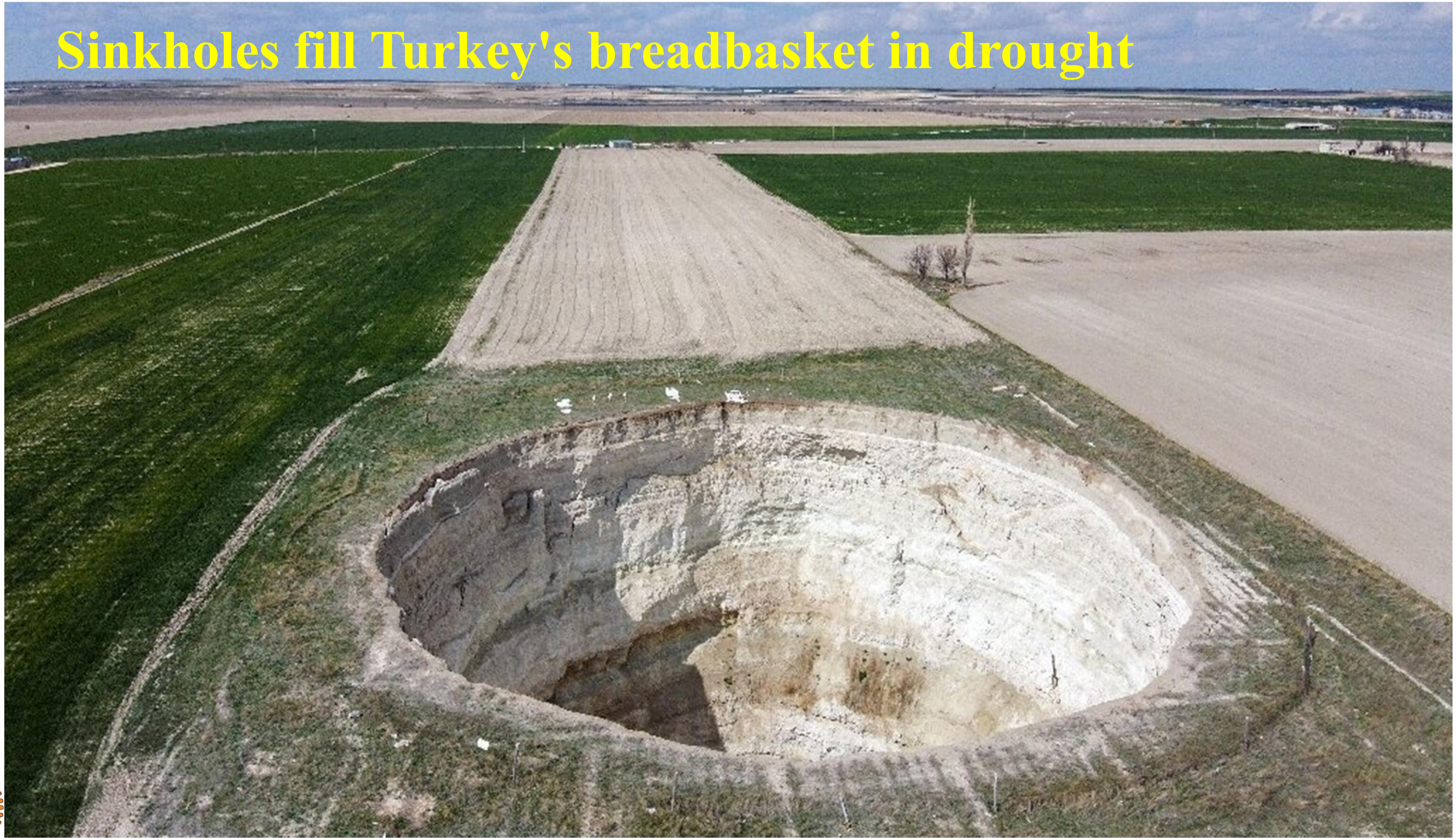
Heaven's Light is Our Guide

Rajshahi University of Engineering & Technology

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:

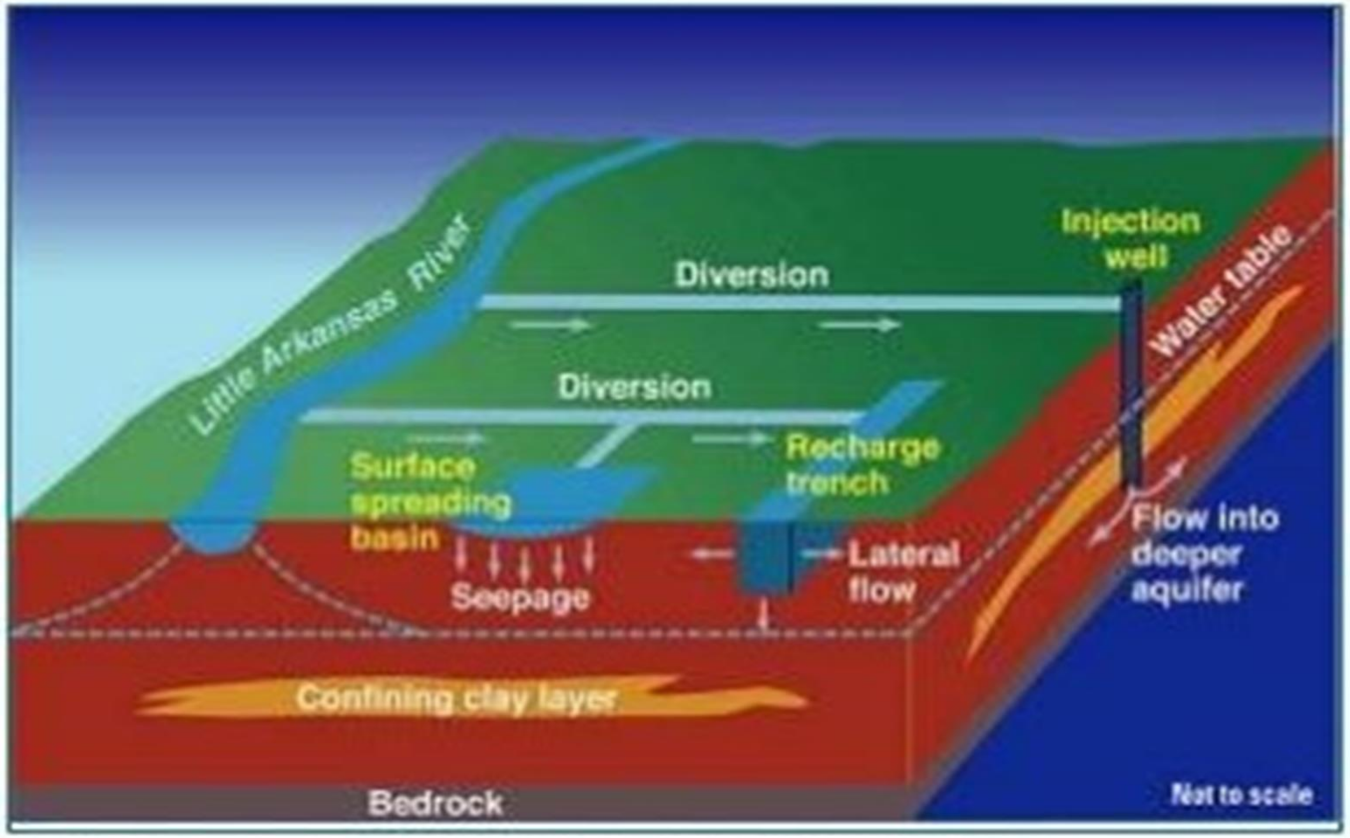
There are three methods of groundwater recharging:

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.

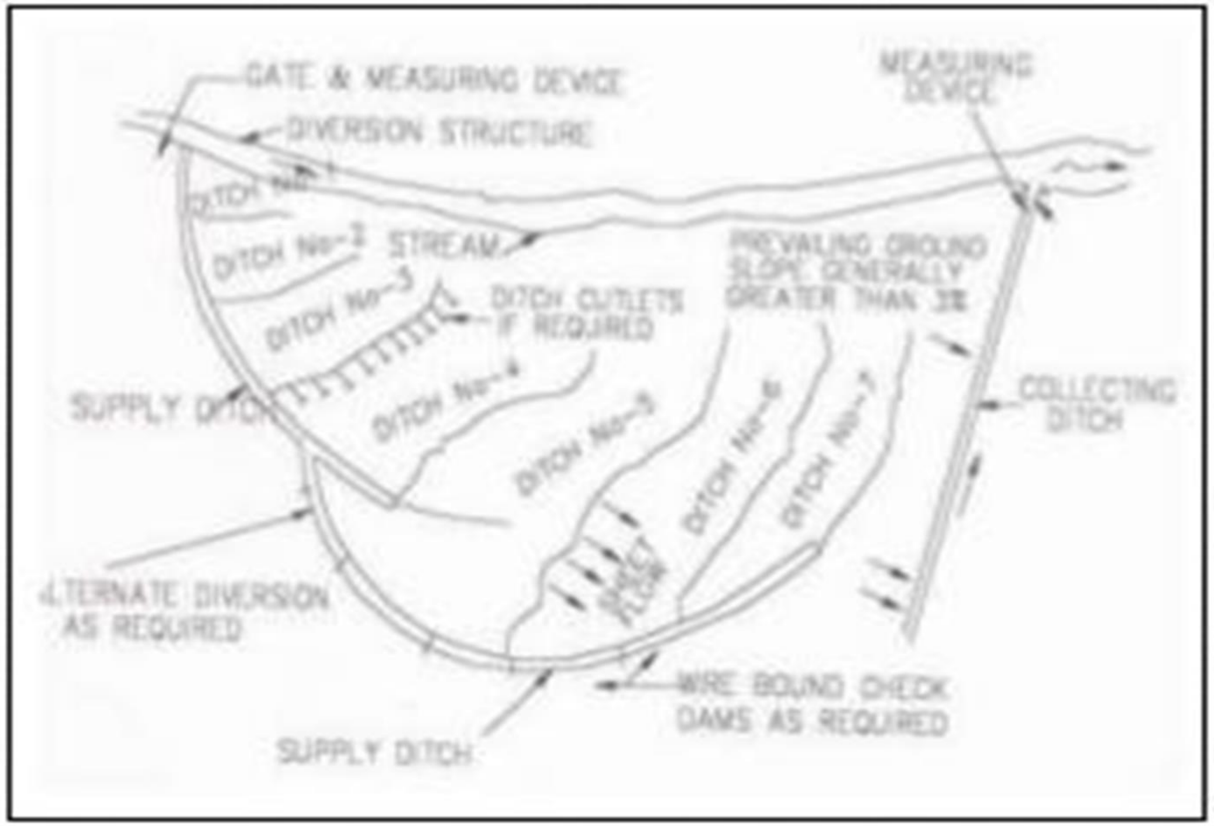
3. Stream Augmentation

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



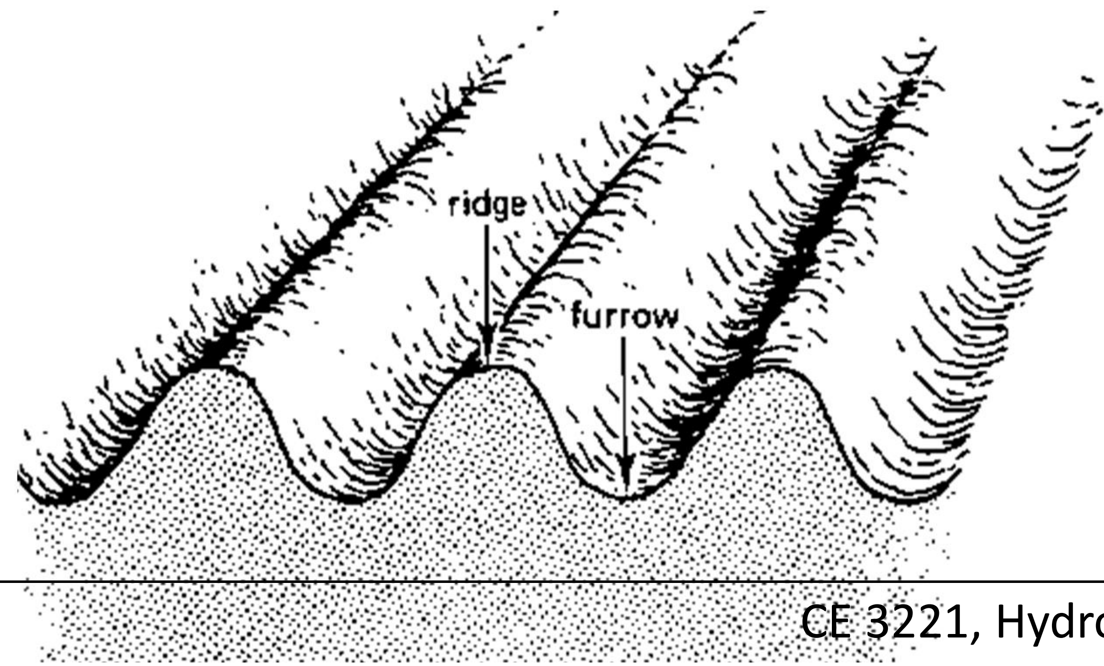
Source: megphed.gov.in

Figure 4 : Ditch and Furrow System

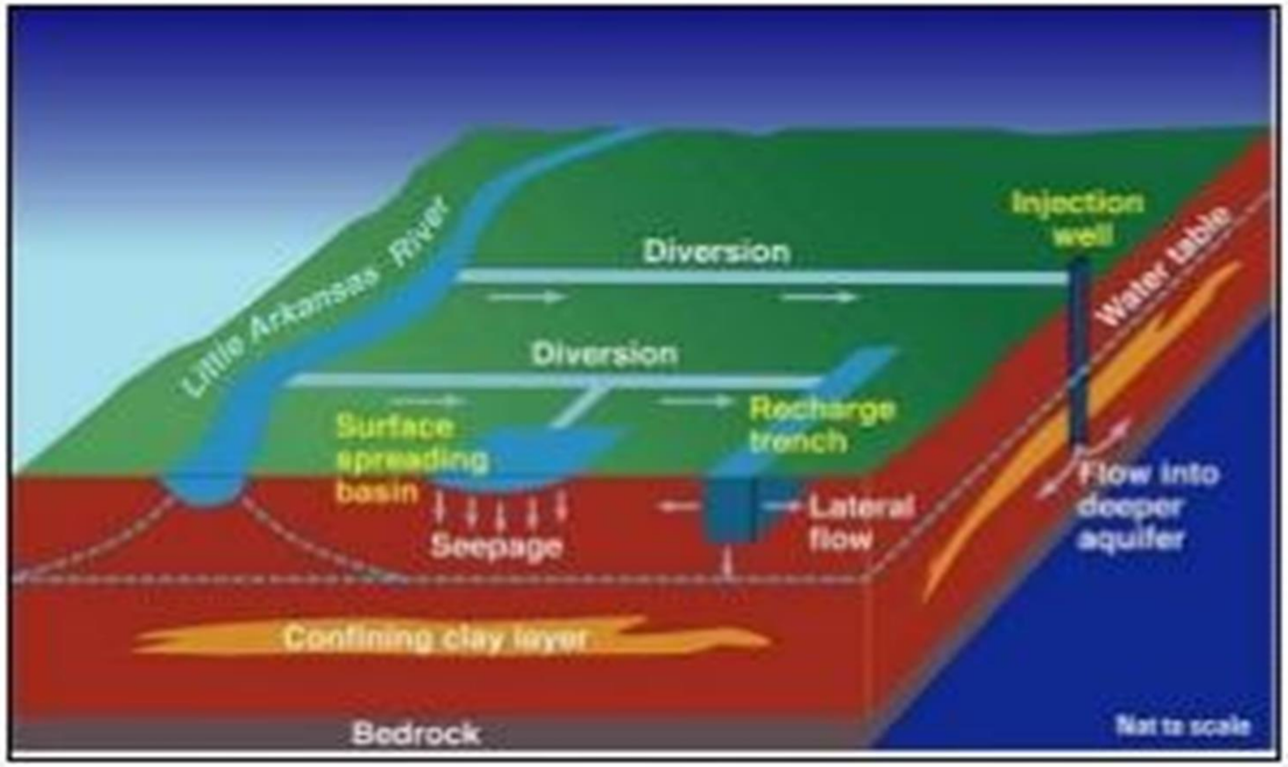
- In areas with irregular topography ditches or furrow provide maximum water contact area for recharge.
- This technique consists of a system of shallow flat bottomed and closely spaced ditches / furrow which are used to carry water from source like stream /canals and provide more percolation opportunity.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

