



Aquifer Testing for Improved Hydrogeologic Site Characterization

Day 2: Pumping Tests

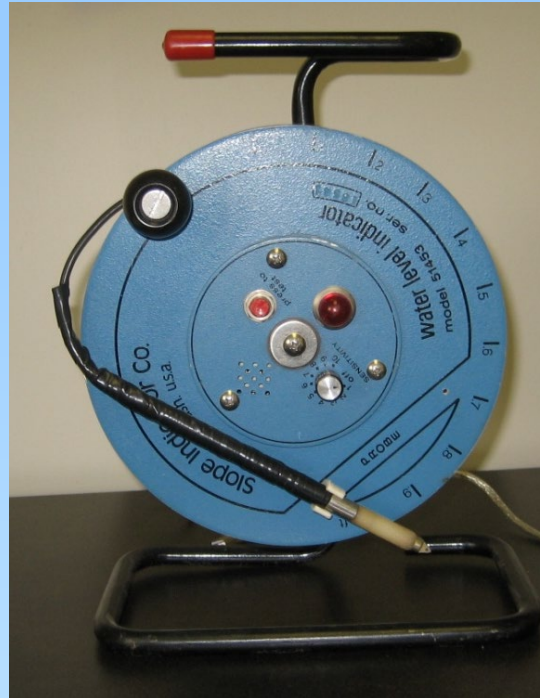
Christopher J. Neville



Motivation

1. To make you better hydrogeologists.
2. To promote a critical approach to the interpretation of pumping tests.
3. To direct attention to both the estimation of representative properties and the diagnosis of well and formation response.
4. To provide guidance and materials for ongoing self-study.

We live in a golden age of hydrogeologic testing



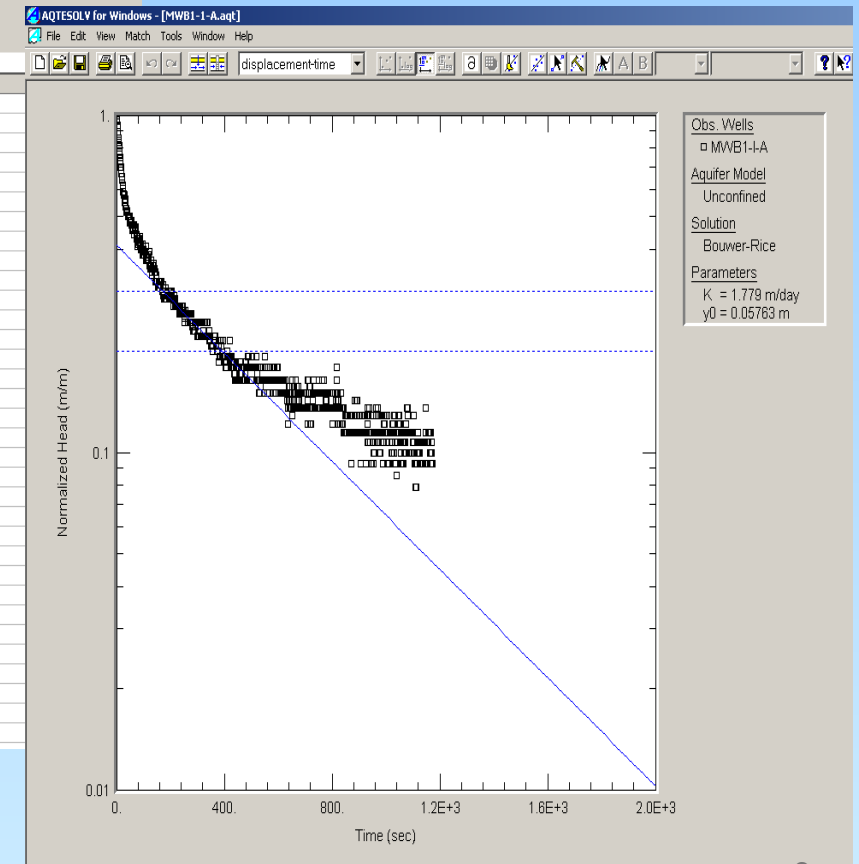
Microsoft Excel - MWB1-7-A.xls

File Edit View Insert Format Tools Data Window Help Adobe PDF

Capture Studio 2.62

H13

	A	B	C	D	E	F
1	Time	MWB1-I-A				
2	14:25:00	1077.4	280.442	0.00	280.442	0.002
3	14:25:01	1077.2	280.44	1.00	280.44	0
4	14:25:02	1077	280.438	2.00	280.438	-0.002
5	14:25:03	1077.2	280.44	3.00	280.44	0
6	14:25:04	1077.2	280.44	4.00	280.44	0
7	14:25:05	1077.2	280.44	5.00	280.44	0
8	14:25:06	1077.2	280.44	6.00	280.44	0
9	14:25:07	1077.2	280.44	7.00	280.44	0
10	14:25:08	1077.2	280.44	8.00	280.44	0
11	14:25:09	1077	280.438	9.00	280.438	-0.002
12	14:25:10	1077.2	280.44	10.00	280.44	0
13	14:25:11	1077.2	280.44	11.00	280.44	0
14	14:25:12	1077	280.438	12.00	280.438	-0.002
15	14:25:13	1077.2	280.44	13.00	280.44	0
16	14:25:14	1077.2	280.44	14.00	280.44	0
17	14:25:15	1077	280.438	15.00	280.438	-0.002
18	14:25:16	1077.2	280.44	16.00	280.44	0
19	14:25:17	1077	280.438	17.00	280.438	-0.002
20	14:25:18	1077.2	280.44	18.00	280.44	0
21	14:25:19	1077.2	280.44	19.00	280.44	0
22	14:25:20	1077.2	280.44	20.00	280.44	0
23	14:25:21	1077.2	280.44	21.00	280.44	0
24	14:25:22	1077	280.438	22.00	280.438	-0.002
25	14:25:23	1077.2	280.44	23.00	280.44	0
26	14:25:24	1077.2	280.44	24.00	280.44	0
27	14:25:25	1076.7	280.435	25.00	280.435	-0.005
28	14:25:26	1077.2	280.44	26.00	280.44	0
29	14:25:27	1077	280.438	27.00	280.438	-0.002
30	14:25:28	1077.2	280.44	28.00	280.44	0
31	14:25:29	1077	280.438	29.00	280.438	-0.002
32	14:25:30	1077	280.438	30.00	280.438	-0.002
33	14:25:31	1077.2	280.44	31.00	280.44	0

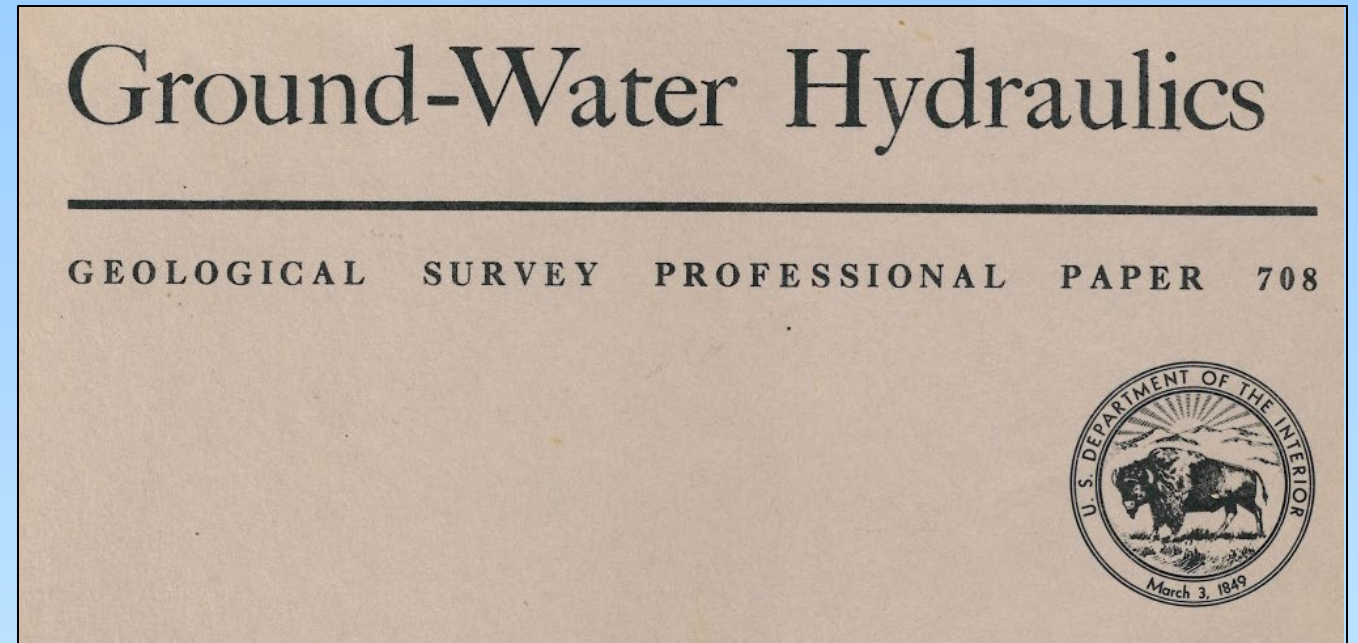
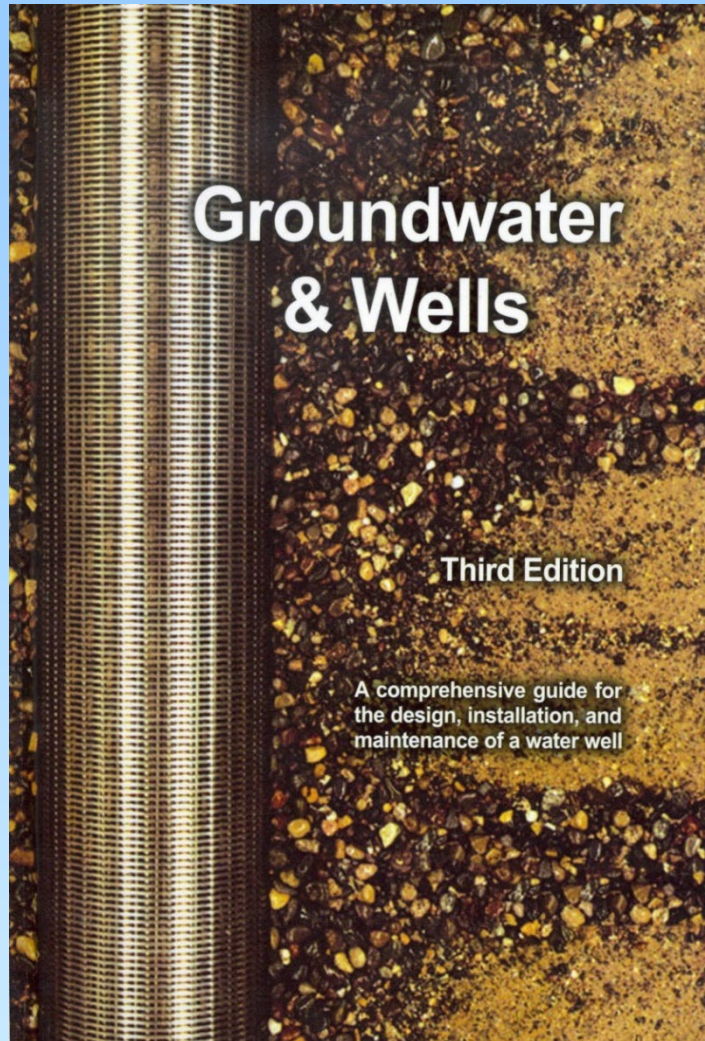


