



INTRODUCTION

General Instructions:

The completion of this Lab does NOT require a formal Lab report or write up. Instead you will present your data by completing a Lab Template. This template is available as a separate document. **Only the completed LAB4: CONFINED AQUIFER PUMPING RESULTS needs to be turned in for credit!!!**

Reading Assignments:

In preparation for this Lab and the other pumping lab, READ the following in your FREE Open Access Textbook(s):

- Kresic, 2024, Hydrogeology 101: Lecture 3.1; 4; 6.2; 9.1; 14.6.4; 15.3.3
 - Freeze & Cherry, 1979, Groundwater: Chapter 2, Chapter 8
- (Optional) and if you have it, READ the following in your *optional* Textbook:
- Hölting & Coldewey, 2019, Hydrogeology: Section 4; 16.3.1

GENERAL INSTRUCTIONS ON COMPLETING THE LAB and GRADING:

For ALL assignments use a citation's database:

ZOTERO citations database

ZOTERO is a citations database that incorporates itself into Word and your Browser.

Free open source software available at <https://www.zotero.org/>

Note: You may use a different citations database, if desired. But you MUST use a citations database!

NOTE: After downloading and installing ZOTERO, take an hour or two to become familiar with the operation of the software. One of your first tasks will be to set the citation style to the United States Geologic Survey (USGS) format in ZOTERO. The USGS citation system will be required for this course and your final product.

Loading the USGS citation format into ZOTERO: Once Zotero Standalone is installed, click on "Preferences" under the Edit tab. Once there click on "Cite" and go to the "Styles" tab. Click on the "Get additional styles..." below the Styles Manager Box. When the Zotero Styles Repository Window opens, click on the "geology" button within the "Fields" section. A list of geology journals should now appear. Scroll down to the U.S. Geological Survey and click on it. The U.S.G.S style will now be part of your Zotero system and you can set your citations to be formatted accordingly in Zotero.

General Writing Instruction Summary:

- Use professional language, which means AVOID first person expressions such as "I", "we", "our". Use normal prose, active voice and third party language. Do NOT use informal wording, contractions, jargon, slang terms, or superlatives. Exclude similes/metaphors (and humor!)
- Use present tense to report well accepted facts, e.g. 'Pyrite is a sulfide mineral'. Use past tense to describe specific results, e.g. 'When acid was applied, the specimen effervesced'
- Be quantitative wherever relevant (stats, numbers etc.).

Subscript & Superscript

Use appropriate subscript and superscript, especially when it comes to chemical formulas and mathematical units..

Acceptable examples: 2.9 g/cm³, H₂O, PO₄³⁻, a_g=9.8m/s²

Unacceptable examples: 2.9 g/cm3, H2O, PO4 3-, ag=9.8m/s^2

- Use precise concrete language, no ambiguity e.g, 'correlated' ≠ 'related'. Use simple language – no unnecessary "frills" (distractions). Pay attention to sentence structure and grammar



COMPILING TABLES, FIGURES and EQUATIONS

GRAPHICS are the heart of any report. Nothing is more true than in science that a picture is worth a thousand words. Always compile graphics first and then write your text focusing on your graphic. In order to create good graphics and photographs, follow the instructions below.

Cameras and Photos:

Cell phones with a 7.2MP camera are usually ok. When taking pictures, lighting and background is key. This means dark objects should be photographed with light or white backgrounds (sheet of paper) and visa versa for light objects. Having adequate lighting will also help to get sharp, crisp, in focus pictures. Blurry and out of focus pictures are not acceptable.

Graphics:

You should be able to modify, enhance, annotate or overlay graphics. Minimum resolution is 300dpi. Make sure graphics are crisp, clear and any label is easily readable. All graphics should have a caption stating the author and/or citation. Preferably use lossless graphic formats, such as .tif or .bmp. Unfortunately .jpg is NOT lossless and will degrade a little every time you open and save it again in order to manipulate picture contents.

Graphics Editor Software: You will need a graphics editor and learn how to use it. Windows comes with its default Windows Paint editor. It is found in the Windows Accessories Folder. For a more advanced option with many more professional features you may try GIMP: <https://www.gimp.org/> This is a FREE, open source image editor working across all computing platforms (Windows, Apple, Linux, etc.). The software comes with ample documentation and examples on how to manipulate any picture or graphic.