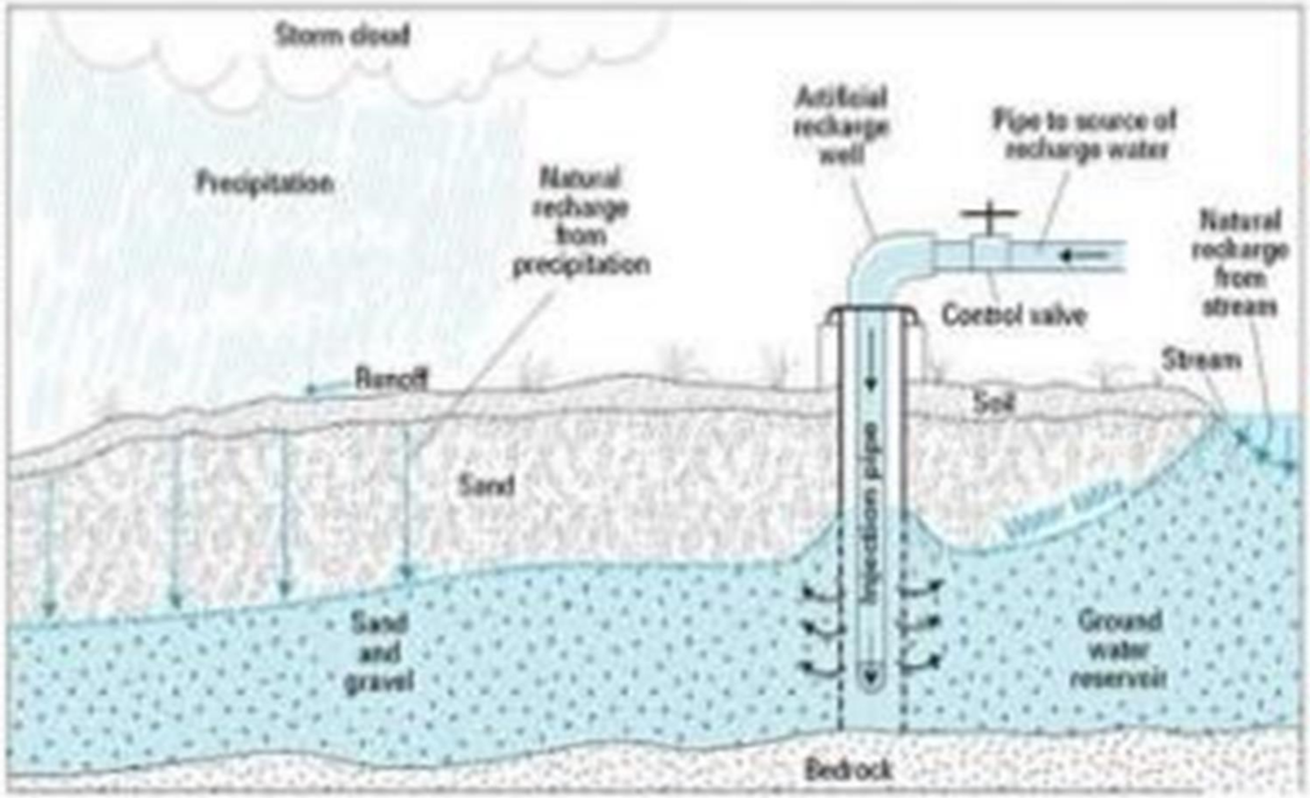


Source: www.indiawaterportal.org

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

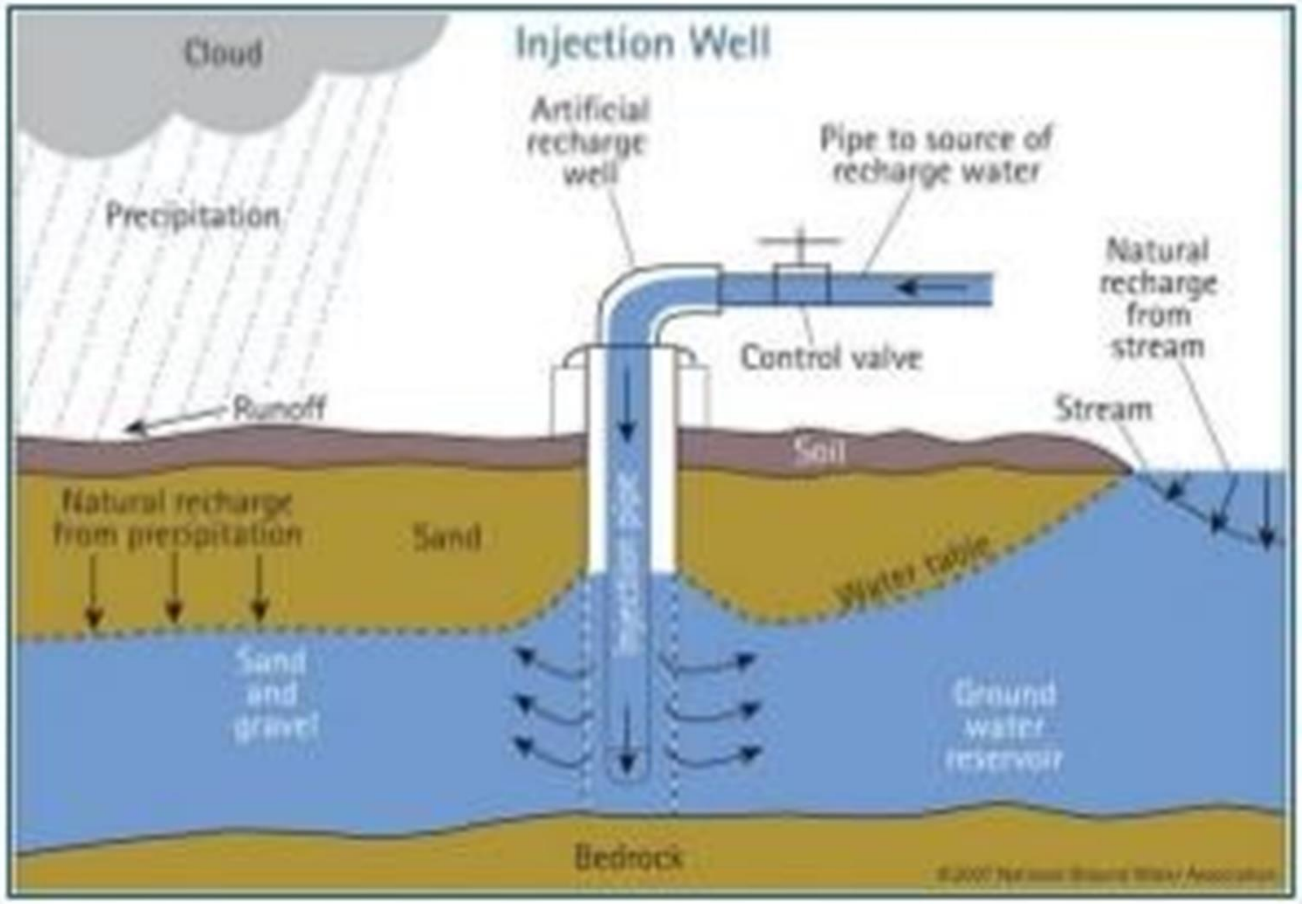


Source:www.ngwa.org

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

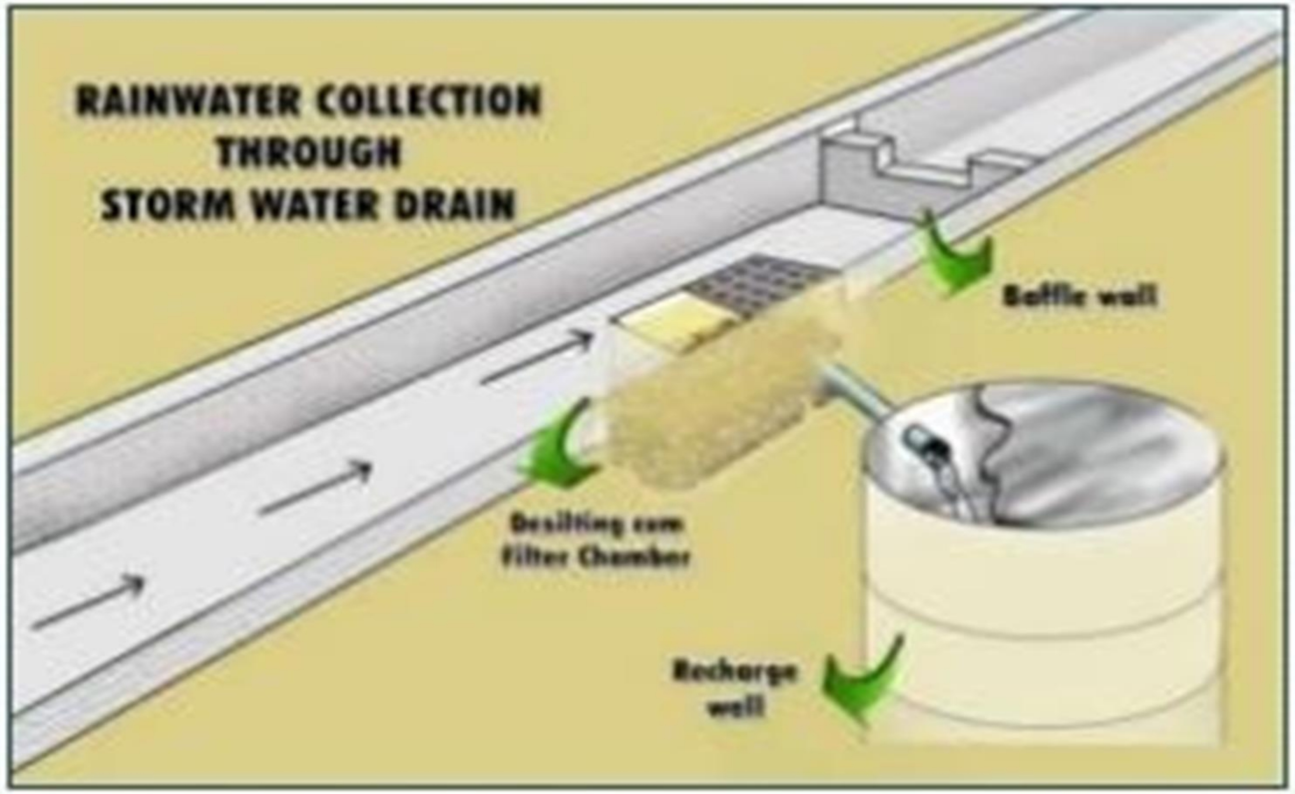


Source: www.ngwa.org

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

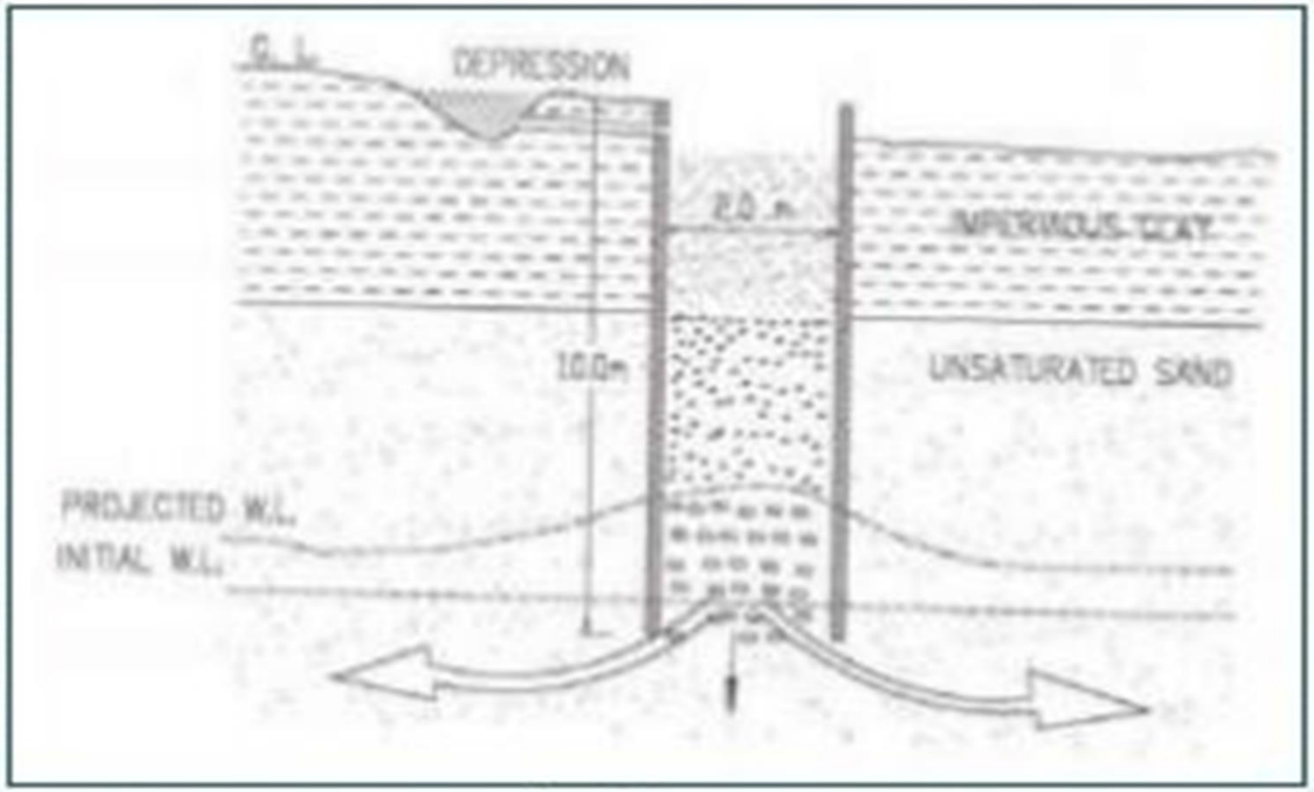


Source: www.indiawaterportal.org

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

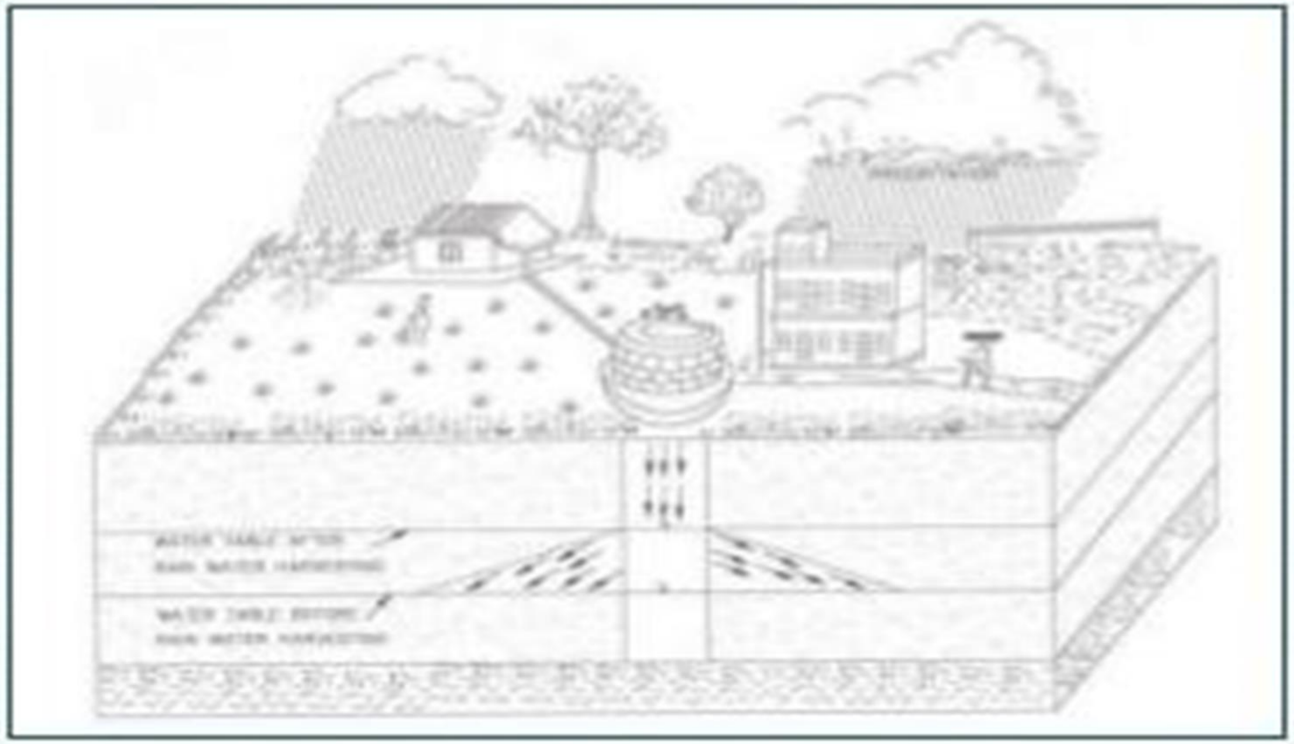


Source: megphed.gov.in

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

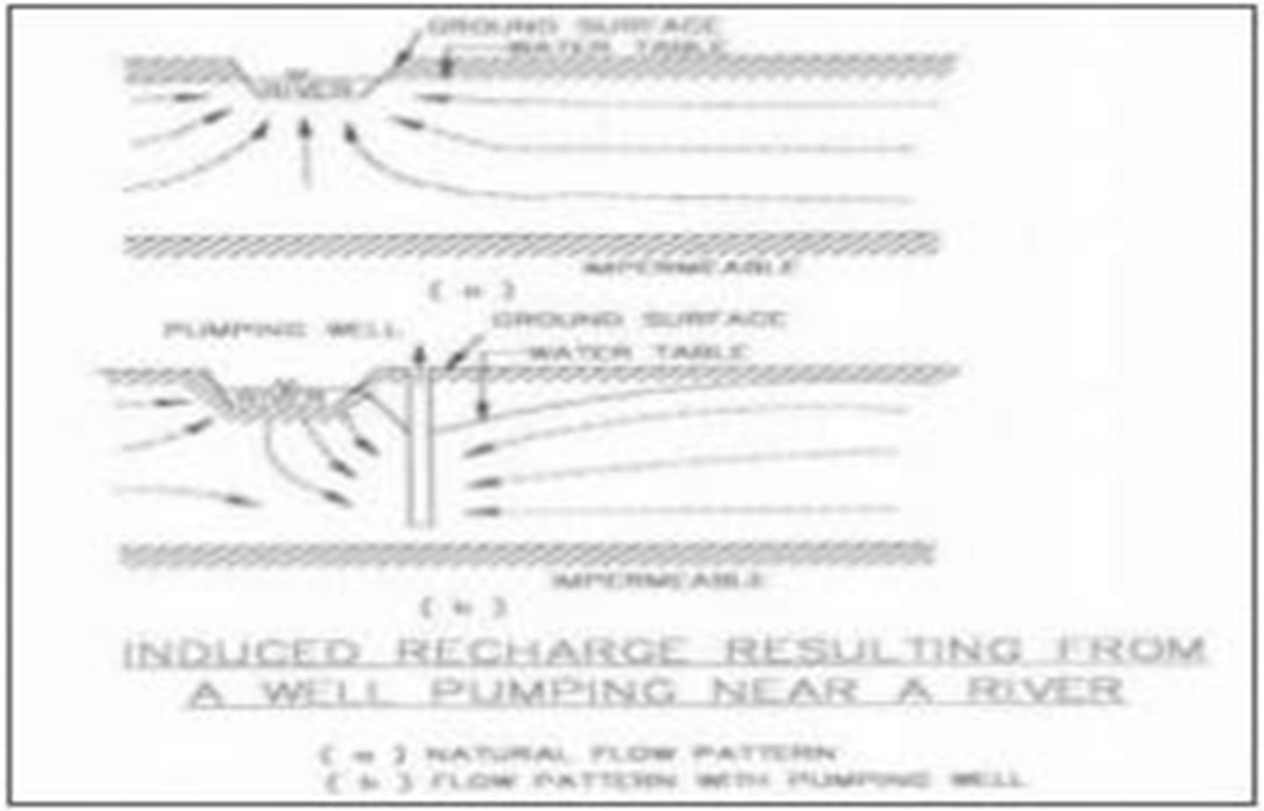


Source: megphed.gov.in

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

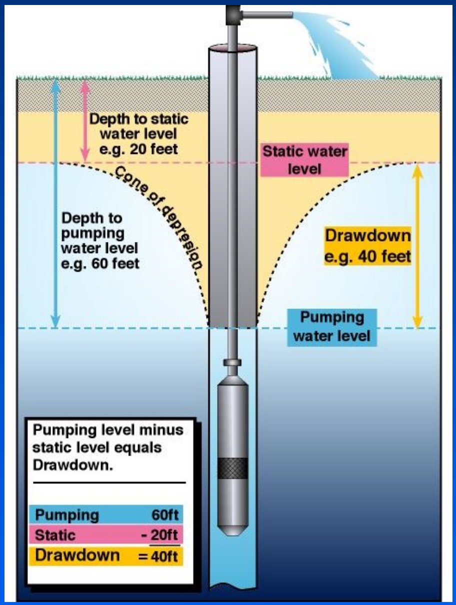
- 1.Http:\\megphed.gov.in\knowledge\RainwaterHarvest\Chapter9.pdf.
- 2. M.A.Sophocleous, "Combining the soil water balance and water-level fluctuation methods to estimate natural ground water recharge - practical aspects". Journal of hydrology, Vol.124, 229 (1991).
- 3.cgwb.gov.in/documents/Guide on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

