Today’s agenda

- Boundaries during pumping tests
- Linear superposition and image wells
- Regional groundwater flow

Well interference and Linear Superposition *over Space*

- Can be used to determine drawdown due to pumping from multiple wells (diagram below)
- Can be used to represent boundary conditions using image wells (Image Well Theory & Superposition)

Recall:

$$h_o - h(r,t) = \frac{Q}{4\pi T} W(u)$$

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

Multiple Pumping Wells:

Add predicted drawdowns at respective radii to get superposed resulting drawdown cone

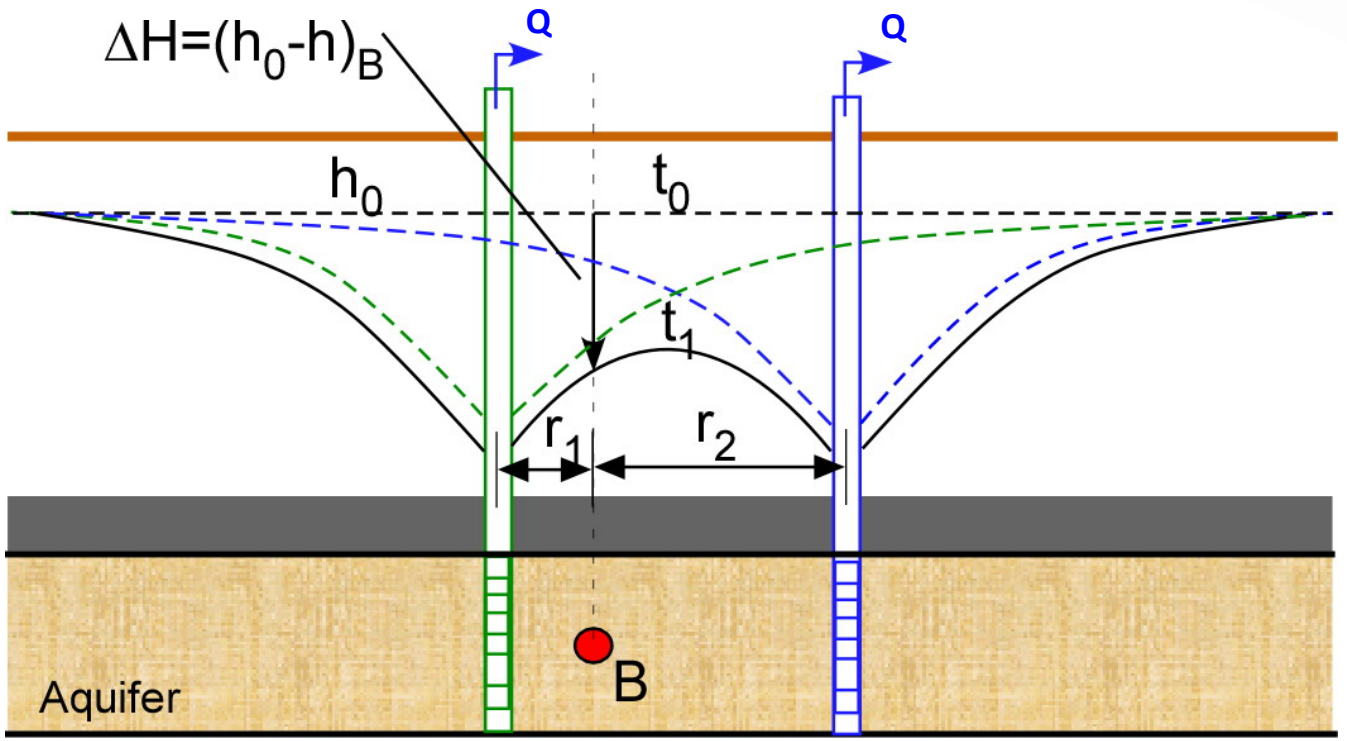
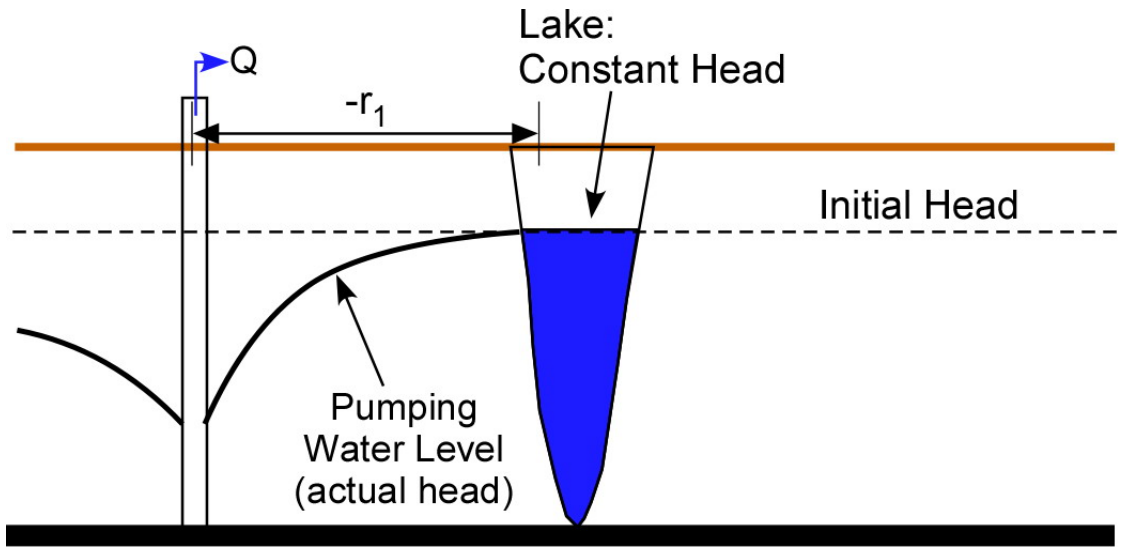


Image Well Theory & Superposition

Consider a constant head boundary:



To maintain a constant head at a lake:

- Introduce an image well
- It **recharges** (artificially)
- It creates a cone of ***impression*** (a **negative** cone of depression)
- Resultant cone is due to pumping well and recharge well

Image Well Theory & Superposition

Consider a constant head boundary:

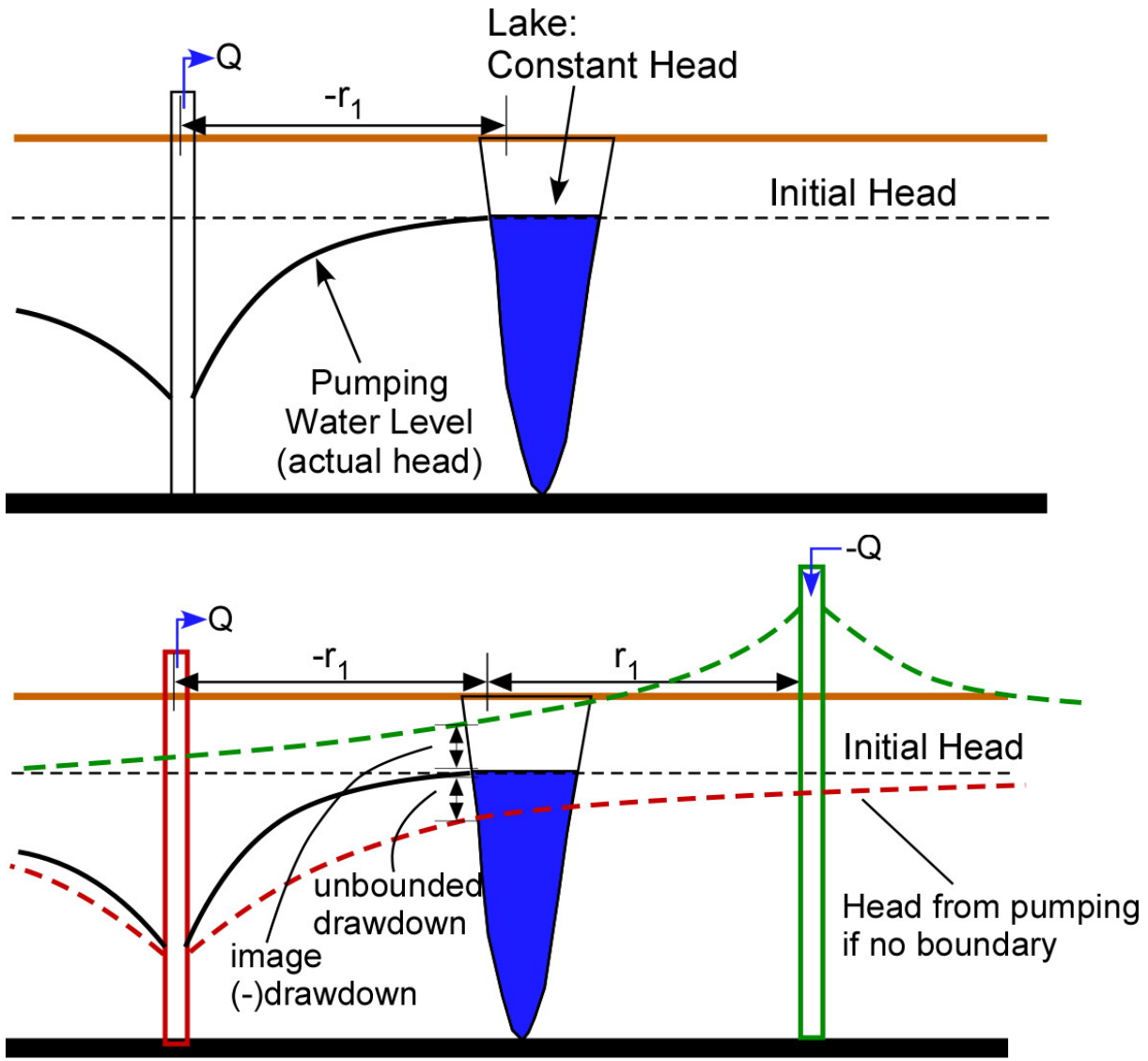
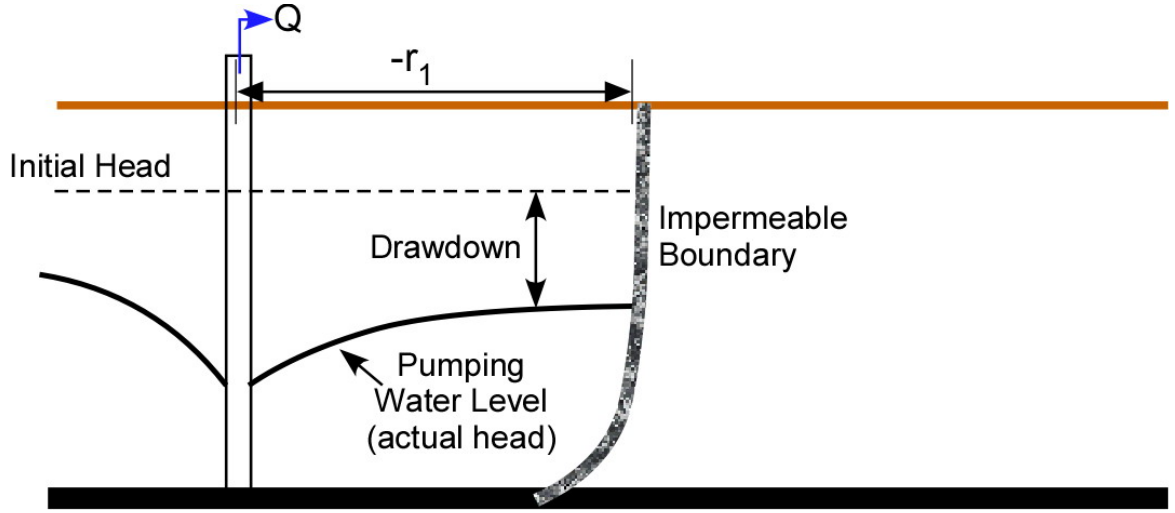
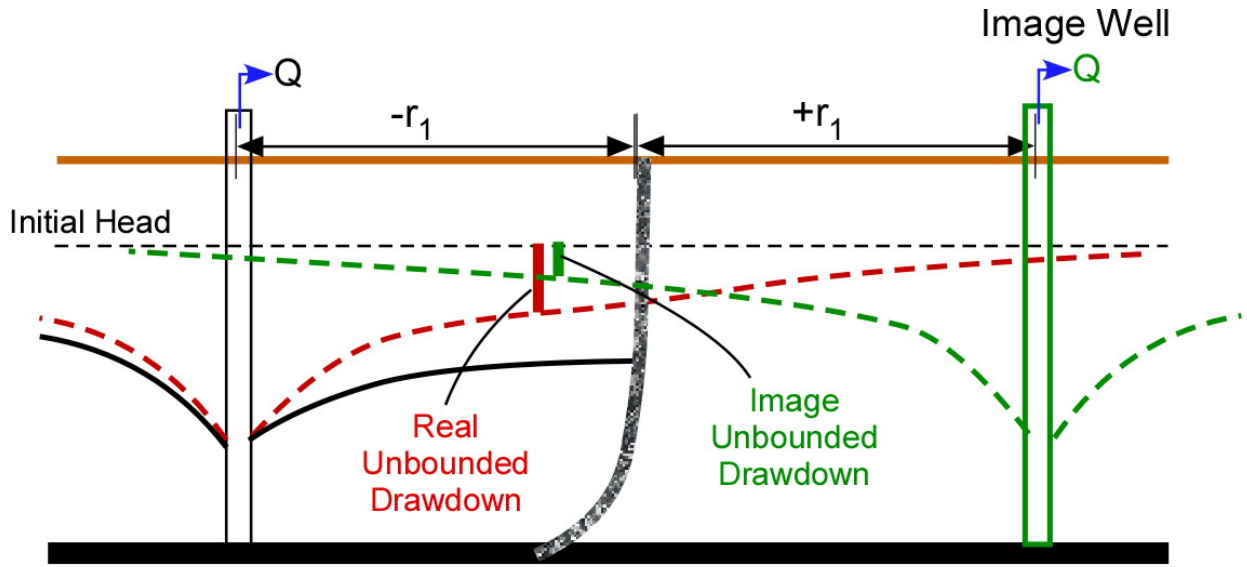