Outline

1. Key concepts in groundwater hydraulics
2. Setting the stage for the interpretation of pumping tests
3. Foundations of pumping test interpretation, Part 1
4. Foundations of pumping test interpretation, Part 2
5. Interpretation of pumping tests in aquifers with linear boundaries
6. Interpretation of pumping well drawdowns
7. The significance and interpretation of recovery data
8. Success factors in pumping test practice

Key concepts in groundwater hydraulics

Reference materials

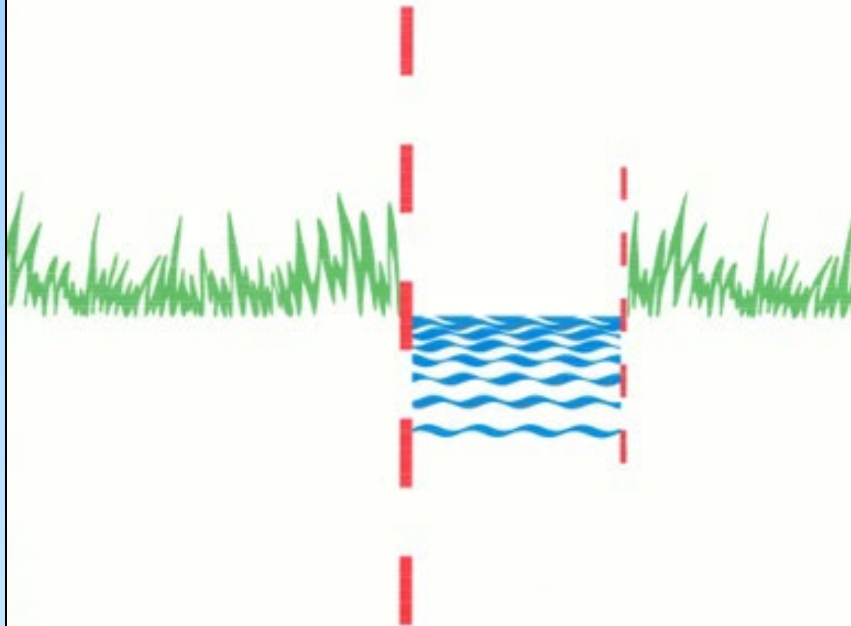


ILRI publication 47

Analysis and Evaluation of Pumping Test Data

Second Edition (Completely Revised)

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WATER WELL TESTING IN THE ATHABASCA OIL SANDS, COMPLEMENTARY GUIDANCE

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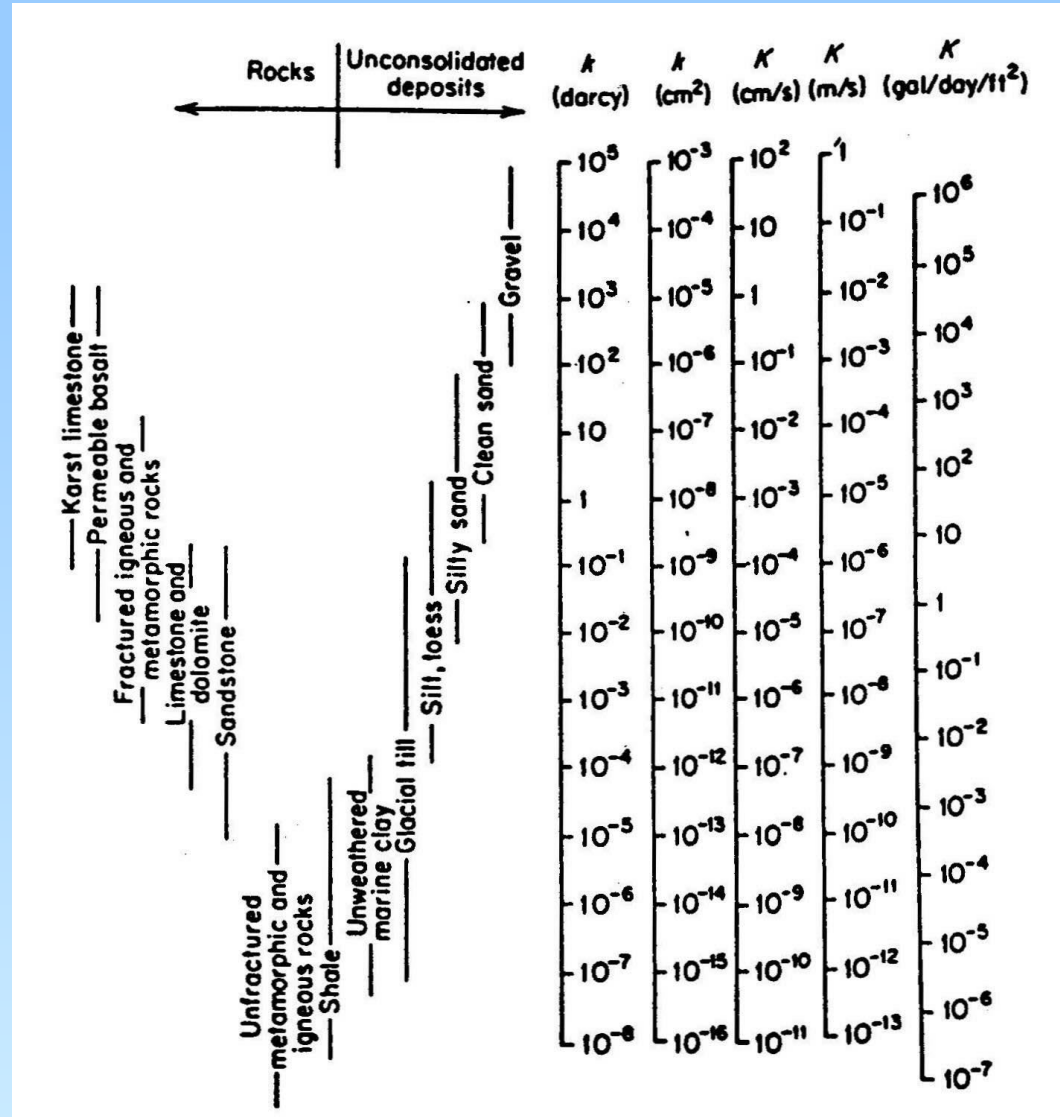
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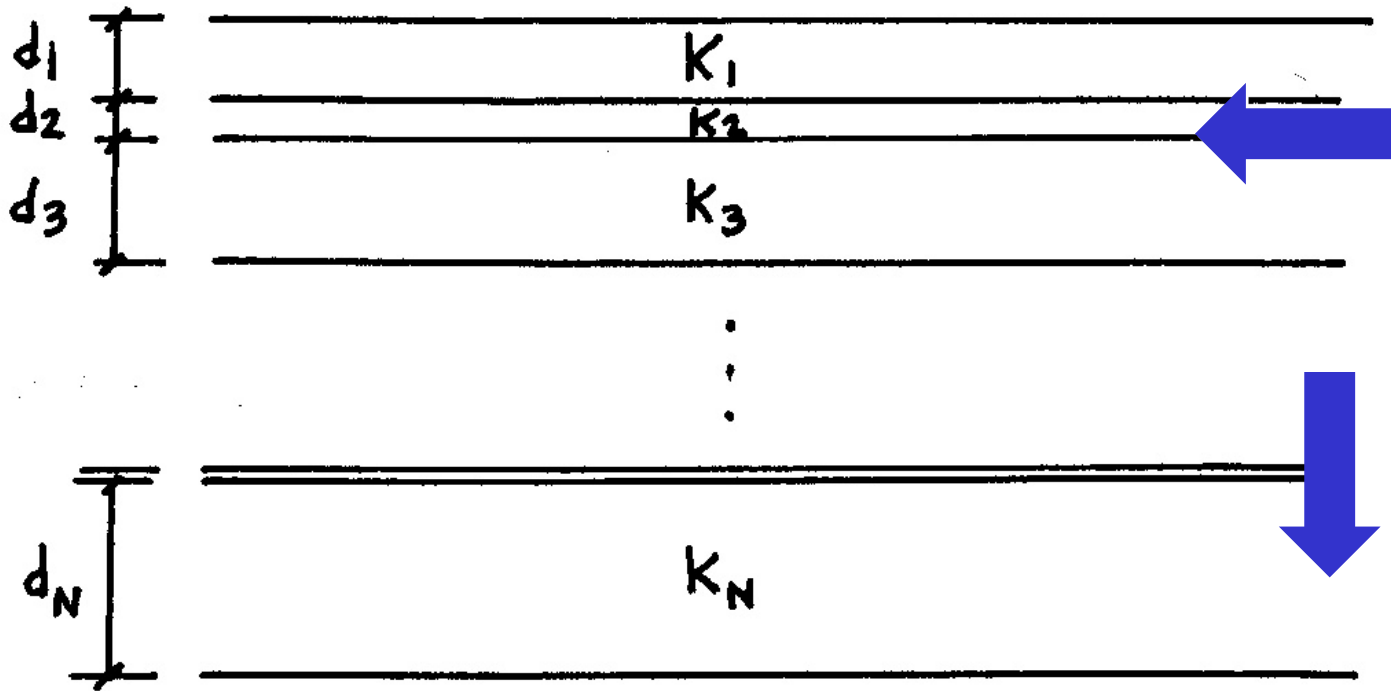


