Cooper- Jacob Method of Solution

For small values of r and large values of t, u is small.

$$u = \frac{r^2 S}{4Tt}$$

$$W(u) = -0.5772 - lnu + u - \frac{u^2}{2x2!} + \frac{u^3}{3x3!} - \frac{u^4}{4x4!} + \cdots \ldots$$

negligible

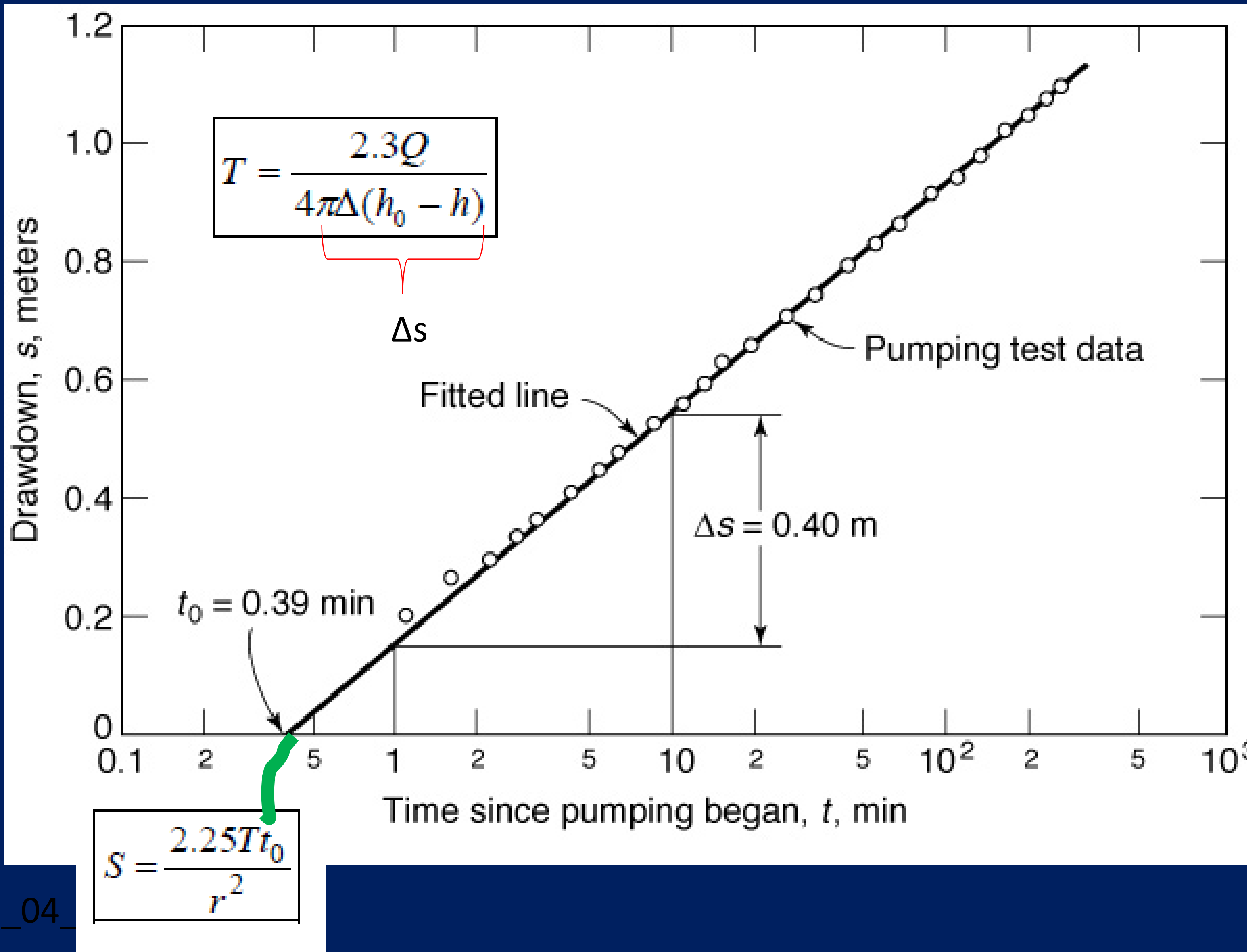
$$s = h_0 - h = \frac{Q}{4\pi T} W(u) = \frac{2.3Q}{4\pi T} (log_{10} \frac{2.25Tt}{r^2 S})$$

For this equation to be valid

$u<0.01$

Cooper- Jacob Method of Solution

Time-Drawdown Data in a single observation well (r= constant)



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Time Variations of Groundwater Levels

Secular variations (extend over periods of years-alternating series of wet and dry years)

Seasonal variations (influences such as rainfall and irrigation pumping)

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.

