

SITE DEWATERING

Dr. Sherif A Y Akl

Source:

Lecture Notes by Prof. Dr. Mostafa AbuKiefa

Cairo University



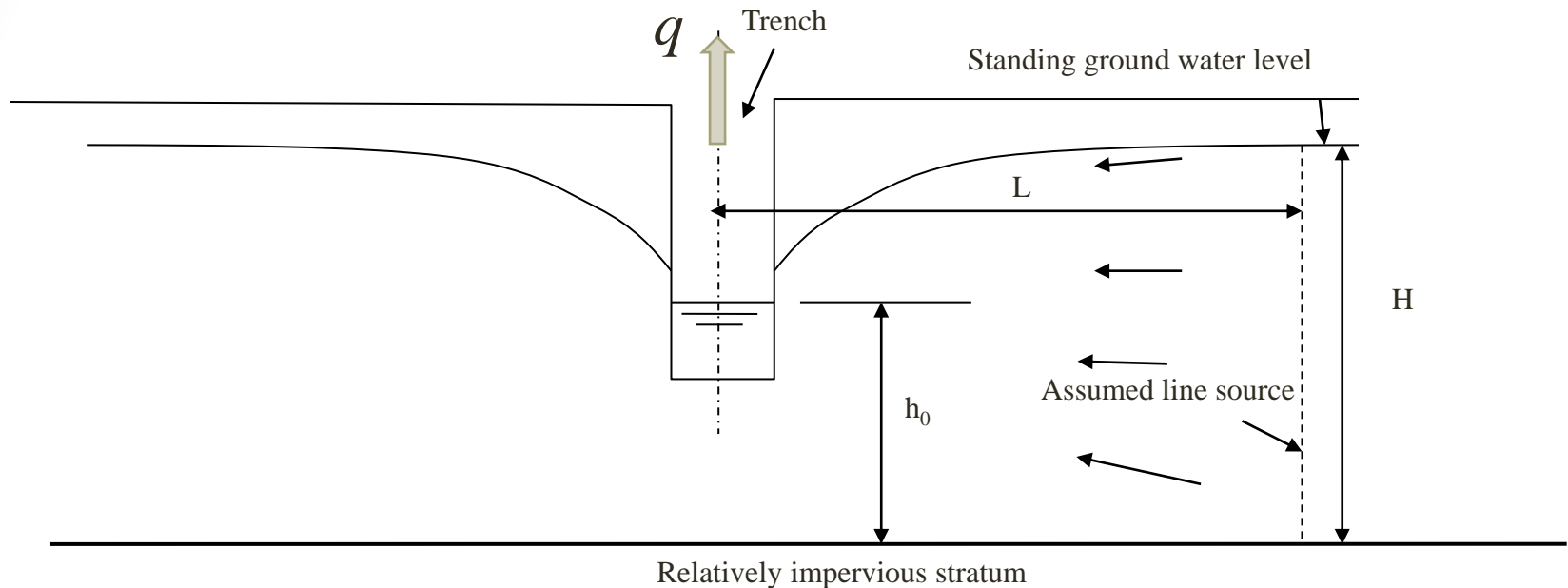
Dewatering Systems

Gravity Drainage Methods

- 1. Sumps, Trenches, and Pumps**
- 2. Well Point Systems**
- 3. Deep Well Systems**



Gravity Flow To Trench Excavation (Slot)



$$q = \left[0.73 + 0.27 \left(\frac{H - h_0}{H} \right) \right] \frac{K}{2L} (H^2 - h_0^2) \quad \begin{array}{l} H, h_0, L \text{ [m]} \\ K \text{ [m/sec]} \end{array}$$

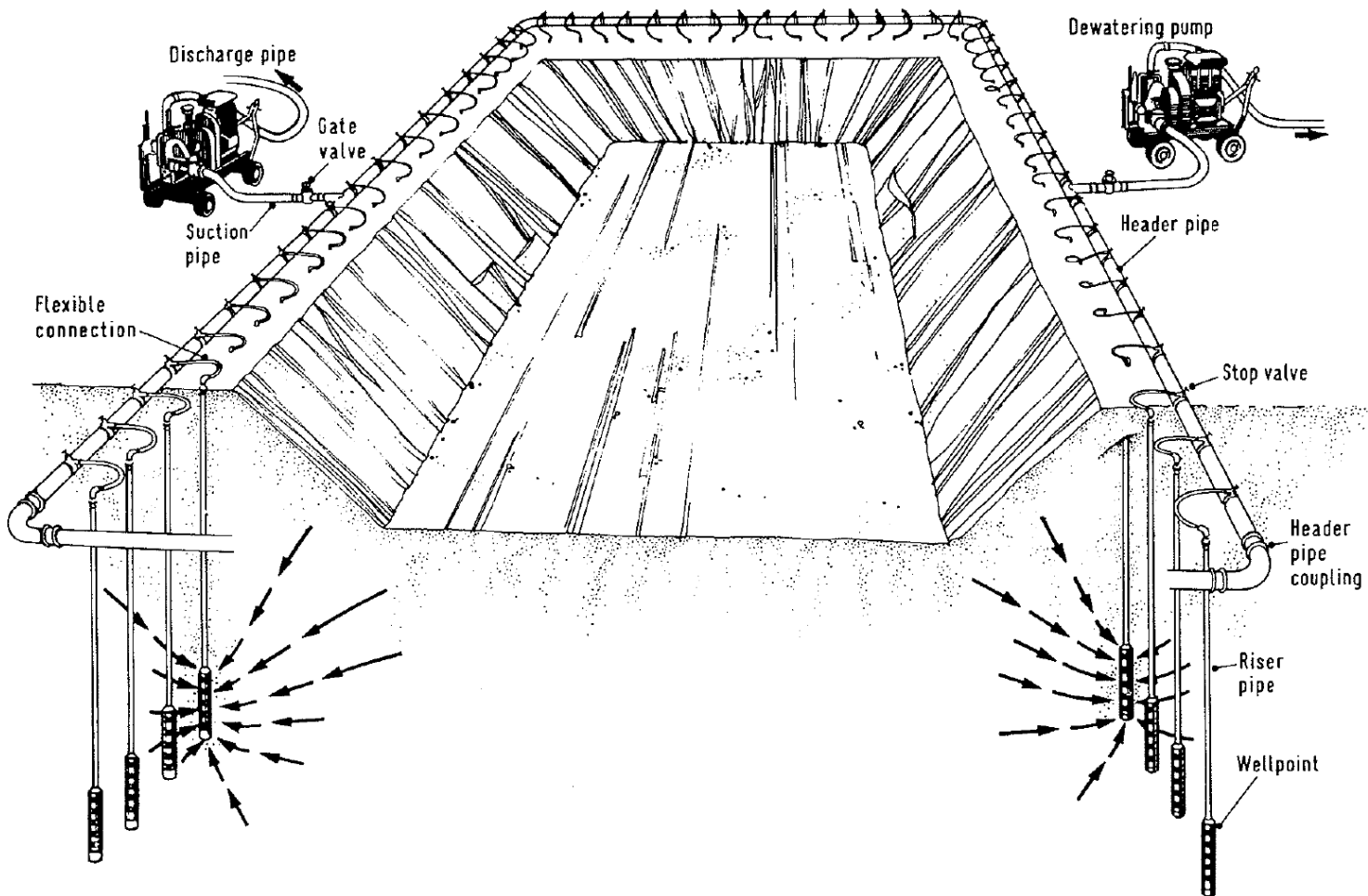
$$L = 1500 (H - h_0) \sqrt{K} \quad \begin{array}{l} H, h_0, L \text{ [m]} \\ K \text{ [m/sec]} \end{array}$$