Thank You

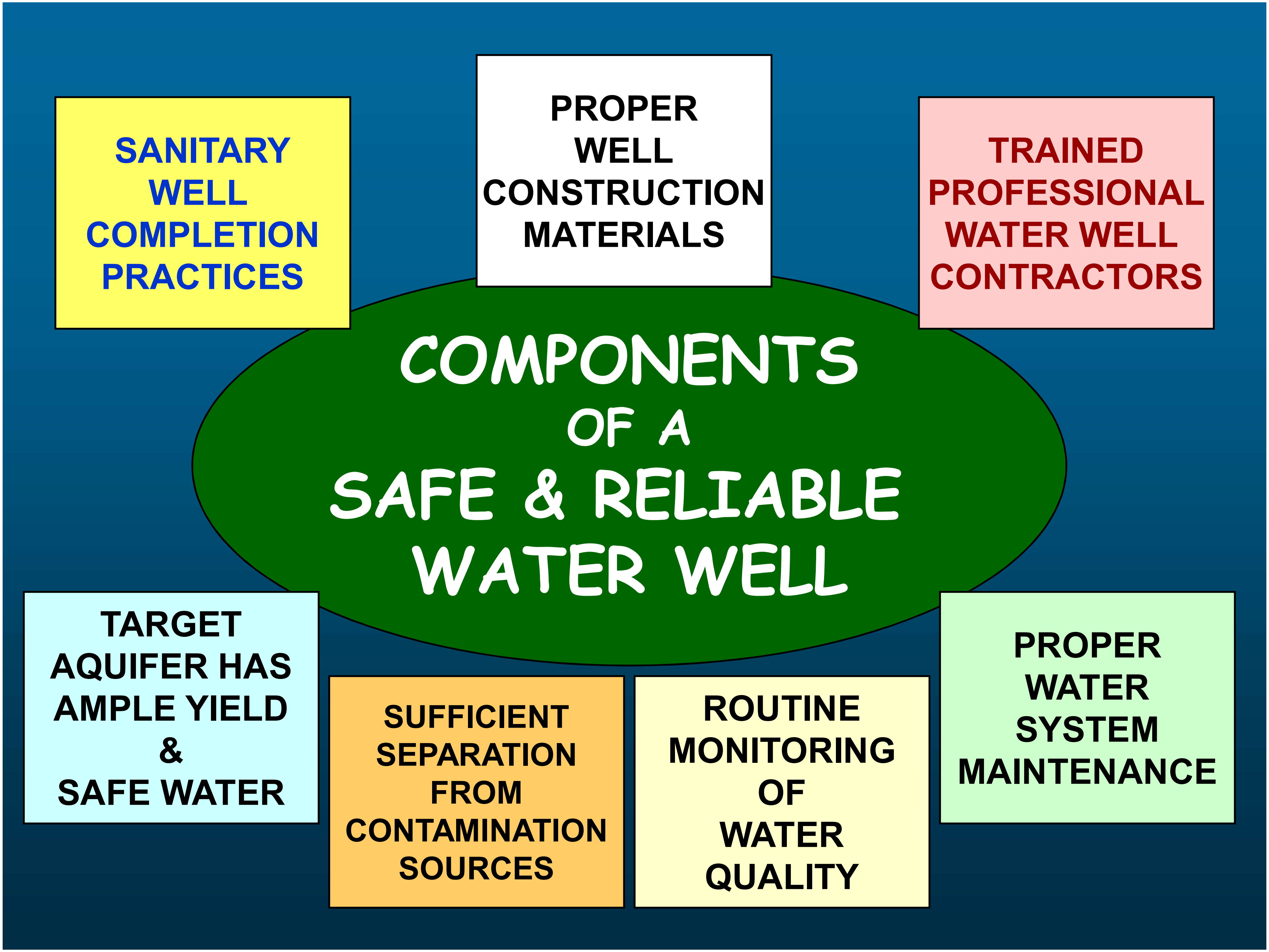
For

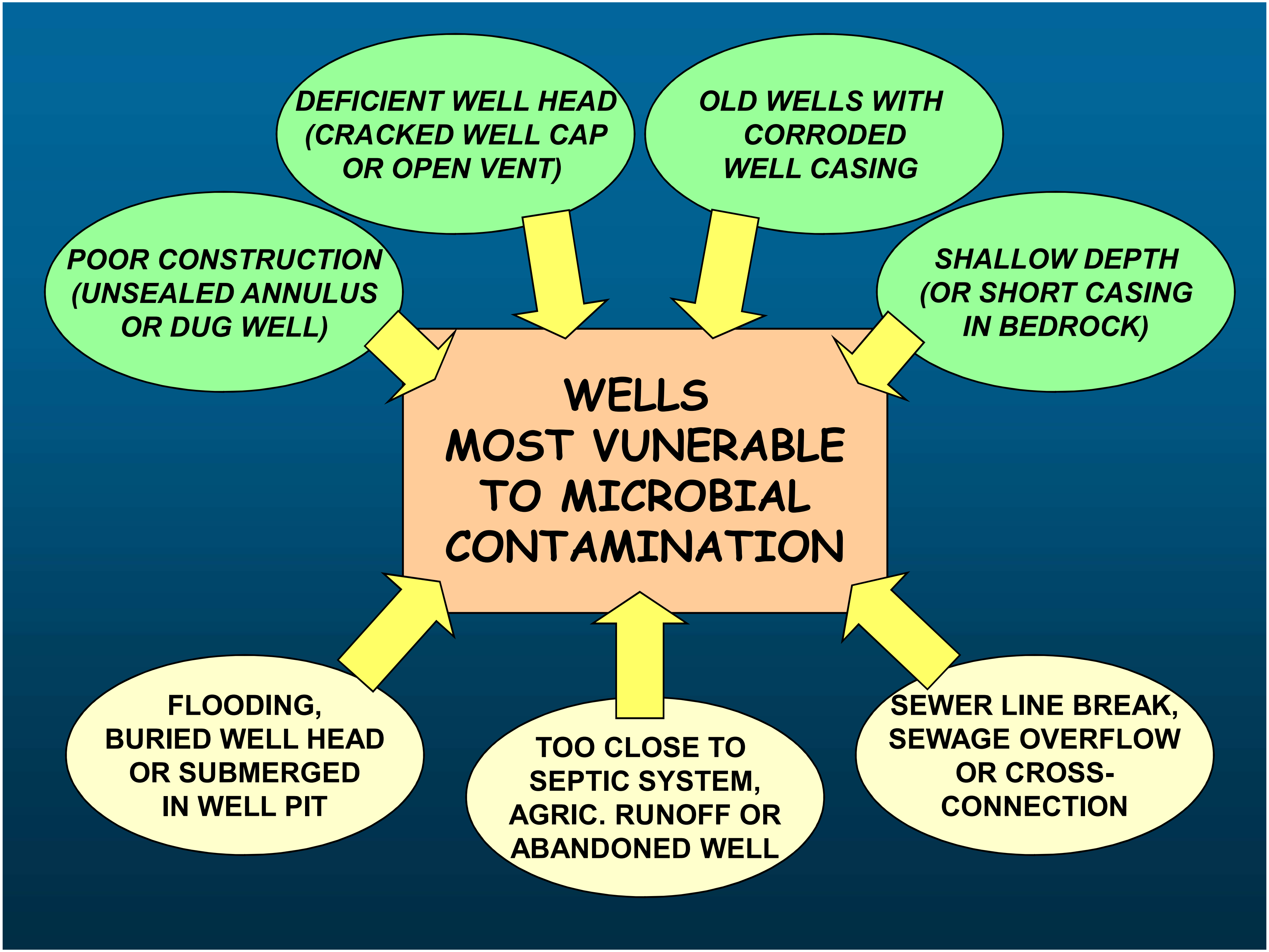
Your Attention

WATER WELL
Drilling & Construction

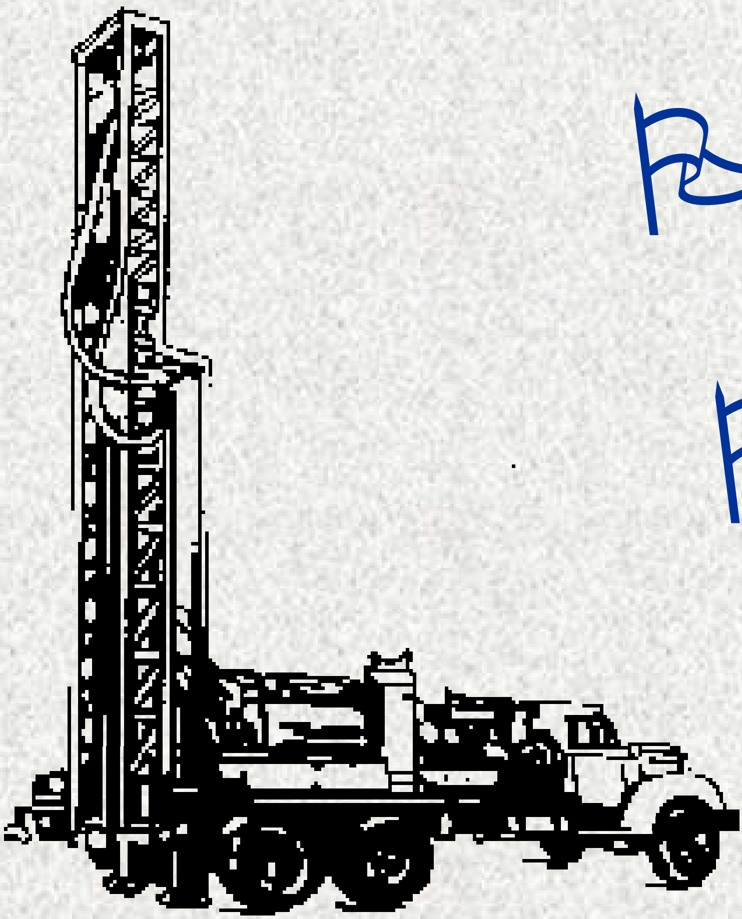


DEQ


COMPONENTS OF A SAFE & RELIABLE WATER WELL
SANITARY WELL COMPLETION PRACTICES
PROPER WELL CONSTRUCTION MATERIALS
TRAINED PROFESSIONAL WATER WELL CONTRACTORS
TARGET AQUIFER HAS AMPLE YIELD & SAFE WATER
SUFFICIENT SEPARATION FROM CONTAMINATION SOURCES
ROUTINE MONITORING OF WATER QUALITY
PROPER WATER SYSTEM MAINTENANCE

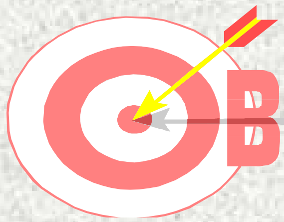

WELLS MOST VUNERABLE TO MICROBIAL CONTAMINATION
DEFICIENT WELL HEAD (CRACKED WELL CAP OR OPEN VENT)
OLD WELLS WITH CORRODED WELL CASING
POOR CONSTRUCTION (UNSEALED ANNULUS OR DUG WELL)
SHALLOW DEPTH (OR SHORT CASING IN BEDROCK)
FLOODING, BURIED WELL HEAD OR SUBMERGED IN WELL PIT
TOO CLOSE TO SEPTIC SYSTEM, AGRIC. RUNOFF OR ABANDONED WELL
SEWER LINE BREAK, SEWAGE OVERFLOW OR CROSS-CONNECTION

Types of Water Wells



- DRILLED
- DRIVEN
- DUG

WATER WELL DESIGN



OBJECTIVES

- ❖ **Provide well that meets needs of owner**
- ❖ **Obtain highest yield with minimal drawdown (consistent w/ aquifer capabilities)**
- ❖ **Provide suitable quality water (potable and turbidity-free for drinking water wells)**
- ❖ **Provide long service life (25+ years)**

NEW: Minimize impacts on neighboring wells & aquatic environments

DRILLED WELLS

➔ Terminated in glacial drift (sand, gravel) or bedrock

➔ Constructed with rotary, cable tool, jetting, hollow rod or auger drilling methods

➔ 2 in. or larger casing
(Domestic wells: 4 – 6 inch diameter)

DRILLED WELLS

- ➔ Casing material: Steel or PVC plastic
- ➔ Installed by well drilling contractors
- ➔ Much more common than driven or dug wells
- ➔ Most are >50 ft. deep (avg. 125 ft.)
- ➔ ***MOST SANITARY WELL TYPE***

WATER WELL DRILLING METHODS

IN MICHIGAN

MOST COMMON:

ROTARY
(Mud & Air)

84%

LESS COMMON:

CABLE TOOL
10%

AUGER
2.5%

JETTING
1%

HOLLOW ROD
0.5%

OTHER
2%

EMERGING TECHNOLOGY

DUAL TUBE ROTARY

HORIZONTAL

SONIC


Rotary


Cable Tool

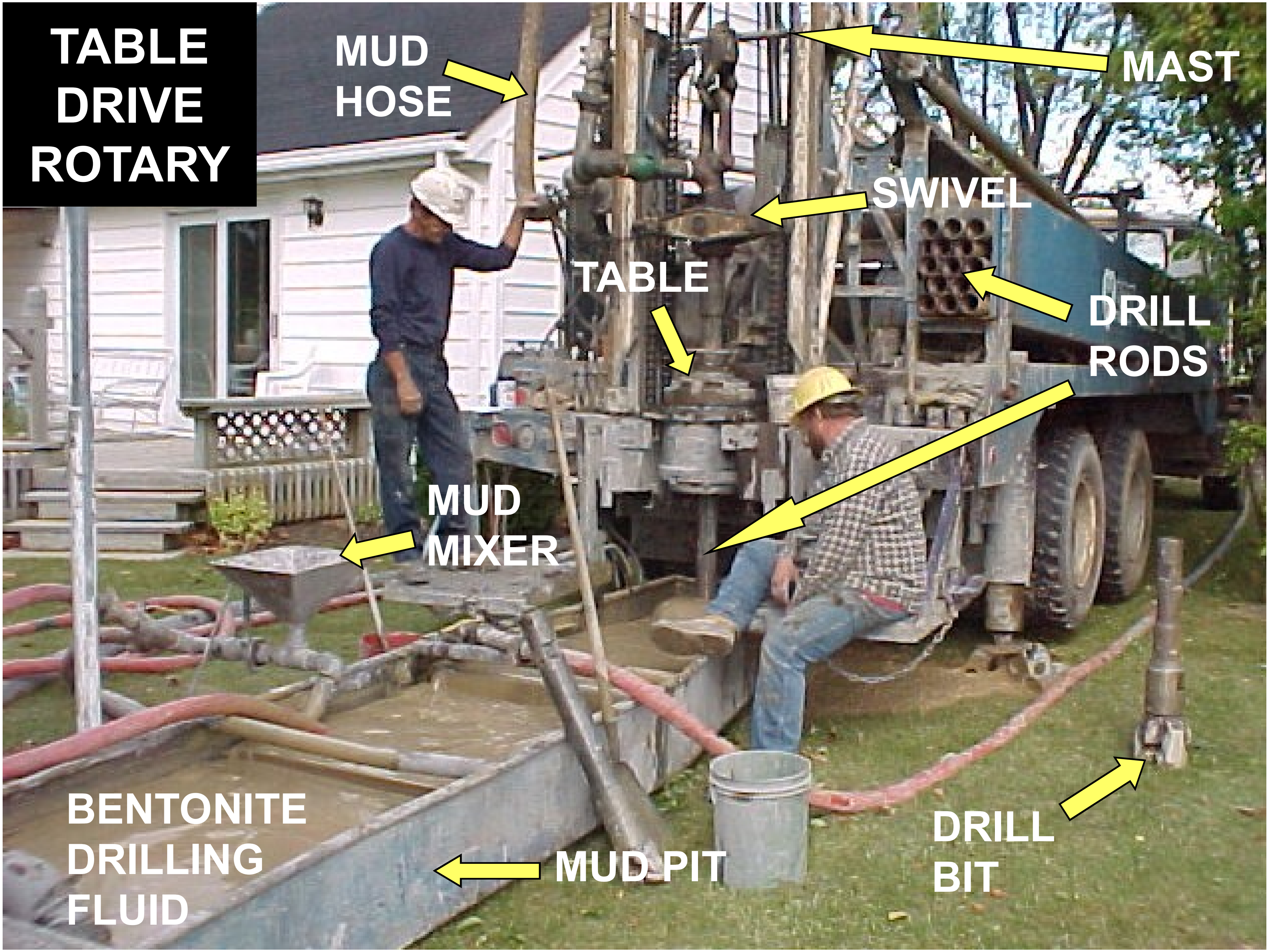
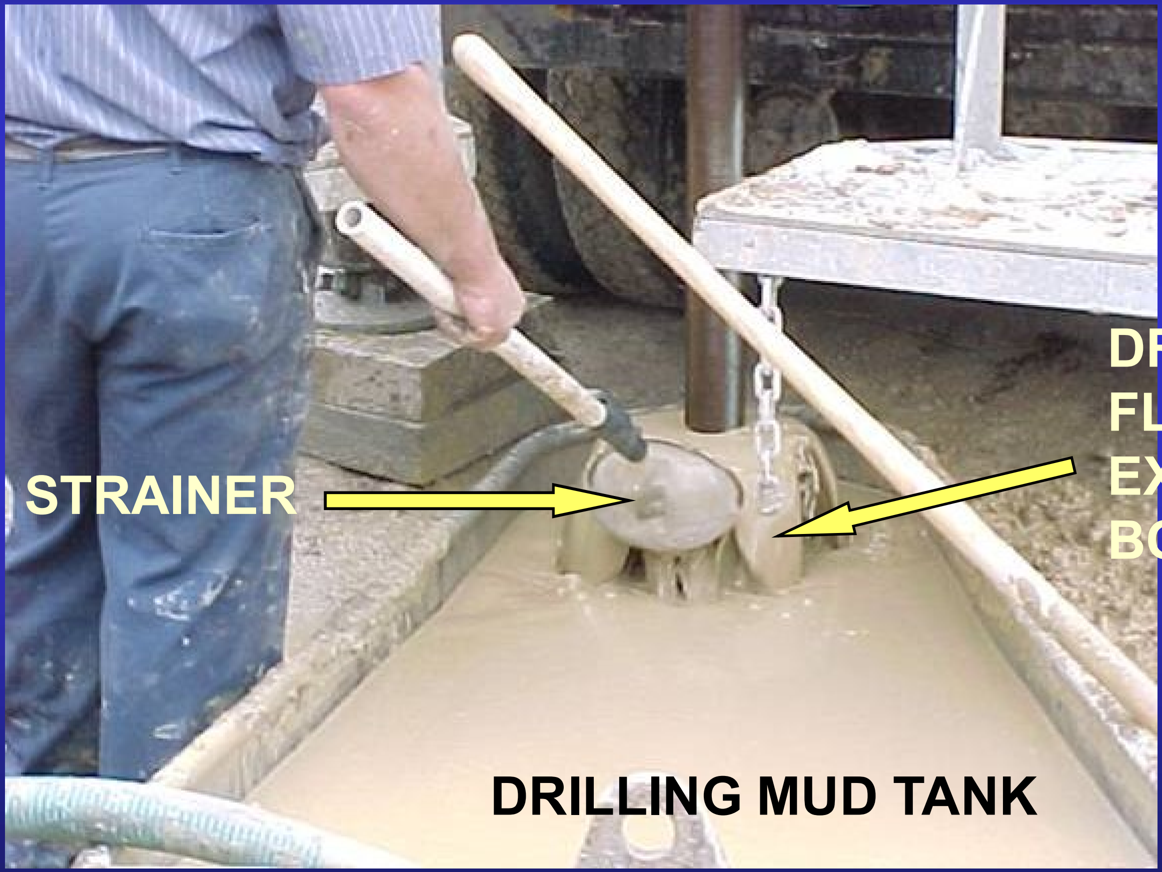


TABLE
DRIVE
ROTARY
MUD
HOSE
MAST
SWIVEL
TABLE
DRILL
RODS
MUD
MIXER
BENTONITE
DRILLING
FLUID
MUD PIT
DRILL
BIT

TOP HEAD DRIVE ROTARY

DRILLING RIG OPERATOR CHECKING DRILL CUTTINGS

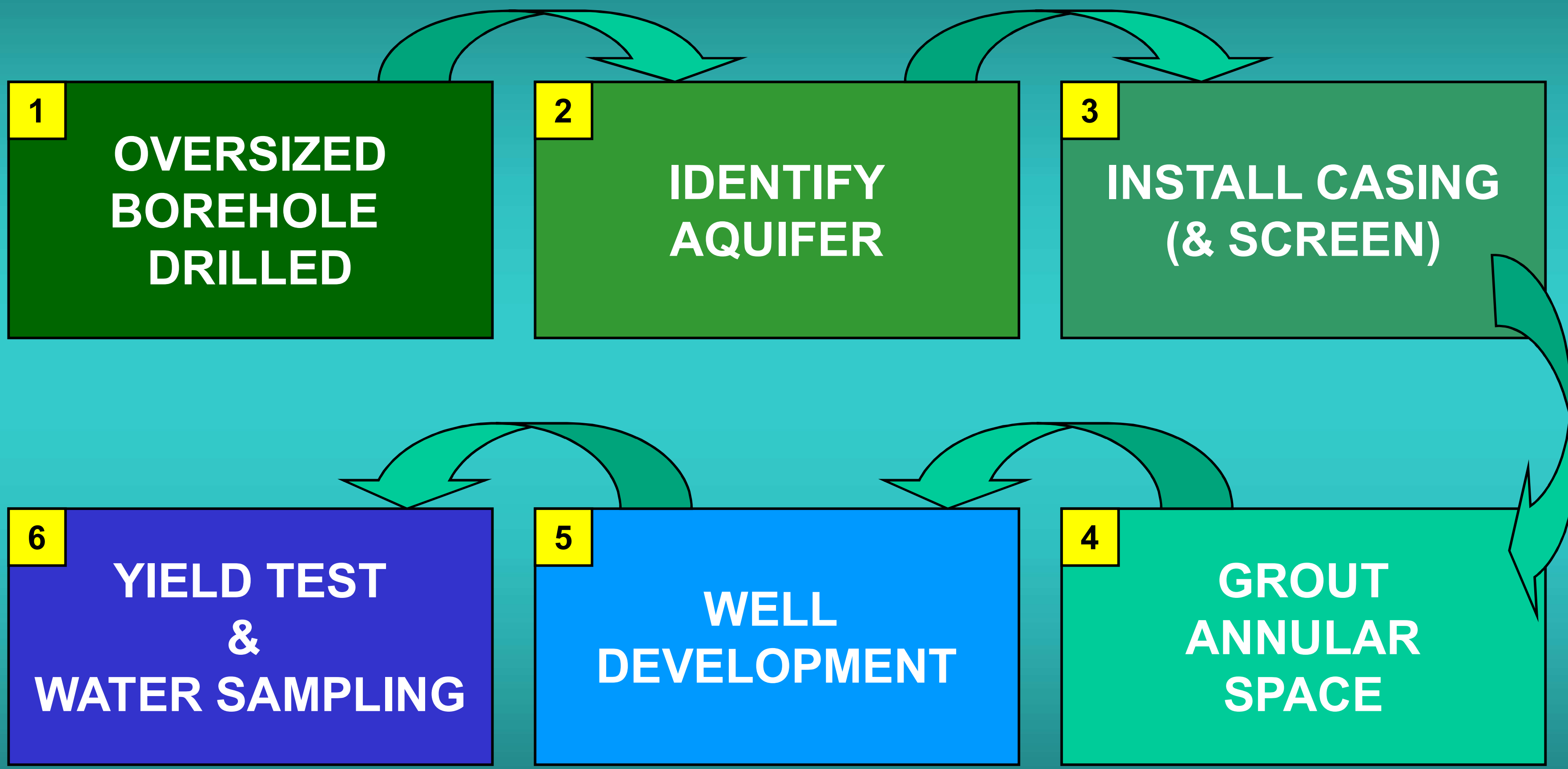


DRILLER COMPLETING THE WATER WELL RECORD

WATER WELL & PUMP RECORD DESCRIBES:

WELL DEPTH
CASING LENGTH
GEOLOGIC MATERIALS PENETRATED
STATIC WATER LEVEL
PUMPING WATER LEVEL
PUMPING RATE
GROUTING MATERIALS
WELL LOCATION
PUMPING EQUIPMENT
DRILLERS NAME
DRILLING RIG OPERATOR

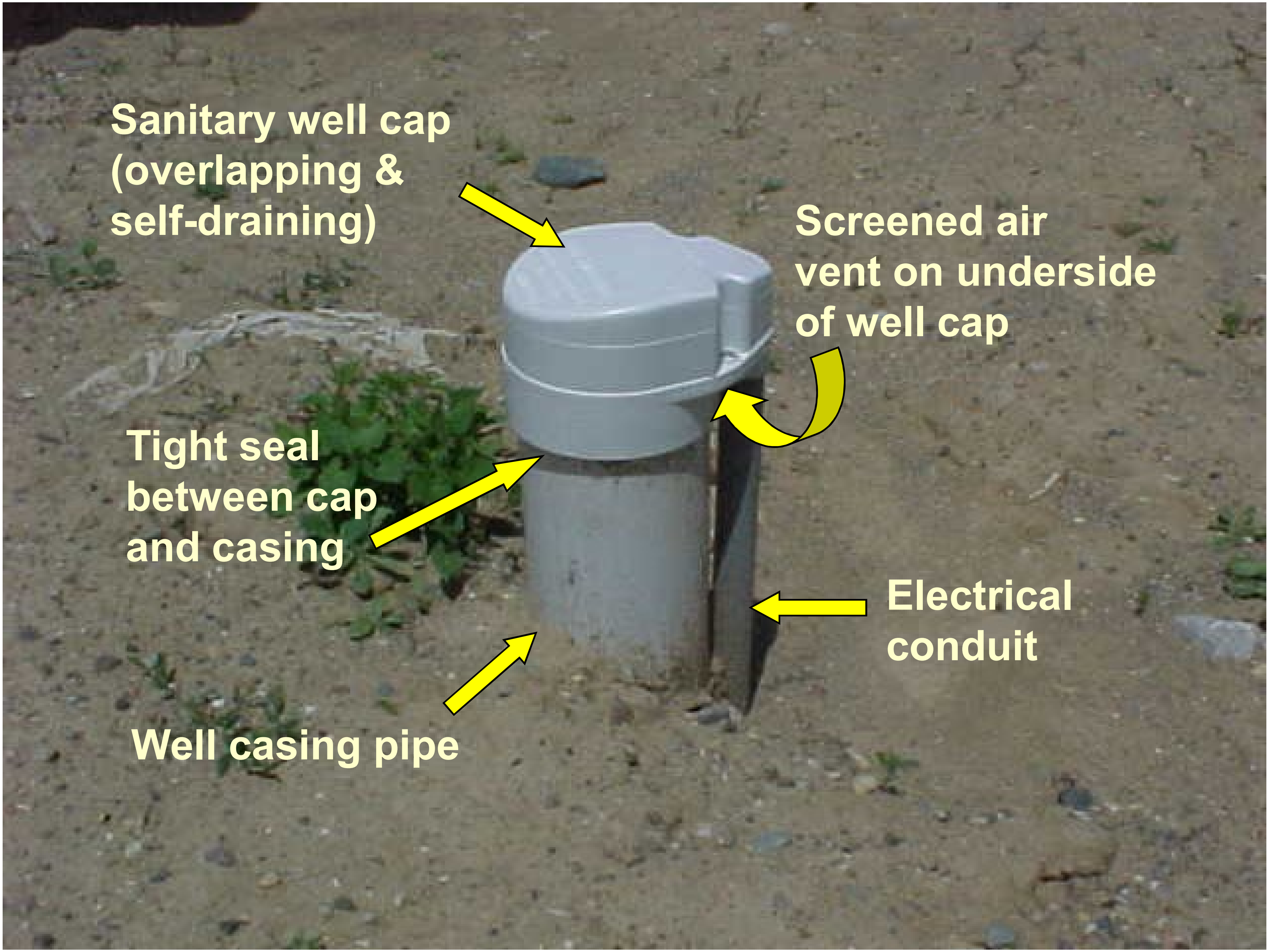
TYPICAL ROTARY WELL CONSTRUCTION SEQUENCE



Bentonite Drilling Fluid
- *Functions* -

- **REMOVAL OF DRILL CUTTINGS FROM BOREHOLE**
- **STABILIZE THE BOREHOLE**
- **COOL AND LUBRICATE DRILL BIT**
- **CONTROL FLUID LOSS TO GEOLOGIC FORMATIONS**
- **DROP DRILL CUTTINGS INTO MUD PIT**
- **FACILITATE COLLECTION OF GEOLOGIC DATA**
- **SUSPEND CUTTINGS WHEN DRILLING FLUID CIRCULATION STOPS**

Temporary well cap - installed between well drilling and pump hook-up

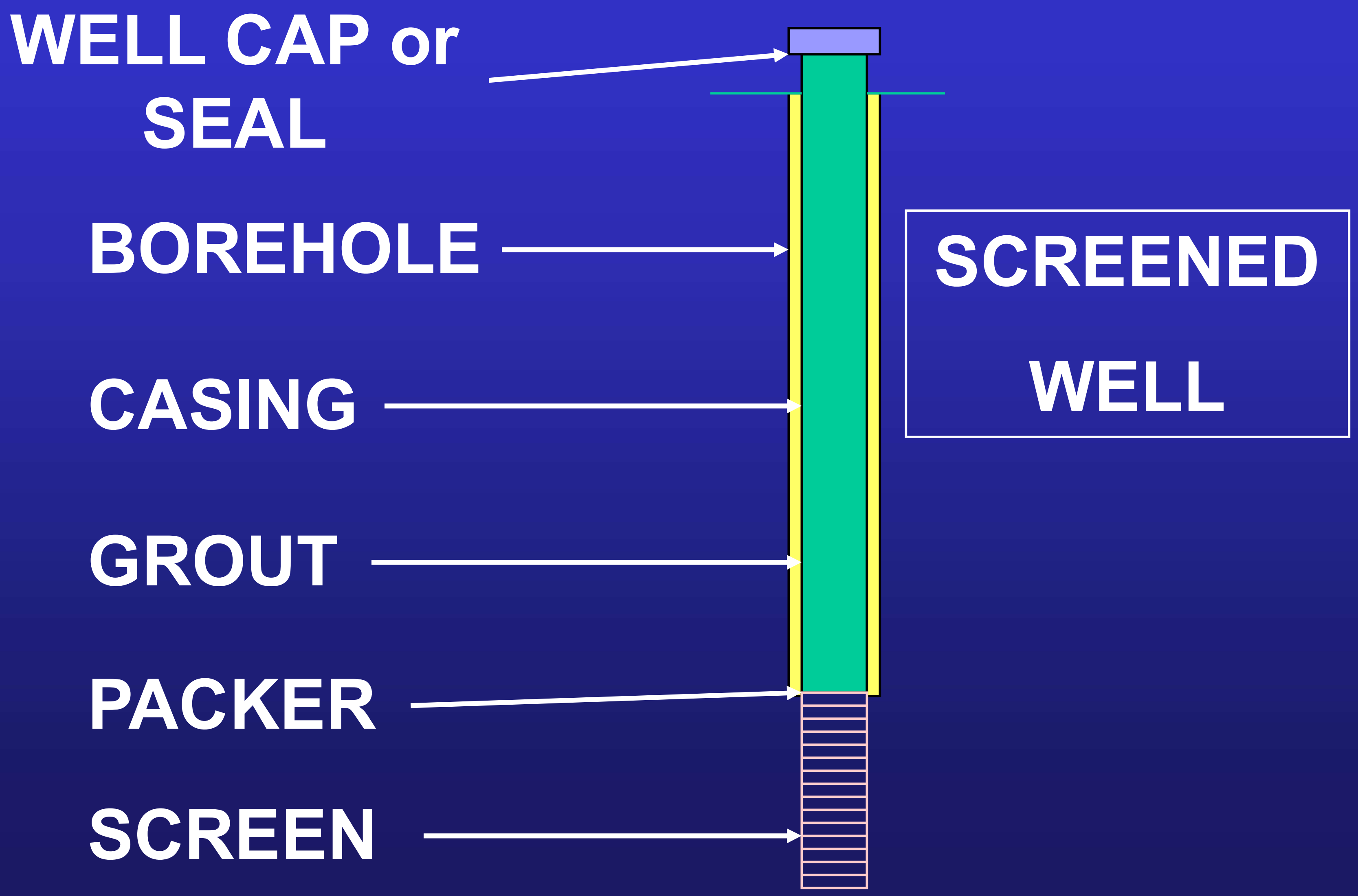

Sanitary well cap (overlapping & self-draining)
Screened air vent on underside of well cap
Tight seal between cap and casing
Electrical conduit
Well casing pipe

This drilled well has an older style well cap that does not seal tightly to the well casing.

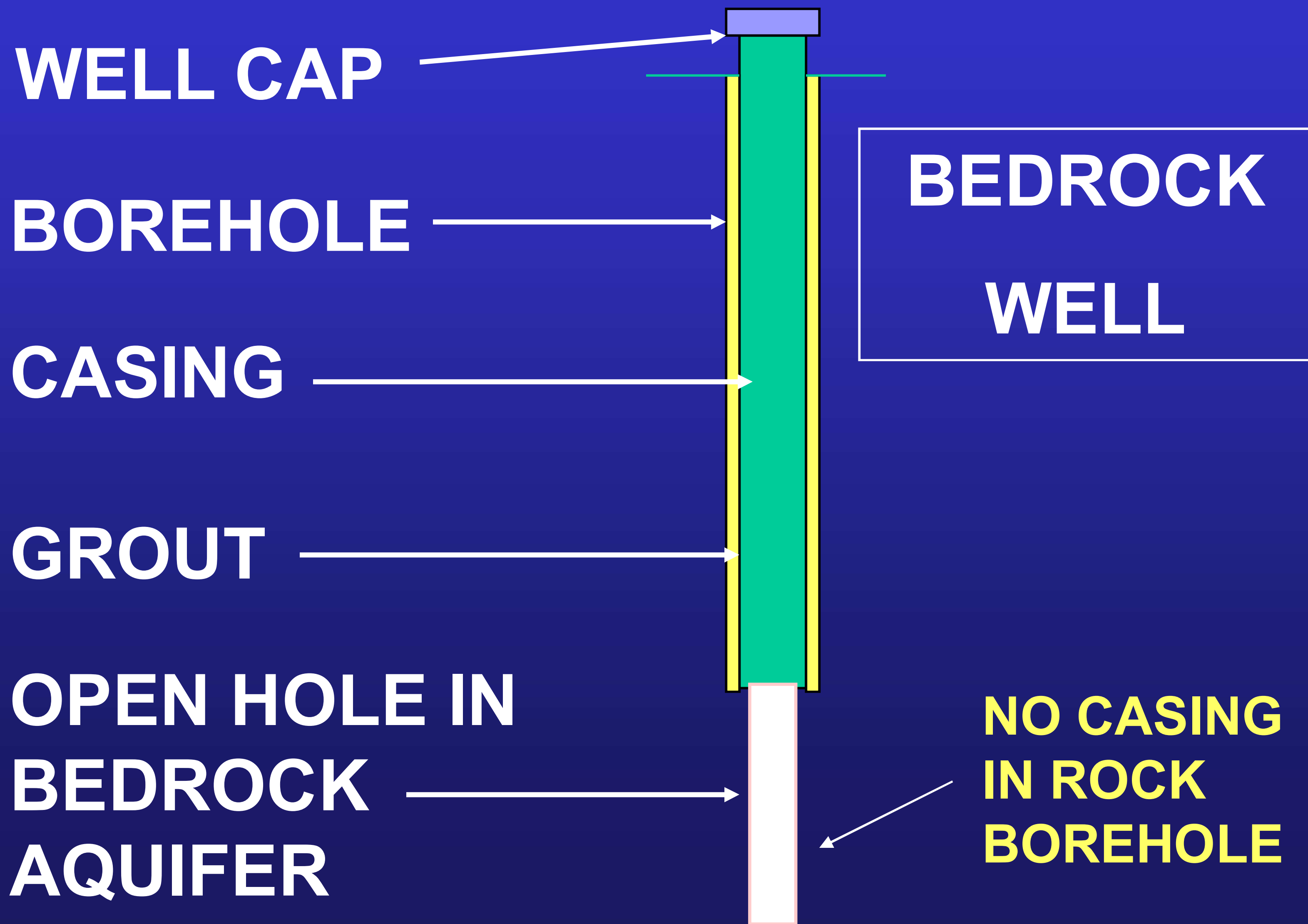
Insects and small animals can enter the well and contaminate the drinking water.

Caps of this design are not acceptable and should be replaced.

DRILLED WELL COMPONENTS



DRILLED WELL COMPONENTS



BOREHOLE

Vertical circular boring to reach aquifer (water bearing geologic material)

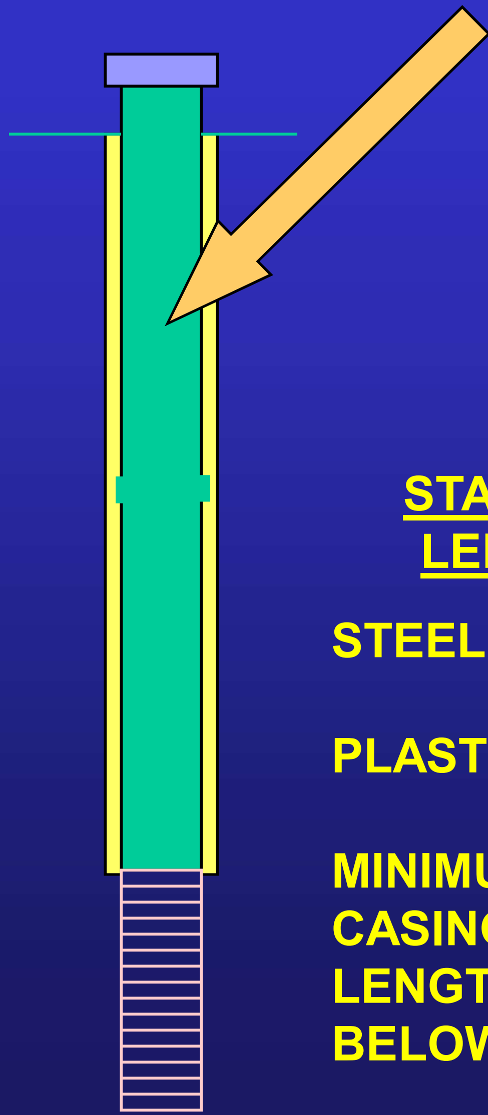
MINIMUM 2 IN. LARGER THAN CASING IF GROUTING THRU CASING

MINIMUM 2 7/8 IN. LARGER THAN CASING IF GROUTING WITH GROUT PIPE OUTSIDE CASING

CASING

Steel or plastic pipe installed to keep borehole wall from collapsing

Houses submersible pump or turbine bowls & drop pipe



STANDARD LENGTHS

STEEL 21 FT.

PLASTIC 20 FT.

MINIMUM CASING LENGTH BELOW GRADE 25 FT.

WELL CAP or SEAL

Mechanical device to prevent contaminants (including insects) from entering well casing

OVERLAPPING

SEALED TIGHTLY TO CASING

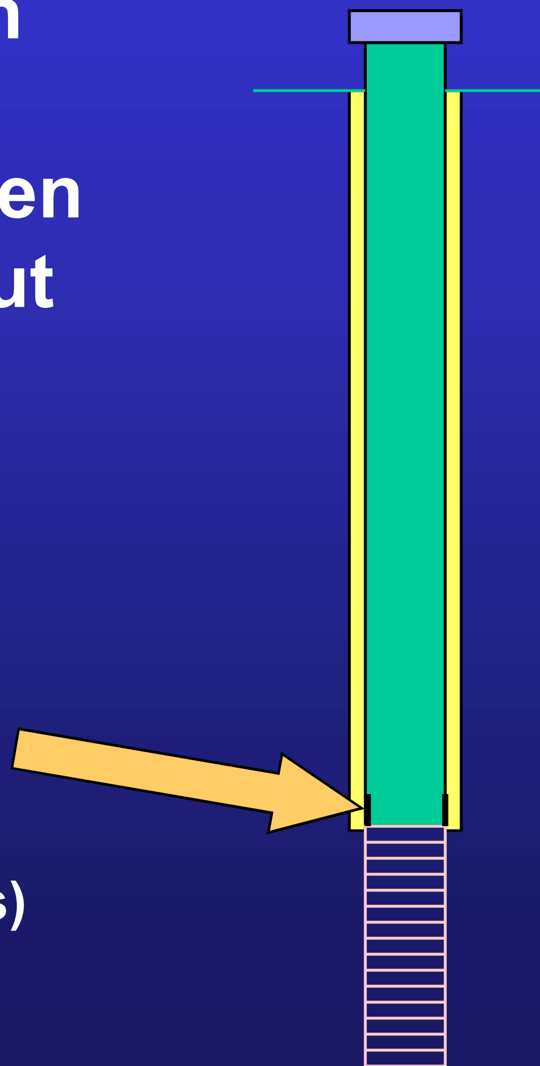
SCREENED AIR VENT

TIGHT SEAL TO ELECTRICAL CONDUIT

Device that seals space between casing & telescoped screen to keep sand out of well

