XX CONGRESSO BRASILEIRO DE ÁGUAS SUBTERRÂNEAS
XXI ENCONTRO NACIONAL DE PERFURADORES DE POÇOS
06 a 08 de Novembro de 2018 | Campinas - SP

Fenágua 2018
FEIRA NACIONAL DA ÁGUA

Aplicação prática dos testes de vazão em poços

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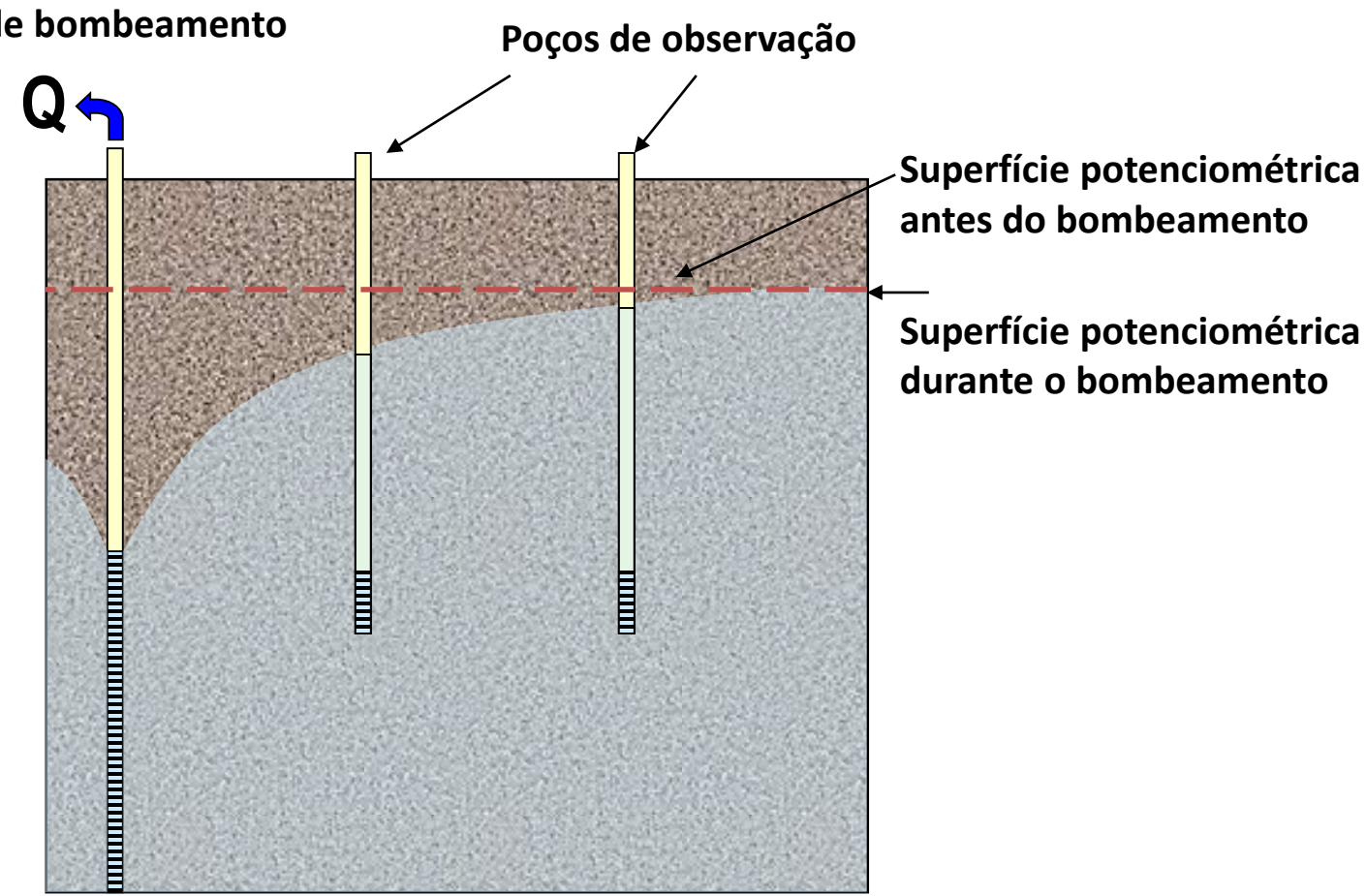
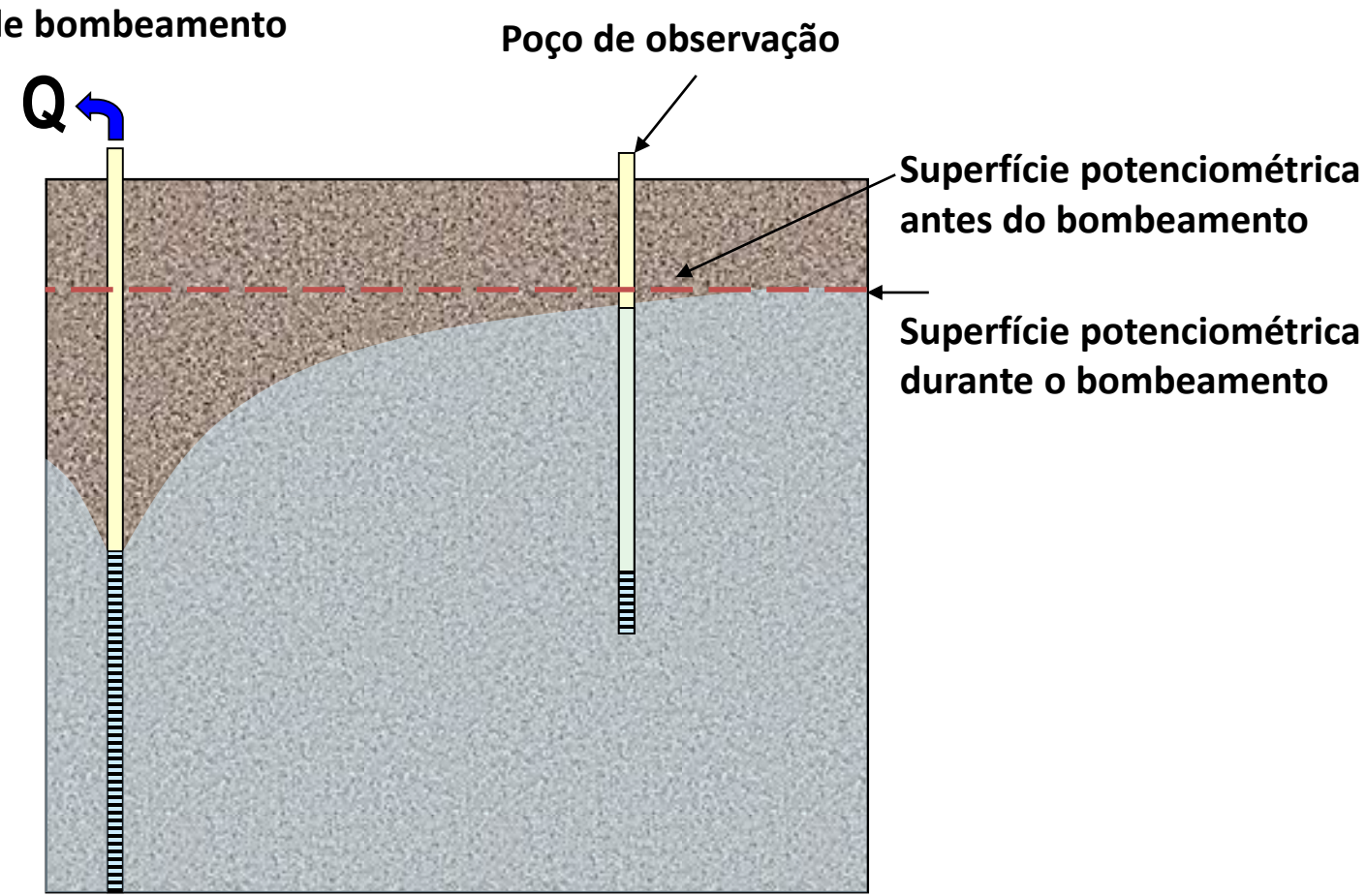