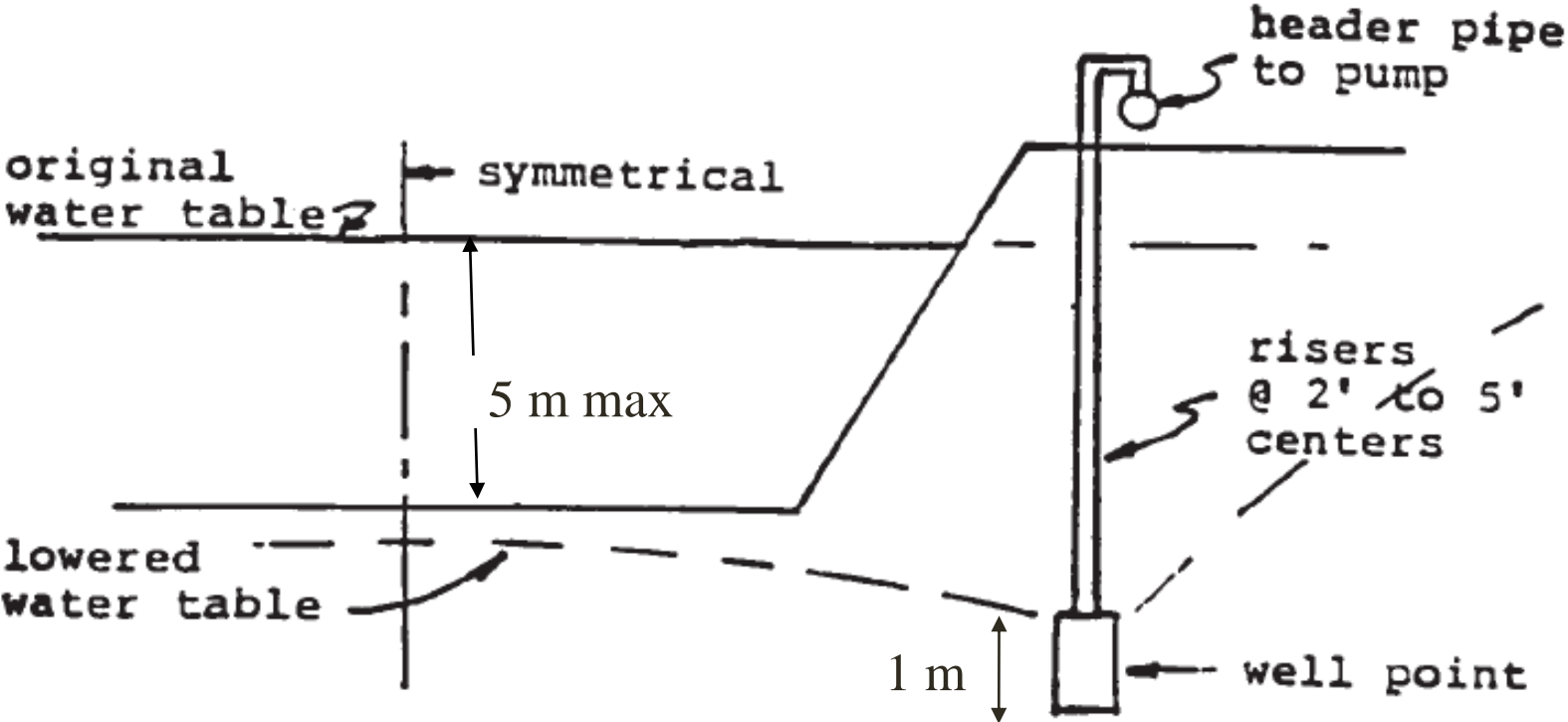
2- Well Point Method



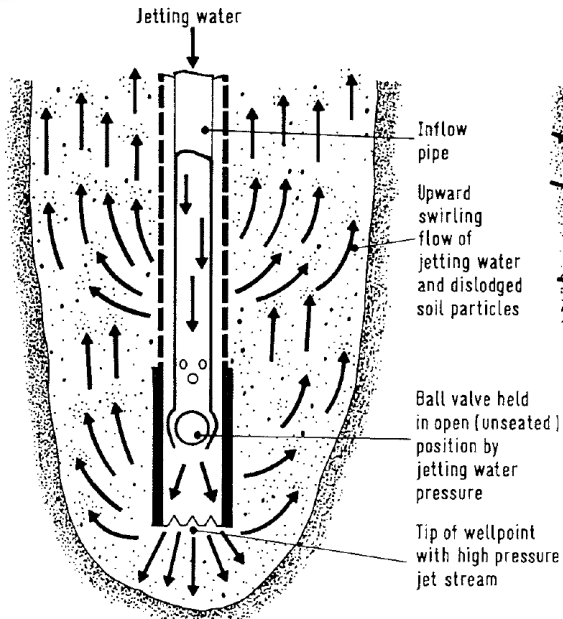
Single Stage Well Point System



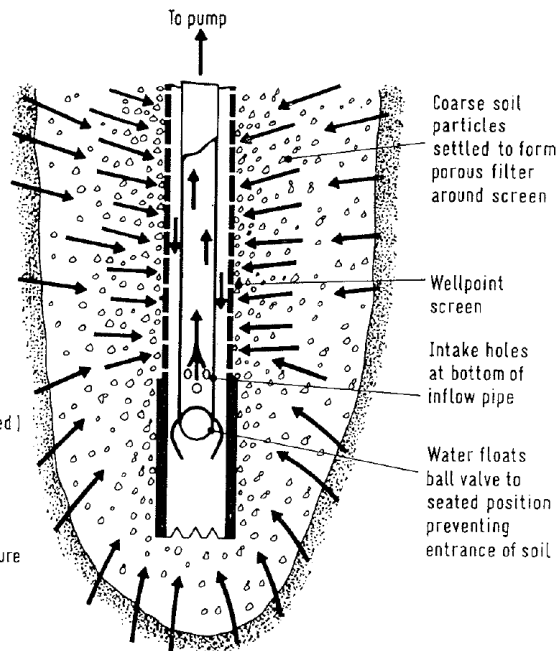
Components of the System



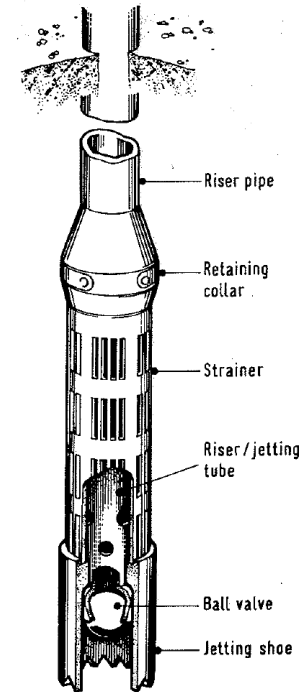
WELL POINTS



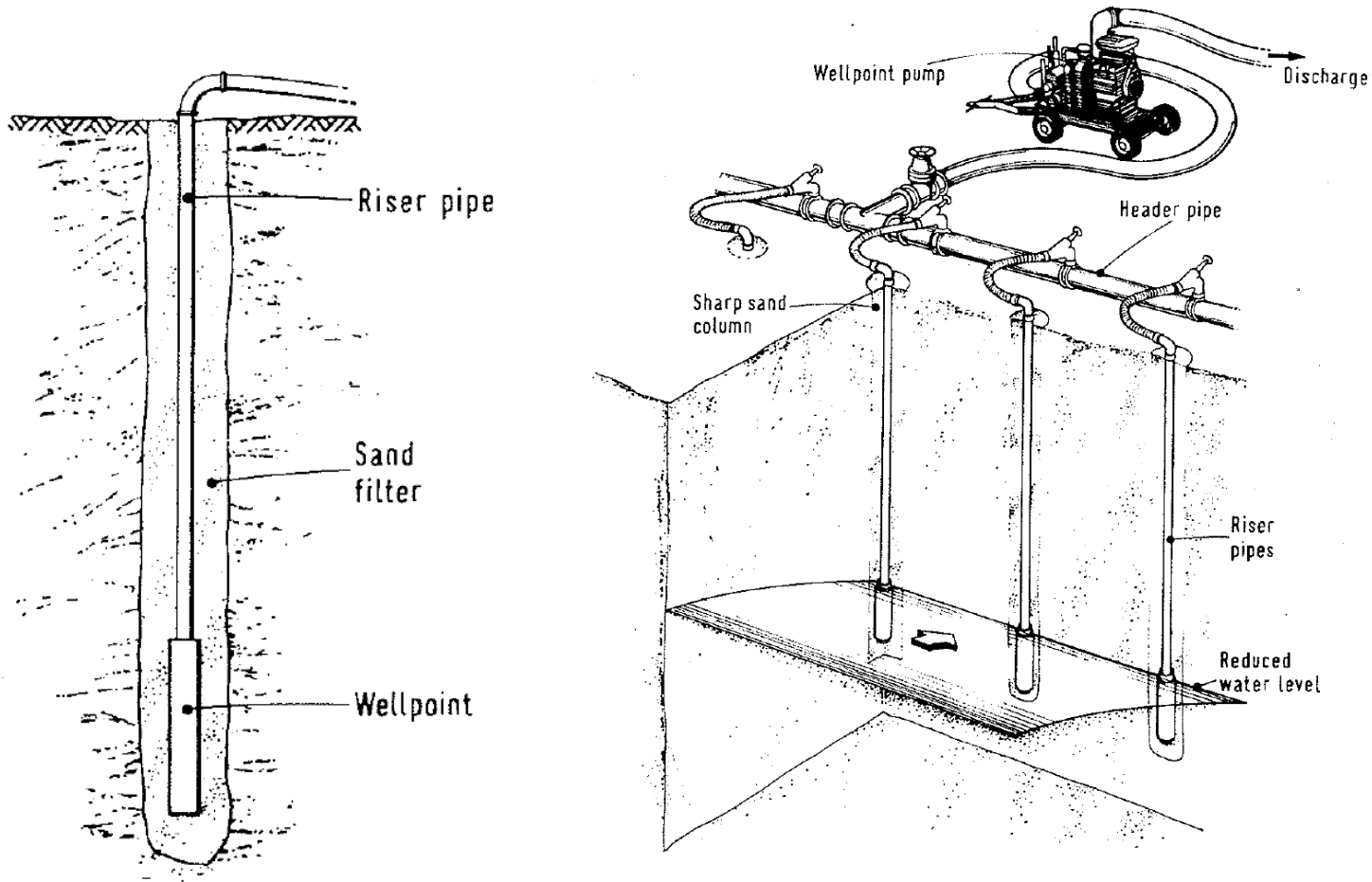
Jetting action of wellpoint.



Dewatering action of wellpoint.