PACKER

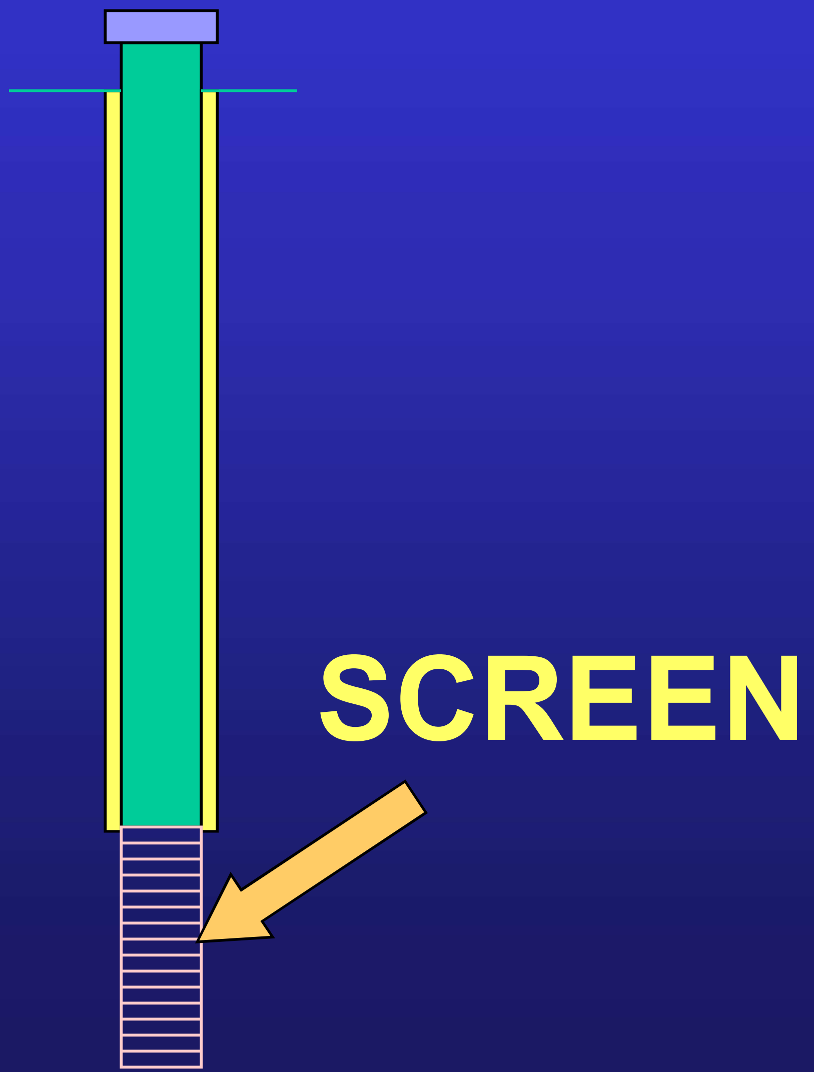
(Coupling with neoprene rubber flanges)

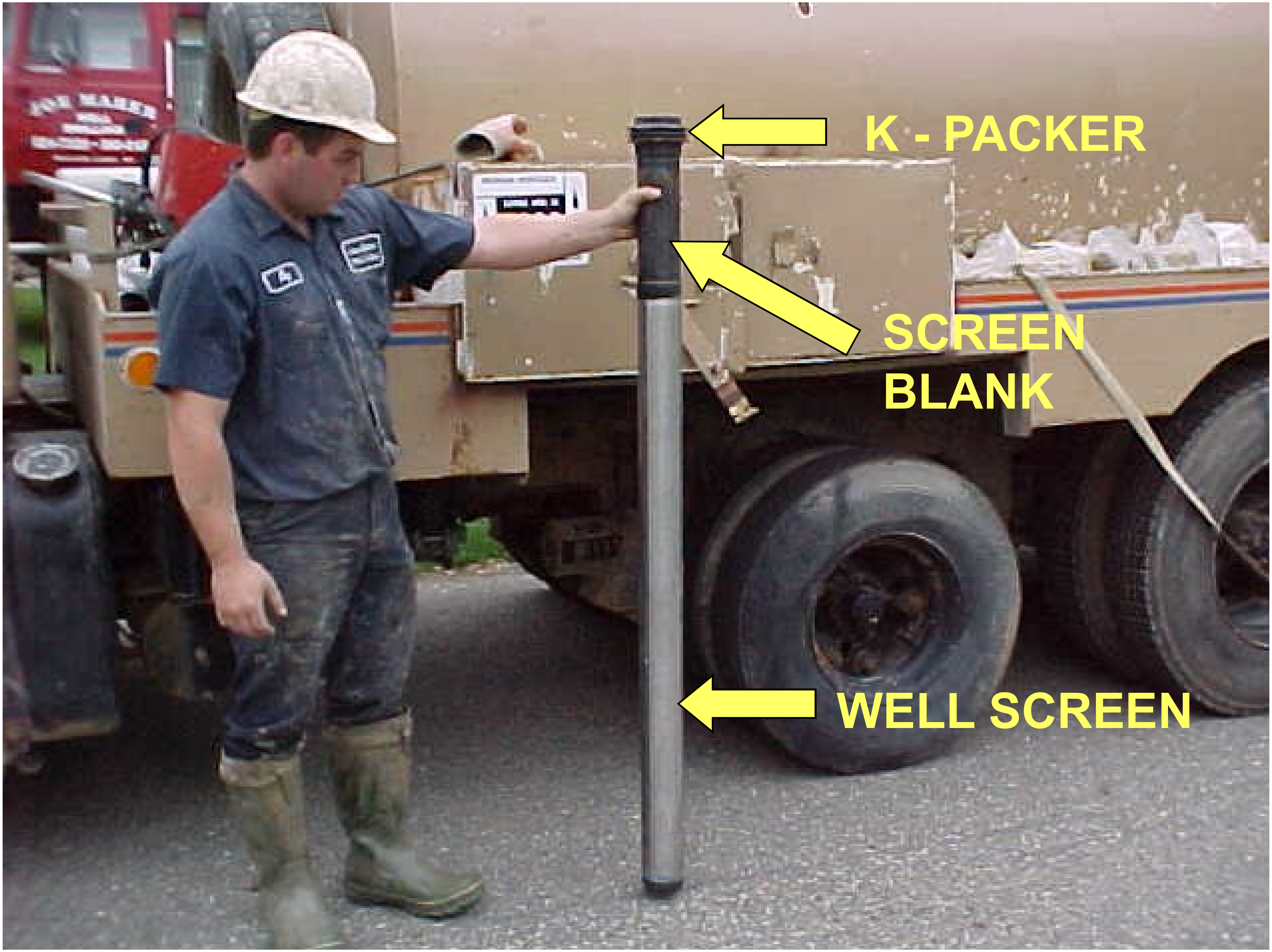


Intake device to allow water to enter well and keep sand out

Structural support of aquifer material

Wire-wrapped screen most common

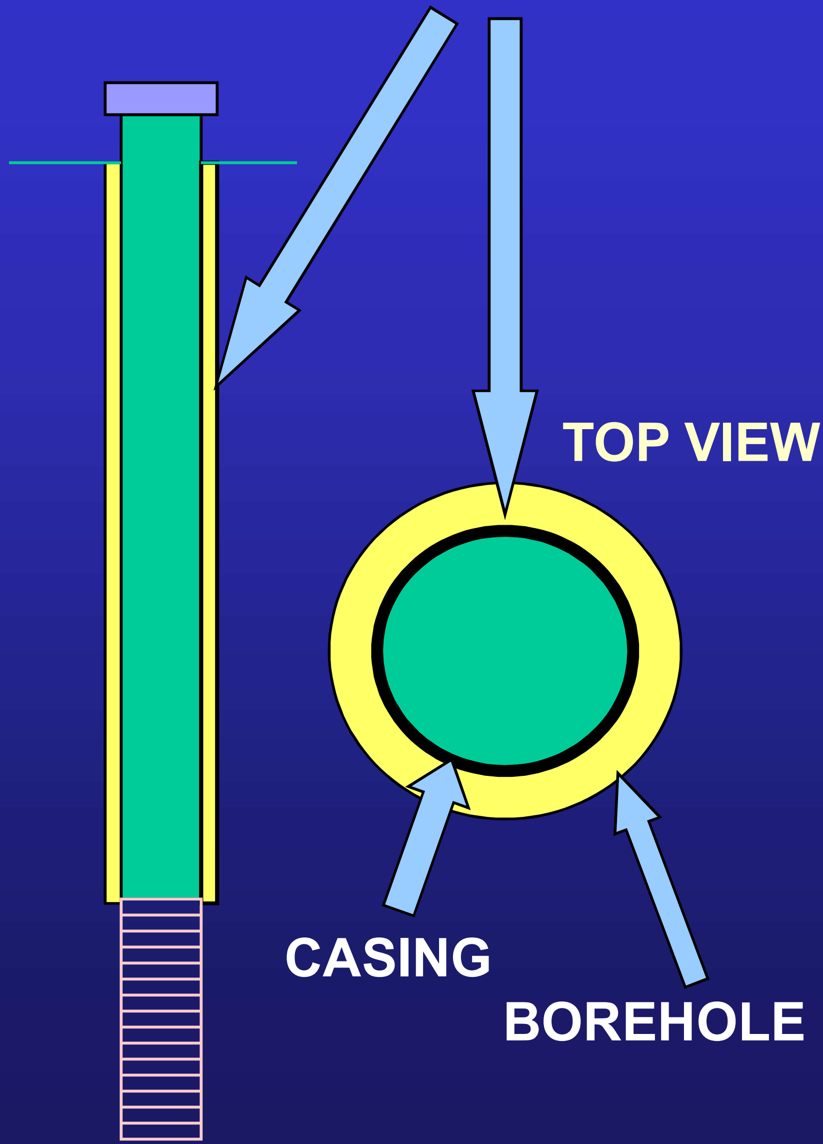



K - PACKER
SCREEN BLANK
WELL SCREEN

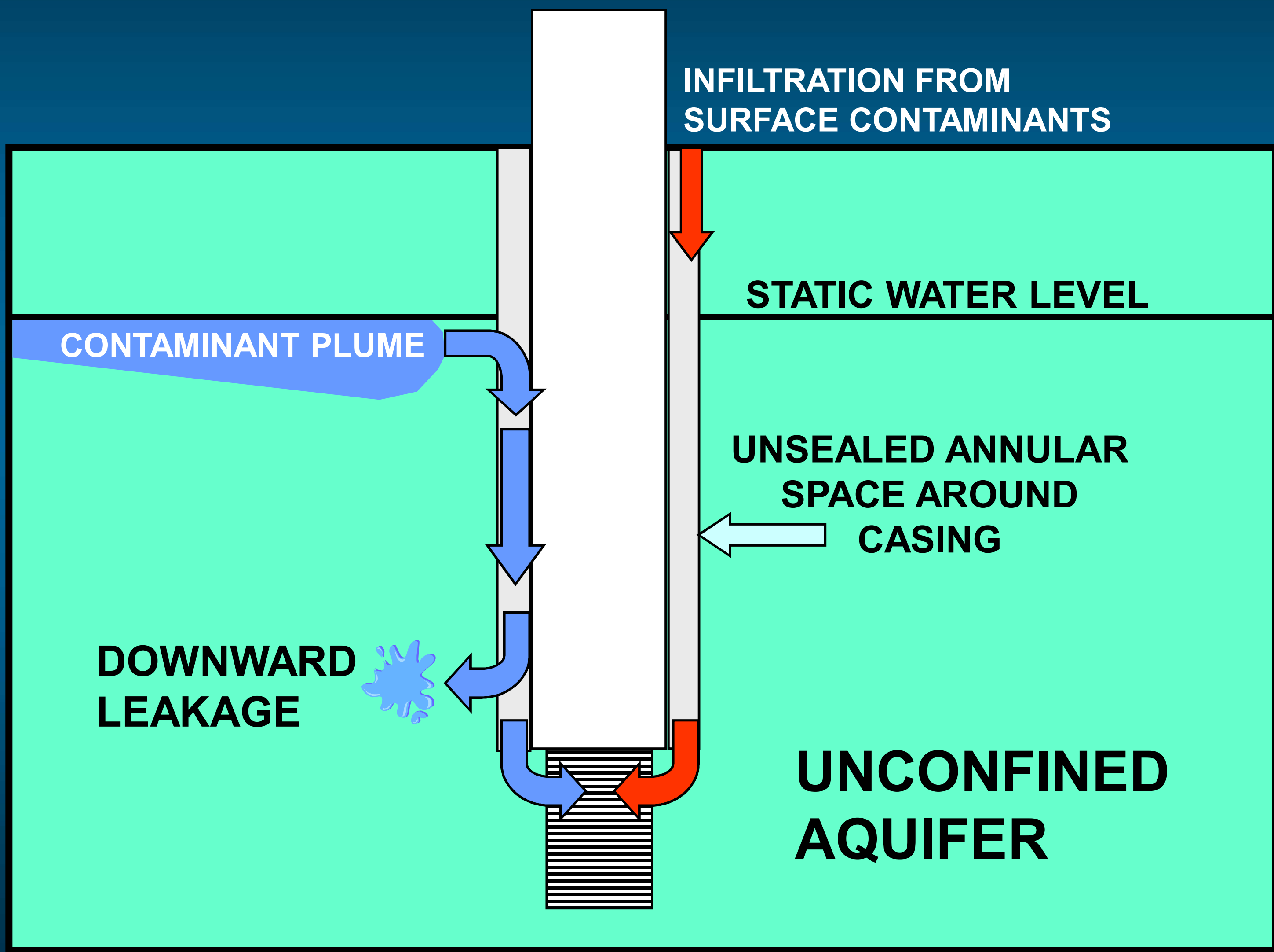
GROUT

Impermeable cement or bentonite clay slurry placed in annular space between borehole and casing to:

- prevent well contamination
- maintain separation of aquifers
- preserve artesian aquifers

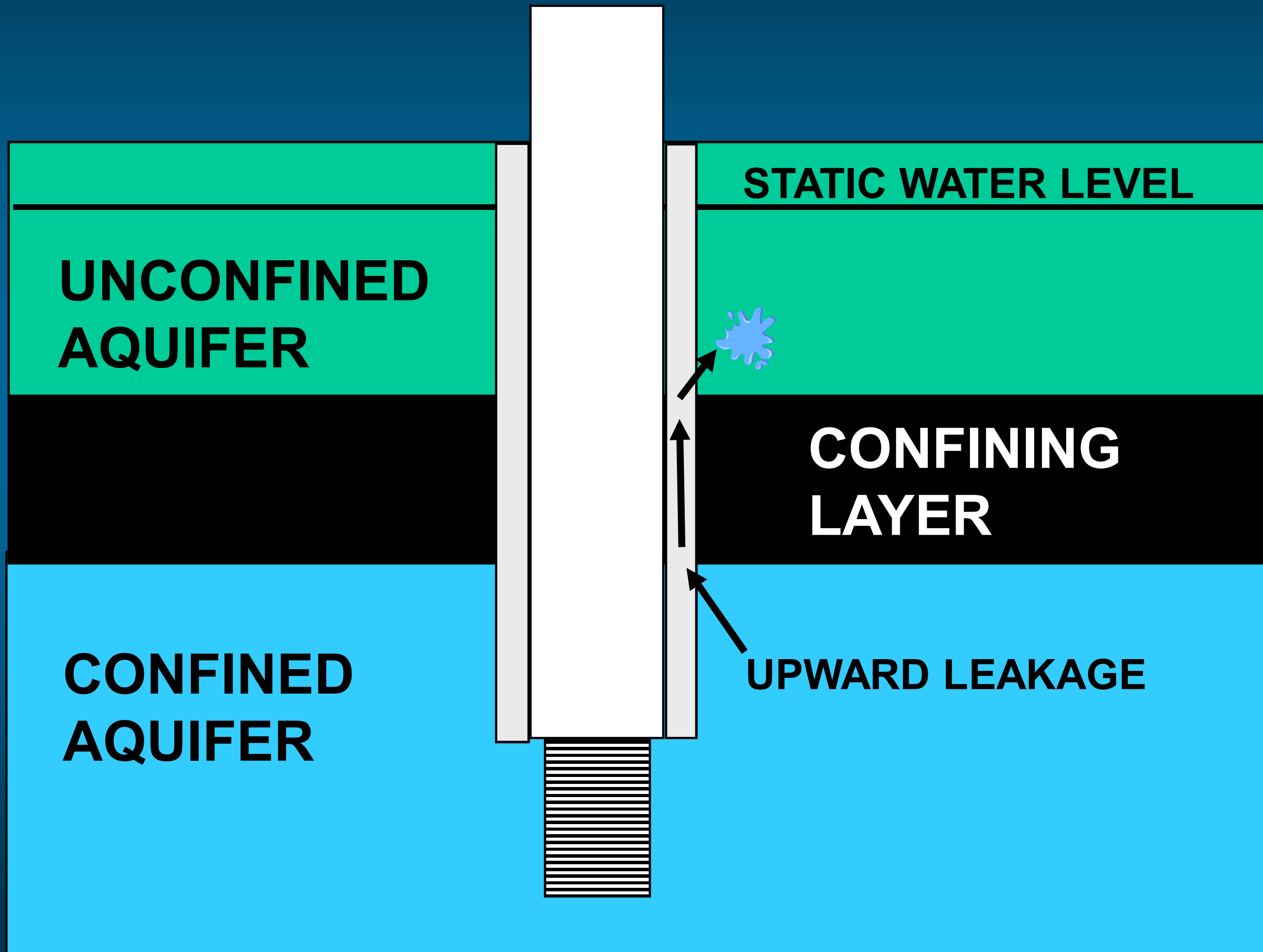


DOWNWARD LEAKAGE AROUND UNGROUTED CASING



UPWARD LEAKAGE AROUND UNGROUTED CASING

(Artesian Condition)



BENEFITS OF WELL GROUTING

- ***PREVENT CONTAMINANT MIGRATION FROM SURFACE (Keeps surface runoff from moving downward along well casing)***
- ***SEAL OFF POOR QUALITY AQUIFERS (Prevents mixing of water from different aquifers)***
- ***PRESERVE ARTESIAN AQUIFER PROPERTIES***
- ***ADDED SEALING OF CASING JOINTS***

WELL GROUTING MATERIALS

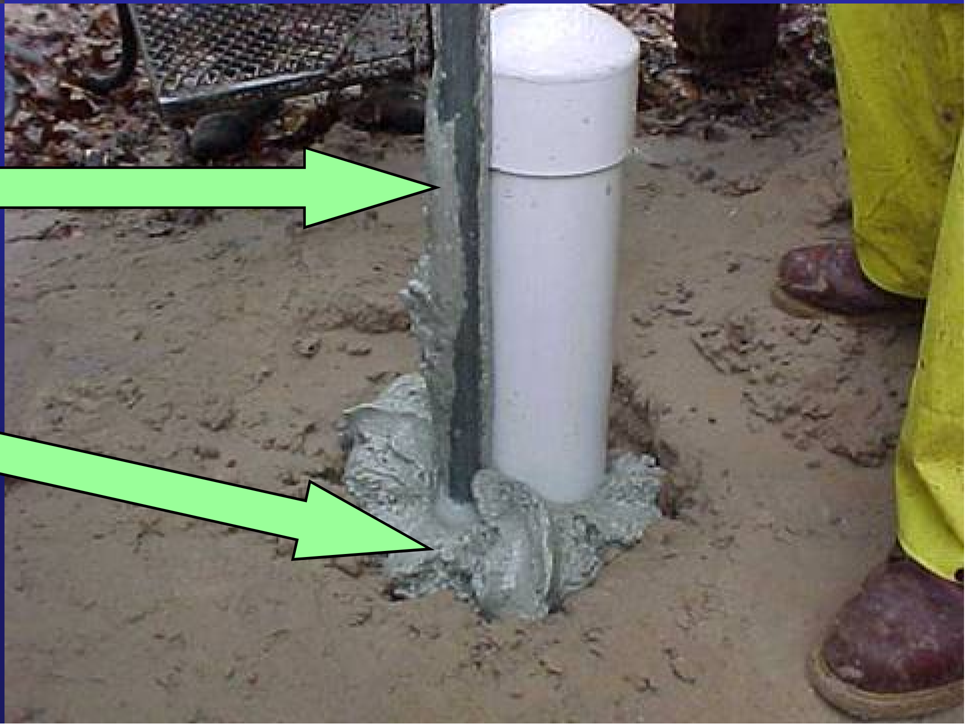
TYPE	*COMPOSITION*	*CHARACTERISTICS*
BENTONITE SLURRY	POWDERED BENTONITE & WATER GRANULAR BENTONITE, POLYMER & WATER	▪FLEXIBLE LOWER STRENGTH SEAL ▪MAY SUBSIDE IN VADOSE ZONE ▪MOST POPULAR DUE TO LOWER COST AND TARGETED MARKETING ▪WASH-OUT UNDER ARTESIAN PRESSURE ▪NO HEAT OF HYDRATION
NEAT CEMENT	PORTLAND CEMENT & WATER	▪MORE WIDELY USED IN OIL FIELD THAN WATER WELLS ▪HIGHER STRENGTH RIGID SEAL ▪BEST CHOICE FOR BEDROCK WELLS & FLOWING WELLS ▪HEAT OF HYDRATION & MICROANNULUS CONCERNS
CONCRETE GROUT	PORTLAND CEMENT, SAND & WATER	▪MORE PERMEABLE THAN NEAT CEMENT GROUT ▪MORE DIFFICULT TO PUMP (ABRASIVE) ▪GOOD CHOICE FOR LARGE DIAMETER WELLS