December 15, 2012

Hydraulic conductivity



Effective hydraulic conductivities of stratified formations

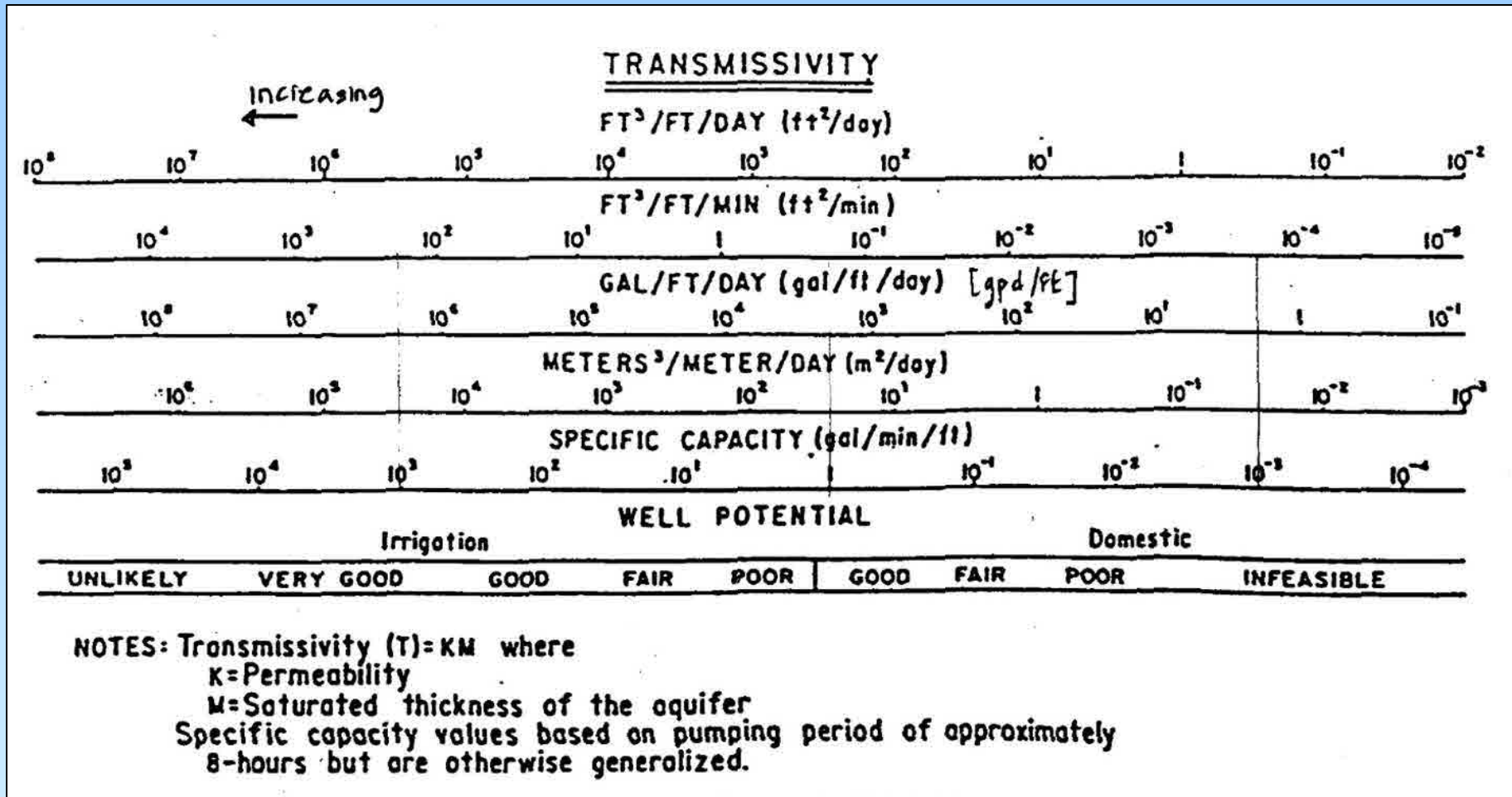


$$\bar{K}_H = \frac{\sum_{i=1}^N K_i d_i}{\sum_{i=1}^N d_i}$$

$$\bar{K}_V = \frac{\sum_{i=1}^N d_i}{\sum_{i=1}^N \frac{d_i}{K_i}}$$

Transmissivity, T

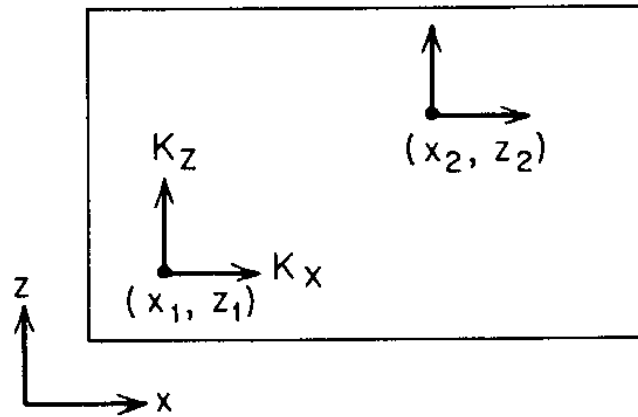
$$T = K_H \times B = \sum_{i=1}^N K_i d_i$$