Long-period fluctuations of levels

Alternating series of wet and dry years, in which the rainfall is above or below the mean, will produce long-perid fluctuations of levels. Rainfall is not an accurate indicator of groundwater level changes. Recharge is the governing factor (assuming annual withdrawals are constant). It depends on rainfall intensity and distribution and amount of surface runoff.

If pumping exceeds recharge, a downward trend of groundwater levels may continue for many years.

Fluctuations due to meteorological phenomena:

1) Atmospheric pressure- In confined aquifers, when atmospheric pressure increases, water level decreases (the relationship is inverse). No such effect in unconfined aquifers

When atmospheric pressure changes are expressed in terms of a column of water, the ratio of water level change to pressure change expresses the barometric efficiency of an aquifer.

$$B = \frac{\gamma \Delta h}{\Delta p_a}$$

2) Rainfall

Rainfall is not an accurate indicatior of groundwater recharge because of surface and subsurface losses as well as travel time for vertical percolation. The travel time may vary from a few minures to months or years. In arid and semi-arid regions- recharge from rainfall might be zero. Shallow water tables show definite responses to rainfall.

The rise due to response to recharge from rainfall: $\Delta h = P/S_y$ P= portion of rainfall percolating to 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 inland from the submarine outcrop of the aquifer. With distance, inland amplitudes of the waves decrease.

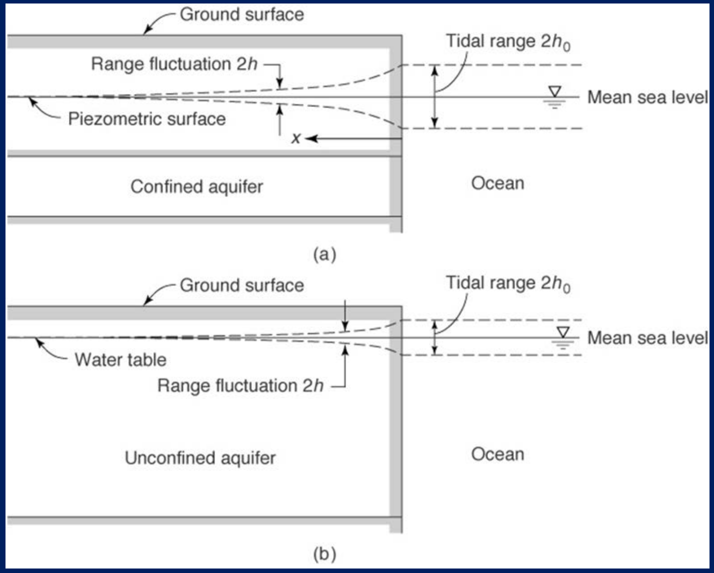
$$h = h_0 * e^{-x\sqrt{\pi n e/Tto}}$$

h= half range of the rise or fall of the piezometric surface with reference to the mean level

X is the distance inland from the outcrop- m

h_o= amplitude, or half-range, of the tide

t_o= tidal period



Groundwater Tracers

How to determine groundwater flow velocity and flow direction by using tracers?

An ideal tracer should

a) be susceptible to quantitative determination in minute concentrations,
b) Be absent or nearly so from the natural water
c) Not react chemically with the natural water or be absorbed by the porous media
d) Be safe in terms of human health
e) Be in expensive and readily available.

Water-soluble dyes (sodium fluorescein) detected by colorimetry, soluble chloride and sulfate salts and sugars detected chemically and strong electrolytes, which can be detected by electrical conductivity.

Groundwater flow direction, groundwater flow velocity, recharge area determination.