GRANULAR BENTONITE
POURED INTO
MIX WATER

PORTABLE
GROUTING MACHINE
(MIXER & PUMP)

GROUT PIPE
TO BOTTOM OF
ANNULAR SPACE

BENTONITE GROUT
RETURN
AT SURFACE
(GELATIN – OATMEAL TEXTURE)



WELL GROUTING

ROTARY *VS.* *CABLE TOOL*

GROUT PIPE IN ANNULAR SPACE

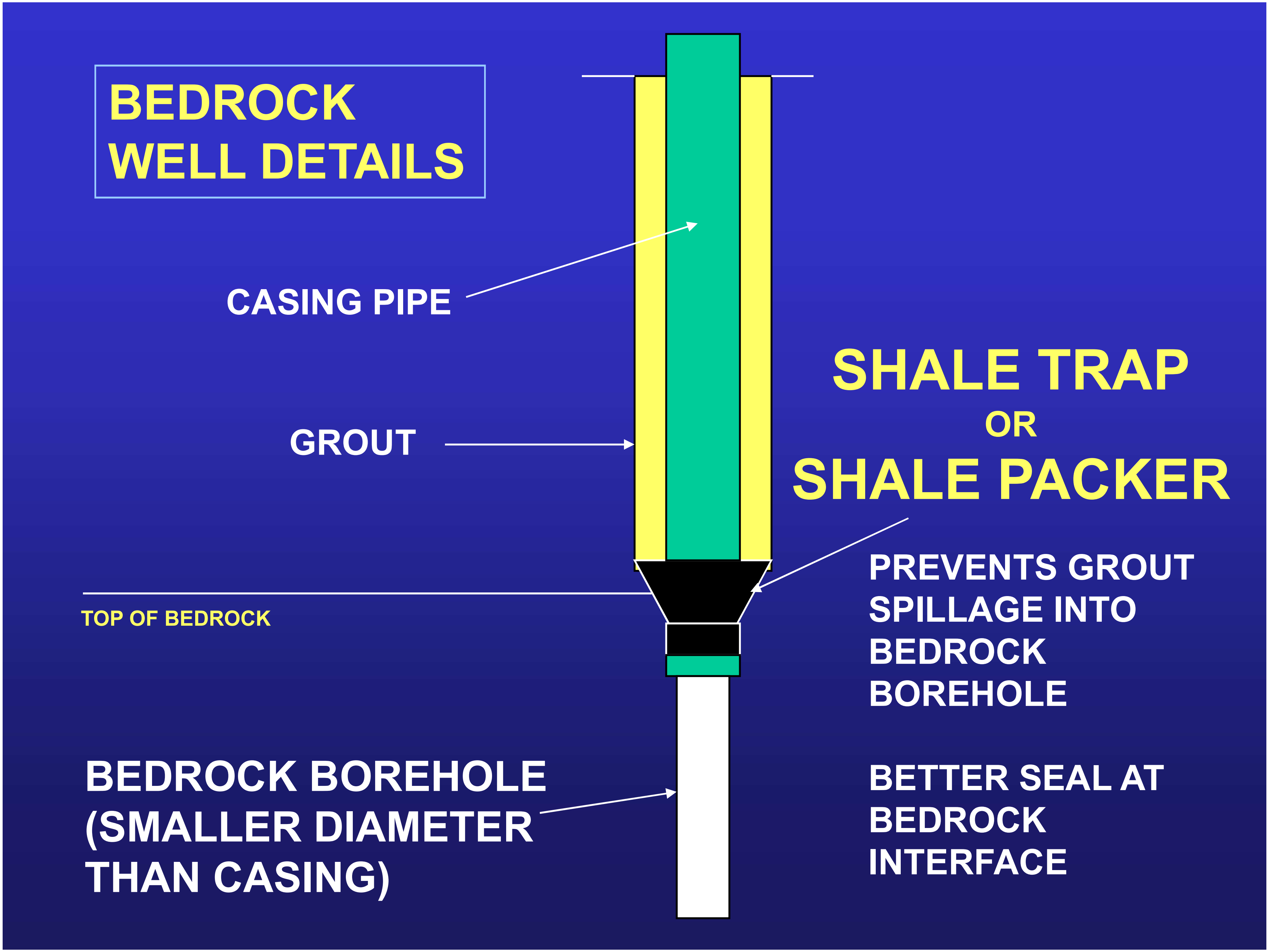
WELL CASING IN OVERSIZED BOREHOLE

GROUT PUMPED FROM BOTTOM

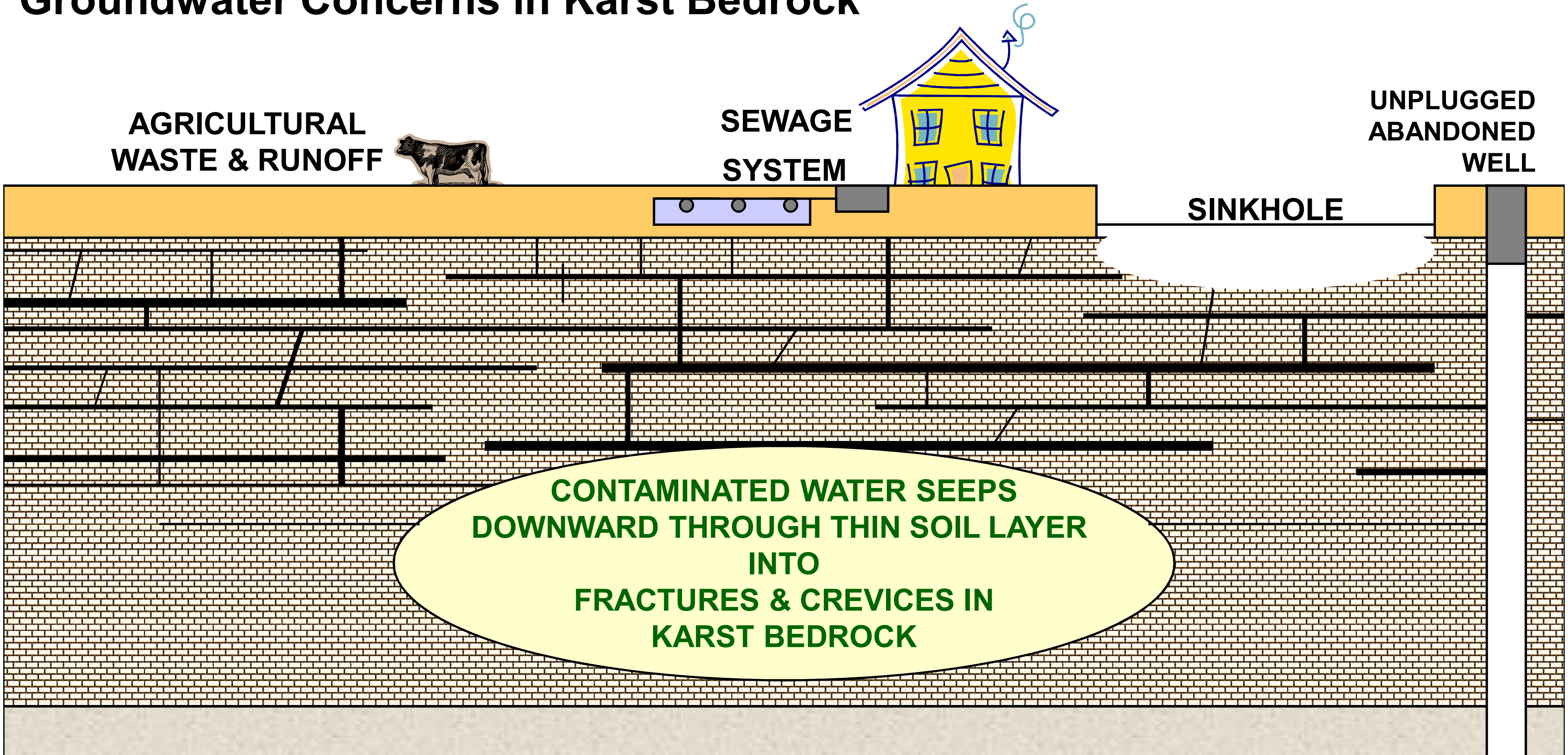
DRY GRANULAR BENTONITE POURED AROUND CASING

GROUT FOLLOWS DRIVE SHOE AS CASING IS DRIVEN

- DEPTH OF GROUT TRAVEL IS UNCERTAIN
- LIMITED BY HIGH WATER TABLE

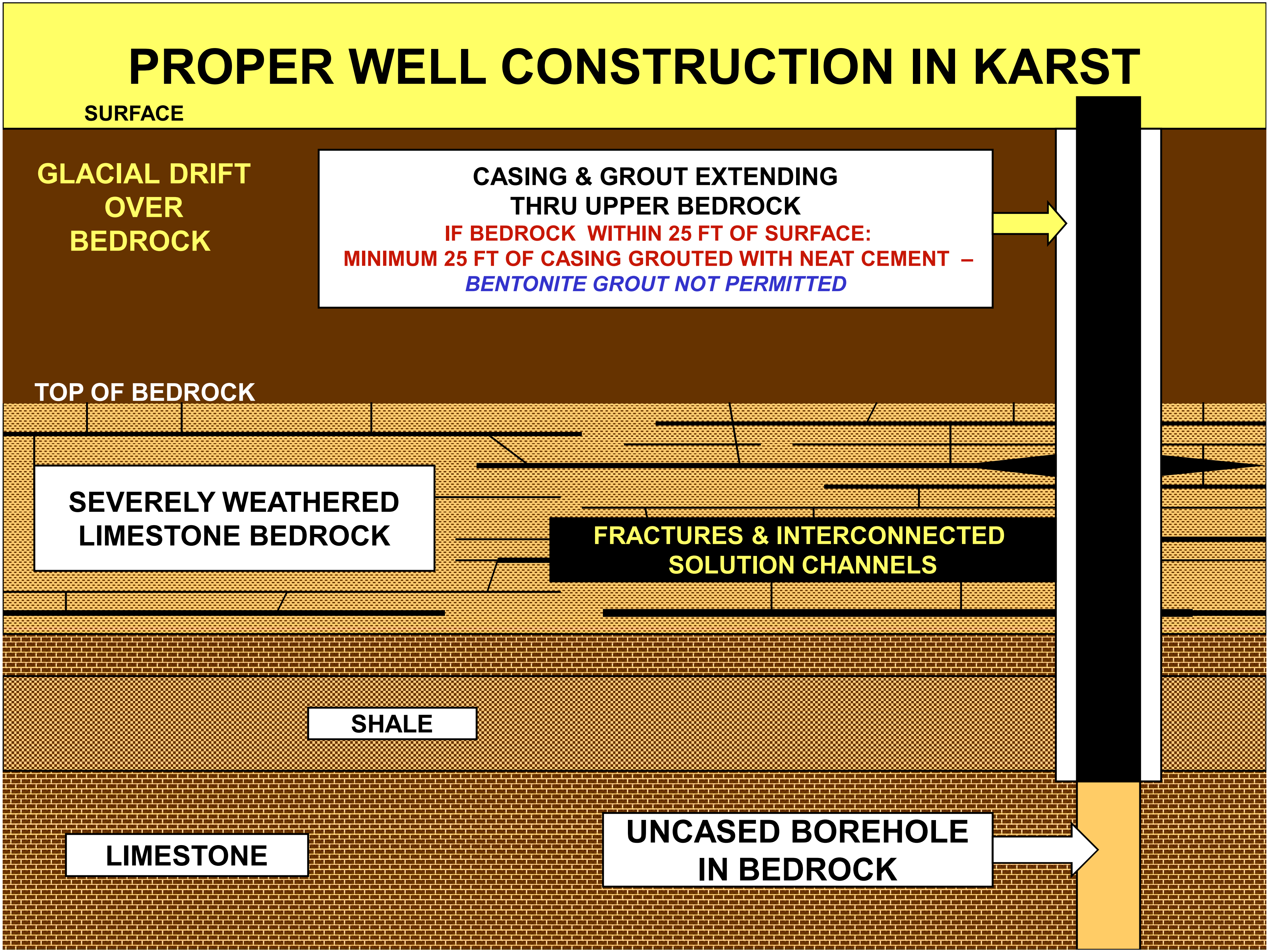

BEDROCK
WELL DETAILS
CASING PIPE
GROUT
SHALE TRAP
OR
SHALE PACKER
PREVENTS GROUT
SPILLAGE INTO
BEDROCK
BOREHOLE
TOP OF BEDROCK
BEDROCK BOREHOLE
(SMALLER DIAMETER
THAN CASING)
BETTER SEAL AT
BEDROCK
INTERFACE