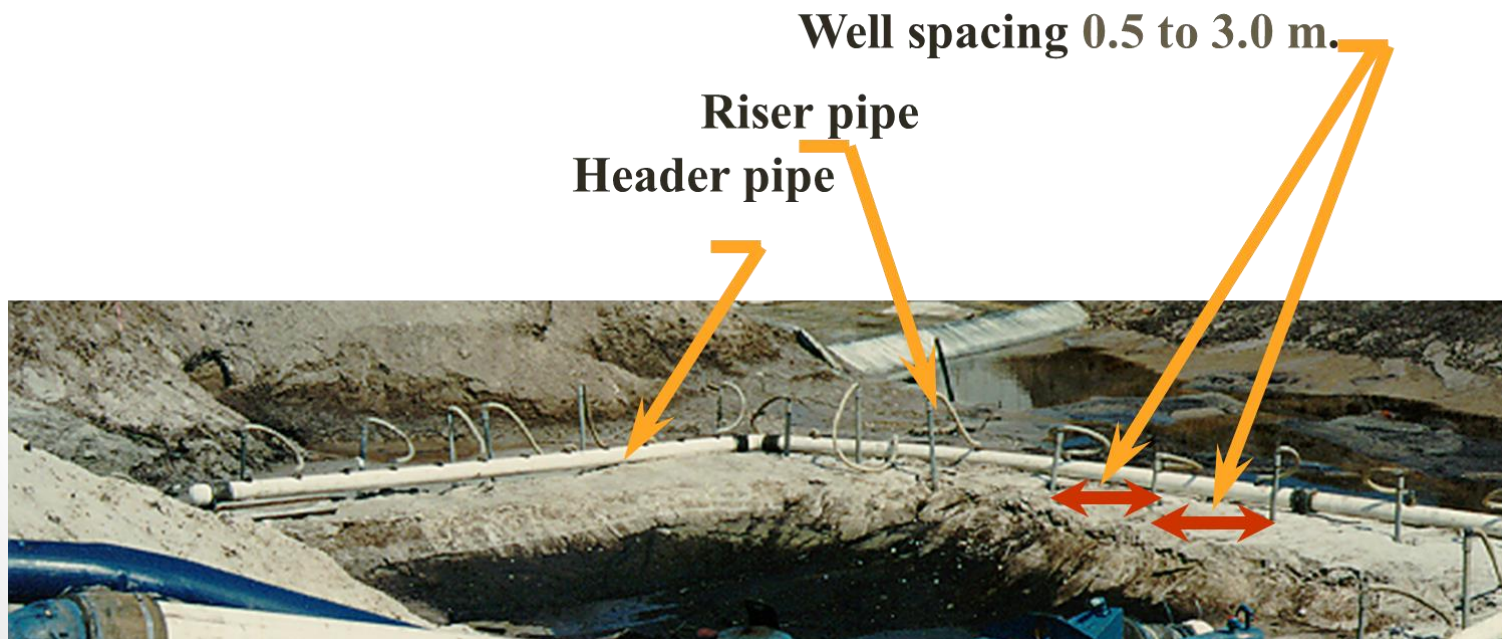


RISER and HEADER



RISINGS SPACING

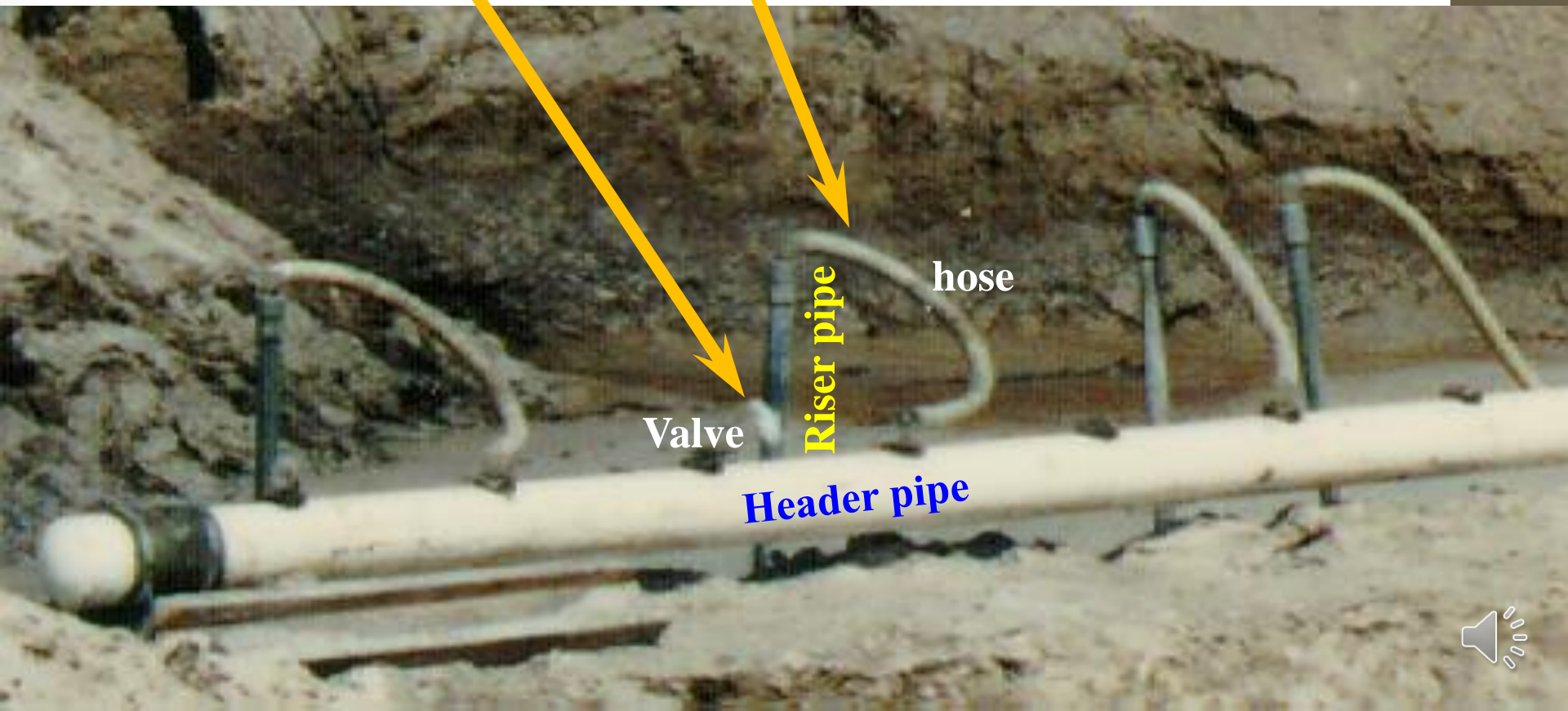
- Multiple closely spaced wells connected by pipes to a strong pump
- Spacing range from 0.5 m to 3.0 m



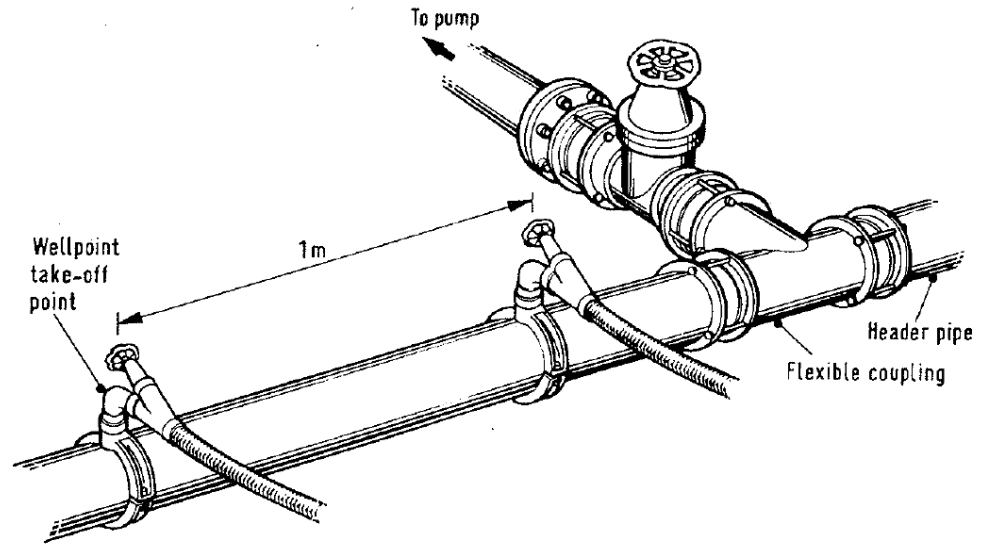
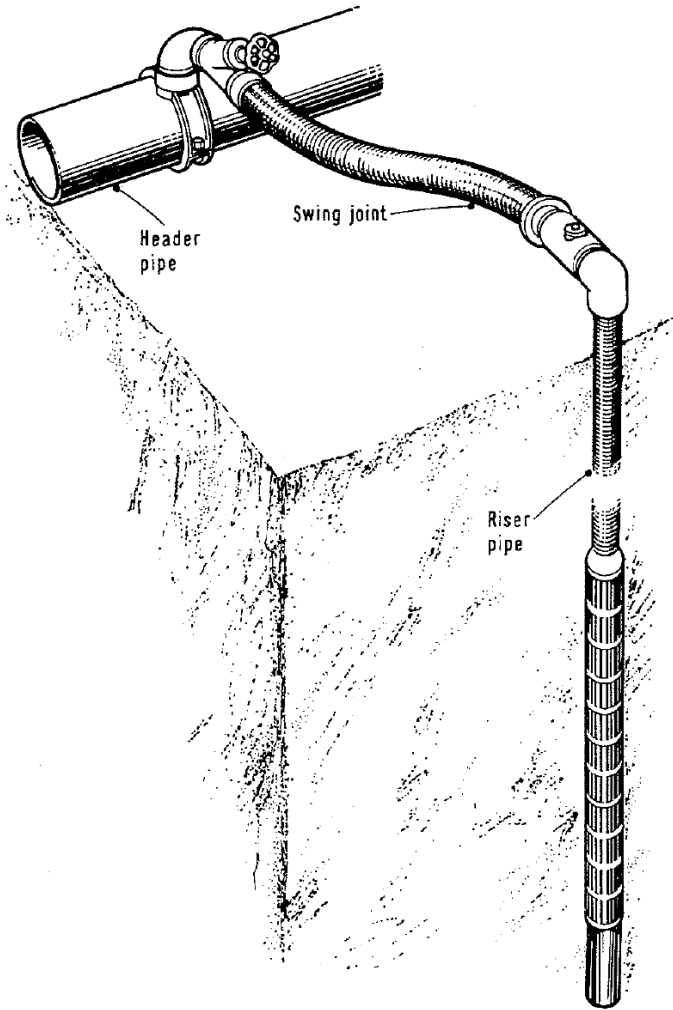
CONNECTIONS

💧 Riser connected to header with hose (or pipe and elbows)

💧 Valve



Header TO PUMPS

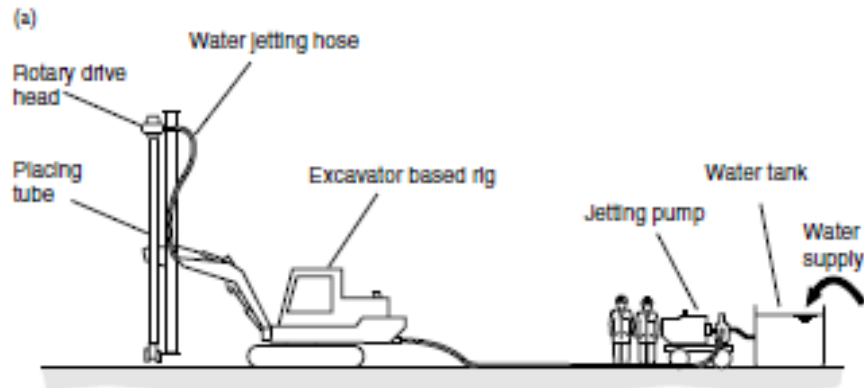


PUMPING

- 💧 In permeable soils drawdown is usually obtained within several hours.
- 💧 If the soil is less permeable drawdown can require several days.