Screen Capture Software: A screen capture or snipping software is advantageous in order to only grab the part of a graphic from the screen that is important or necessary. Windows 10 comes with a default snipping tools, such as “Snip & Sketch” found in its own folder or “Snipping Tool” found in the Windows Accessories Folder. Note: When snapping a picture, make sure it is large enough on the screen to capture enough pixels to have adequate resolution for the final product.

NOTE: Compiling acceptable and good looking graphics and photographs is very involved and can not be rushed. These are often the heart of any report and should be compiled BEFORE writing. Last minute thrown together graphics will without doubt lower your grade.



COMPOSITION, LAYOUT, WRITING & GRAMMAR SUMMARY

Language

The following list is an example of common faults in language usage and attribution.

Errors / Mistakes / Faults	Examples with margin <i>Fault Counts & Codes</i>
Spelling: incl. capitalization errors & spacing	The mineral <u>florite</u> has a <u>mohs</u> hardness of four. Nicolas Steno <u>_</u> was trained in the classical texts on science.
Grammar: incl. punctuation, superfluous words, transpositions	Isometric crystals are also isotropic Here light propagates at the same speed. Rocks are composed of many many <u>(minerals mixed.)</u>
Style: incl. paragraph, repetitive expressions / words, erroneous expression / words, sub- or superscription, unprofessional style, word insertion	<i>Para.</i> ... in the geologic sciences.¶Near the end of the 19 th a new theory ... <i>rep</i> ... is a <u>light colored</u> mineral. These <u>light colored</u> minerals are often <u>light</u> ... Stalactites hang from the <u>sealing?</u> of a limestone cave. <i>sup</i> The density of quartz is 2.65 g/cm ³ . I was investigating the outcrop with <u>my group</u> . Sodium sulfate forms a chalky, <u>incoherent</u> precipitate. <i>amorphous?</i> ^
Sentence: incl. grammar, run-on, strings of nouns	The density of gold is greater <u>then?</u> the density of silver. Pyrite has a symmetrical crystal <u>structure</u> , it is cubic. <u>Skarn mineral zonation?</u> is apparent in the sample.

Content

Errors in content are spelled out. Severe infractions may count for multiple errors.

Errors / Mistakes / Faults	Examples with margin <i>Fault Counter & Codes</i>
Unclear / erroneous statements	<i>unclear, units?</i> <u>Mohs hardness of the mineral in question is 16.5.</u>
False / nonsense	<i>Nonsense</i> <u>Glaciation cause severe metamorphism of the region</u>

TABLES, FIGURES & EQUATIONS SUMMARY

Tables

Each table must be sufficiently complete that it could stand on its own, separate from text.

Only HORIZONTAL lines are allowed in tables. Do NOT use any VERTICAL lines.

DO consecutively number and caption tables and refer to them accordingly within your text. Captions go ABOVE the table.

DO provide a short description of your table within the caption.

DO place your tables appropriately, closest to their mention in the text.

DO make sure tables are legible and reproduce well. Print can be smaller than text, with an 8pt size minimum.

DO appropriately label columns. Do NOT forget units for numeric values.

AVOID splitting tables across pages.



Figures

Each figure must be sufficiently complete that it could stand on its own, separate from text.

DO number and caption figures consecutively and refer to them accordingly within your text. Captions go BELOW the figure.

DO provide a short description of your figure within the caption.

DO place your figures appropriately, closest to their mention in the text.

DO use appropriate citations for figures that are NOT your own. If you use a figure that has been modified by you, the phrase “modified after....” is most appropriate. Photos should show the name of the photographer.

DO make sure figures are legible and reproduce well. Print can be smaller than text, with an 8pt size minimum. Use a minimum resolution of 300dpi. This is a common publication standard.

AVOID cluttering of figures with too much detail. Simplify if necessary.

AVOID moire patterns in photos, a nuisance in copied or scanned pictures. Most scanners come with a moire pattern removal tool.