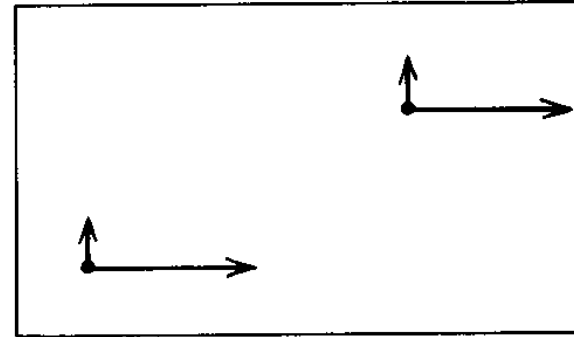
Homogeneity - Heterogeneity

Isotropy - Anisotropy

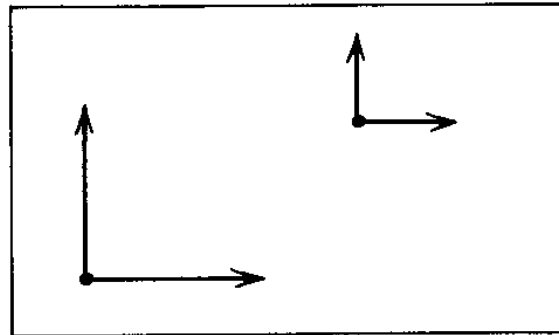
Homogeneous, Isotropic



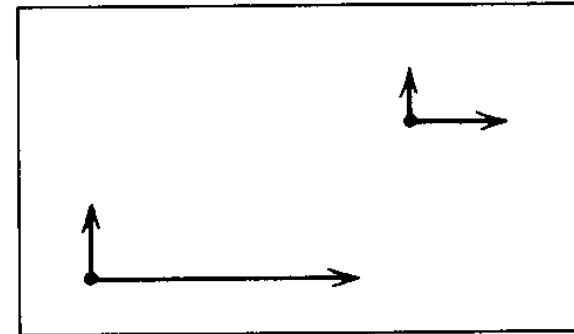
Homogeneous, Anisotropic



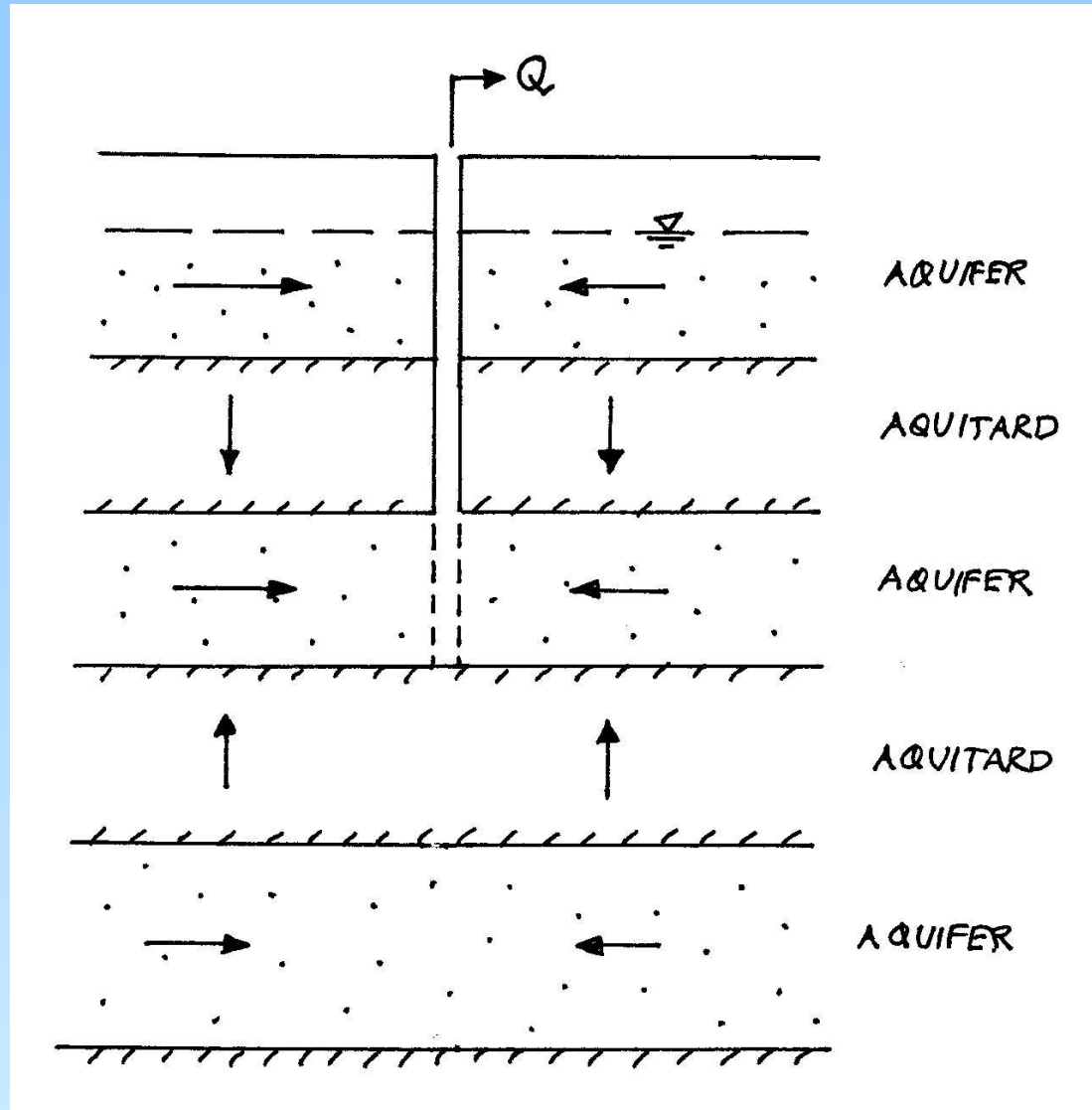
Heterogeneous, Isotropic



Heterogeneous, Anisotropic

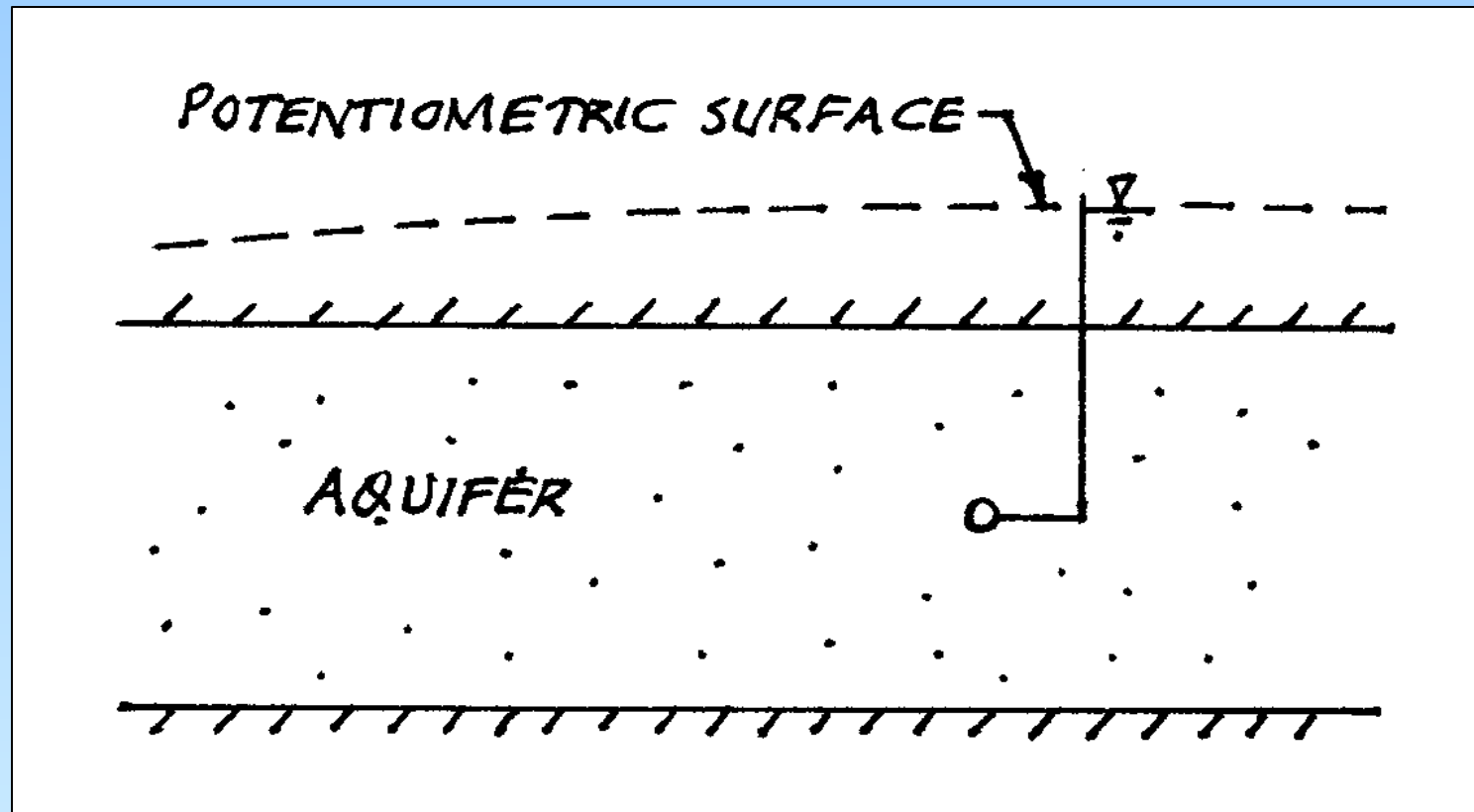


Aquifers and aquitards



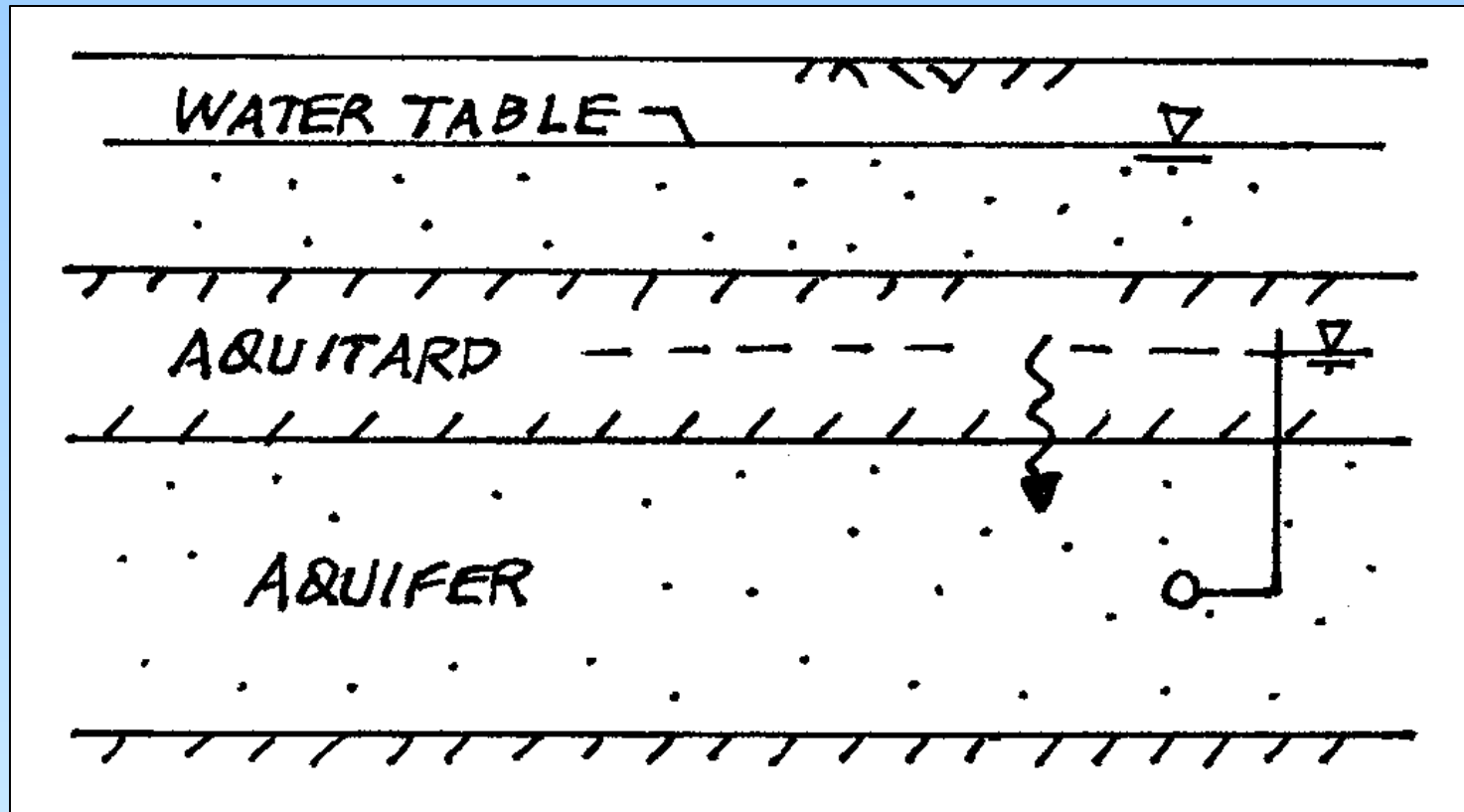
Aquifer types

Confined aquifer



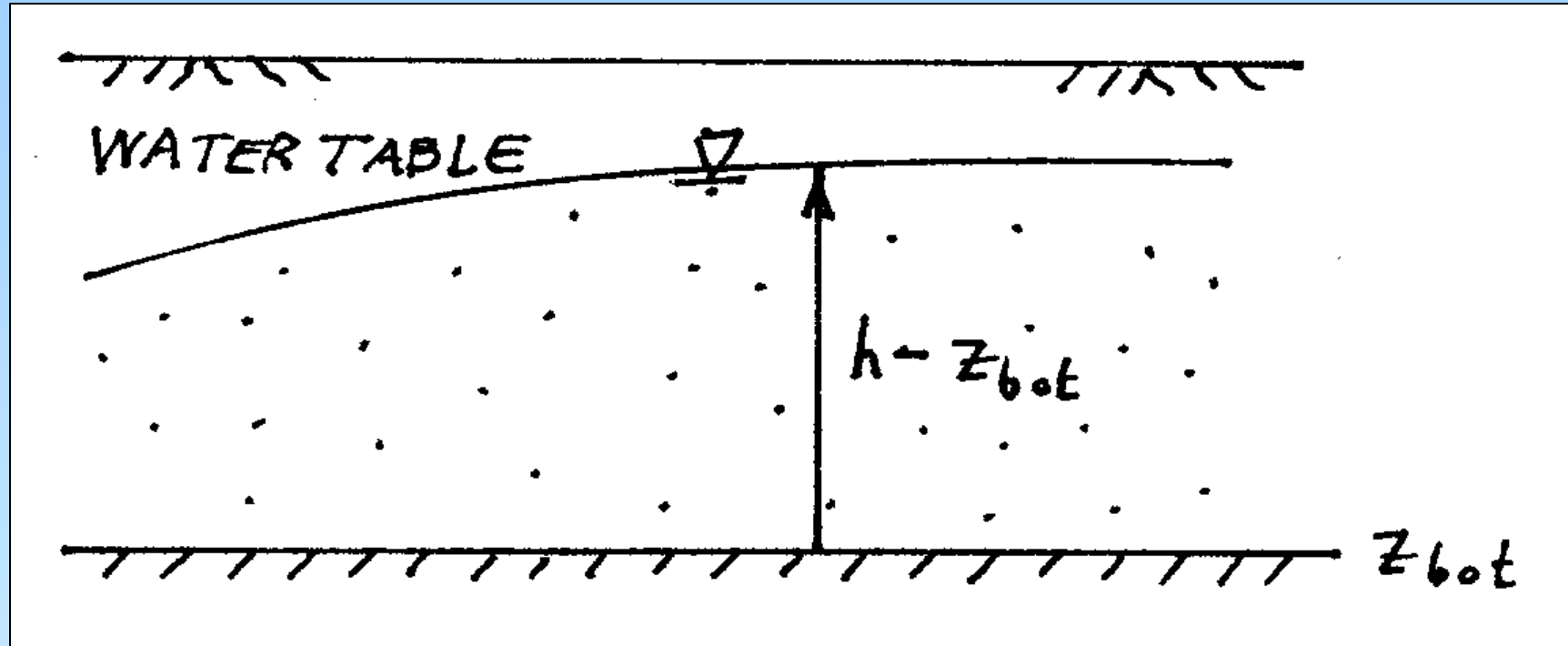
Aquifer types (2)

