# Water Level Fluctuations
# (Causative factors and their measurements)

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# Water Level Fluctuations
## (Causative factors and their measurements)

A groundwater level, whether it be the water table of an unconfined aquifer or the piezometric surface of a confined aquifer, indicates the elevation of atmospheric pressure of the aquifer. Differences between supply and withdrawal of groundwater cause levels to fluctuate.

Stream flow variations are closely related to groundwater levels.

Other diverse influences on groundwater levels include:

1. **Evapotraspiration**
2. **Meteorological**
3. **Tidal phenomena**
4. **Urbanization**
5. **earthquakes**
6. **External loads**

Subsidence of land surface occur due to changes in underlying groundwater conditions

## Stream flow and groundwater levels

Where a stream channel is in direct contact with an unconfined aquifer, the Stream may recharge the groundwater or receive discharge from the groundwater.

1. Gaining stream
2. Losing stream

**Bank Storage:** During a flood period of a stream, groundwater levels are temporarily raised near the channel by inflow from the stream. The volume of water so stored and released after the flood is referred to as “bank storage”.

**Base Flow:** Stream flow originating from groundwater discharge is referred to as groundwater runoff or base flow. During periods of rainfall stream flow is derived primarily from surface flow, whereas during extended dry periods all stream flow may be contributed by base flow.

## Fluctuations due to Evapotraspiration

Unconfined aquifers with water tables near ground surface frequently exhibit diurnal fluctuations due to evaporation or transpiration. Both processes causes a discharge of groundwater into the atmosphere.

From a practical stand point, it is difficult to segregate evaporation and traspiration losses from groundwater, therefore, the combined loss, is referred to as evapotraspiration (or consumptive use) is normally measured.

## Fluctuations due to Meteorological Phenomenon

1) **Atmospheric pressure:** changes in atmospheric pressure produce sizable fluctuations in wells penetrating confined aquifers. For an unconfined aquifer, atmosphere pressure changes are transmitted directly to the water table, both in the aquifer and in a well (no pressure difference occur)
2) **Rainfall:** Rainfall is not accurate indicator of groundwater recharge because of surface and subsurface losses as well as travel time for vertical percolation.

**3. Wind:** Minor fluctuations of water levels are caused by wind blowing over the tops of wells. As a gust wind blows across the top of a casing, the air pressure within the well is suddenly lowered and as a consequence, the water level quickly rises. After the gust passes, the air pressure in the well rises and the water level falls.

**4. Frost:** In regions of heavy frost it has been observed that shallow water tables decline gradually during the winter and rise sharply in early spring before recharge from ground surface could occur. The fluctuations can be attributed to the presence of a frost layer above the water table.

**Fluctuations due to Tides:** In coastal aquifers in contact with the ocean, sinusoidal fluctuations of groundwater levels occur in response to tides. If the sea level varies with a simple harmonic motion, a train of sinusoidal waves is propagated in land from the submarine outcrop of the aquifer.

**Urbanization effect:** The process of urbanization often causes changes in groundwater levels as a result of decreased recharge and increased withdrawal. Urbanization on groundwater levels are:

1. Reduced groundwater recharge due to paved surface areas and storm sewers
2. Increased groundwater discharge by pumping wells
3. Decreased groundwater recharge due to export of wastewater collected by sanitary sewers.

**Fluctuations due to Earthquakes:** Earthquakes have a variety of effects on groundwater i.e. sudden rises or falls of water levels in wells, changes in discharge & appearance of new springs and eruption of mud out of the ground.

**Fluctuations due to External Loads:** The application of load compresses the aquifer and increases the hydrostatic pressure. Thereafter the pressure decreases and approaches its original value as water flows radially away from the point where the load is applied. Thus, initially the load is shared by the confined water and the solid material of the aquifer, however, as the water flows radially outward, an increasing proportion of the load is borne by the structure of the aquifer.

## LAND SUBSIDENCE AND GROUNDWATER

Changes in groundwater levels or subsurface moisture conditions may be responsible for subsidence of the land surface.