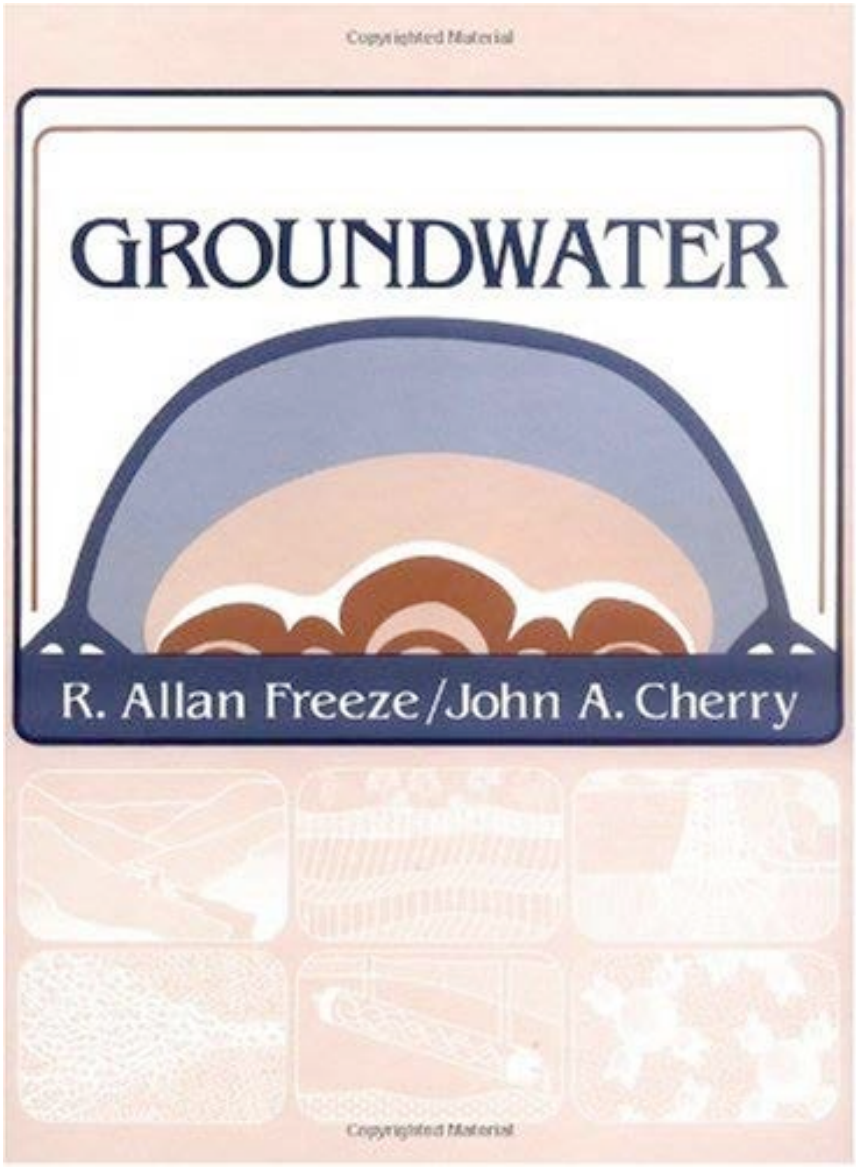
Image Well Theory & Superposition

Consider an impermeable boundary:

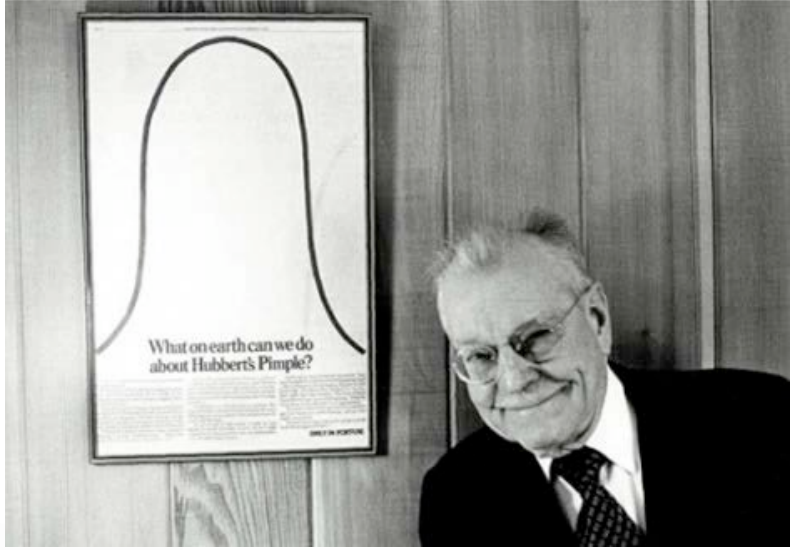




Regional Groundwater Flow

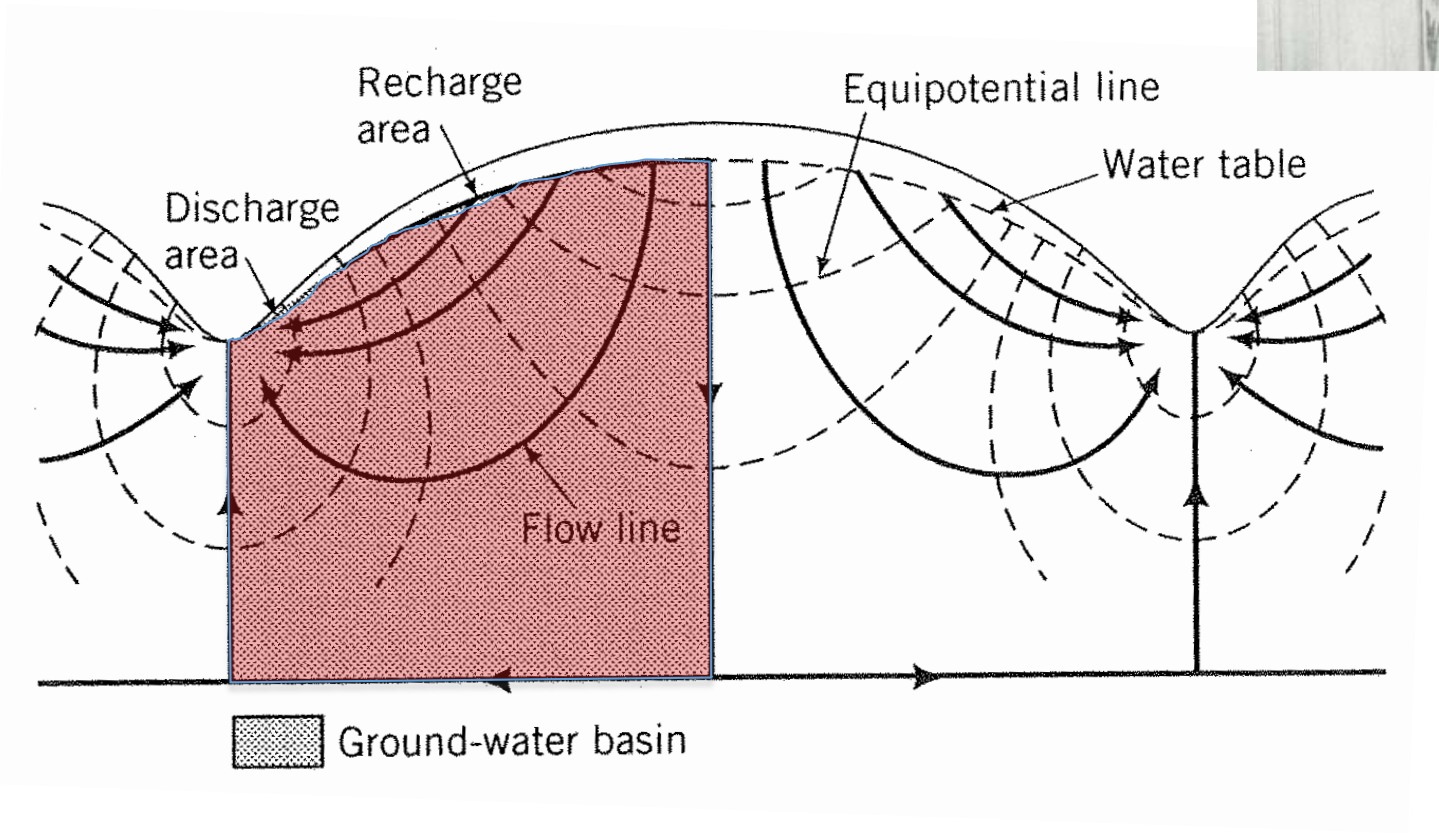


M. King Hubbert (1940)



Hubbert. 1940. The theory of ground water motion, *The Journal of Geology*, 48(8):785-944.

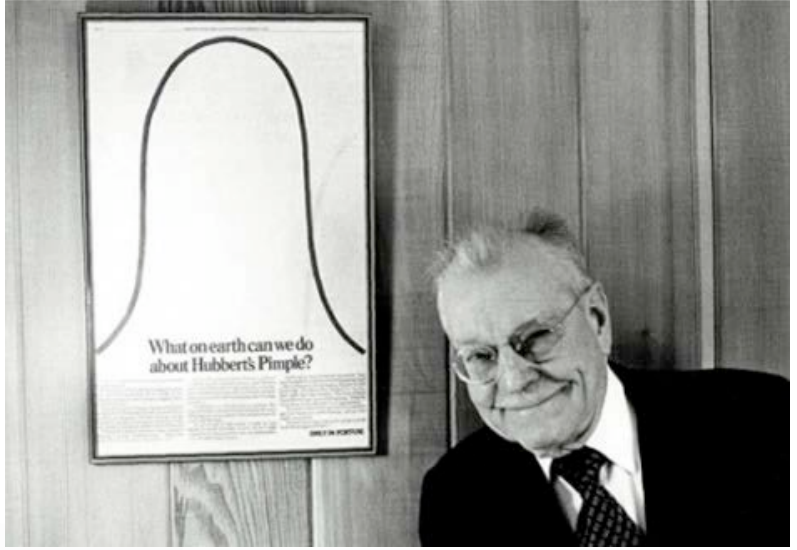
Regional, steady-state flow from uplands to streams:



1. Water table is "subdued replica" of topography

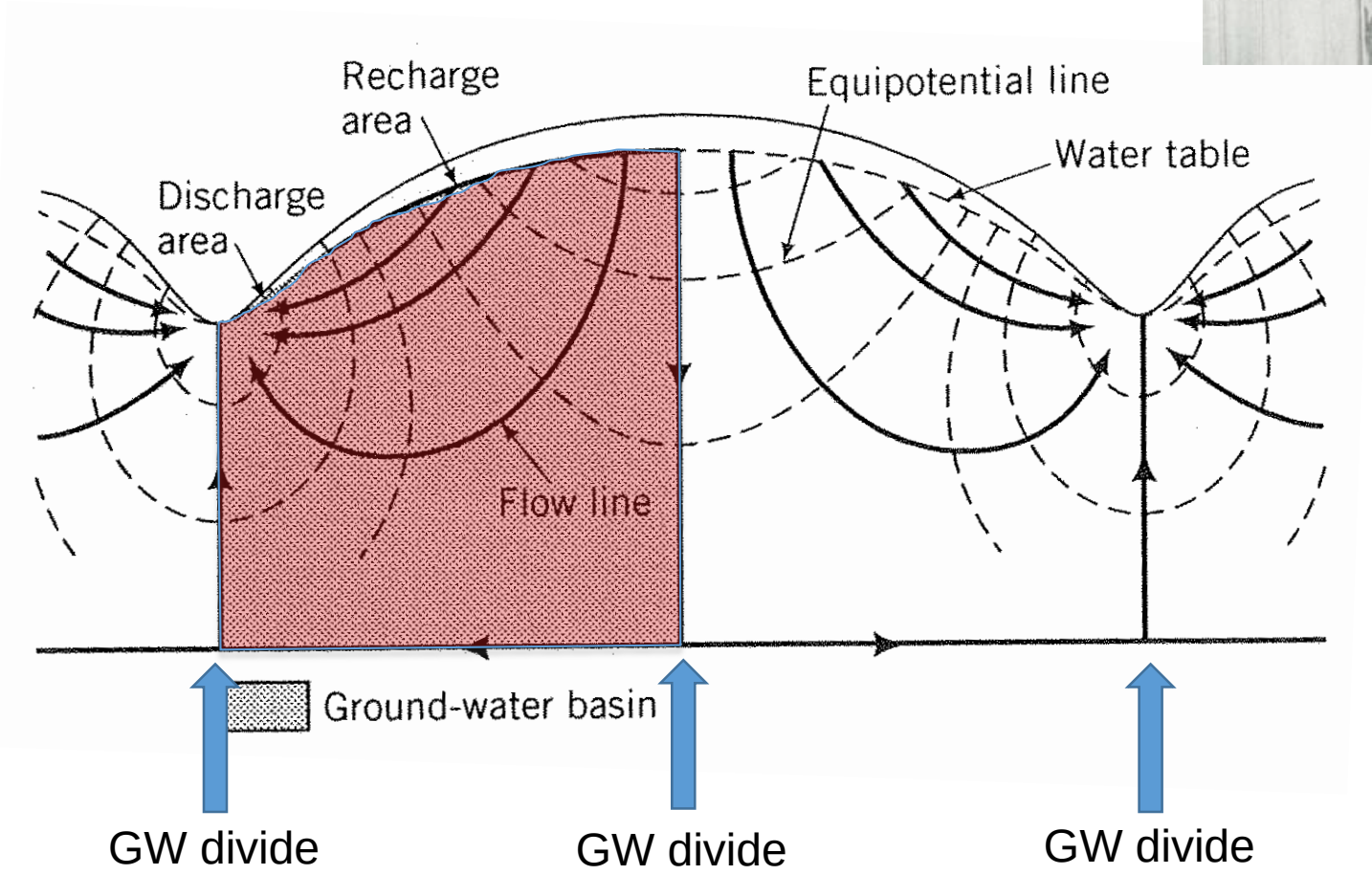
2. CLOSED System

M. King Hubbert (1940)



Hubbert. 1940. The theory of ground water motion, *The Journal of Geology*, 48(8):785-944.

Regional, steady-state flow from uplands to streams:

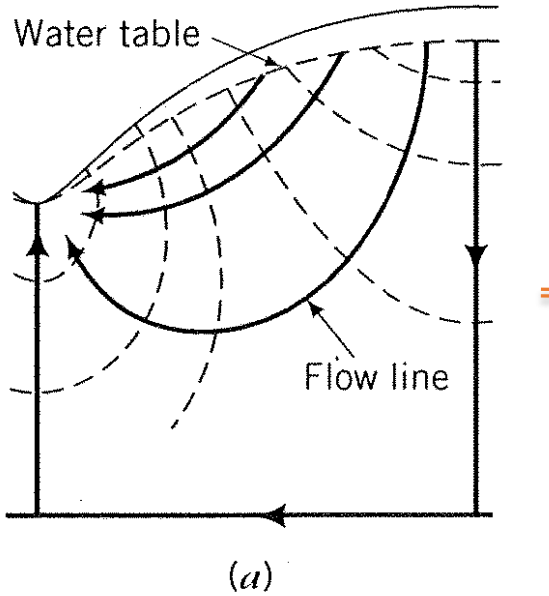


1. Water table is "subdued replica" of topography

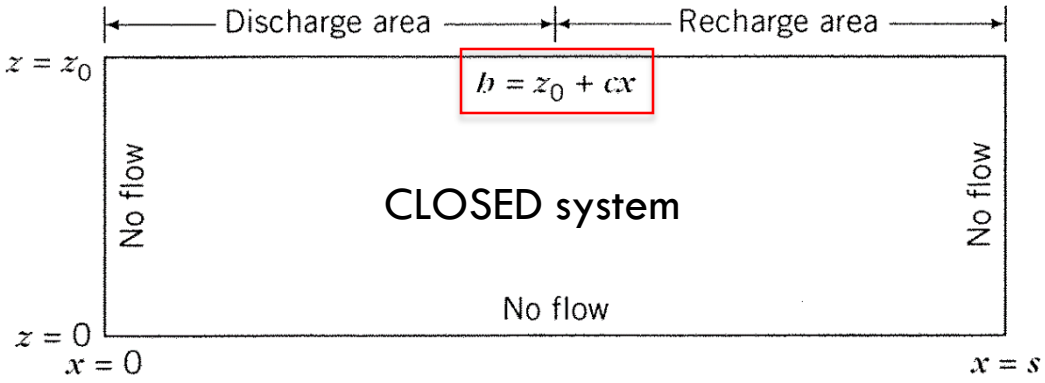
2. CLOSED System

J. Tóth (1962 and 1963)

How does the configuration of the water table affect flow in groundwater basins?

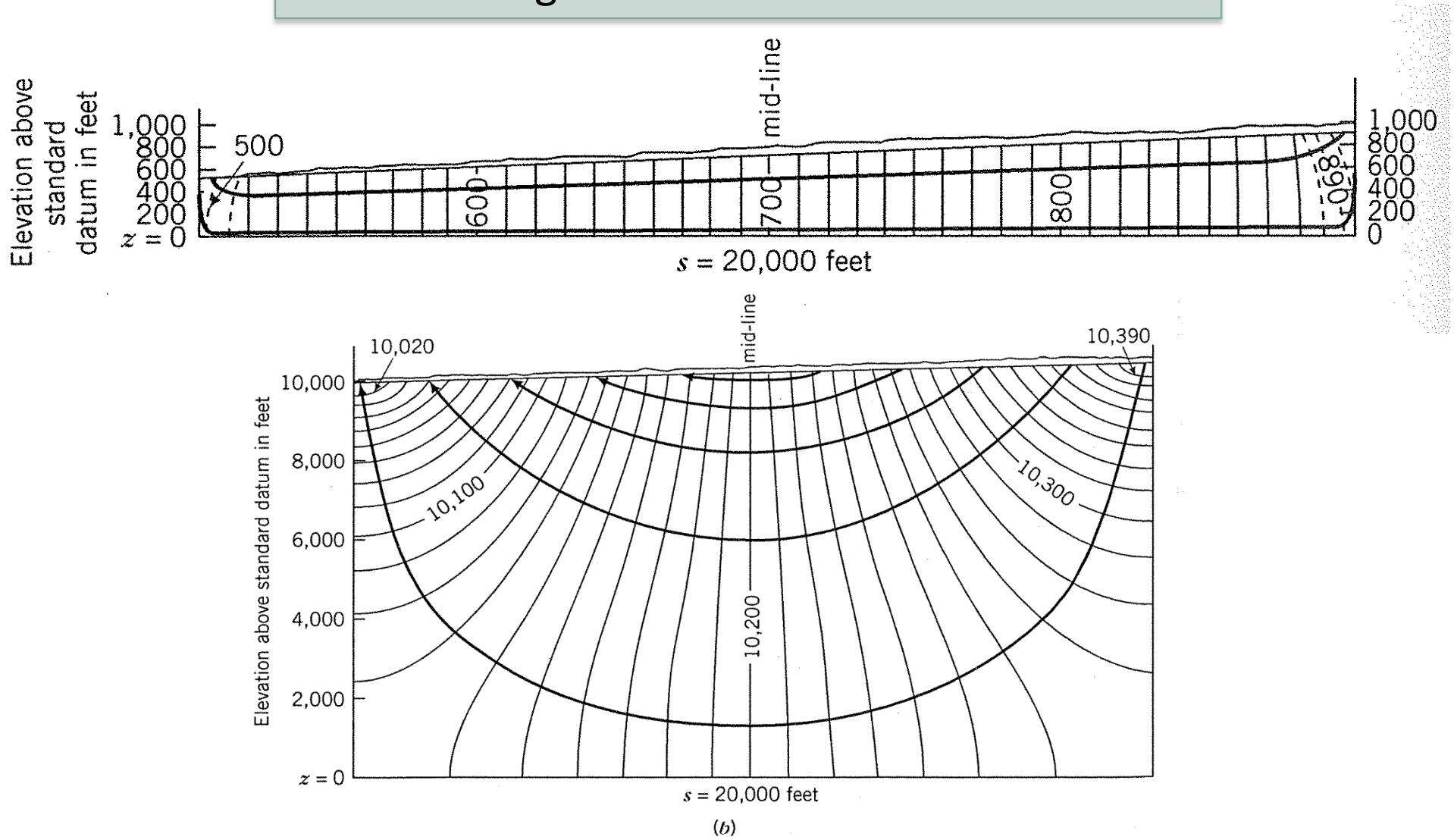


Start with the WT as a linear slope:



J. Tóth (1962 and 1963)

Effects of groundwater basin dimensions:



$$h = z_0 + \frac{cs}{2} - \frac{4cs}{\pi^2} \sum_{m=0}^{\infty} \frac{\cos\left[(2m+1)\,\pi x/s\right] \cosh\left[(2m+1)\,\pi z/s\right]}{(2m+1)^2 \cosh\left[(2m+1)\,\pi z_0/s\right]}$$

J. Tóth (1962 and 1963)

How does topography of the water table impact patterns of flow?