Leaky aquifer

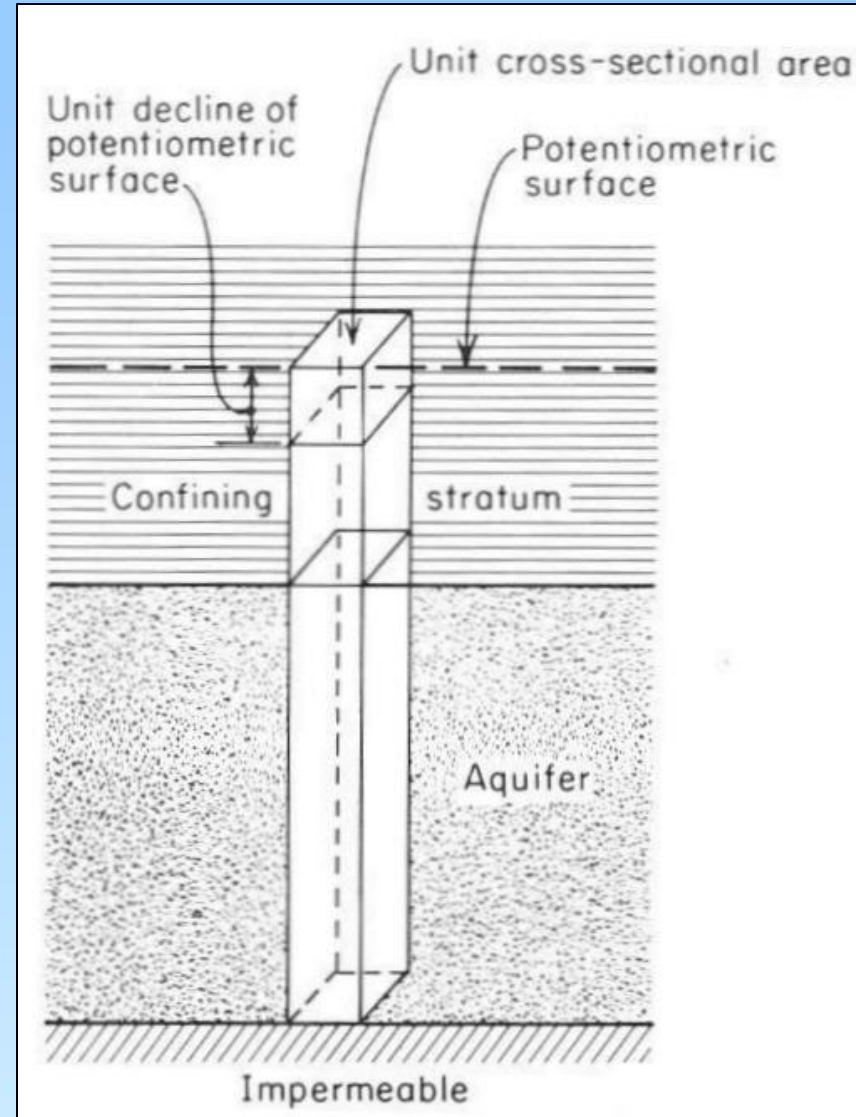


Aquifer types (3)

Unconfined aquifer

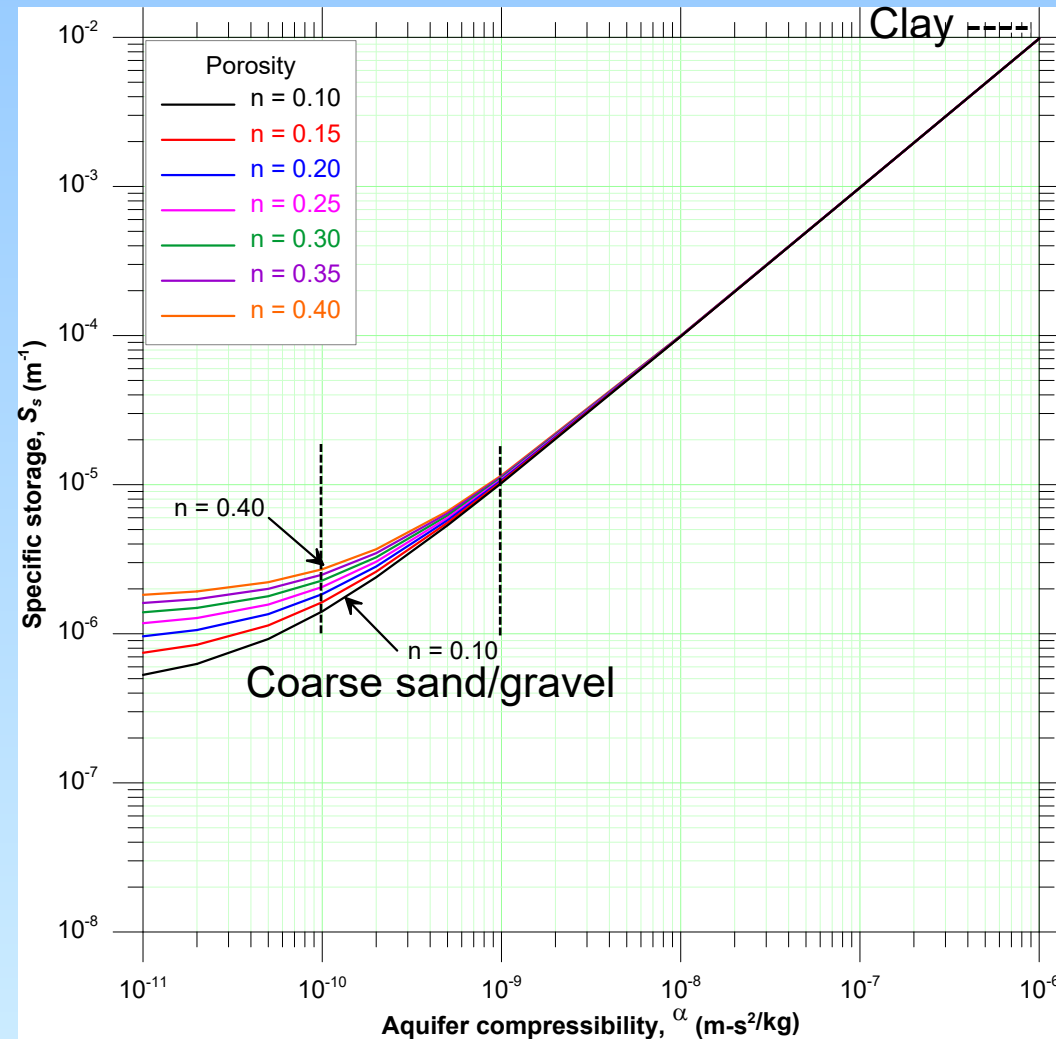


Confined storage coefficient, S (Storativity)