GRAPHS

Understand graphs: Bar graphs and/or line graphs are used when plotting nominal vs. ratio or interval data. Scatter plot graphs are used when plotting numeric vs. numeric data.

DO make sure that the graph axis are appropriately labeled and scaled. Axis should have titles as well as scalar units.

DO use electronic means to generated graphs. Hand drawn graphs are no longer acceptable.

Equations & Computations

Equations should contain explanation of symbols used.

A reader should be able to follow where your values or numbers come from. Indicate accordingly.

WRITE DOWN UNITS!!!!

Show equations used before indicating any computation

Acceptable Example: $F = m \times a = 0.034kg \times 9.8m/s^2 = 0.33 kgm/s^2$

where m is mass of the object in kg as determined with a triple beam balance and a is the gravitational acceleration. F indicates force expressed in kgm/s^2 or N (Newtons).

Unacceptable example: The answer is 0.33. This is obtained by multiplying gravity by 0.034.

Introduction: Confined Aquifer Pumping

General Instructions:

During this LAB you will analyze pumping data from a well drilled into a confined aquifer. Your task is to plot the indicated graphs and calculate the following from the data:

1. Transmissivity
2. Hydraulic Conductivity
3. Storativity
4. Approx. Diameter of the draw down funnel

In order to solve for these parameters you will need the following:

- (2) Log-Log Graph Paper **IMPORTANT: Physical size of graph paper MUST BE THE SAME, including same scalar and number of log cycles!**
- Calculator or better yet, Excel spreadsheet
- 1/u vs. W(u) constant curve drawn to scale of your graph paper used ... or use the included curve and graph paper!
- Ruler, Pencil(s)



CONFINED AQUIFER PUMPING ANALYSIS using the Theis Method

Intro: How to use the Theis Method overview.

☑ You may also watch a lecture excerpt video explaining the method at :

https://youtu.be/dOBXme61_XQ

- A. Use two sheets of Log-Log Graph paper of same size/dimensions/ log-cycles. *Note: Log-Log Paper has a direction, there is a up, down, left and right. Make sure your two graph papers are oriented the same with the smallest numbers in the lower left hand corner and the highest numbers in the upper right-hand corner.*
- B. Plot the W(u) and 1/u (**Inverse of u!**) on one graph with W(u) on the Y axis and 1/u on the X axis. If possible, draw on transparent graph paper.
- C. On the other graph paper plot drawdown in the observation well and time. Drawdown should be on the Y axis and time on the X axis. To simplify you may want to plot time in seconds.
- D. Overlay both graphs and match the resulting curves. Keep graph papers parallel to each other (NO TILTING) when moving the graph to get a match. Once satisfied do NOT move the papers.
- E. Pick one point, ANY POINT, covered by both graph papers. The points do NOT have to be on the graph itself. Use a pin and poke a hole through both overlain graph papers. Now read off the hole coordinates both on the W(u) vs 1/u graph and the Δh vs t graph.
- F. Read the graph data from the pin-hole: Δh, t, W(u), and 1/u. Don't forget to convert 1/u to u. Plug this data into the Theis equations. BE CAREFUL WITH YOUR UNITS!

The well pumping data and useful equations are given below:

Note 1: Not all data and/or equations given might be useful

Note 2: Do NOT forget to convert into the correct units for your calculations.

Q = 780 gal/hr

Observation Well: r = 367.5ft

Observation Well Data:

Δh(m)	t	
0.62	14.4	min
0.69	22.4	min
0.76	34.8	min
0.83	54.2	min
0.94	1.750	hrs
1.01	2.722	hrs
1.04	3.393	hrs
1.08	4.233	hrs
1.11	5.278	hrs
1.15	6.582	hrs
1.18	8.208	hrs
1.22	10.235	hrs
1.25	12.763	hrs
1.29	15.917	hrs
1.33	19.848	hrs
1.36	24.752	hrs
1.4	1.2861	days
1.43	1.6038	days
1.47	2.0000	days