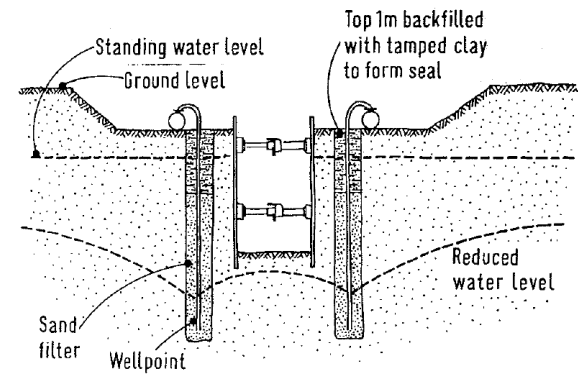
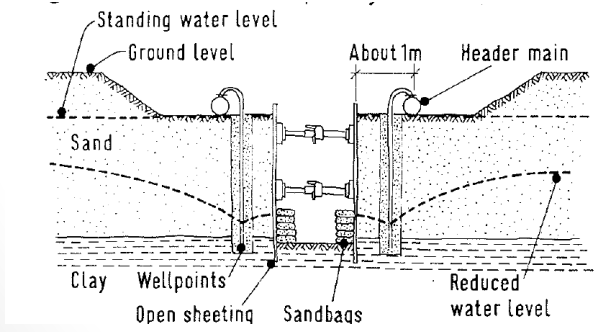
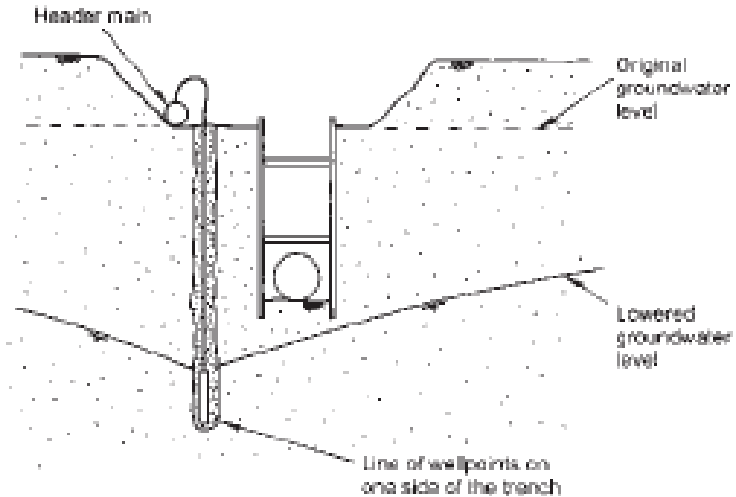
Installation using specialized machines



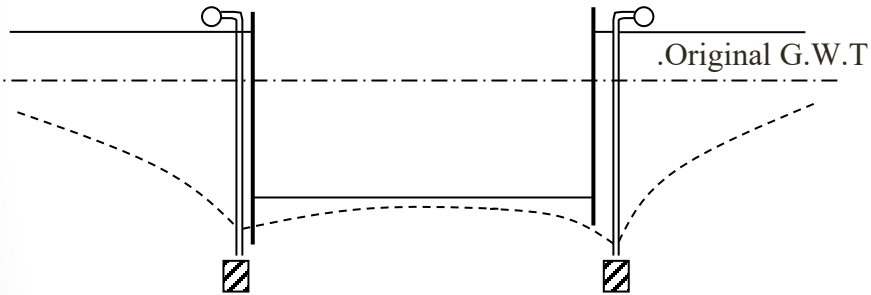
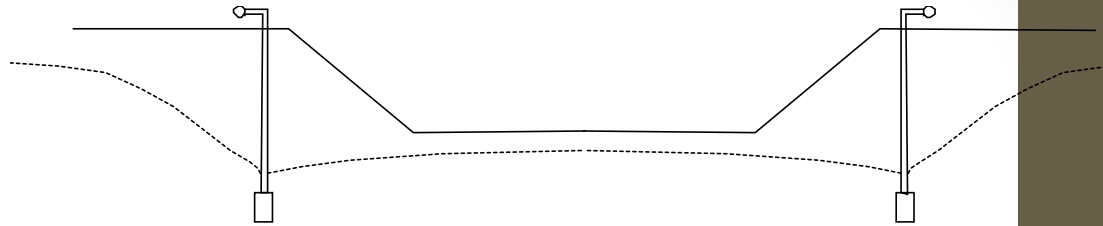
Installation using regular drilling



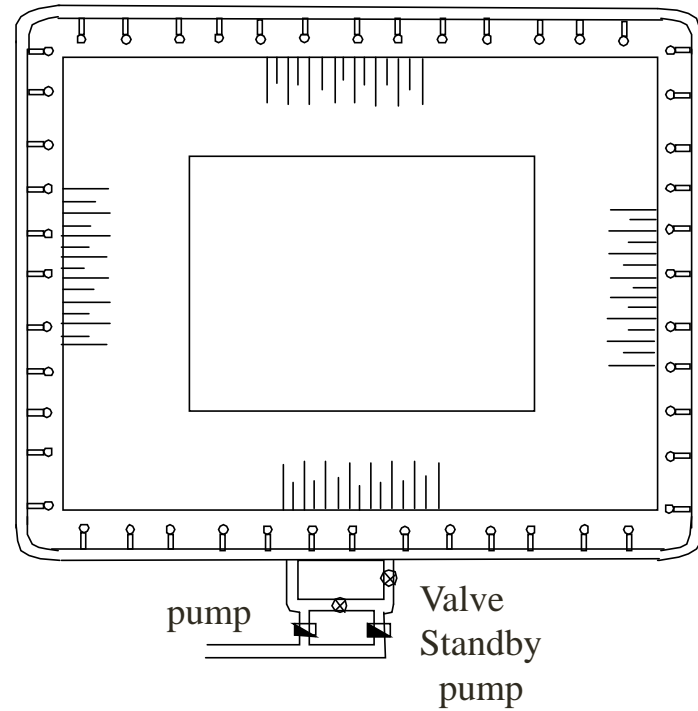
Applications of Single Stage Well Point System



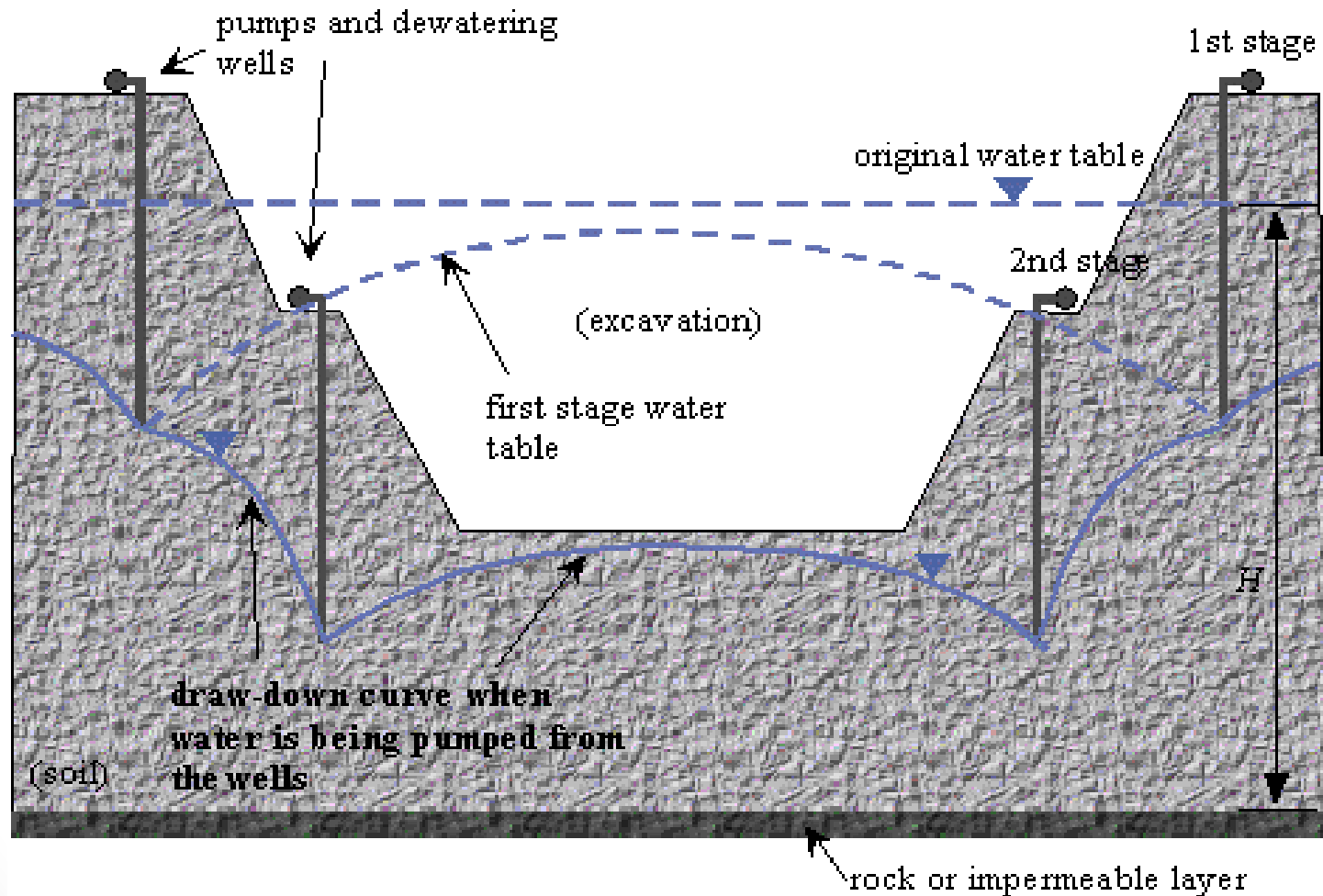
Applications of Single Stage Well Point System