Poço de bombeamento
Q
Poços de observação
Superfície potenciométrica antes do bombeamento
Superfície potenciométrica durante o bombeamento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Poço de observação
Superfície potenciométrica antes do bombeamento
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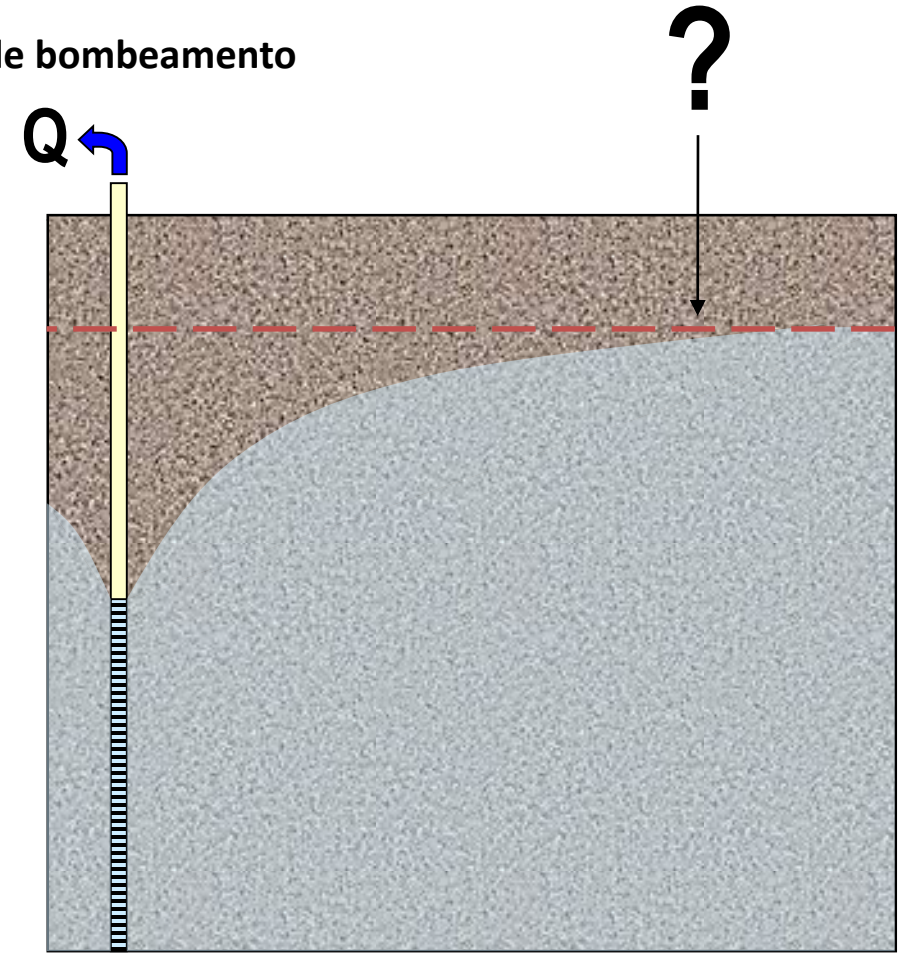
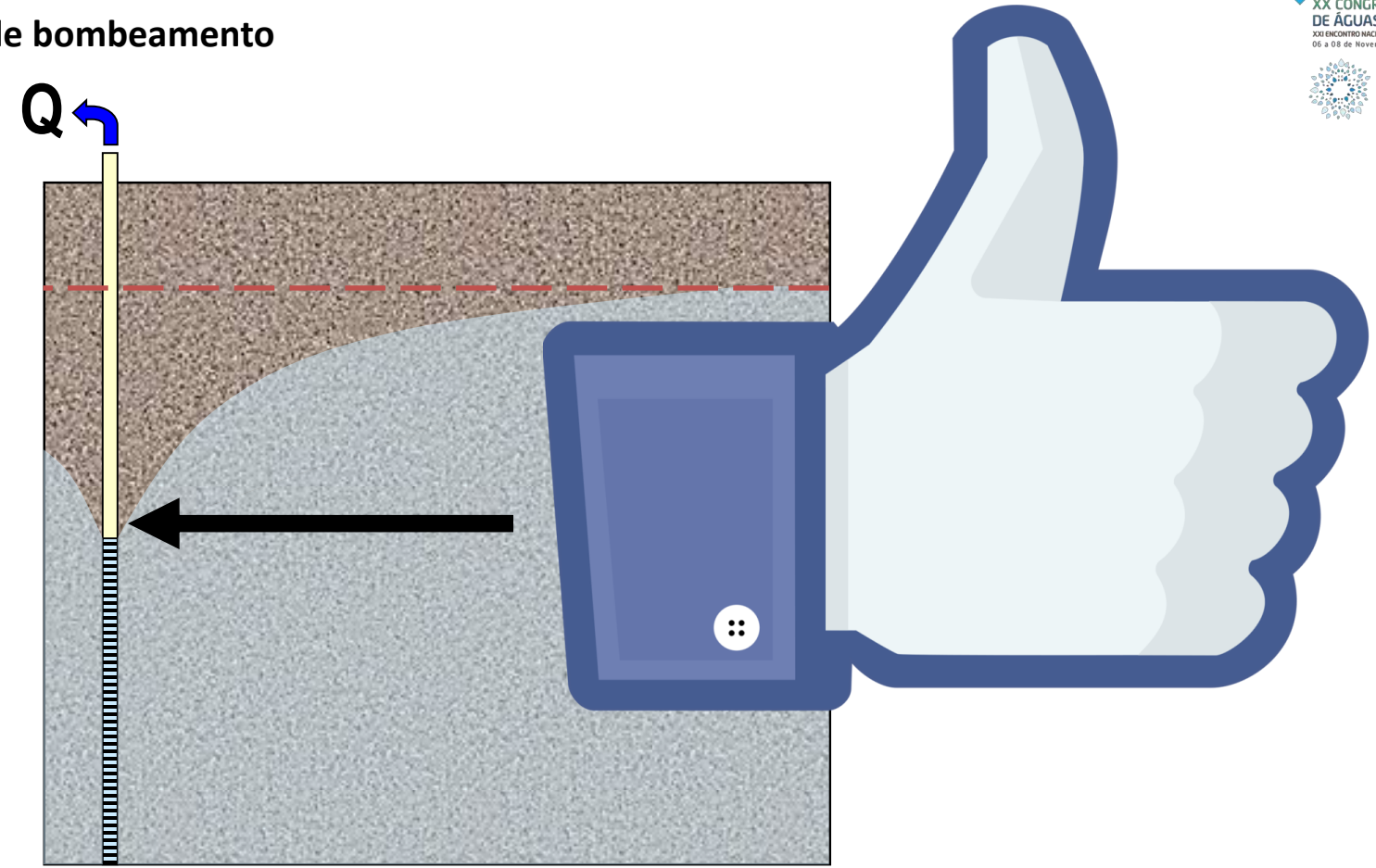
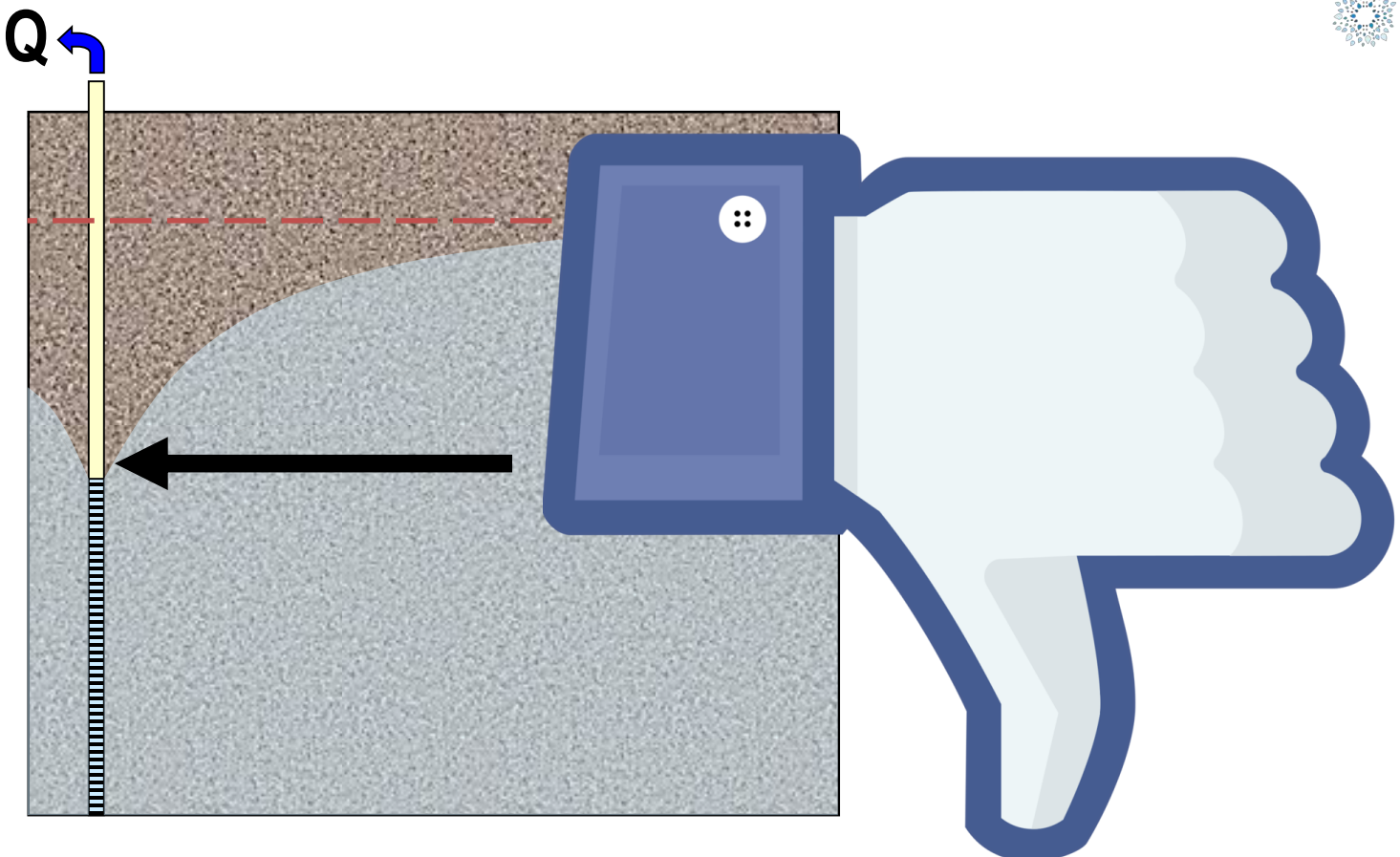
Poço de bombeamento