YAVUZLAR

Saline Water Intrusion in Aquifers

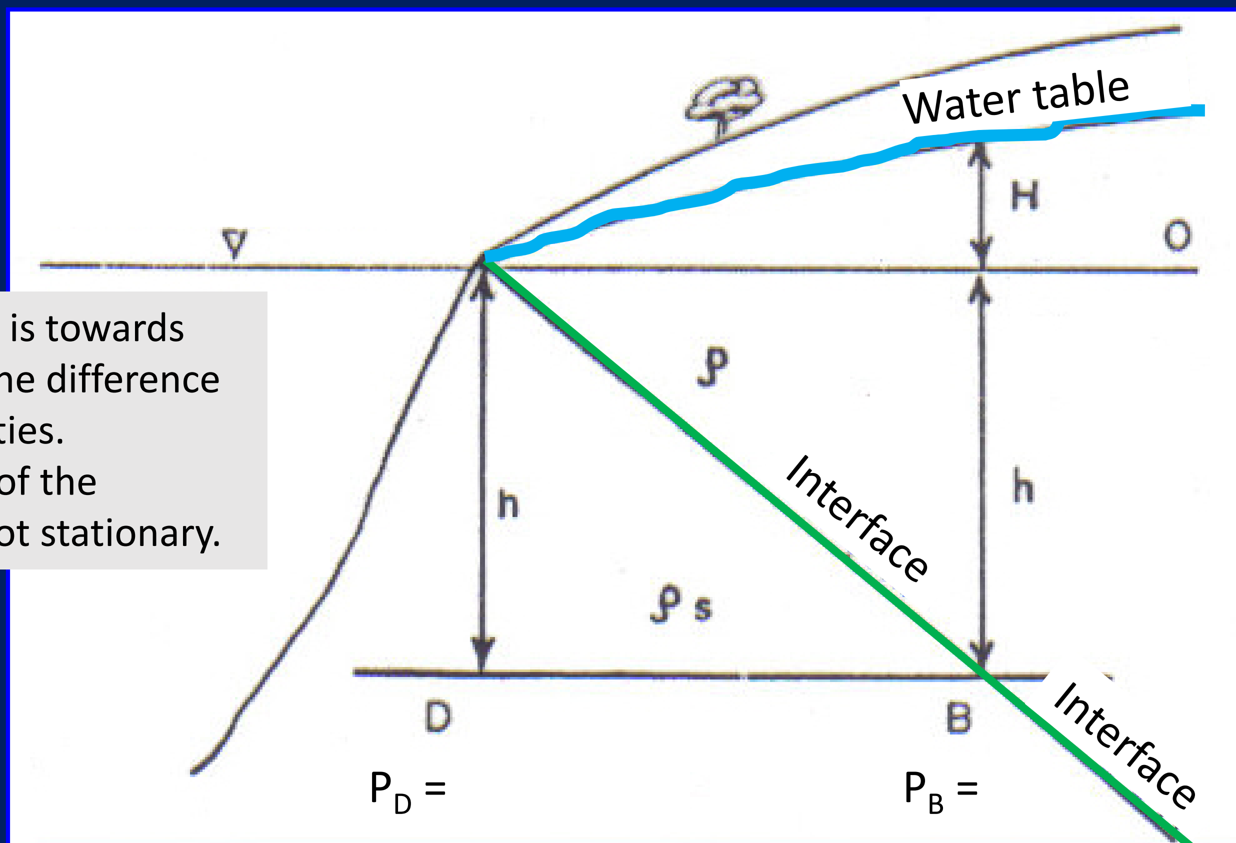
Intrusion of saline water occurs where saline water displaces or mixes with freshwater in an aquifer. The phenomenon can occur

a) in deep aquifers with the upward advance of saline waters of geologic origin,
b) in shallow aquifers from surface waste discharges,
c) and in coastal aquifers from an invasion of seawater.

Ghyben-Herzberg relation between fresh and saline waters

In 1889 Badon Ghyben worked in the Holland coast and in 1901 Herzberg worked in the Baltic Sea. They worked independently, and found out that salt water occured underground, not at sea level but at a depth below sea level of about 40 times the height of the fresh water above sea level. This distribution was attributed to a hydrostatic equilibrium existing between the two fluids of different densities.

The interface is towards land due to the difference in fluid densities.
The location of the interface is not stationary.



Ghyben-Herzberg model

The water table 30 m from the shoreline is located 0.65 m above sea level in an unconfined coastal aquifer. Determine the depth to the saltwater interface at this location using the Gyhben-Herzberg relation.