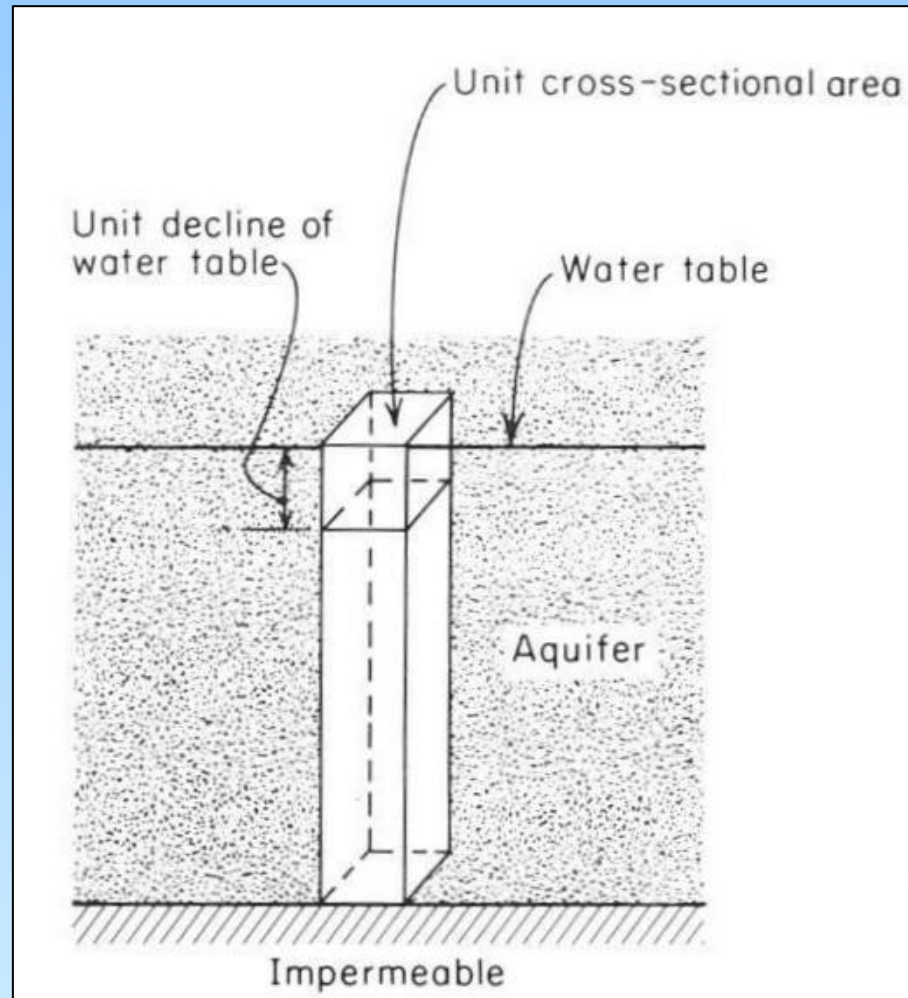
$$S_s = \rho_w g (\alpha + n\beta)$$

$$S = S_s B$$

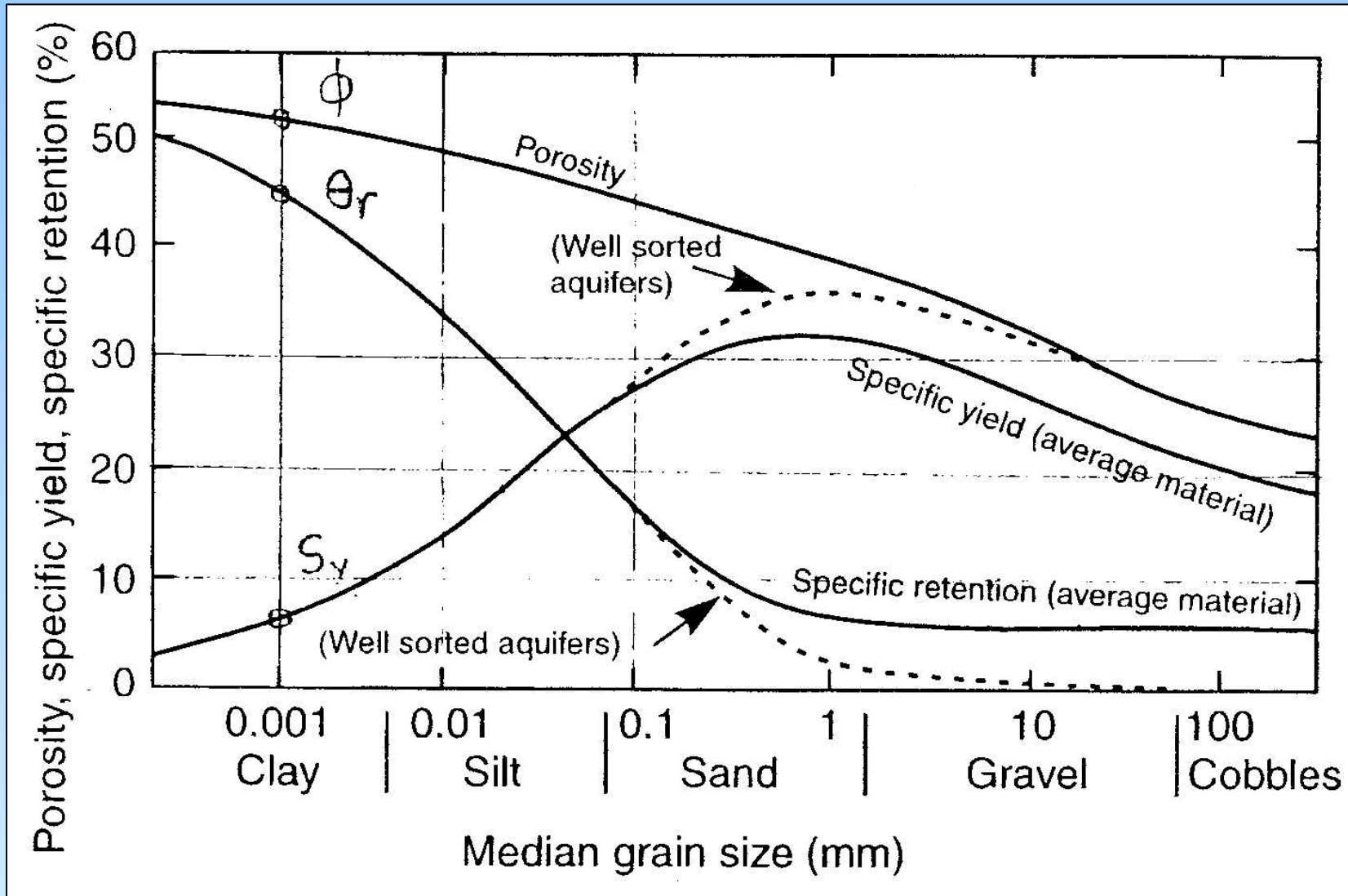


Lohman (1972)
 $S_s \sim 3 \times 10^{-6} / \text{m}$

Unconfined storage coefficient, S_y (Specific yield; Drainable porosity)



$$S_Y = \phi - \theta_r$$





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ENVIRONMENTAL AND WATER RESOURCE CONSULTANTS

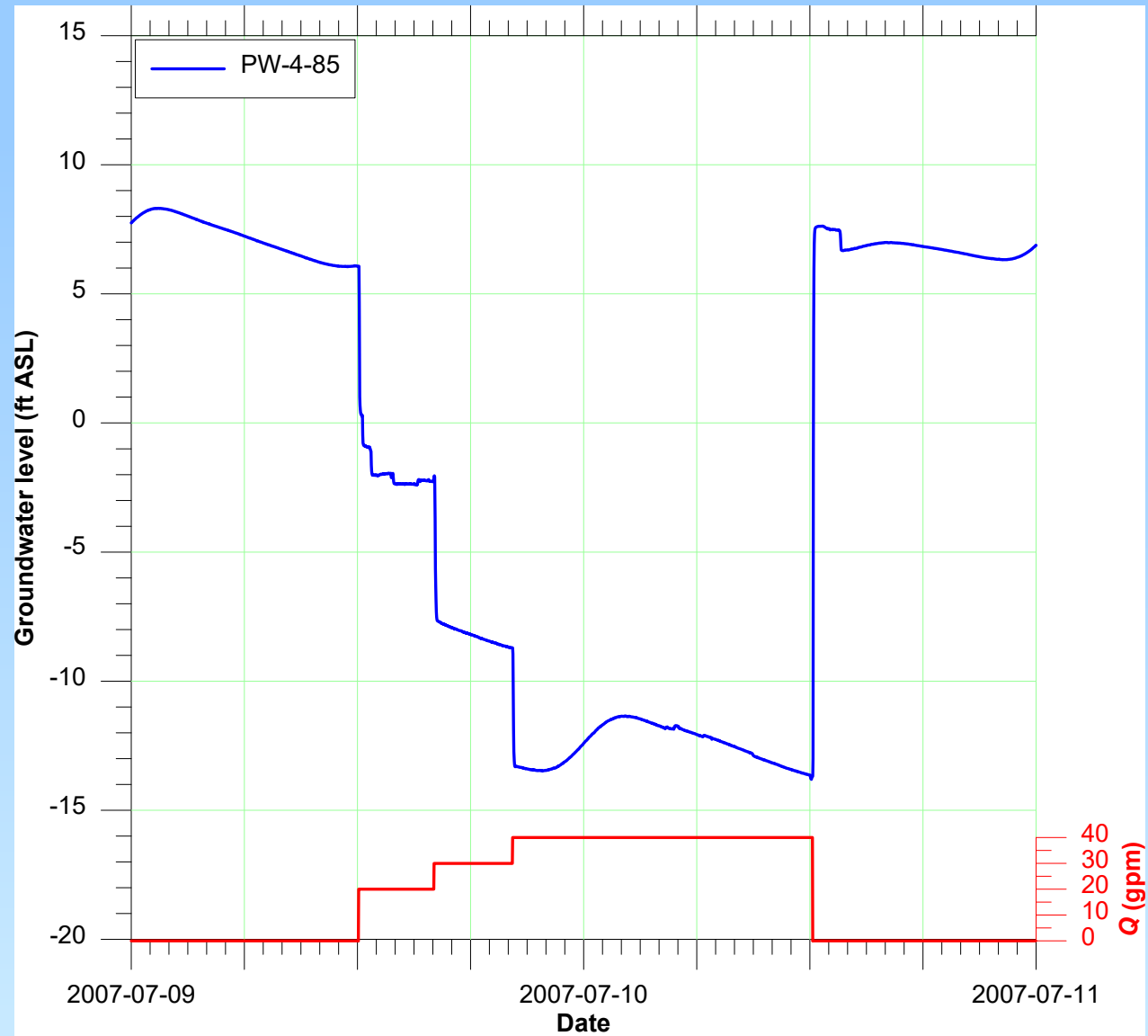
Setting the stage: What do hydrogeologists do when they interpret a pumping test?

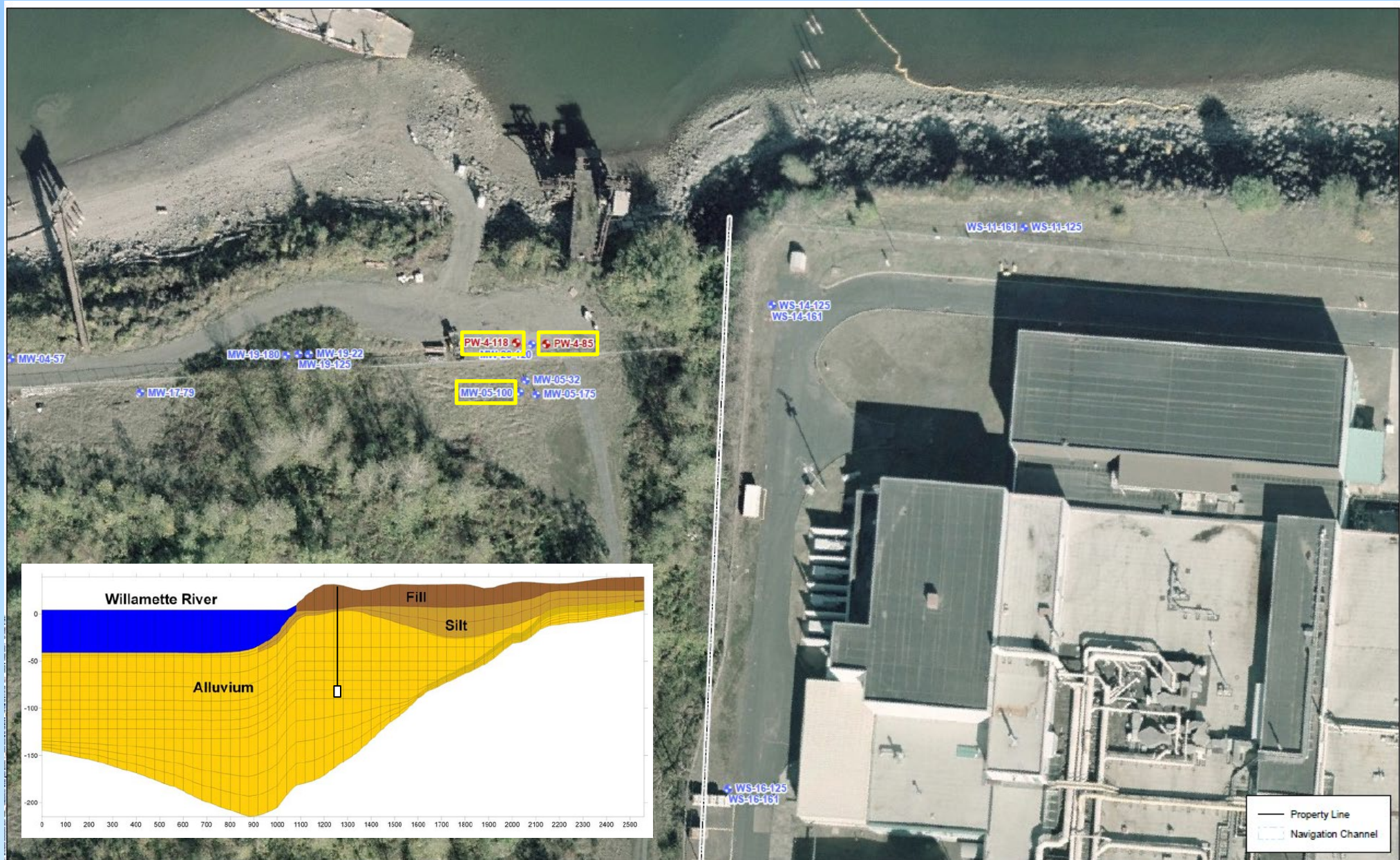
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Steps in the interpretation of a pumping test