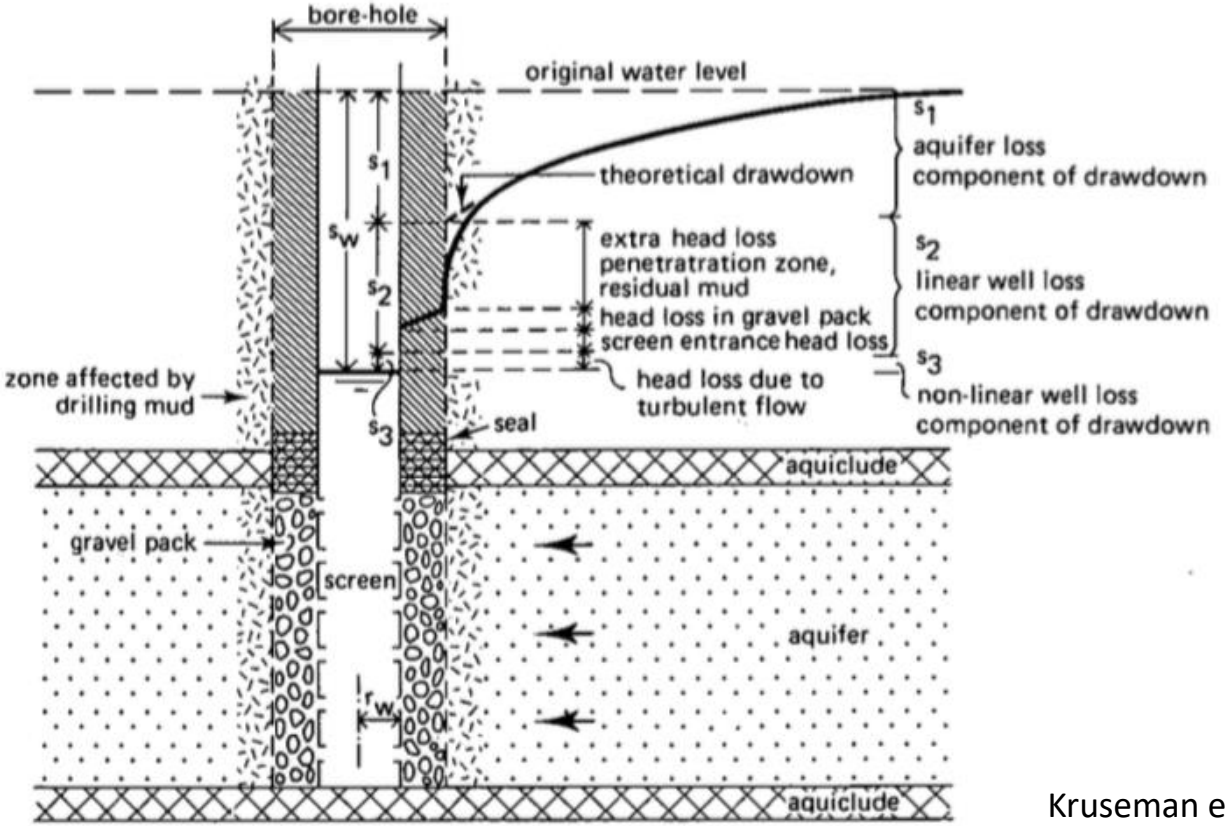
Poço de bombeamento



Poço de bombeamento

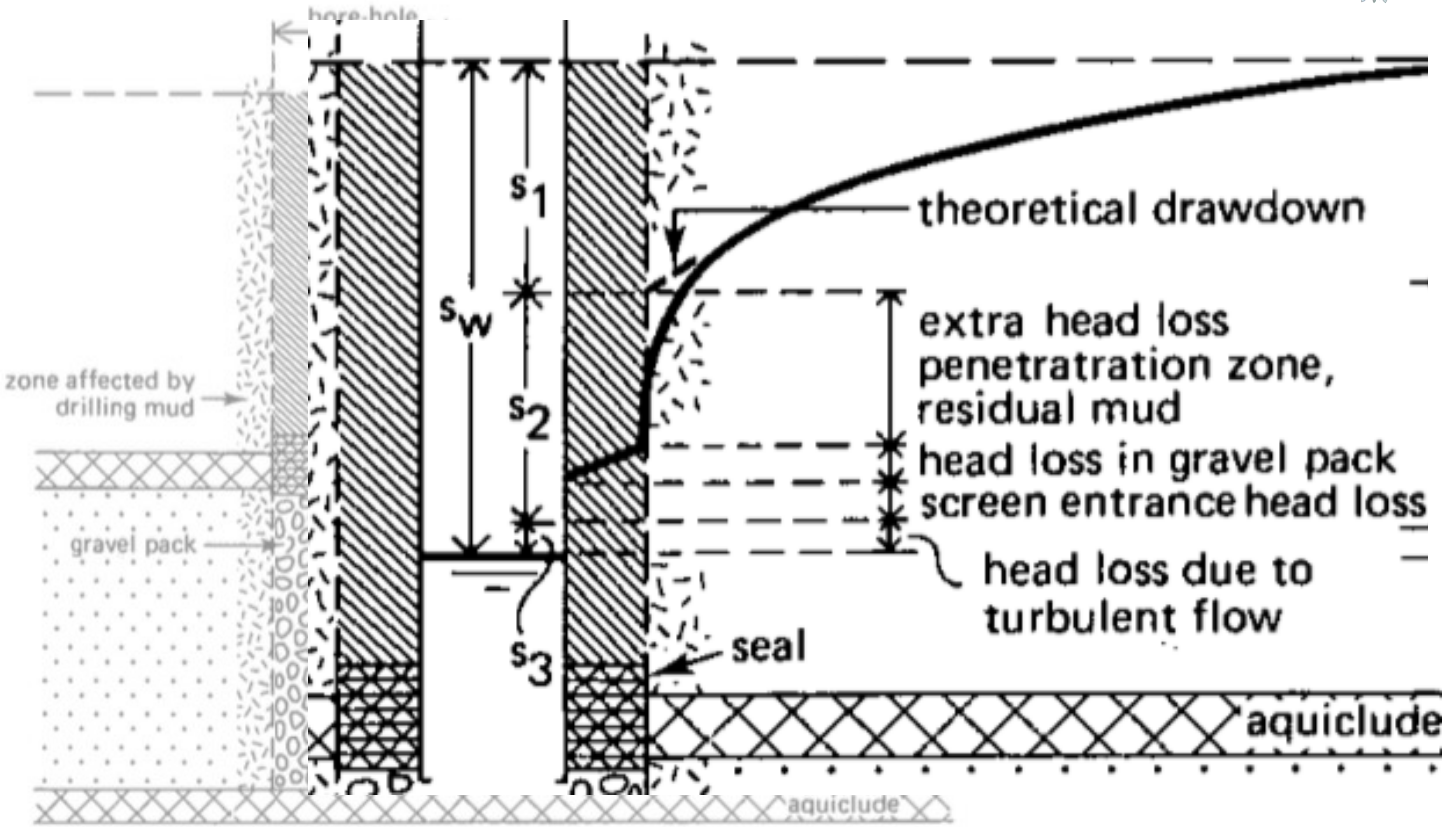


Perdas de Poço

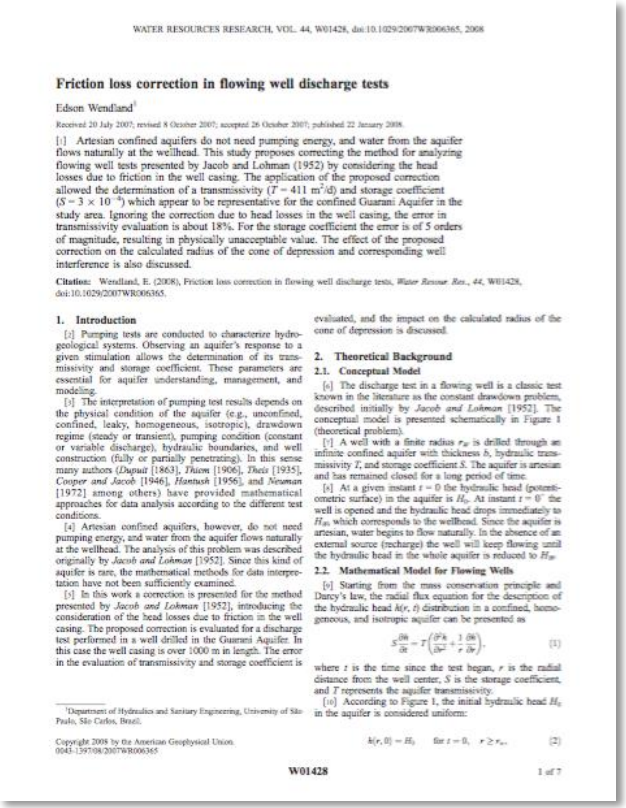


Kruseman e De Ridder, 1994

Perdas de Poço



Perdas de Poço



WATER RESOURCES RESEARCH, VOL. 44, W01428, doi:10.1029/2007WR006365, 2008

Friction loss correction in flowing well discharge tests

Edson Wendland[1]

Received 20 July 2007; revised 8 October 2007; accepted 26 October 2007; published 22 January 2008.

[1] Artesian confined aquifers do not need pumping energy, and water from the aquifer flows naturally at the wellhead. This study proposes correcting the method for analyzing flowing well tests presented by Jacob and Lohman (1952) by considering the head losses due to friction in the well casing. The application of the proposed correction allowed the determination of a transmissivity ($T = 411$ m^2/d) and storage coefficient ($S = 3 \times 10^{-6}$) which appear to be representative for the confined Guarani Aquifer in the study area. Ignoring the correction due to head losses in the well casing, the error in transmissivity evaluation is about 18%. For the storage coefficient the error is of 5 orders of magnitude, resulting in physically unacceptable value. The effect of the proposed correction on the calculated radius of the cone of depression and corresponding well interference is also discussed.

Citation: Wendland, E. (2008), Friction loss correction in flowing well discharge tests, *Water Resour. Res.*, *44*, W01428, doi:10.1029/2007WR006365.

1. Introduction

[2] Pumping tests are conducted to characterize hydrogeological systems. Observing an aquifer's response to a given stimulation allows the determination of its transmissivity and storage coefficient. These parameters are essential for aquifer understanding, management, and modeling.

[3] The interpretation of pumping test results depends on the physical condition of the aquifer (e.g., unconfined, confined, leaky, homogeneous, isotropic), drawdown regime (steady or transient), pumping condition (constant or variable discharge), hydraulic boundaries, and well construction (fully or partially penetrating). In this sense many authors (*Dupuit* [1863], *Thiem* [1906], *Theis* [1935], *Cooper and Jacob* [1946], *Hantush* [1956], and *Neuman* [1972] among others) have provided mathematical approaches for data analysis according to the different test conditions.