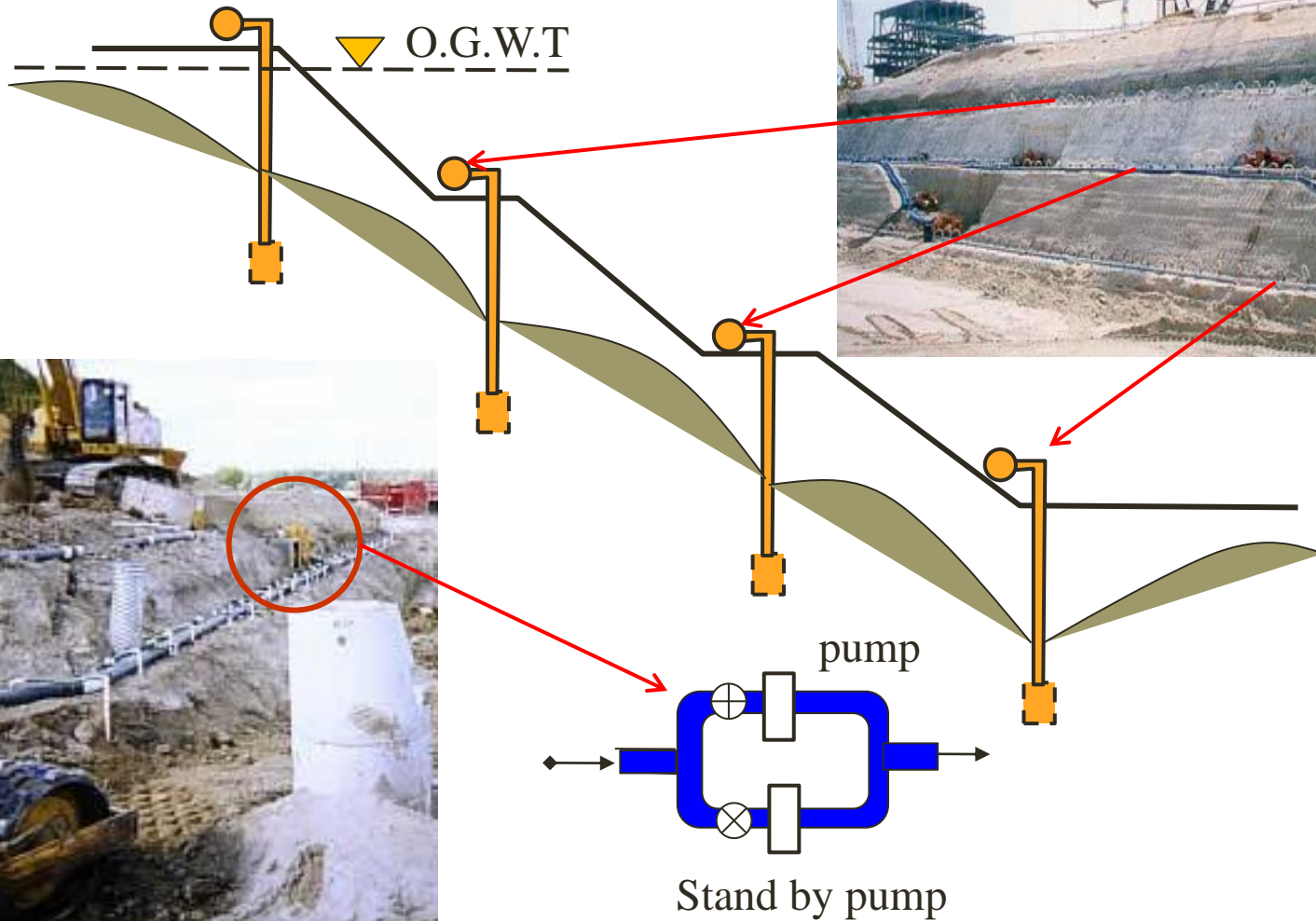
Well Point System Around Sheet Piled Excavation



Multi-stage well point system

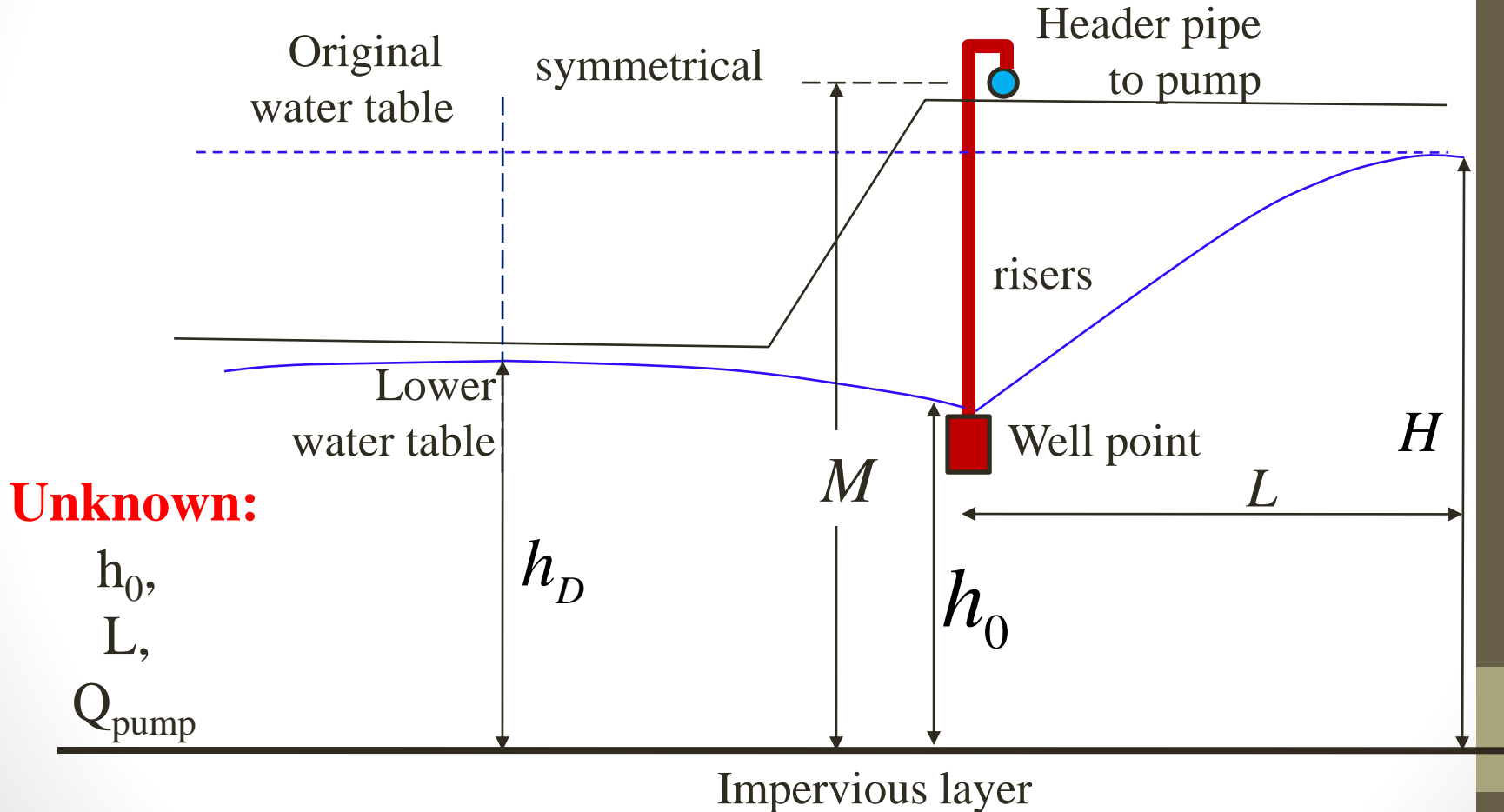


Multi-stage well point system



Design of Well Point System

As two parallel trenches (slots)



STEP ONE Calculate h_0 and L

$$h_0 = \frac{h_D}{\left(\frac{1.48}{150\sqrt{K}}\right) + 1}$$

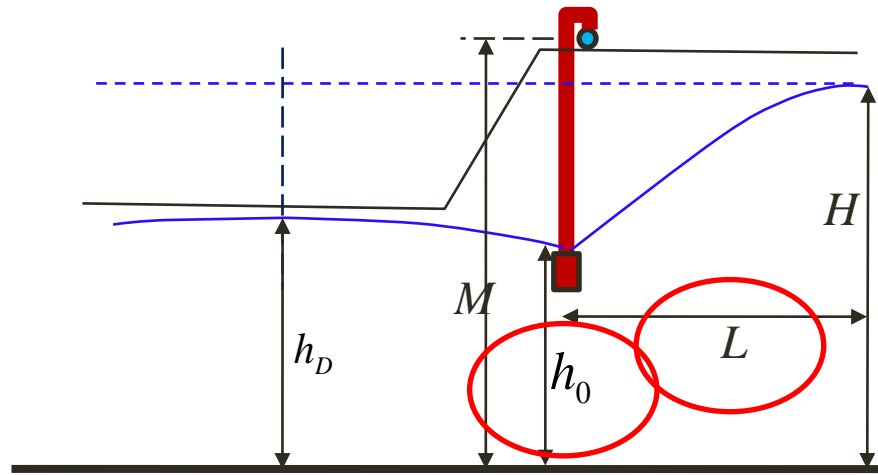
$$L = 150 (H - h_0)\sqrt{K}$$

(1)

K [cm/sec],

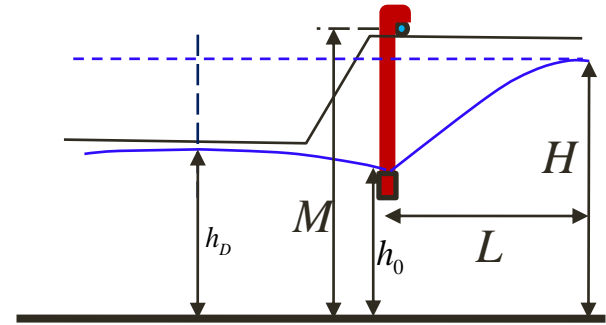
h_D , L & h_0 [m]

(2)



STEP TWO *Check Vacuum at pump (V)*

The vacuum at pump (V) must be sufficient to raise water from the desired water level to the level of pump intake, the following condition must be satisfied:



$$V \geq M - h_0 + \text{Losses} \quad \neq 7.0m$$

In the riser pipe

(0.2 – 0.4 m)

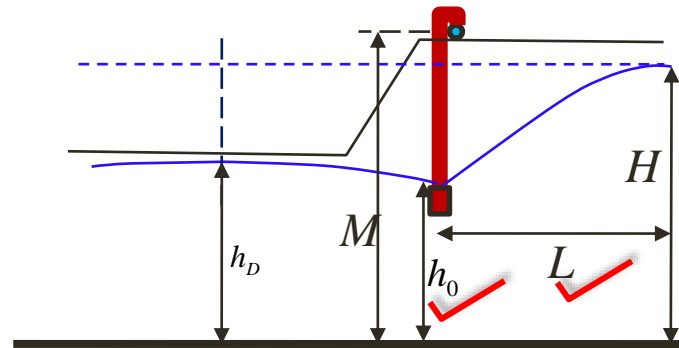
In the header pipe

(0.5 – 1.0 m)