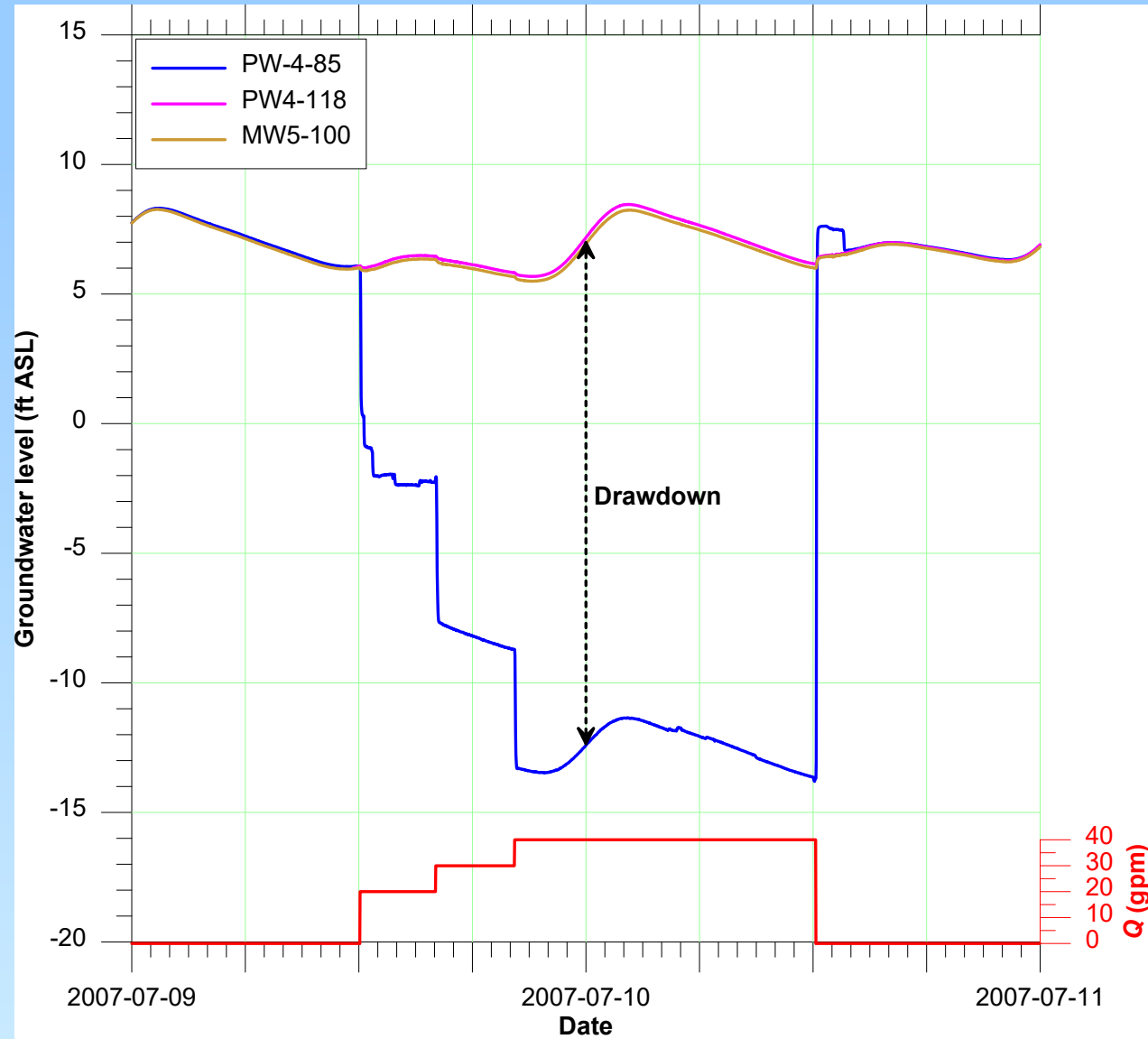
1. Data processing
2. Interpretation
3. Assessment