[4] Artesian confined aquifers, however, do not need pumping energy, and water from the aquifer flows naturally at the wellhead. The analysis of this problem was described originally by *Jacob and Lohman* [1952]. Since this kind of aquifer is rare, the mathematical methods for data interpretation have not been sufficiently examined.

[5] In this work a correction is presented for the method presented by *Jacob and Lohman* [1952], introducing the consideration of the head losses due to friction in the well casing. The proposed correction is evaluated for a discharge test performed in a well drilled in the Guarani Aquifer. In this case the well casing is over 1000 m in length. The error in the evaluation of transmissivity and storage coefficient is evaluated, and the impact on the calculated radius of the cone of depression is discussed.

2. Theoretical Background

2.1. Conceptual Model

[6] The discharge test in a flowing well is a classic test known in the literature as the constant drawdown problem, described initially by *Jacob and Lohman* [1952]. The conceptual model is presented schematically in Figure 1 (theoretical problem).

[7] A well with a finite radius r_w is drilled through an infinite confined aquifer with thickness b, hydraulic transmissivity T, and storage coefficient S. The aquifer is artesian and has remained closed for a long period of time.

[8] At a given instant $t = 0$ the hydraulic head (potentiometric surface) in the aquifer is H_0. At instant $t = 0^+$ the well is opened and the hydraulic head drops immediately to H_w, which corresponds to the wellhead. Since the aquifer is artesian, water begins to flow naturally. In the absence of an external source (recharge) the well will keep flowing until the hydraulic head in the whole aquifer is reduced to H_w.

2.2. Mathematical Model for Flowing Wells

[9] Starting from the mass conservation principle and Darcy's law, the radial flux equation for the description of the hydraulic head $h(r, t)$ distribution in a confined, homogeneous, and isotropic aquifer can be presented as

$$S\frac{\partial h}{\partial t} = T\left(\frac{\partial^2 h}{\partial r^2} + \frac{1}{r}\frac{\partial h}{\partial r}\right), \qquad (1)$$

where t is the time since the test began, r is the radial distance from the well center, S is the storage coefficient, and T represents the aquifer transmissivity.

[10] According to Figure 1, the initial hydraulic head H_0 in the aquifer is considered uniform:

$$h(r, 0) = H_0 \qquad \text{for } t = 0, \quad r \geq r_w. \qquad (2)$$

[1]Department of Hydraulics and Sanitary Engineering, University of São Paulo, São Carlos, Brazil.