Losses ~ 1.0 m



STEP THREE *Determine discharge per unit length (q/m')*

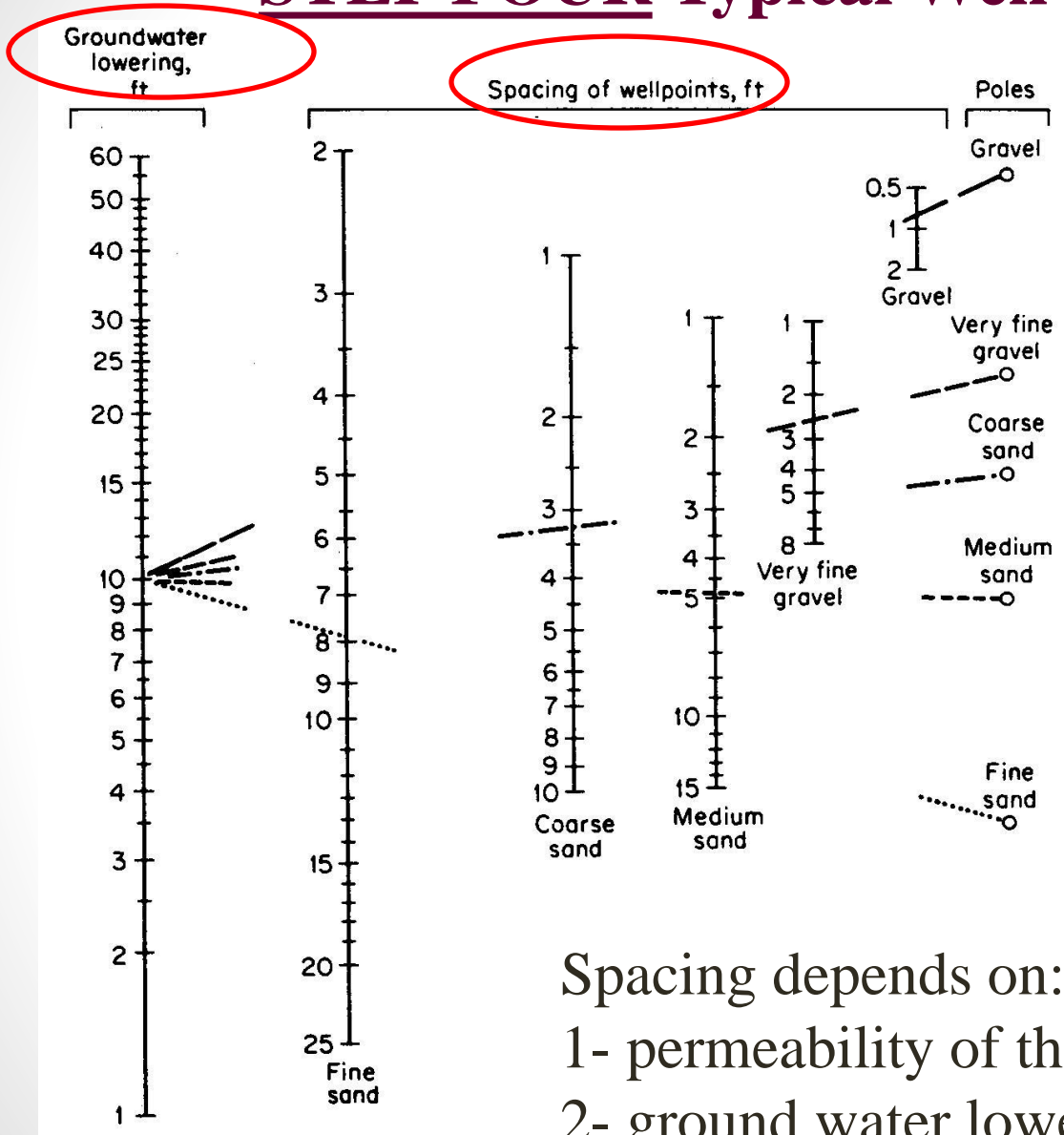


$$q = \left[0.73 + 0.27 \left(\frac{H - h_0}{H} \right) \right] \frac{K}{2L} (H^2 - h_0^2)$$

Where K [m/sec] and
 q [$m^3/\text{sec}/m'$]



STEP FOUR Typical Well Point Spacing



NAVFAC (1982)

$$\text{Groundwater Lowering} * 3.28 \text{ ft}$$

$$a = \text{spacing} * 0.3048 \text{ m}$$

Spacing depends on:

- 1- permeability of the aquifer and soil type
- 2- ground water lowering



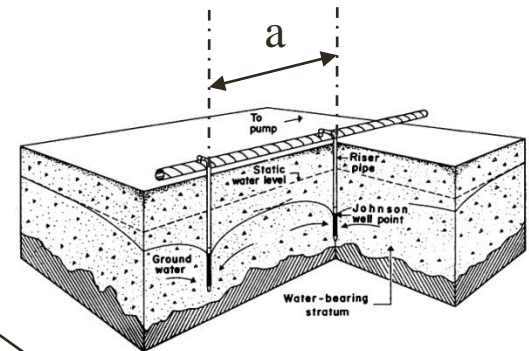
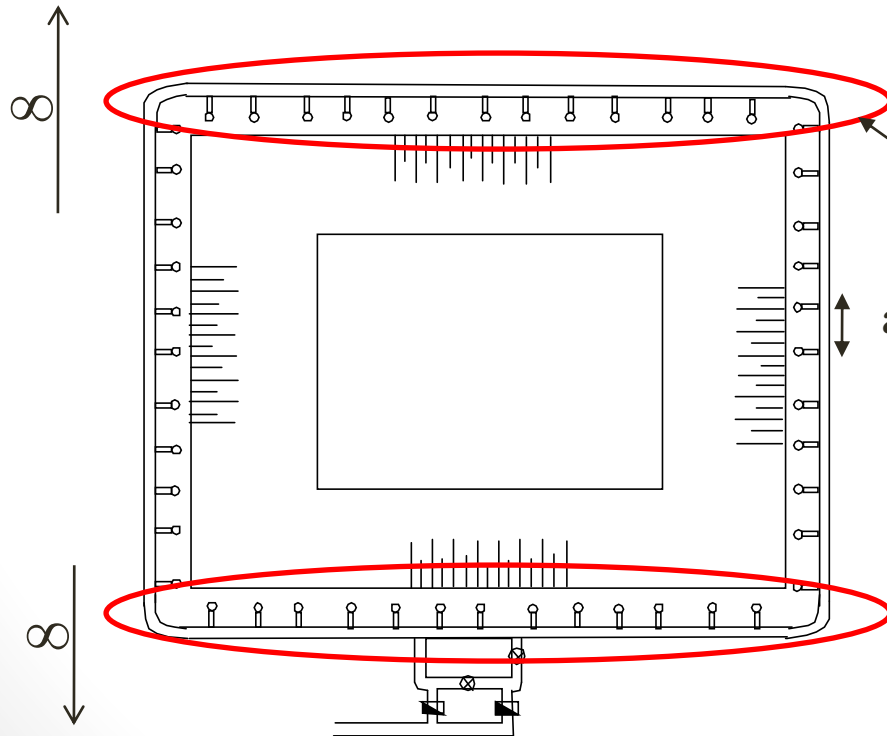
STEP FIVE Determine discharge per well point ($q_{w.p.}$)

$$q_{w.p.} = q \times a \times 1.35$$

Where:

q = Discharge per unit length of slot.

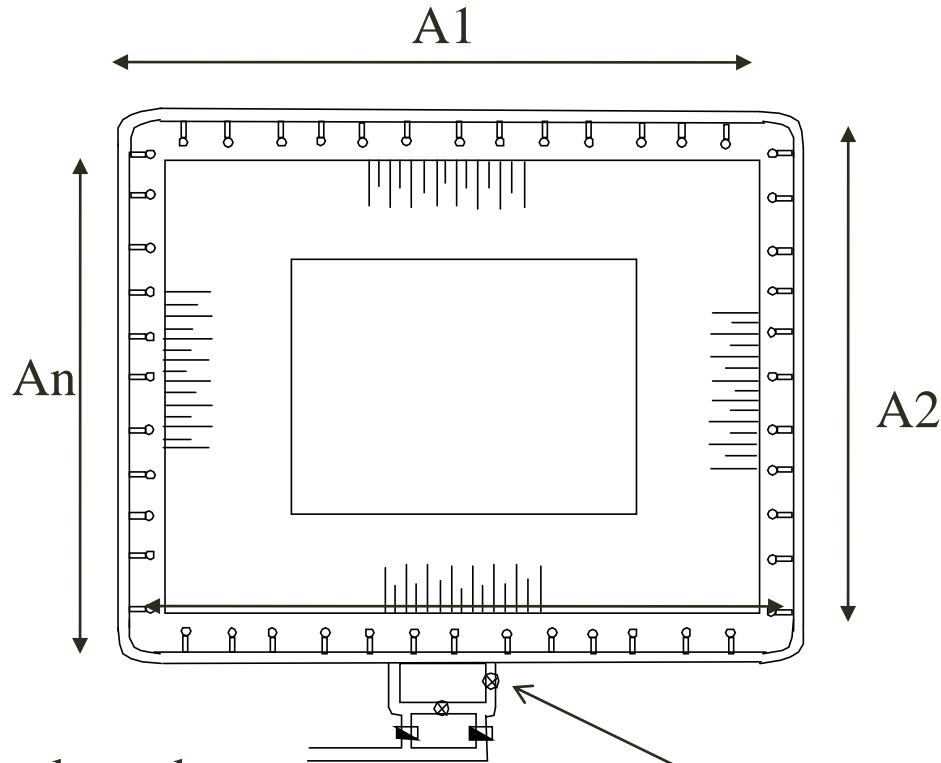
a = Spacing between well points.