**Lowering of Piezometric surface:** Land subsidence has been observed to accompany extensive lowering of the piezometric surface in regions of heavy pumping from confined aquifers.

*The subsidence can be explained based on fundamentals of soil mechanics and pressure diagram for a confined aquifer overlain by an unconfined aquifer.*

Initially, the total (geostatic) pressure Pt at any depth is where Ph is the hydraulic pressure and Pi is intergranular pressure. Pt = Ph+Pi.

If pumping in the confined aquifer lowers the piezometric surface while the water table remains unchanged due to an impermeable clay layer separating the aquifers; then equation becomes - $P_t = P_h' + P_i'$

$P_h' < P_h$ and $P_i' > P_i$ for both the confined aquifer and the clay layer.

Adjustments to these new pressure distributions will take place essentially instantaneously in the permeable, coarse grained aquifer, because sand and gravel are relatively incompressible, the increased inter granular pressure has a negligible effect on the aquifer.

But in the impermeable formations (fine grained clay) this adjustment may take months to years, because clayey materials are highly compressible, the increased inter-granular pressure ($P_i'-P_i$) causes the clay layer to be compacted. This reduces its porosity, while water contained in the clay pores is squeezed downward into the confined aquifer.

The control measure for this type of land subsidence is increasing piezometric levels reducing pumping and by recharge of water through injection wells.

**Hydro-compaction:** Collapse of the ground surface has been observed to occur when water is applied to certain types of soils. Ex: 1) loose, moisture deficient alluvial deposits and 2) moisture deficient loess deposits.

# Groundwater Legislation

**The legislative considerations for development and management of groundwater is:**

Control and regulation of groundwater use – i.e.

- To prevent overdraft and mining of aquifers
- To prevent groundwater pollution

## Need for control and regulation of groundwater use

- Global groundwater represent only 0.6% of worlds total water wealth in the hydrosphere
- The availability of groundwater at the point of water requirement avoiding costly conveyance cost
- Increasing population demands more groundwater
- Excessive withdrawals results overdraft, land subsidence, water quality deterioration and uneconomic pumping conditions

## 1) Status of legislation, regulation and control in India

Groundwater being STATE subject.

As per Entry 17 of list II of 7th schedule of the Constitution of India, only States are empowered to enact laws in control and regulate groundwater exploitation.

The groundwater (control and regulation) bill of 1970 envisages the setting up of a GROUNDWATER AUTHORITY and

introduction of:

- a licensing system for extraction of groundwater in notified areas
- Registration of existing users in notified areas
- Imposition of penalty for contravening (breaking the law) certain provisions.

Only Gujarat State has executed groundwater legislation in India

# 2) Control by Financing Agencies:

In recent years, availability of institutional finance (for construction and energisation of wells) has increased prospects of reaching critical stage of overdraft in some parts of the country. Control is not exercised by the financing agencies to prevent indiscriminate sinking of wells.

STATE GROUNDWATER ORGANISATION accords clearance for implementation of well sinking and energisation of wells based on the groundwater balance studies of the area.

The groundwater balance is estimated by applying the concept of the STATE OF GROUNDWATER DEVELOPMENT.

$$\text{State of Development} = \frac{\text{Net estimated extraction}}{\text{Net estimated recharge}} \times 100$$

On the basis of State of groundwater development, areas have been classified as 1) White area (upto 60%), 2) Grey area (60-80%) and 3) Dark area (>80%).

# Groundwater Pollution Control:

**If by legislation, the discharge effluents is licensed, it is easier to trace sources of pollution.**

**In India the law relating to prevention and control of pollution is governed by the WATER ACT, 1974.**

**In this act pollution has been explained in a comprehensive manner. Disposal of pollutants into streams or subterranean waters is restricted**

**Under this act, a CENTRAL BOARD OF PREVENTION AND CONTROL OF WATER POLLUTION was constituted. The act also provides for constitution of boards in the STATES.**

**The functions of the Central Board are generally advisory, while the State have regulatory functions of inspection of effluents, treatment plants and the power to impose penalties.**

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