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0043-1397/08/2007WR006365

Wendland, 2008

- **Perdas causaram erro de 18% no cálculo da transmissividade;**
- **Coeficiente de armazenamento teve erro de 500%**

Perdas de Poço

- **Perdas no pré-filtro**
- **Perdas na parede do furo (lama de perfuração)**
- **Perdas no filtro**
- **Perdas por causa de fluxo turbulento**

Perdas de Poço

$$s_w = BQ + CQ^P$$

Onde:

s_w : rebaixamento no poço
B : coeficiente de perdas lineares
C : coeficiente de perdas não lineares
Q : vazão
P : expoente, normalmente = 2

Kruseman e De Ridder, 1994

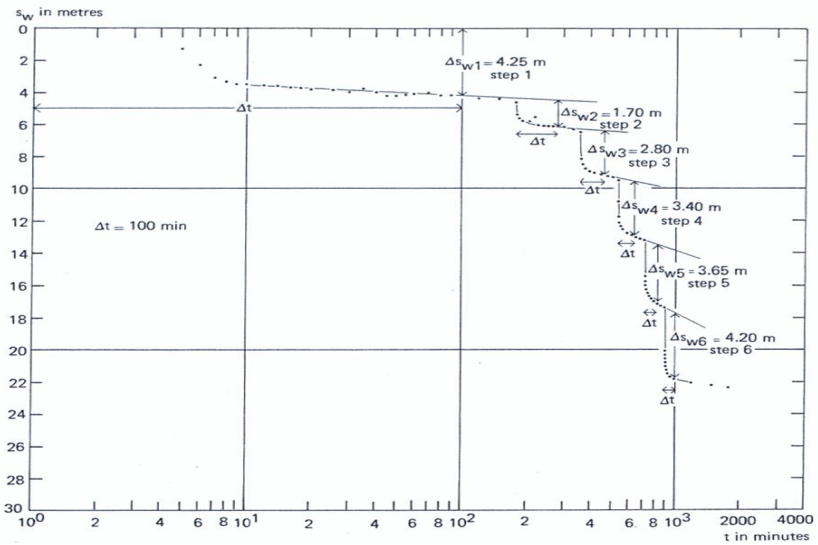
Teste de vazão

Visão Notícias

Avaliação do poço – mas como?

Teste de vazão escalonado

quiterianopolis.ce.gov.br



Kruseman e De Ridder, 1994

O que é o teste de vazão escalonado

- **Bombear em etapas com Q diferentes, crescentes**
- **Q durante a etapa é constante**
- **Cada etapa tem a mesma duração**
- **Varia de ½ a 2h**
- **É determinada pela estabilização do NA na primeira etapa**

O que é o teste de vazão escalonado

- **São usadas, em geral, de 3 a 5 vazões distintas**
- **Q na primeira etapa deve ser baixa**
- **Incrementos de vazão devem gerar rebaixamento significativo**
- **Dados anotados: vazão (Q), tempo (t) e rebaixamento (s_w)**

Para que serve o teste de vazão escalonado

- **Determinar eficiência do poço**
- **Determinar a vazão testes de longa duração**
- **Testar os sistemas envolvidos no bombeamento**
- **Testar os procedimentos para teste de Q constante**
- **Determinar se poço precisa de manutenção**

Determinar qual bomba pode ser usada

Interpretação

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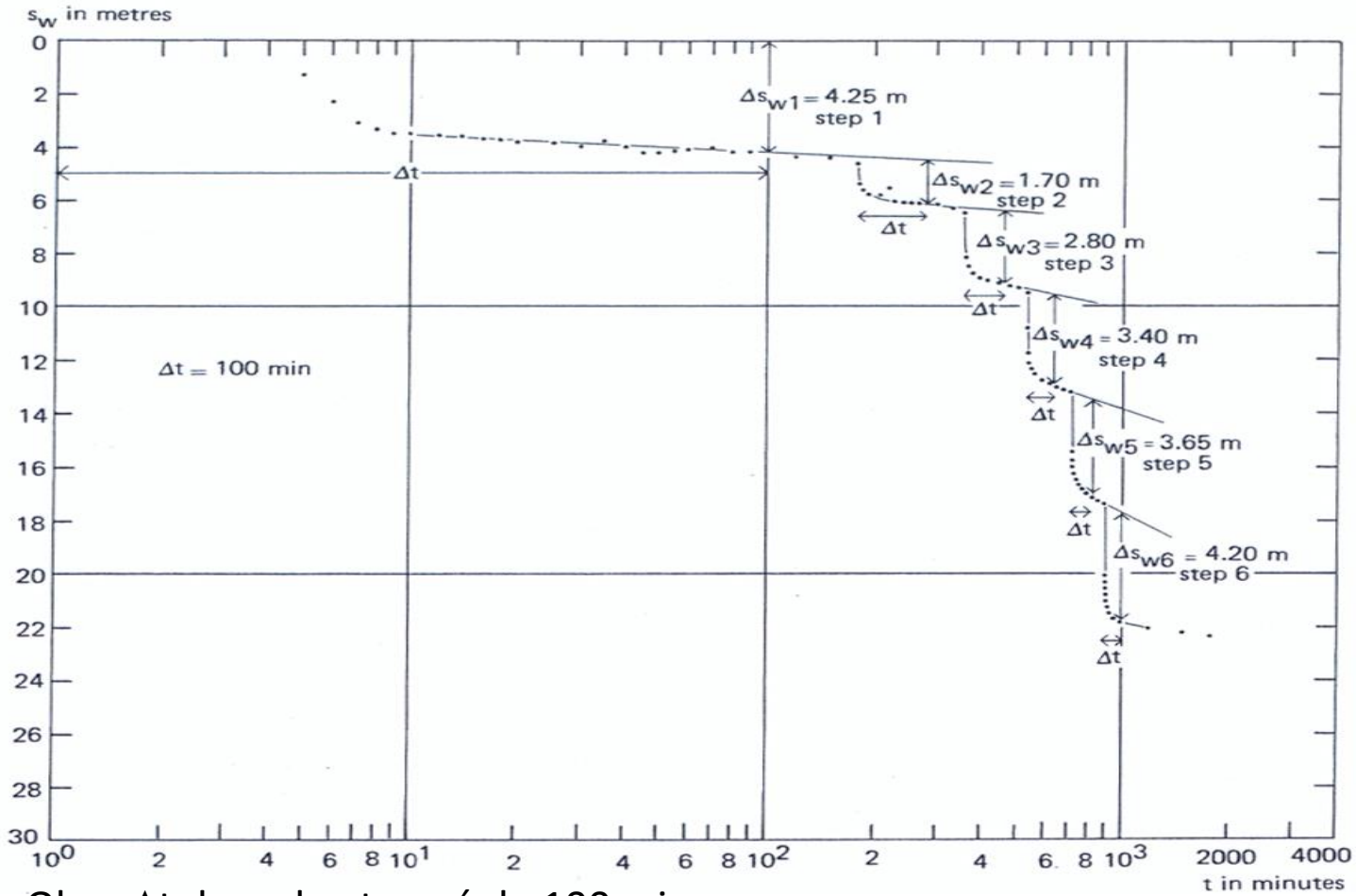
Método de Hantush (1964) e Bierschenk (1963)