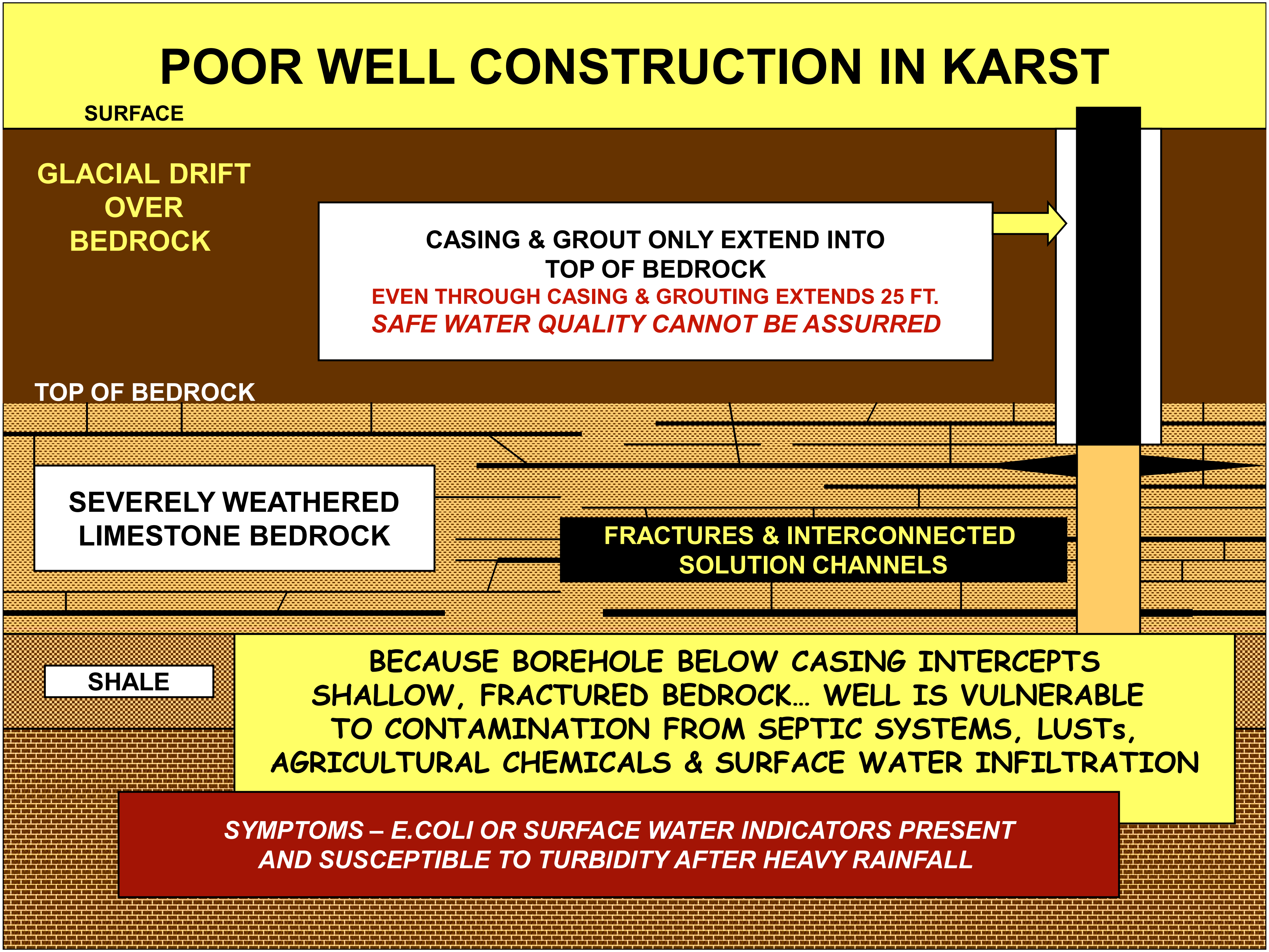
Groundwater Concerns in Karst Bedrock

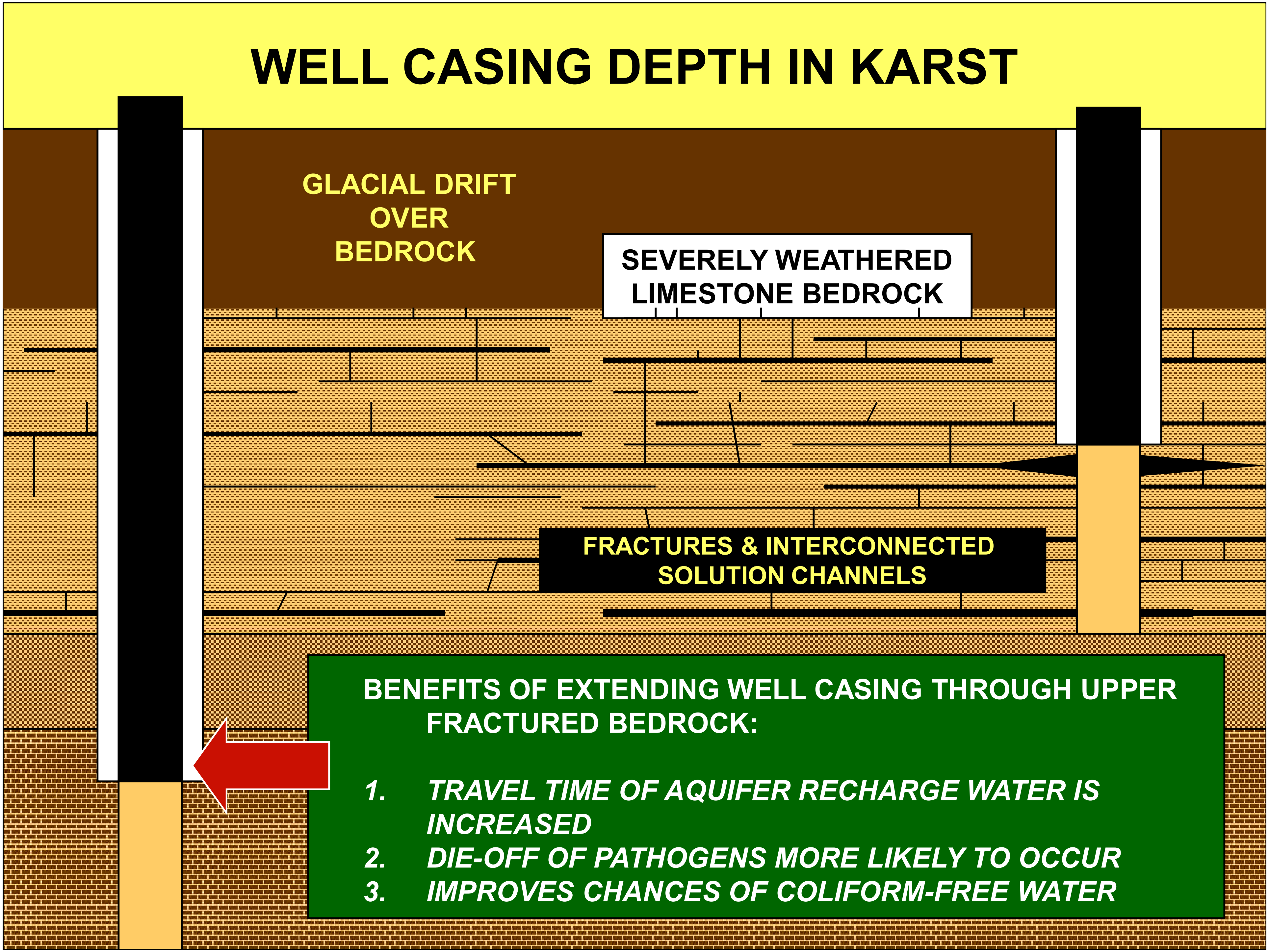


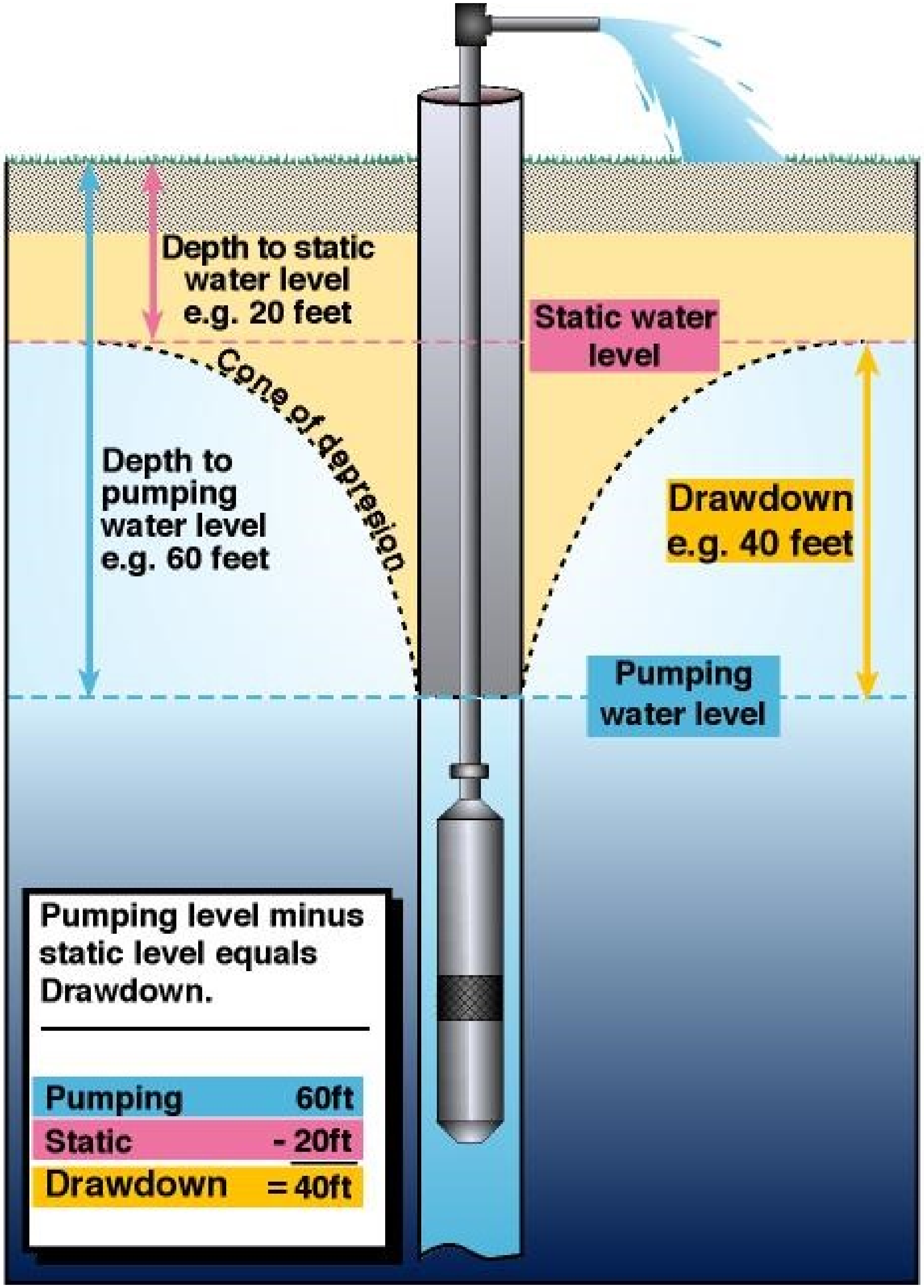
SIGNIFICANT RAINFALL OVER SHALLOW CARBONATE BEDROCK CAN CAUSE:

- ***SURGE IN WATER LEVELS (Increases hydraulic pressure)***
- ***INCREASED SURFACE WATER-TO-GROUNDWATER INTERCHANGE***
- ***FLUSHING OF TURBIDITY & ORGANIC MATTER INTO GROUNDWATER***


PROPER WELL CONSTRUCTION IN KARST
SURFACE
GLACIAL DRIFT OVER BEDROCK
CASING & GROUT EXTENDING THRU UPPER BEDROCK
IF BEDROCK WITHIN 25 FT OF SURFACE:
MINIMUM 25 FT OF CASING GROUTED WITH NEAT CEMENT –
BENTONITE GROUT NOT PERMITTED
TOP OF BEDROCK
SEVERELY WEATHERED LIMESTONE BEDROCK
FRACTURES & INTERCONNECTED SOLUTION CHANNELS
SHALE
LIMESTONE
UNCASED BOREHOLE IN BEDROCK


POOR WELL CONSTRUCTION IN KARST
SURFACE
GLACIAL DRIFT OVER BEDROCK
CASING & GROUT ONLY EXTEND INTO TOP OF BEDROCK
EVEN THROUGH CASING & GROUTING EXTENDS 25 FT.
SAFE WATER QUALITY CANNOT BE ASSURED
TOP OF BEDROCK
SEVERELY WEATHERED LIMESTONE BEDROCK
FRACTURES & INTERCONNECTED SOLUTION CHANNELS
SHALE
BECAUSE BOREHOLE BELOW CASING INTERCEPTS SHALLOW, FRACTURED BEDROCK… WELL IS VULNERABLE TO CONTAMINATION FROM SEPTIC SYSTEMS, LUSTs, AGRICULTURAL CHEMICALS & SURFACE WATER INFILTRATION
SYMPTOMS – E.COLI OR SURFACE WATER INDICATORS PRESENT AND SUSCEPTIBLE TO TURBIDITY AFTER HEAVY RAINFALL

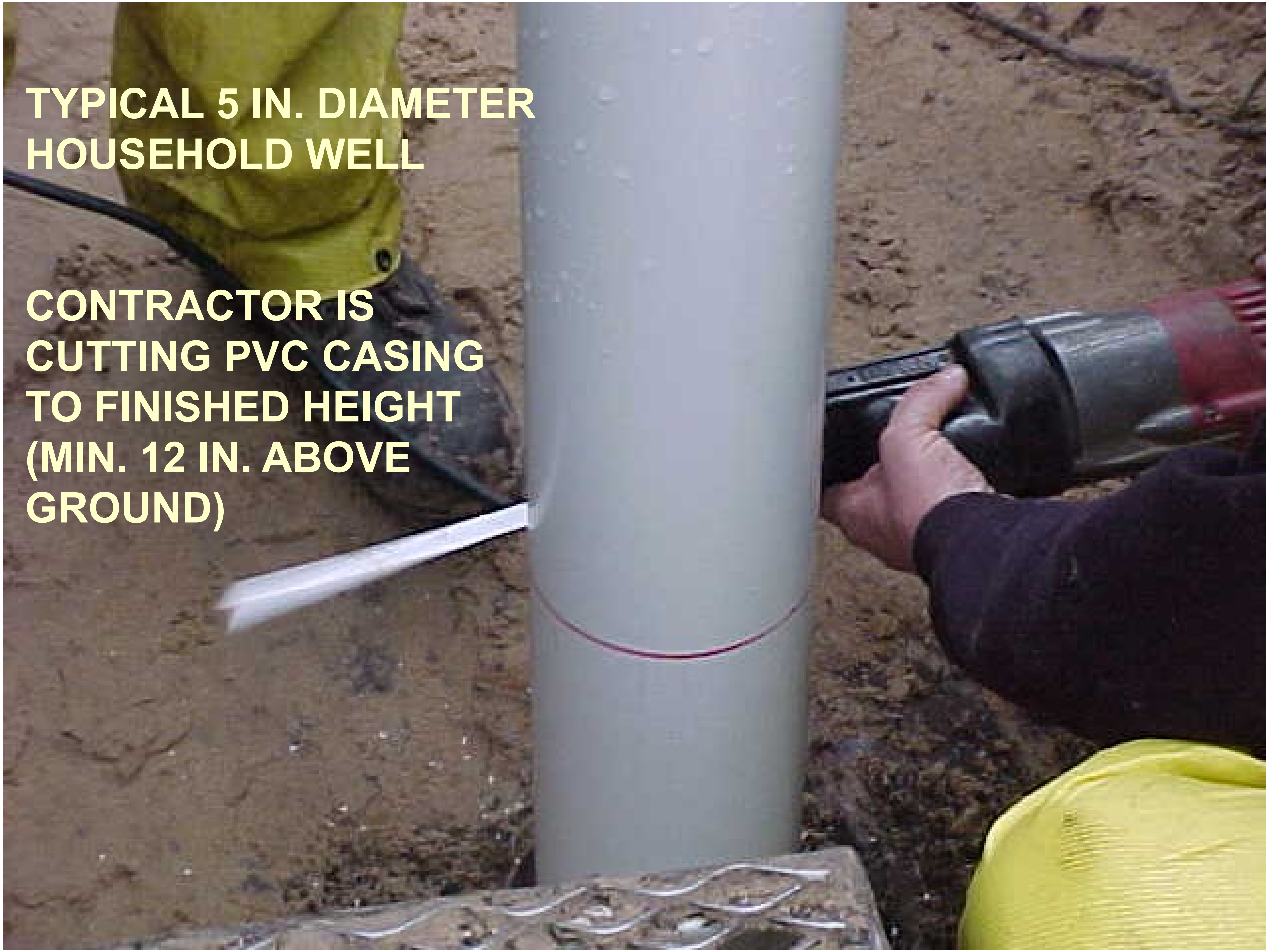

WELL CASING DEPTH IN KARST
GLACIAL DRIFT OVER BEDROCK
SEVERELY WEATHERED LIMESTONE BEDROCK
FRACTURES & INTERCONNECTED SOLUTION CHANNELS
BENEFITS OF EXTENDING WELL CASING THROUGH UPPER FRACTURED BEDROCK:
1. TRAVEL TIME OF AQUIFER RECHARGE WATER IS INCREASED
2. DIE-OFF OF PATHOGENS MORE LIKELY TO OCCUR
3. IMPROVES CHANCES OF COLIFORM-FREE WATER



Depth to static water level e.g. 20 feet
Static water level
Cone of depression
Depth to pumping water level e.g. 60 feet
Drawdown e.g. 40 feet
Pumping water level
Pumping level minus static level equals Drawdown.
Pumping 60ft
Static - 20ft
Drawdown = 40ft

CASING MATERIALS COMPARISON

PVC PLASTIC	VS.	STEEL
Non-corroding		Corrodes
Lower strength		Higher strength
Fewer water quality complaints		Rusty water
Rotary construction only		Suitable for any drilling method
1/3 cost of steel		No heat of hydration impact from cement grout


TYPICAL 5 IN. DIAMETER HOUSEHOLD WELL
CONTRACTOR IS CUTTING PVC CASING TO FINISHED HEIGHT (MIN. 12 IN. ABOVE GROUND)

WELL DIAMETER:

MYTH

Doubling well diameter appreciably increases well yield

FACT

DOUBLING WELL DIAMETER ⤵

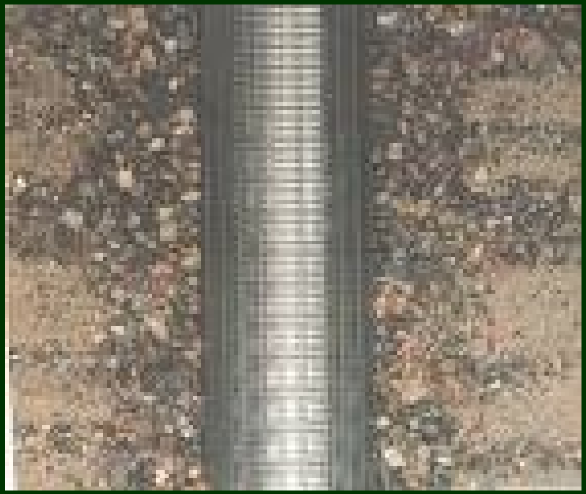
10% YIELD INCREASE

DOUBLING SCREEN LENGTH ⤵

DOUBLES WELL YIELD

SCREENED WELLS

Naturally Developed



Filter Packed

(a/k/a Gravel-Packed)

WELL SCREEN
SET IN
NATIVE GEOLOGIC
MATERIALS
(SAND OR GRAVEL)

GRADED-WASHED
SAND PLACED
OUTSIDE
WELL SCREEN

FILTER - PACK

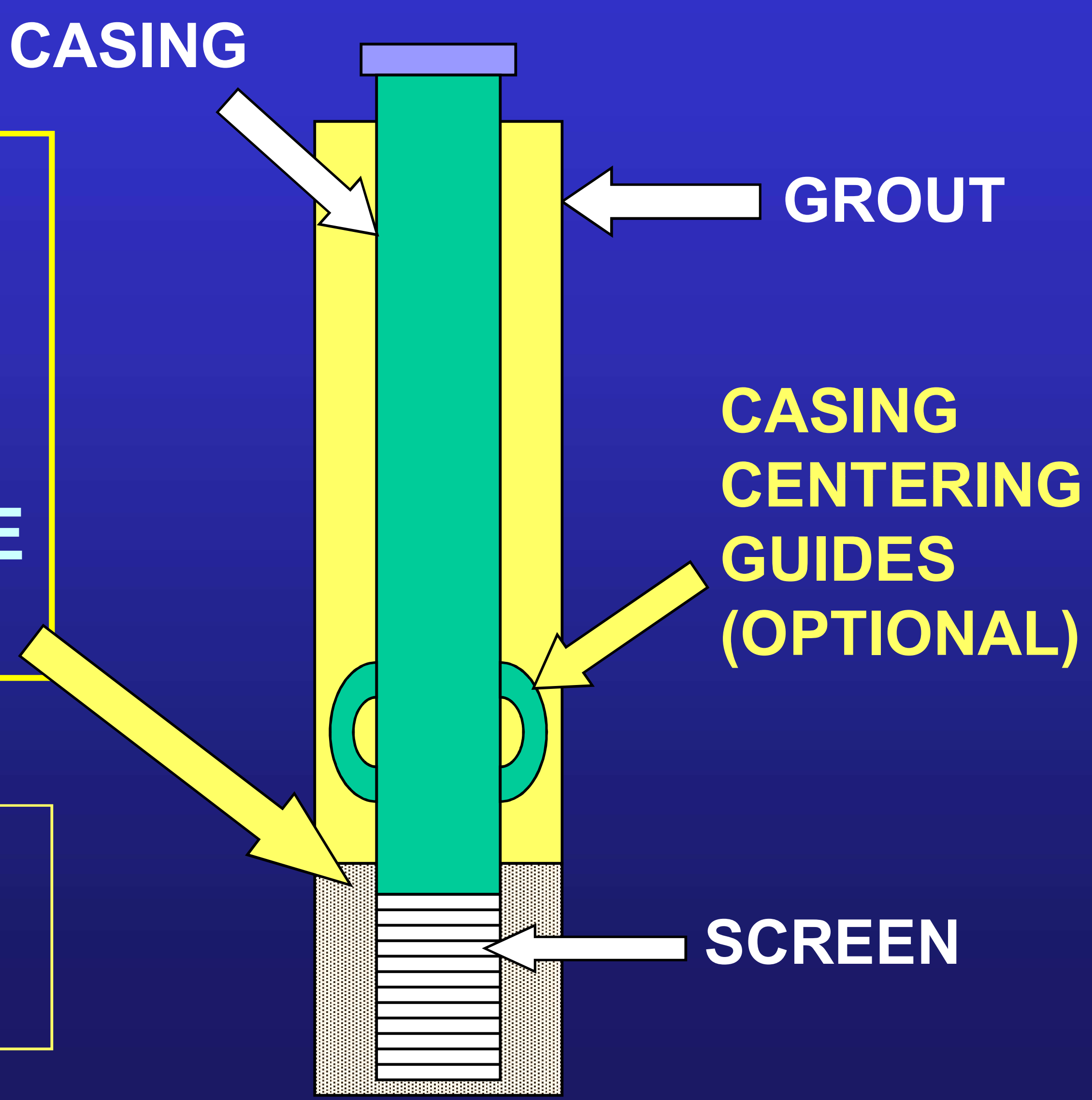
BENEFITS

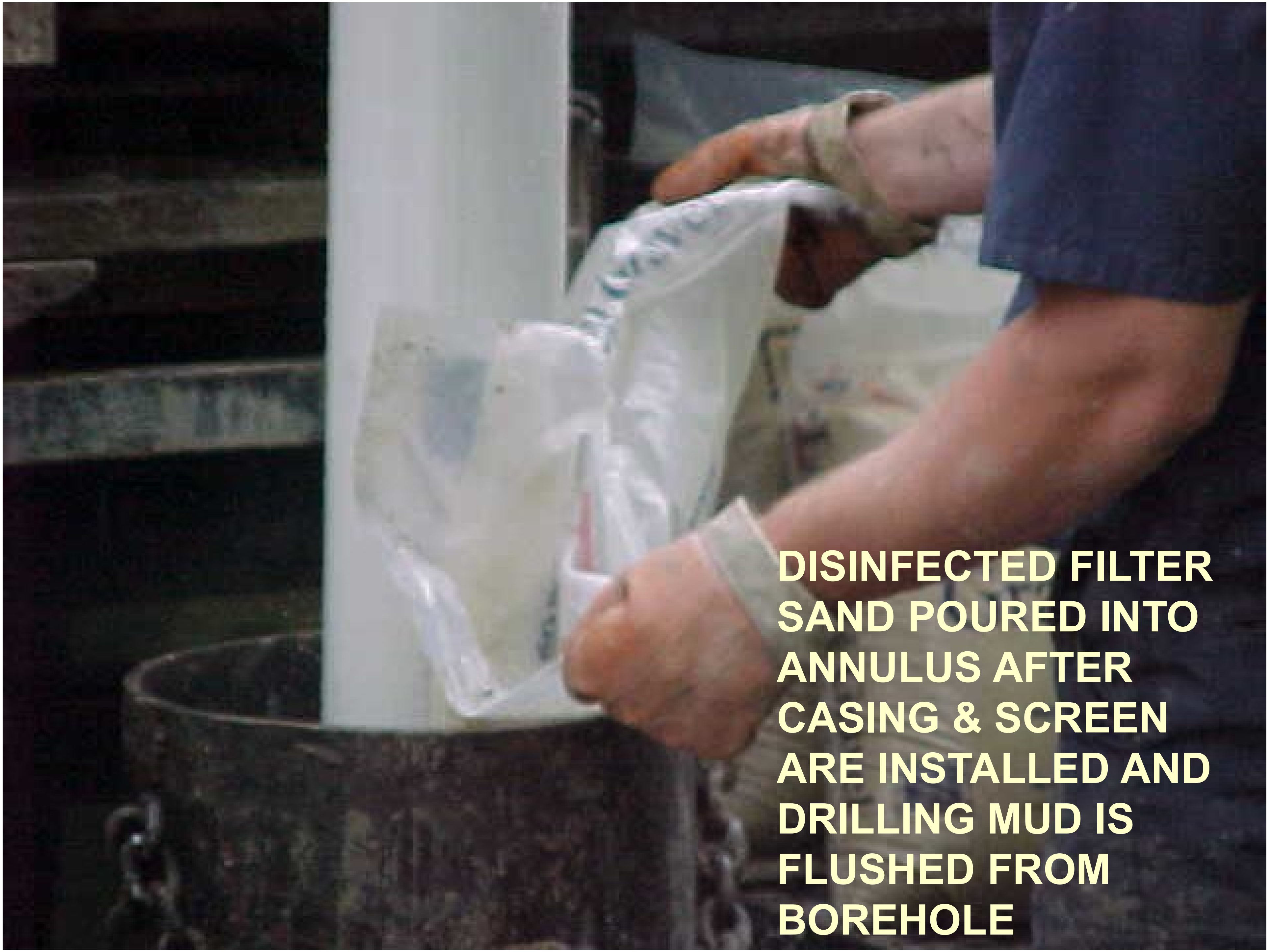
- ↖ Greater porosity
- ↖ Higher hydraulic conductivity
- ↖ Reduced drawdown
- ↖ Higher yield
- ↖ Reduced entrance velocity
- ↖Faster development
- ↖ Easier grouting
- ↖ Longer well life
- ↖ Improved well rehabilitation
- ↖ Reduce sand pumping