35% for
End Effect
(3D Flow)



STEP SIX Determine the number of well points, and the required number of pumps



The excavation boundary
 $= A1 + A2 + \dots + A_n$

No. of risers = $\frac{\text{The excavation boundary}}{\text{spacing}}$

Standby Pumps

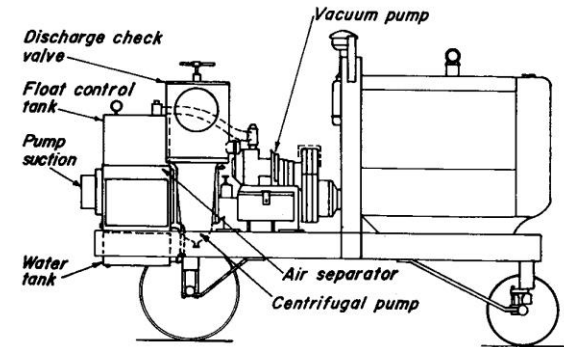
The required No. of pumps = $\frac{\text{No. of risers}}{\sim 50} \times 2$



STEP SEVEN Determine the discharge (Q_{pump}) and the required horsepower for each pump (HP).

$$\text{No. of risers/pump} = \frac{\text{No. of risers}}{\text{No. of working pumps}}$$

$$Q_{pump} = q_{w.p.} \times \text{No. of risers/pump}$$



The horsepower (H.P.) needed for each pump

$$H.P = \frac{\gamma Q_{pump} H_T}{75\eta}$$

Where: $\gamma = 1000 \text{ kg/m}^3$

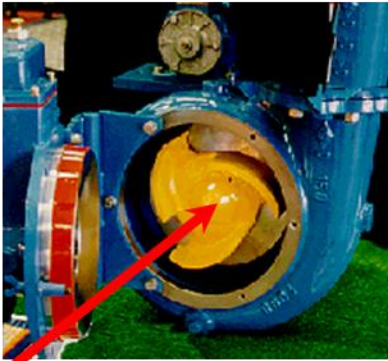
$\eta = \text{efficiency of the pump} = 0.6 \sim 0.7$

$H_T = \text{total head}$

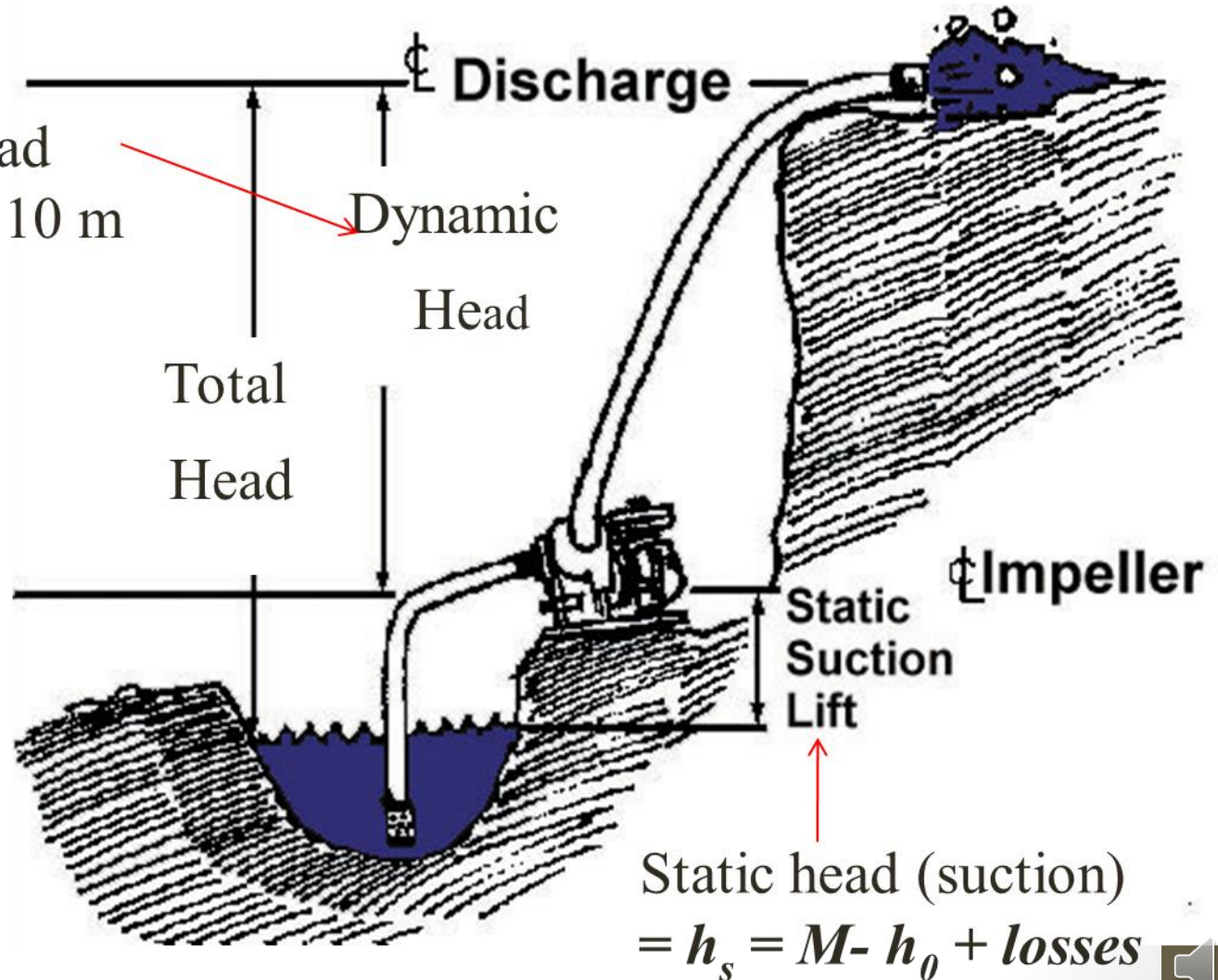


Total head (H_T) = static head (suction) + dynamic head (delivery)

Dynamic head (delivery) ~ 10 m if not given.



Pump Impeller



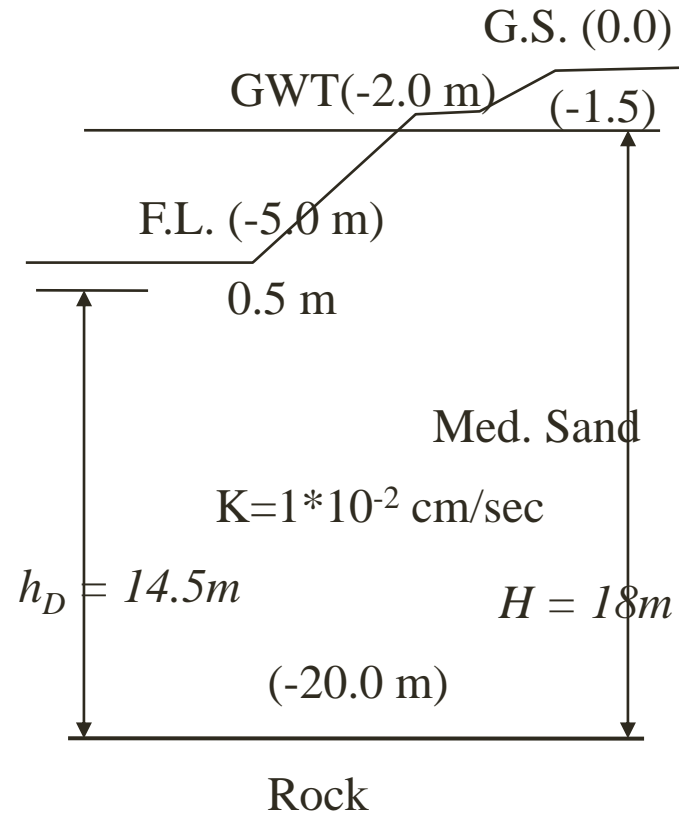
Example

Given:

Excavation	30m*50m
Side slope	1:2
F.L.	-5.0 m
G.W.T.	-2.0 m
Imp. Layer	-20.0 m
Med Sand	$K=1*10^{-2}$ cm/sec

Required:

Design well point system for the site



- Calculate h_0 and L

$$h_D = h_0 \left[\frac{1.48}{1500\sqrt{K}} + 1 \right]$$

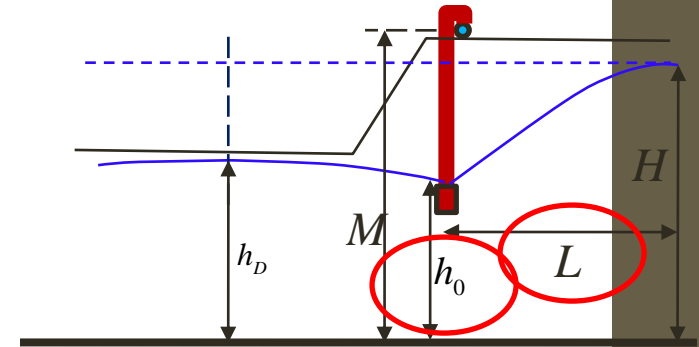
$$14.5 = h_0 \left[\frac{1.48}{1500\sqrt{0.0001}} + 1 \right]$$

$$h_0 = 13.21 \text{ m} \quad \leftarrow$$

$$\begin{aligned} L &= 1500(H - h_0)\sqrt{K} \\ &= 1500(18 - 13.21)\sqrt{0.0001} \\ &= 71.85 \text{ m} \quad \leftarrow \end{aligned}$$

K [m/sec],

h_D, L & h_0 [m]



$$H = 18 \text{ m}$$

$$h_D = 14.5 \text{ m}$$

$$M = 19 \text{ m}$$

$$\begin{aligned} K &= 0.01 \text{ cm/sec} \\ &= 0.0001 \text{ m/sec} \end{aligned}$$



- *Check Vacuum at pump (V)*

$$V \geq M - h_0 + \text{Losses} \quad \neq 7.0m$$

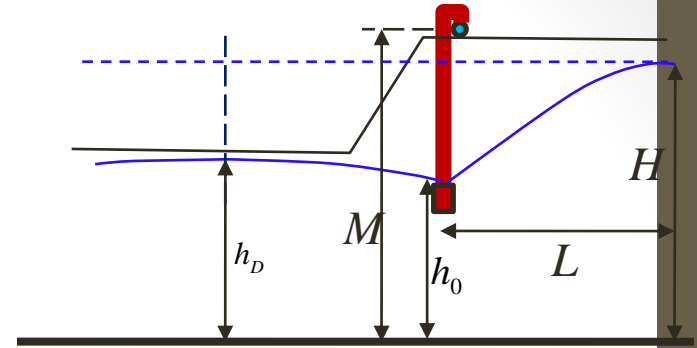
In the riser pipe

(0.2 – 0.4 m)

In the collector pipe (header)

(0.5 – 1.0 m)

Losses ~ 1.0 m



$$V \geq M - h_0 + \text{Losses}$$

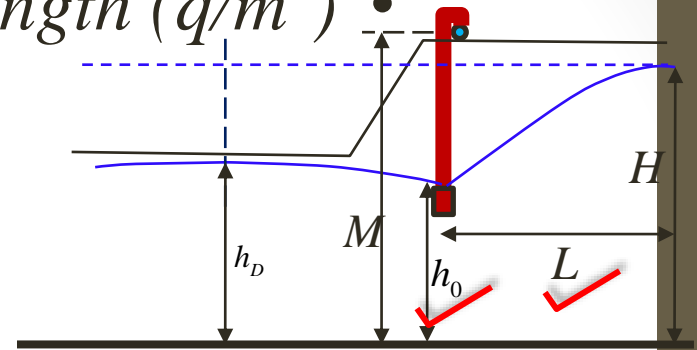
$$V = 19 - 13.21 + 1.0$$

$$= 6.8 m < 7.0m \text{ safe} \quad \leftarrow$$



Determine discharge per unit length (q/m')