- **Serve para aquíferos livres, semi-confinados e confinados**
- **Para um bom resultado, pressupõe pelo menos três vazões, crescentes e constantes**

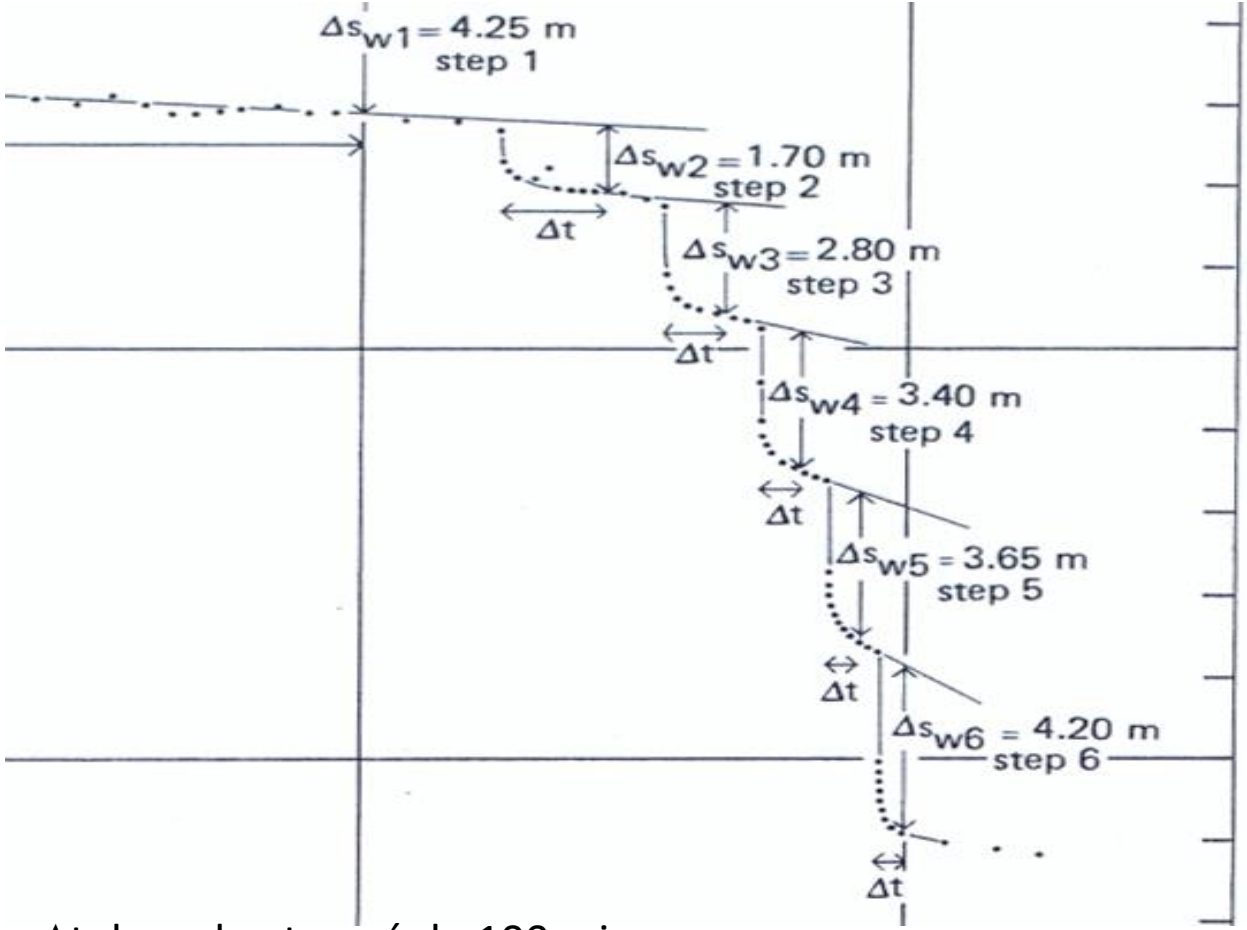
Interpretação

- **Plotar os dados: rebaixamento linear, tempo logarítmico**
- **Extrapolar os dados de cada etapa para a próxima**
- **Determinar os incrementos de rebaixamento Δ_{swi} para cada etapa**
- **Determinar os valores de $s_{w(n)}$ correspondente a cada Q_n a partir da equação $s_{w(n)} = \Delta_{sw(1)} + \Delta_{sw(2)} + \ldots \Delta_{sw(n)}$**