FILTER-PACKED WELL CONSTRUCTION

FILTER-PACK SAND PLACED BETWEEN BOREHOLE & SCREEN BEFORE GROUTING

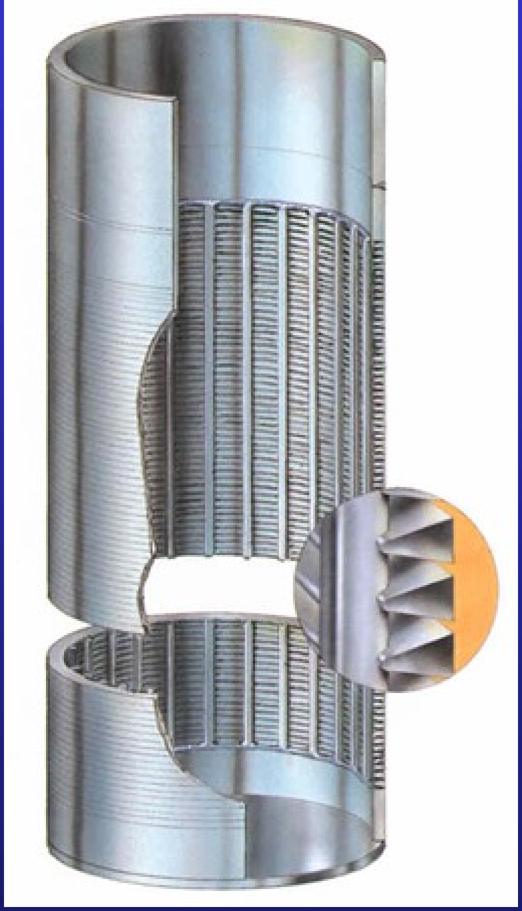
FILTER PACK IS NOT ALLOWED TO EXTEND MORE THAN 10 FEET ABOVE TOP OF SCREEN




DISINFECTED FILTER SAND POURED INTO ANNULUS AFTER CASING & SCREEN ARE INSTALLED AND DRILLING MUD IS FLUSHED FROM BOREHOLE

WELL SCREEN SELECTION CRITERIA

- Maximize % open area



- Non-clogging openings
- Corrosion resistance

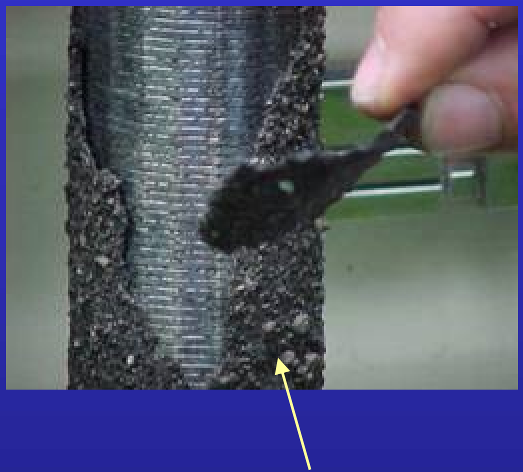
  STAINLESS STEEL vs. PVC PLASTIC

- Column & collapse strength

SCREEN SELECTION CRITERIA

Screen opening size based on aquifer material size:

SIEVE ANALYSIS vs. S.W.A.G.



NATURALLY-DEVELOPED WELL:

40% RETENTION OF AQUIFER MATERIAL

FILTER-PACKED WELL:

90% RETENTION OF FILTER SAND

Screen diameter: BASED ON CASING SIZE

PROVIDE WATER ENTRANCE VELOCITY OF…

<0.1 FT./SEC.

Lower velocity reduces mineral incrustation

EXTENDS WELL SERVICE LIFE

ENTRANCE VELOCITY = $\frac{\text{PUMPING RATE}}{\text{SCREEN OPEN AREA}}$

Example: 6 in. Pipe Size X 8 ft. length

10 slot Continuous slot SS

Pumping rate = 75 GPM

Screen open area (from manufacturer) = 0.21 ft^2/lin ft

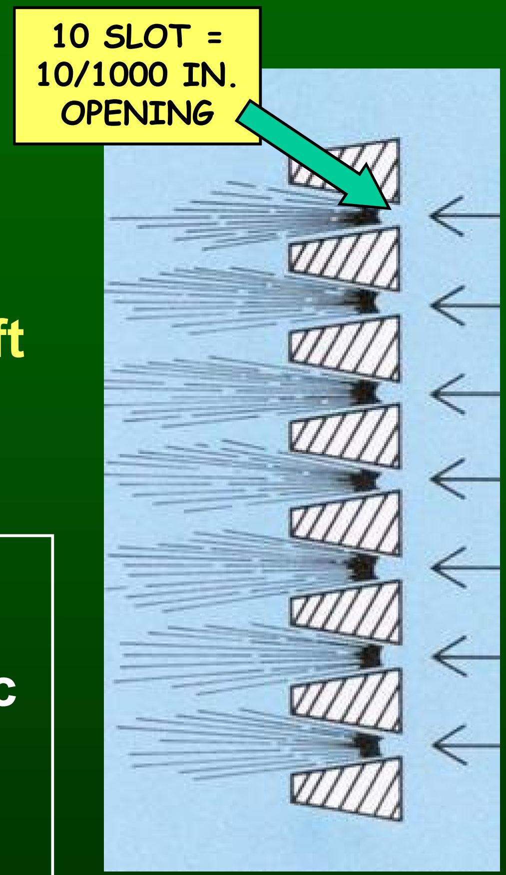
Total screen area = 8 ft x 0.21 ft^2/lin ft = 1.68 ft^2

CONVERT GPM TO FT^3/SEC

75 GPM x 1 ft^3/7.48 gal x 1 min/60 sec = 0.167 ft^3/sec

0.167 ft^3/sec / 1.68 ft^2 = 0.099 ft/sec

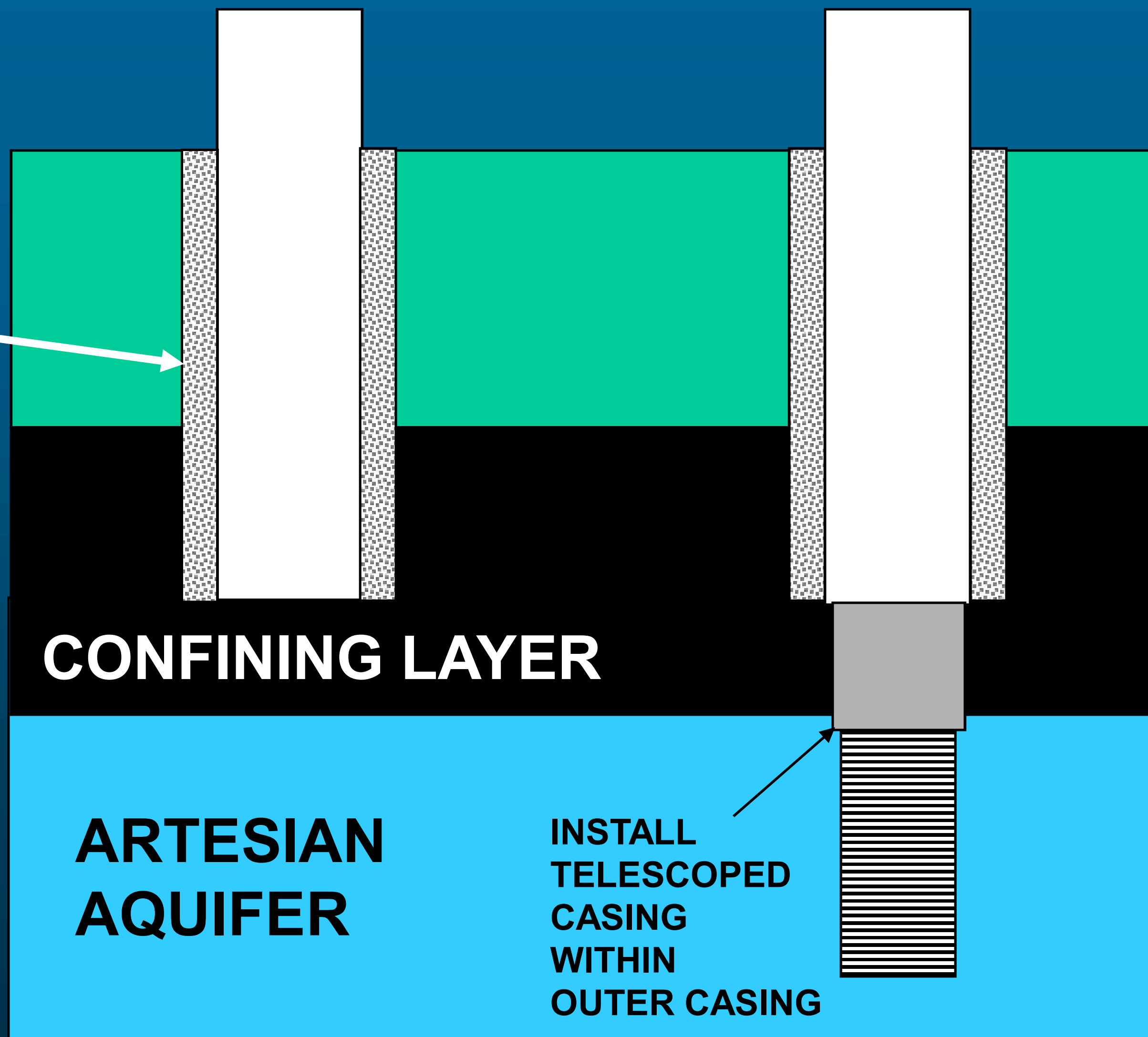
Is an entrance velocity of 0.099 ft/sec acceptable?



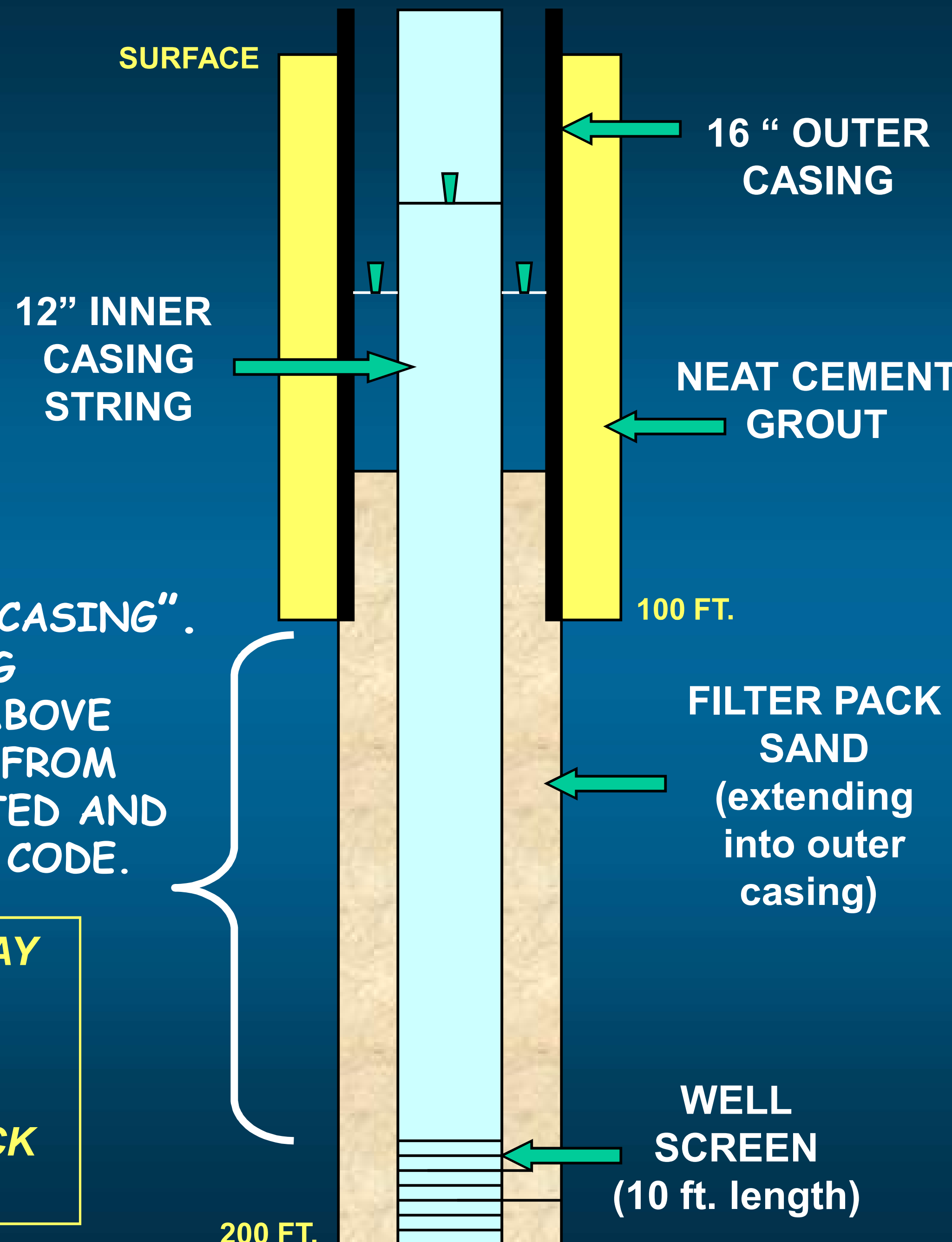
CROSS-SECTION OF SCREEN WIRE

IN KNOWN FLOWING WELL AREAS:

CEMENT CASING INTO CONFINING LAYER BEFORE PENETRATING ARTESIAN AQUIFER



HIGH-CAPACITY WELL DESIGN CONCERNS



INNER CASING IS "PERMANENT CASING". WELL CODE REQUIRES GROUTING FROM NOT MORE THAN 10 FT. ABOVE SCREEN UP TO SURFACE – ZONE FROM 100 FT. TO 190 FT. IS UNGROUTED AND VIOLATES R 325.1634a OF WELL CODE.

PROBLEMS FROM THIS DESIGN MAY INCLUDE:

- ***COMMINGLING OF WATER FROM SEPARATE AQUIFERS***
- ***STAGNANT WATER IN FILTER PACK ABOVE SCREEN***


CLEAN WATER PUMPED
FROM WELL DURING
FINAL DEVELOPMENT
STAGE

DRIVEN WELLS

- ❒ Installed in glacial drift only - CANNOT be driven thru boulders or into bedrock

- ❒ Well point driven into ground with post-driver, tripod w/ weight or sledge hammer

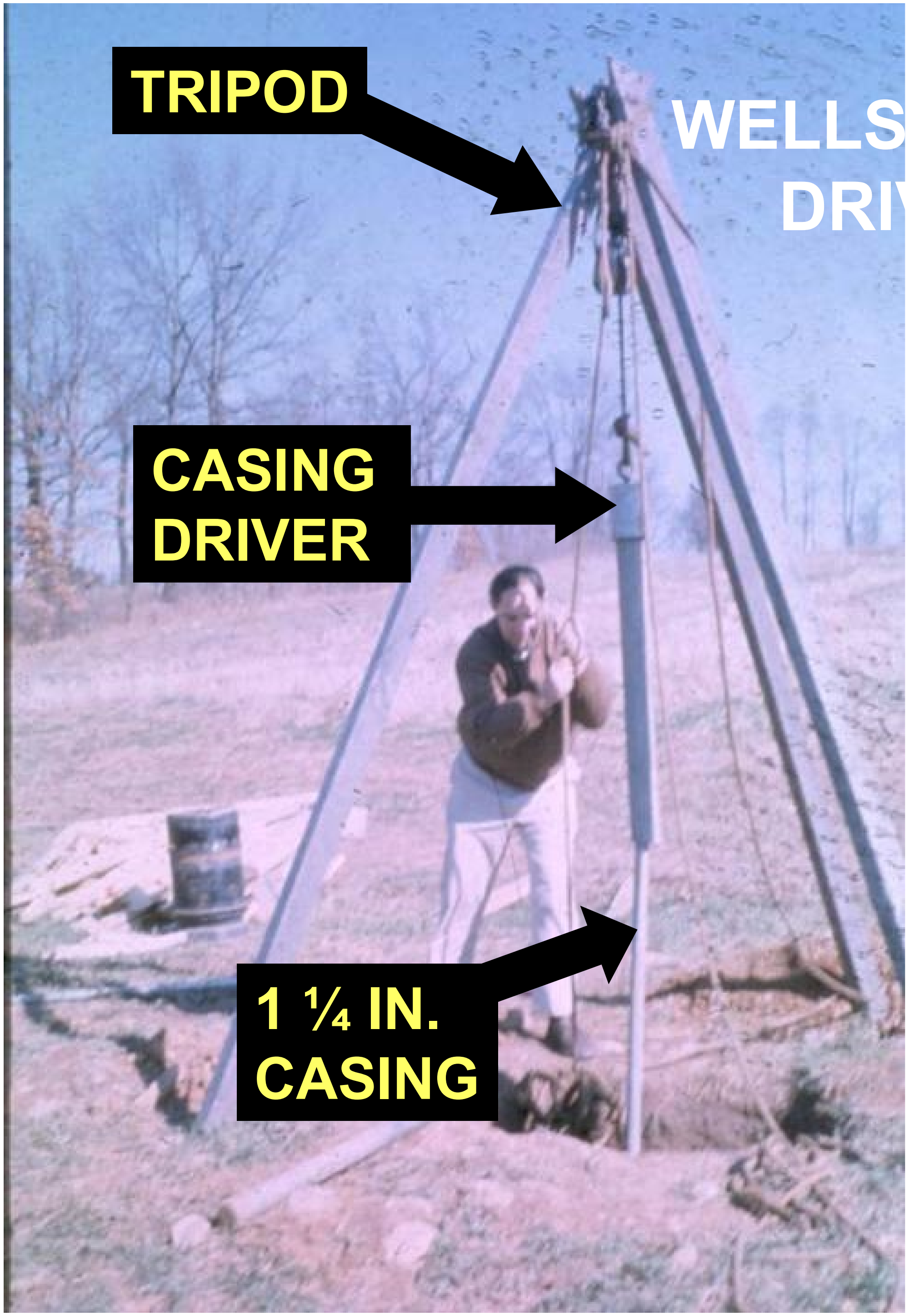
- ❒ 1 1/4 in. to 2 in. diameter

DRIVEN WELLS

- ❐ Installed by property owners
- ❐ Common around lakes and high water table areas
- ❐ Most <35 ft. deep, limited yield (7 gpm or less)

MORE SUSCEPTIBLE TO SURFACE CONTAMINATION THAN DRILLED WELLS

WELLS BEING DRIVEN



DUG WELLS

- Large diameter (18-48 in.)
- Found in low yield areas

- Casing material - concrete crocks w/ loose joints

  Older wells: stones, brick-lined

- Water enters well through loose casing joints


SHALLOW UNSANITARY DUG CROCK WELL


OLD UNSANITARY HAND-DUG WELL
LINED WITH FIELD STONE

DUG WELLS

- Older wells - hand dug
- Now installed (on very limited basis) w/ bucket augers (backhoes – phased out)
- Low well yield - storage in casing (100's of gallons)
- HIGHLY VULNERABLE TO CONTAMINATION

CDC Findings on Dug Wells

- Dug/bored wells had a positive coliform bacteria rate of about 85%
- Wells with brick, concrete or wood casing (dug wells) had coliform positive rates of 60 – 90 %

From *A Survey of the Presence of Contaminants in Water From Private Wells in Nine Midwestern States*, Atlanta, Georgia, U.S. Dept. of Health and Human Services, Public Health Service, Centers for Disease Control, 1996

REMEMBER…..

ALWAYS DRINK UPSTREAM OF THE HERD

QUESTIONS

Contact DEQ Well Construction Program at 517-241-1380

THANKS FOR TAKING STRESS