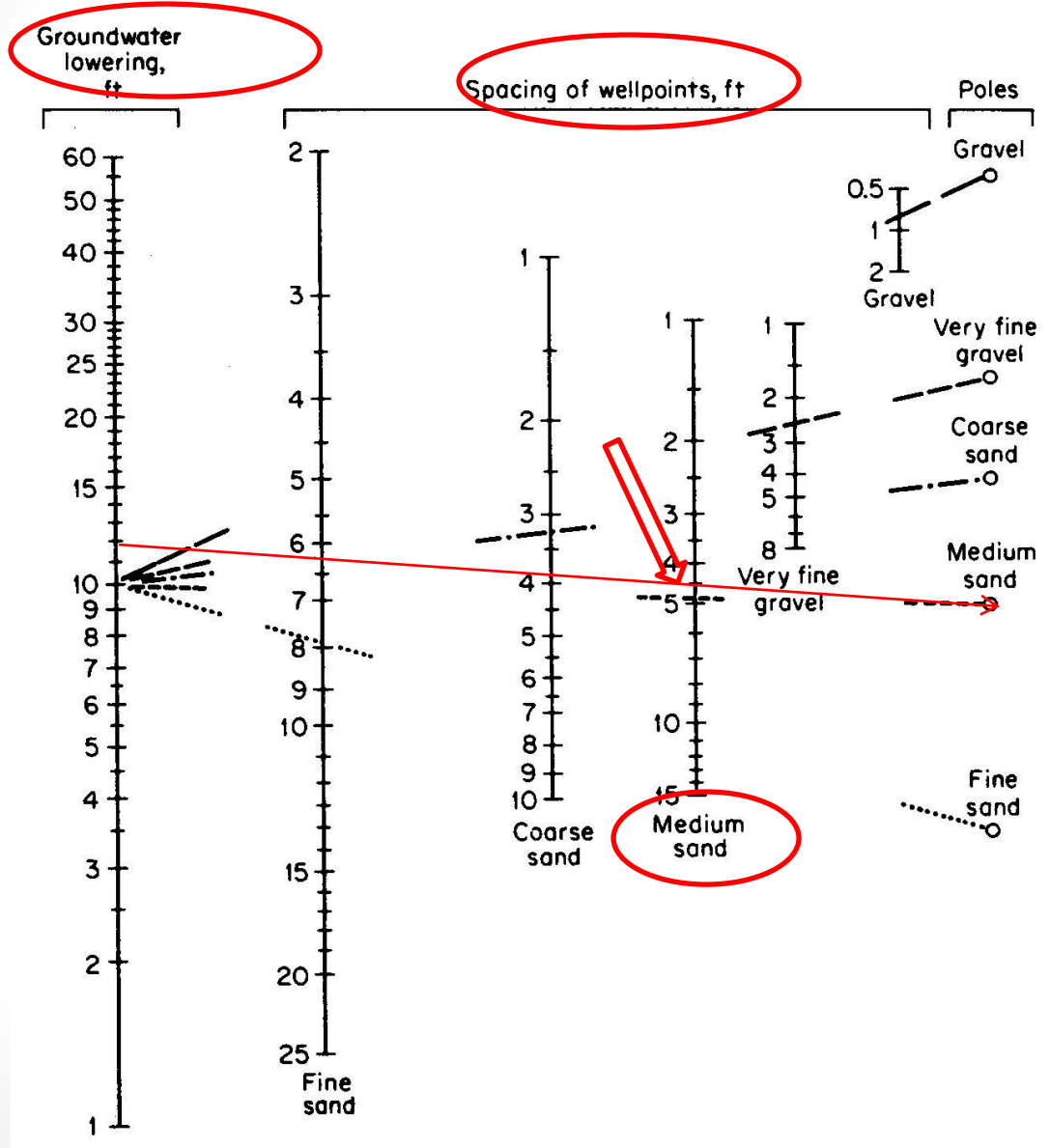
K [m/sec] and
 q [$m^3/sec/m'$]



$$\begin{aligned}
 q &= \left[0.73 + 0.27 \left(\frac{H - h_0}{H} \right) \right] \frac{K}{2L} (H^2 - h_0^2) \\
 &= \left[0.73 + 0.27 \left(\frac{18 - 13.21}{18} \right) \right] \frac{0.0001}{2 * 71.85} (18^2 - 13.21^2) \\
 &= 0.000085 \text{ m}^3 / \text{sec} / \text{m}' = 0.31 \text{ m}^3 / \text{hr} / \text{m}'
 \end{aligned}$$



Typical Well Point Spacing in Granular Soils



$$G.W. \text{ lowering} = 5.5 - 2 = 3.5m = 11.7 \text{ ft}$$

$$a = 4.5 \text{ ft} = 1.3 \text{ m}$$



Determine the number of well points, and the required number of pumps

$$A1 = 50 + (3.5 * 2 + 1) * 2 = 66 \text{ m}$$

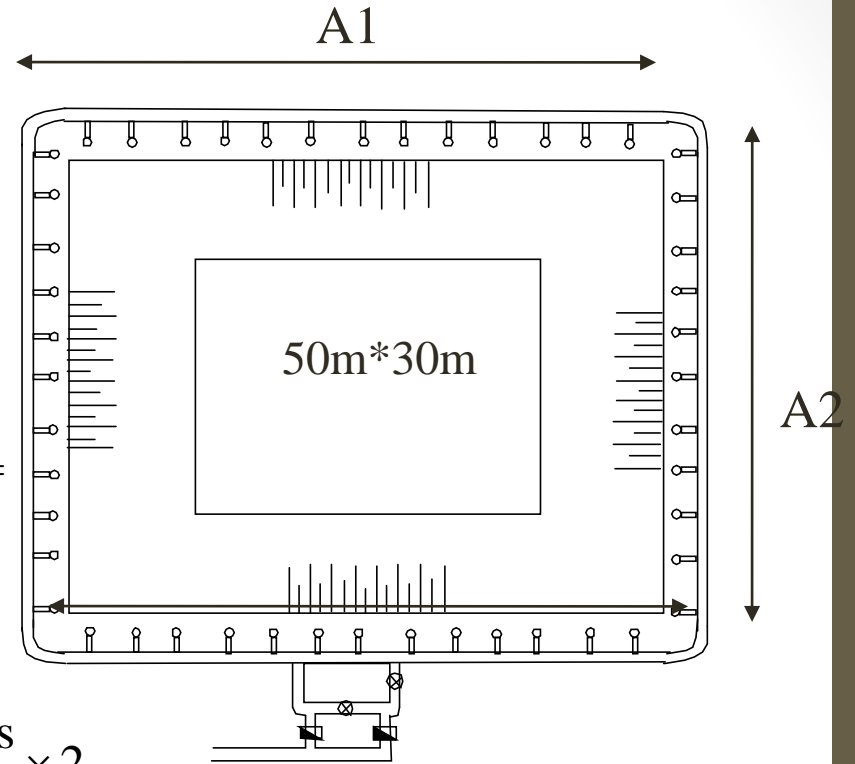
$$A2 = 30 + (3.5 * 2 + 1) * 2 = 46 \text{ m}$$

$$\begin{aligned} \text{The excavation boundary} &= (66 + 46) * 2 \\ &= 224 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{No. of risers} &= \frac{\text{The excavation boundary}}{\text{spacing}} = \frac{224}{1.3} = \\ &172.3 = 173 \end{aligned}$$

$$\begin{aligned} \text{The required No. of pumps} &= \frac{\text{No. of risers}}{\sim 50} \times 2 \\ &= \frac{173}{50} = 3.46 \rightarrow \text{use 4 pumps} + 4 \text{ pumps Standby Pumps} \end{aligned}$$

$$\text{No. of risers/pump} = \frac{\text{No. of risers}}{\text{No. of working pumps}} \rightarrow 43.25 \text{ risers}$$

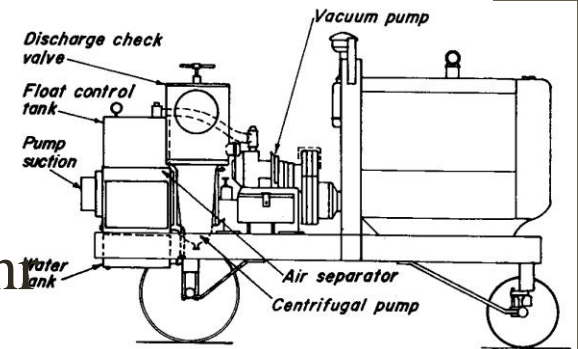


- Determine discharge per well point ($q_{w.p.}$)

$$\begin{aligned}
 q_{w.p.} &= q \times a \times 1.35 \\
 &= 0.31 \times 1.3 \times 1.35 \\
 &= 0.54 \text{ m}^3 / \text{hr}
 \end{aligned}$$

- Determine the discharge (Q_{pump})

$$\begin{aligned}
 Q_{pump} &= q_{w.p.} \times \text{No. of rises/pump} \\
 &= 0.54 \times 43.25 = 23.36 \text{ m}^3/\text{hr} \\
 &\sim 25 \text{ m}^3/\text{hr} = 0.0069 \text{ m}^3/\text{sec}
 \end{aligned}$$



- The required horsepower for each pump (HP).

$$H.P = \frac{\gamma Q_{pump} H_T}{75\eta}$$

Where: $\gamma = 1000 \text{ kg/m}^3$

$\eta = \text{efficiency of the pump} = 0.6 \sim 0.7$

$H_T = \text{total head} \quad [\text{m}]$

$Q_{pump} \quad [\text{m}^3/\text{sec}]$

$$\begin{aligned} \text{Total head } (H_T) &= \text{static head (suction) + dynamic head (delivery)} \\ &= (M - h_0 + \text{losses}) + 10 \text{ m} \\ &= 6.8 + 10 = 16.8 \text{ m} \end{aligned}$$

$$\begin{aligned} H.P &= \frac{\gamma Q_{pump} H_T}{75\eta} \\ &= \frac{1000 \times 0.0069 \times 16.8}{75 \times 0.7} = 2.2 \end{aligned}$$