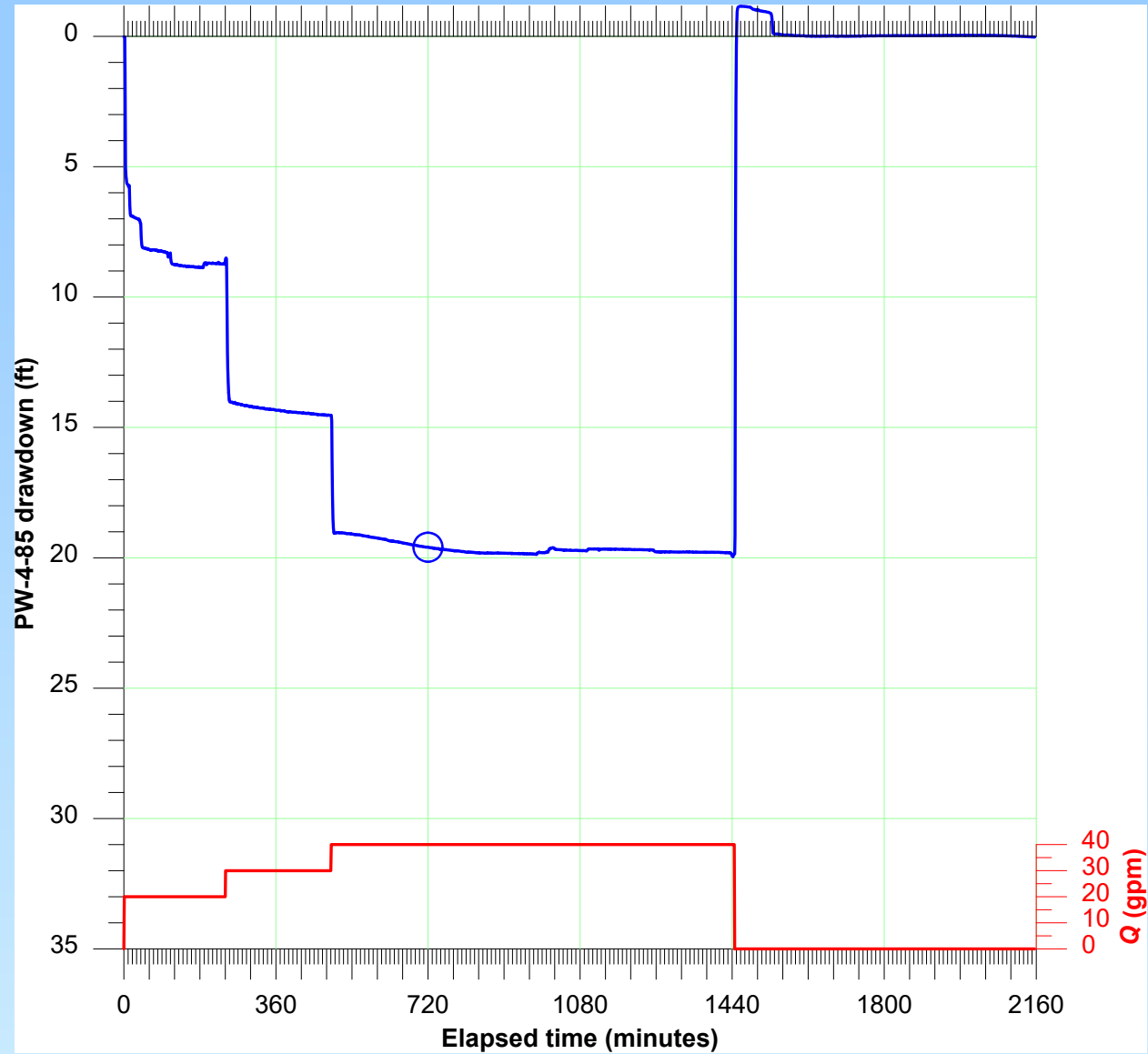
1. Data





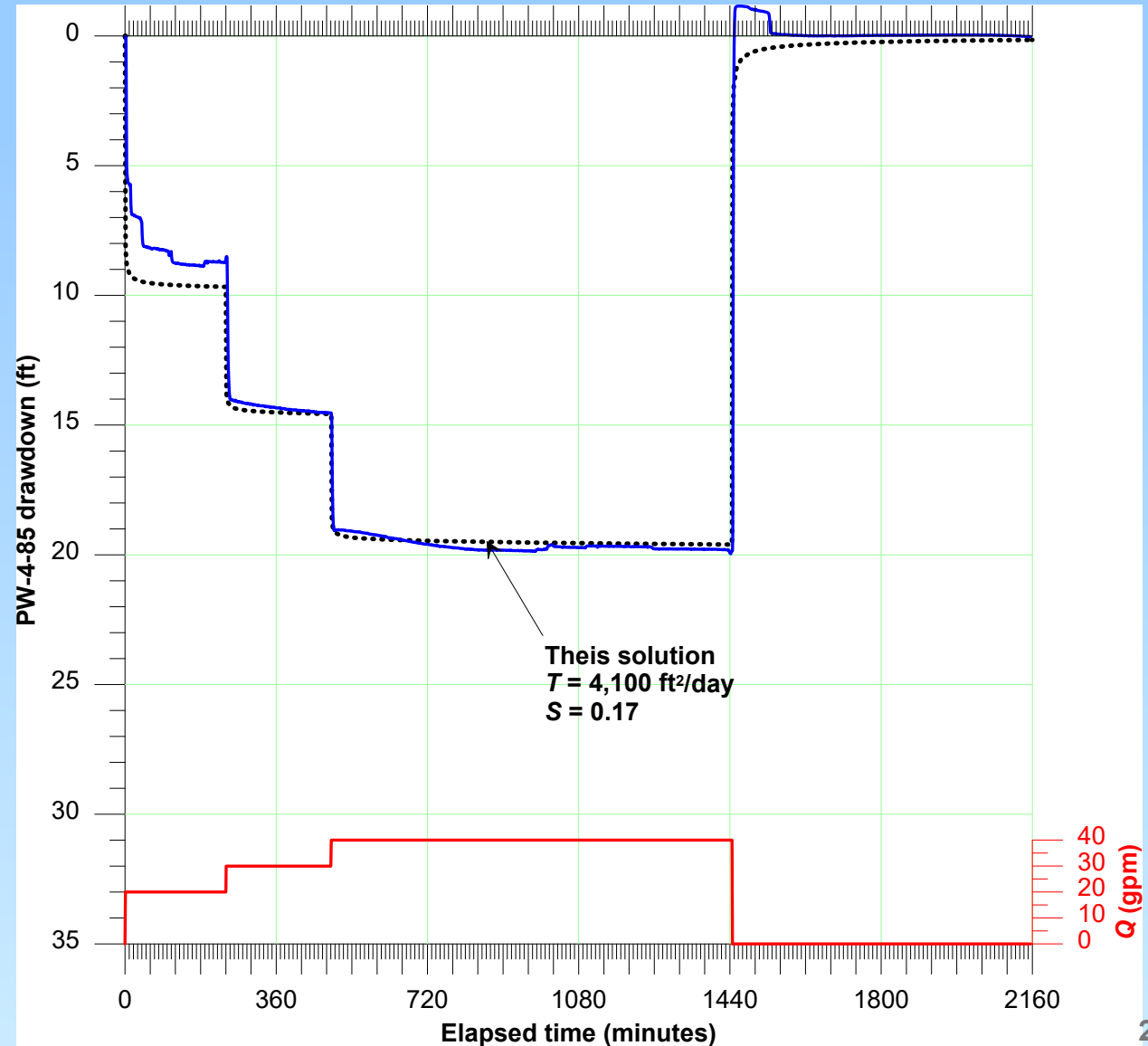
2. Interpretation #1: Drawdown





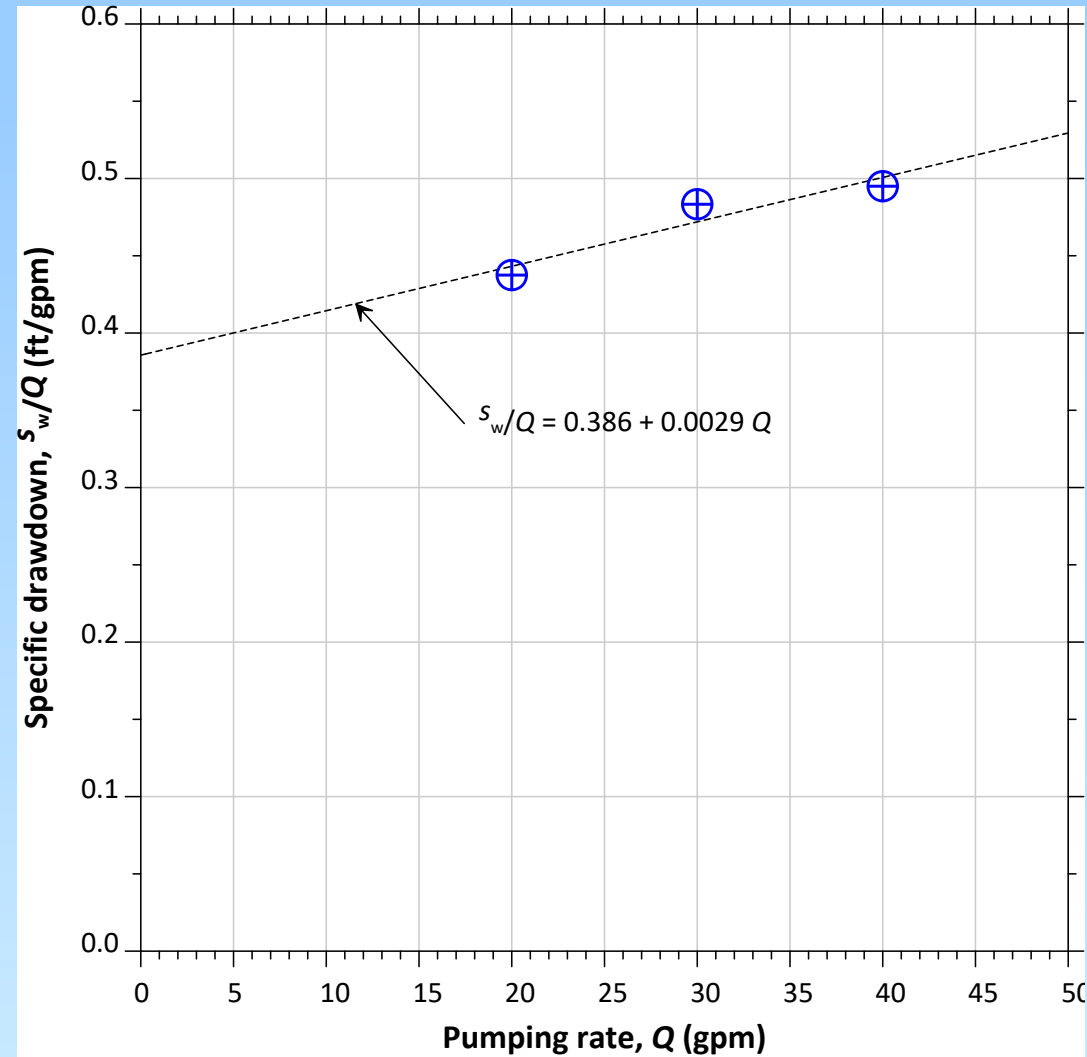
Interpretation #2: Modeling

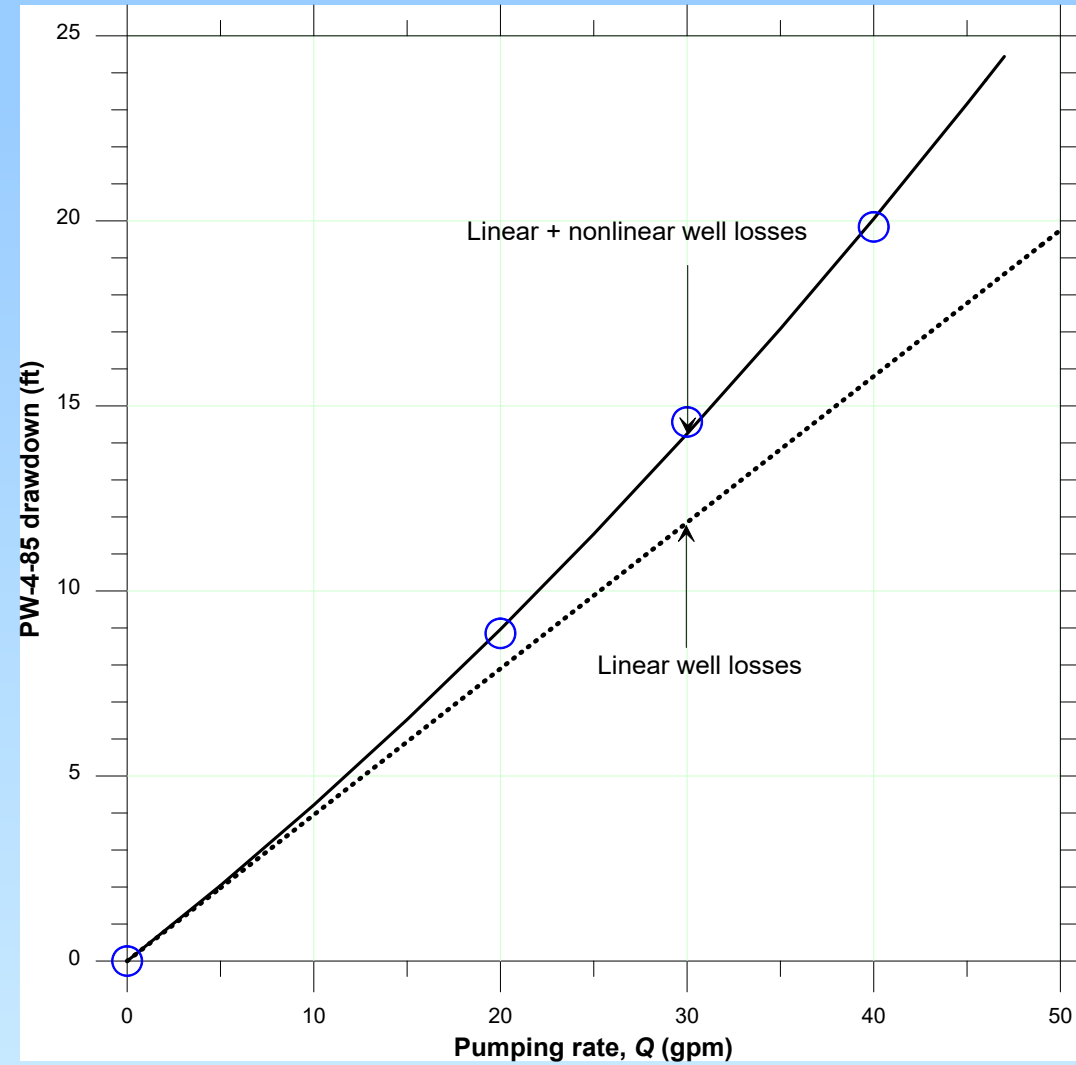
In this context, modeling means matching the data with a theoretical model.



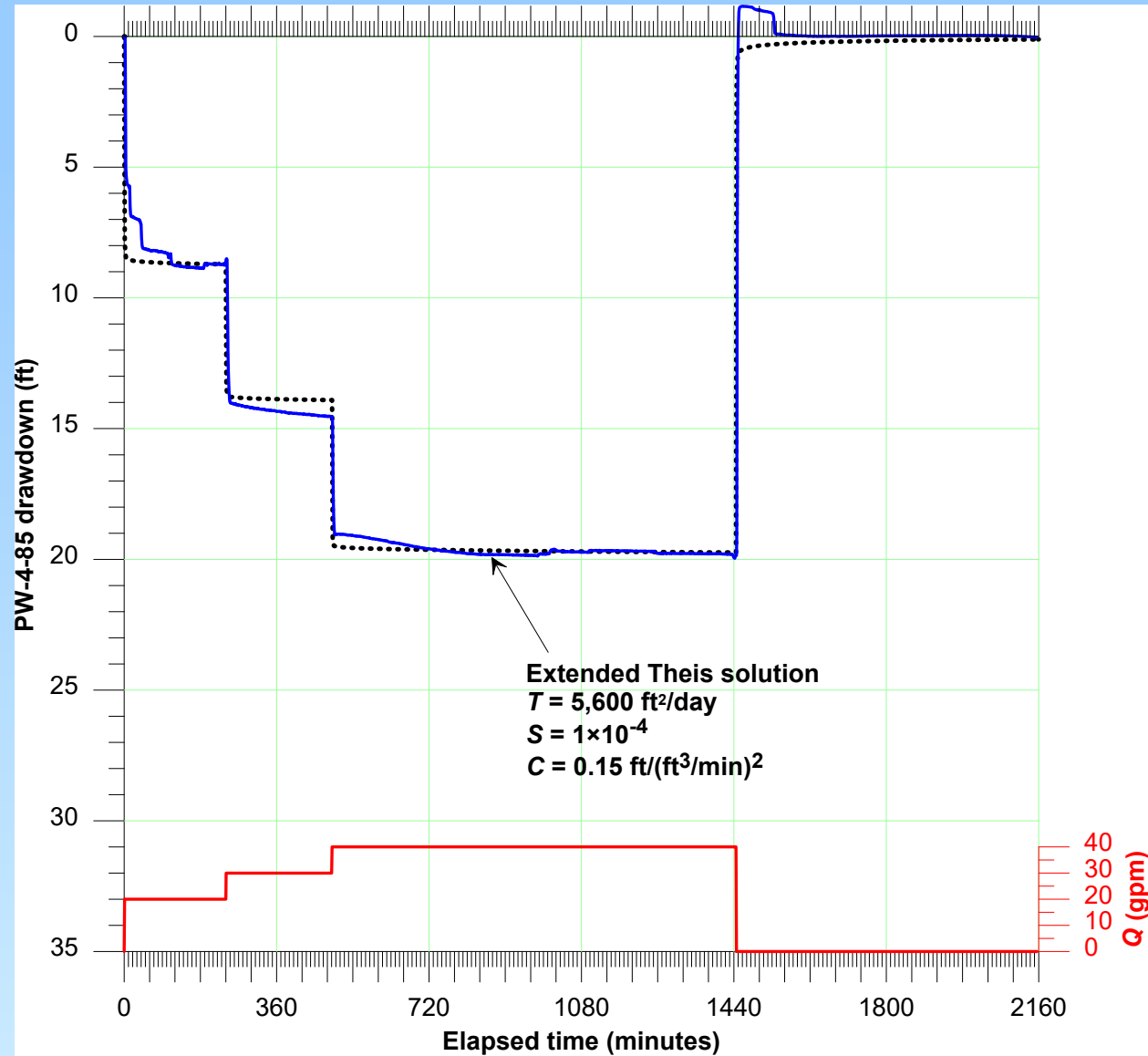
More Modeling

Confined aquifer
 $S = 0.17$?





Yet more modeling



3. Assessment

1. Can we match the data with a theoretical model?
2. Do our inferred parameters make sense?
3. Are our analyses consistent with everything else we know about our site (i.e., our Site Conceptual Model)?

Key points

1. Hydrogeologists measure the pumping rate and groundwater levels. Everything else is interpretation (modeling).
2. Our key responsibility is to assess whether our interpretations make sense.