Obs.: Δt de cada etapa é de 100 min

Kruseman e de Ridder 1994



Obs.: Δt de cada etapa é de 100 min

Kruseman e de Ridder 1994

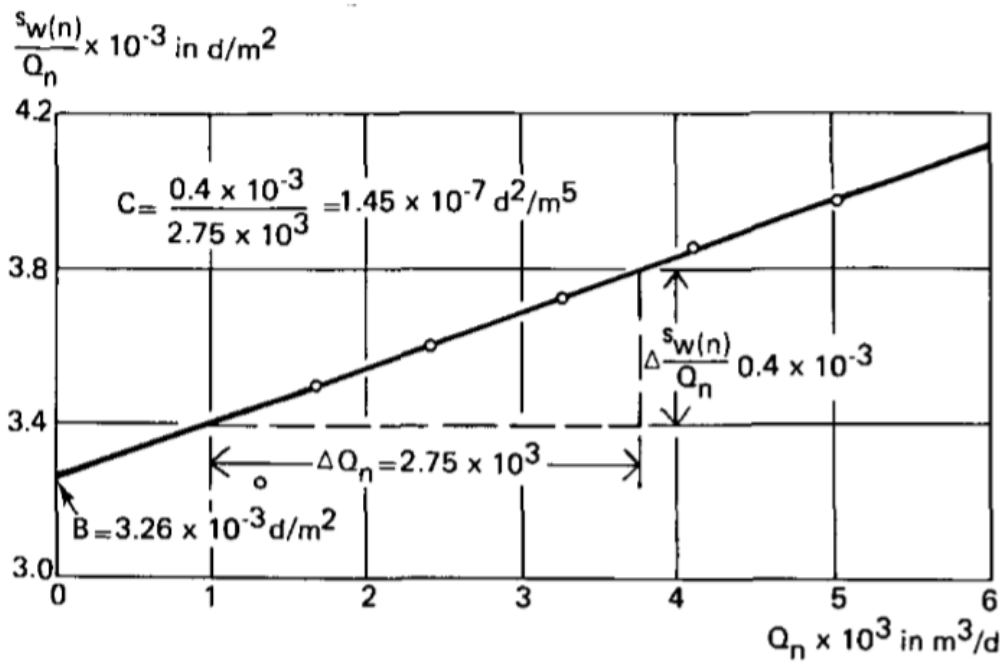
Resultados

Etapa	$\Delta s_{w(n)}$ (m)	$s_{w(n)}$ (m)	Q_n (m^3/d)	$s_{w(n)}/Q_n$ (d/m^2)
1	4,25	4,25	1306	$3,25 \times 10^{-3}$
2	1,70	5,95	1693	$3,51 \times 10^{-3}$
3	2,80	8,75	2423	$3,61 \times 10^{-3}$
4	3,40	12,15	3261	$3,73 \times 10^{-3}$
5	3,65	15,80	4094	$3,86 \times 10^{-3}$
6	4,20	20,00	5019	$3,98 \times 10^{-3}$

Obs.: Δt de cada etapa é de 100 min

Kruseman e de Ridder 1994

Interpretação



Determinar a inclinação da reta:

$$\Delta(s_{w(n)}/Q_n)/\Delta Q_n$$

Esta reta é o valor de C (perdas não lineares)

Obs.: Δt de cada etapa é de 100 min

Resultados

Etapa	$\Delta s_{w(n)}$ (m)	$s_{w(n)}$ (m)	Q_n (m^3/d)	$s_{w(n)}/Q_n$ (d/m^2)
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6	4,20	20,00	5019	$3,98 \times 10^{-3}$

20%!

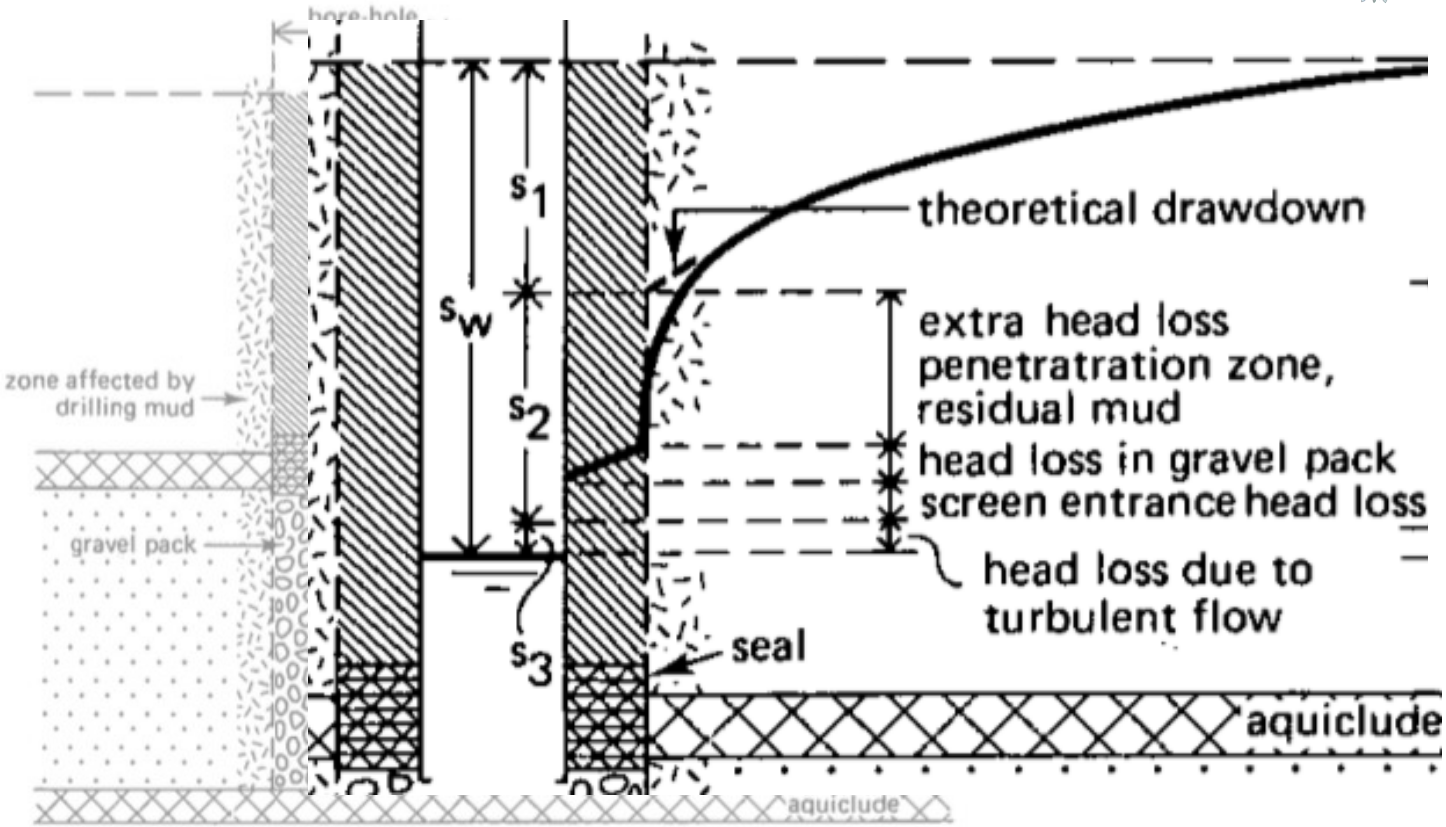
Obs.: Δt de cada etapa é de 100 min

Kruseman e de Ridder 1994

Resultados

$$s_w = (3{,}26 \times 10^{-3})\, Q + (1{,}45 \times 10^{-7}) Q^2$$

Perdas de Poço



Resumo Teste Escalonado

- **Permite testar equipamentos e procedimentos antes de fazer o teste de vazão constante**
- **Permite determinar vazão ideal para o poço, que não gere perdas significativas**
- **Permite avaliar se poço antigo possui perdas muito grandes e precisa de manutenção**
- **Caso tenha sido feito quando poço foi construído, permite comparação**

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Obrigado!

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Influências no ND
Poço de bombeamento

Vazão ideal: se eu colocar uma bomba mais potente, e gastar 50% mais de energia, eu vou obter 50% a mais de água?