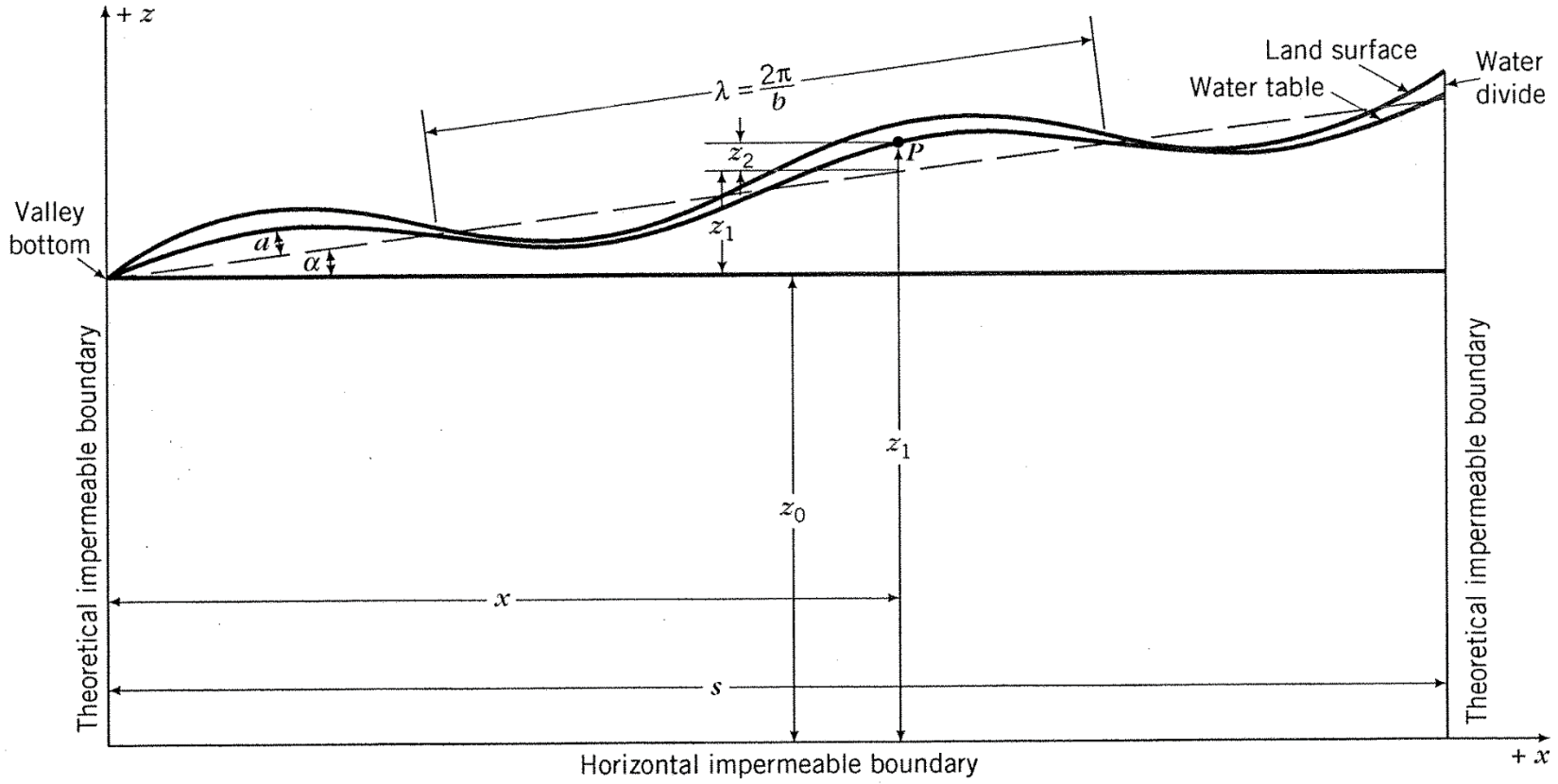
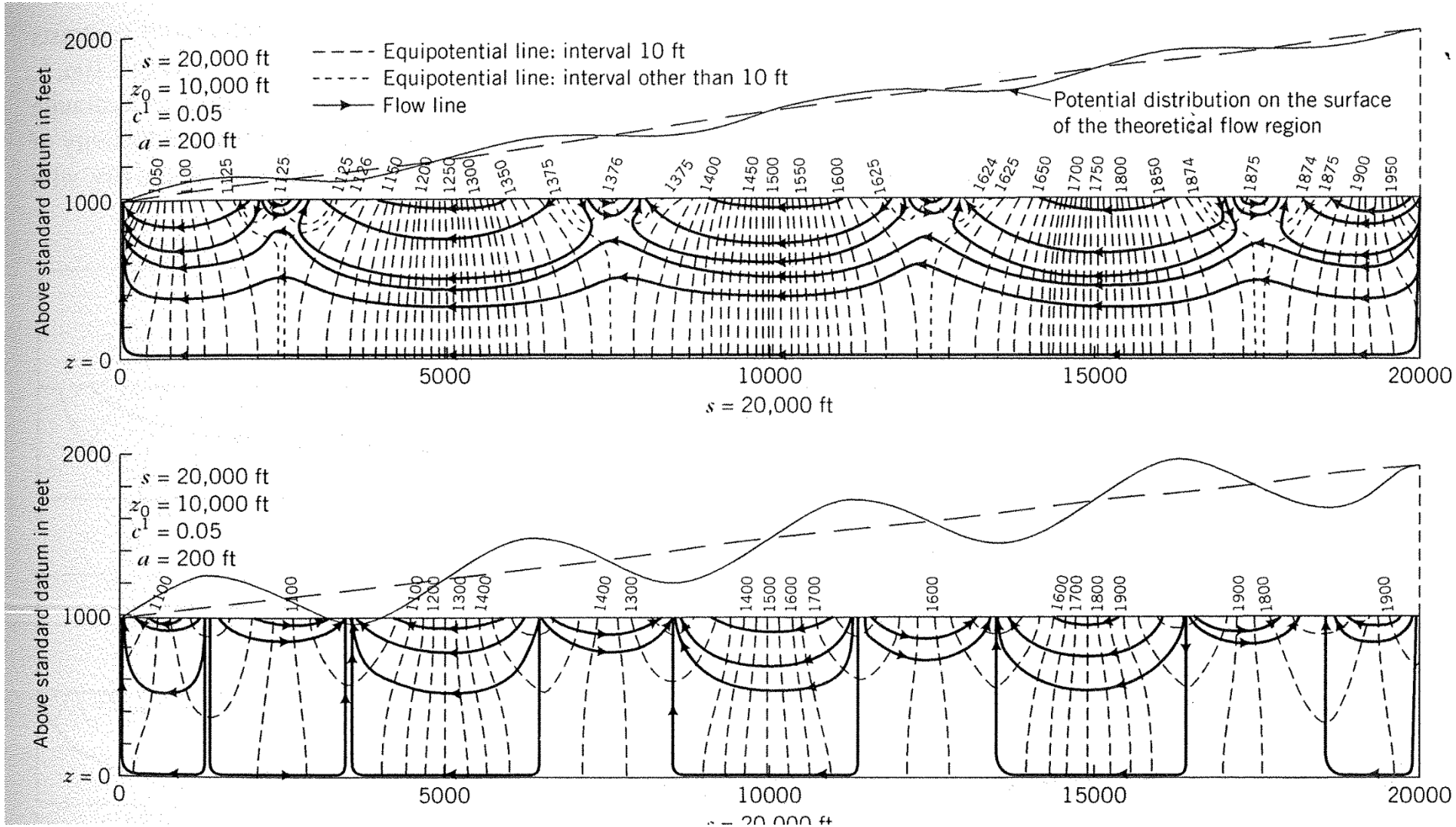
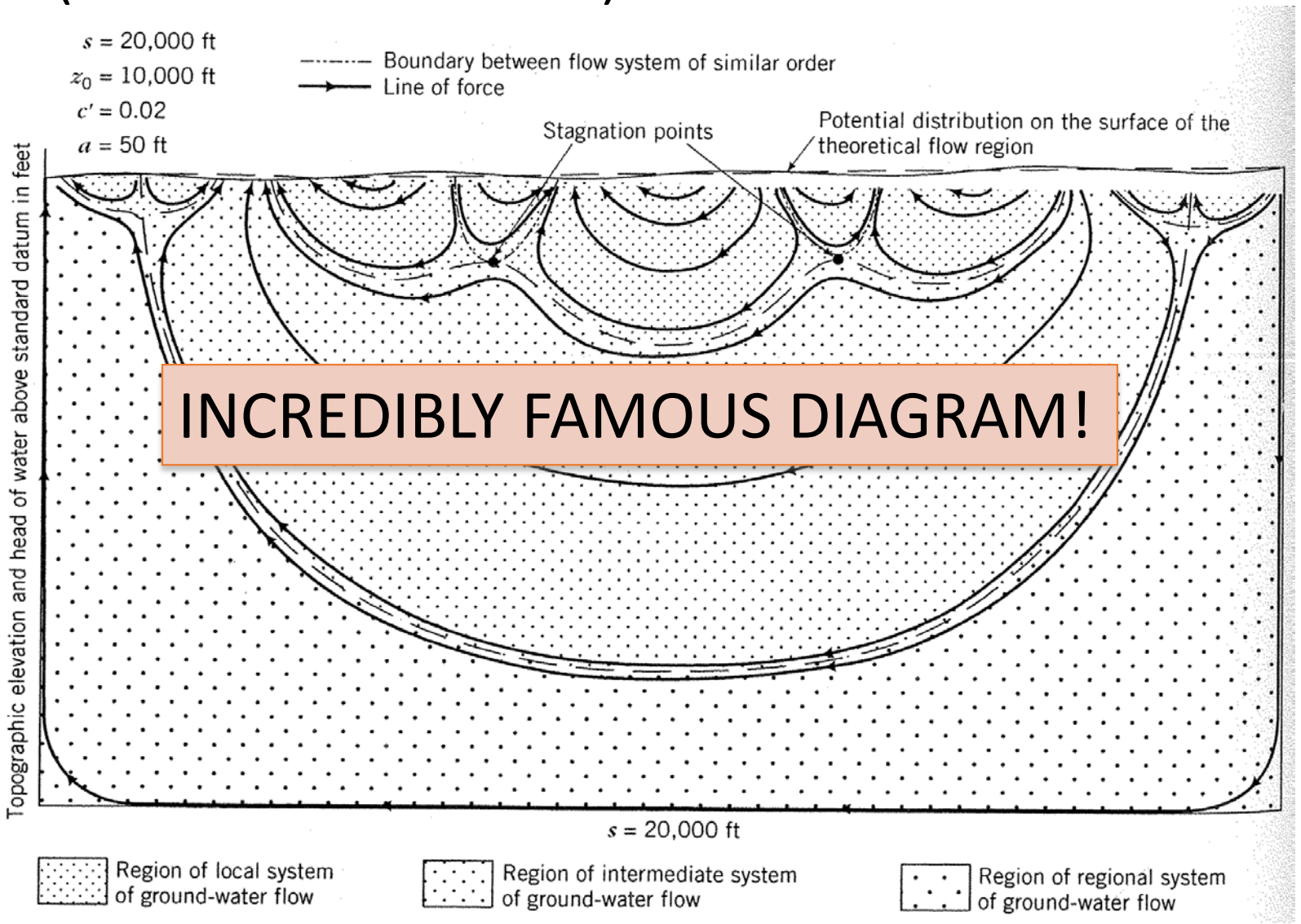


Figure 8.5 Two-dimensional simulation domain for analyzing how a sinusoidal water table with a regional slope affected ground-water flow (from Tóth, *J. Geophys. Res.*, v. 68, p. 4795–4812, 1963). Copyright by American Geophysical Union.

J. Tóth (1962 and 1963)



J. Tóth (1962 and 1963)



INCREDIBLY FAMOUS DIAGRAM!

GROUNDWATER

R. Allan Freeze/John A. Cherry

Tóth's Conclusions

1. If there is little local relief, regional systems develop. If local relief is large, local systems dominate.
2. Water samples collected at nearby locations may be unrelated in origin.
3. Stagnation points form where flow systems meet.
4. Major streams only get water from adjacent topographic highs and regional flow.