Equations (Theis & others):

$$T = \frac{Q}{4\pi \Delta h} W(u)$$

$$S = 4 T \left(\frac{t}{r^2} \right) u$$

$$T = k_f \times b$$

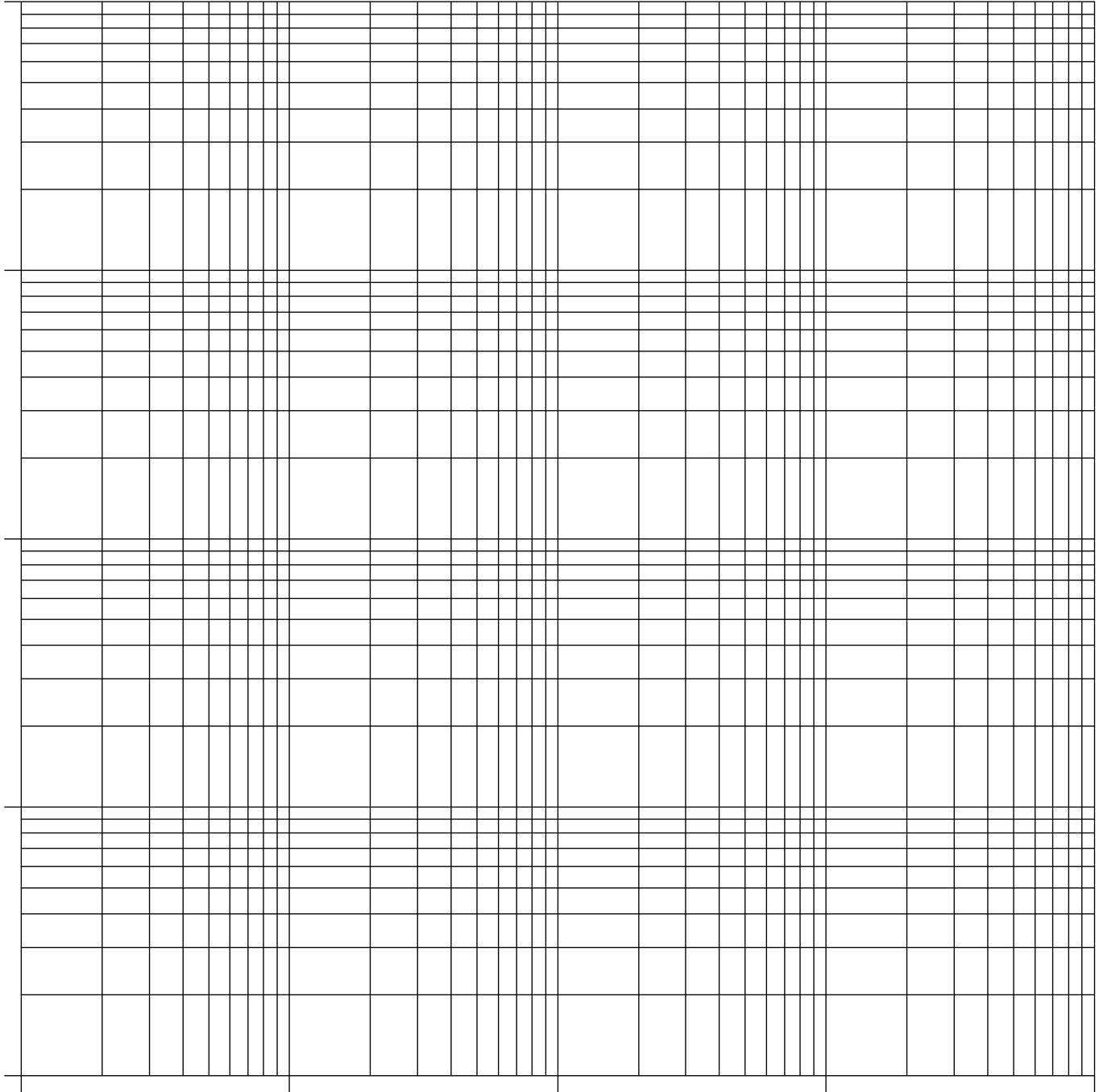
b= 285.4ft



THEIS METHOD - CONFINED AQUIFER PUMPING - CREATE CONSTANT THEIS CURVE

Either complete the graph below or create your own version. **IMPORTANT: Physical size of graph papers MUST BE THE SAME, including same scalar and number of log cycles!**

$1/u$ vs $W(u)$

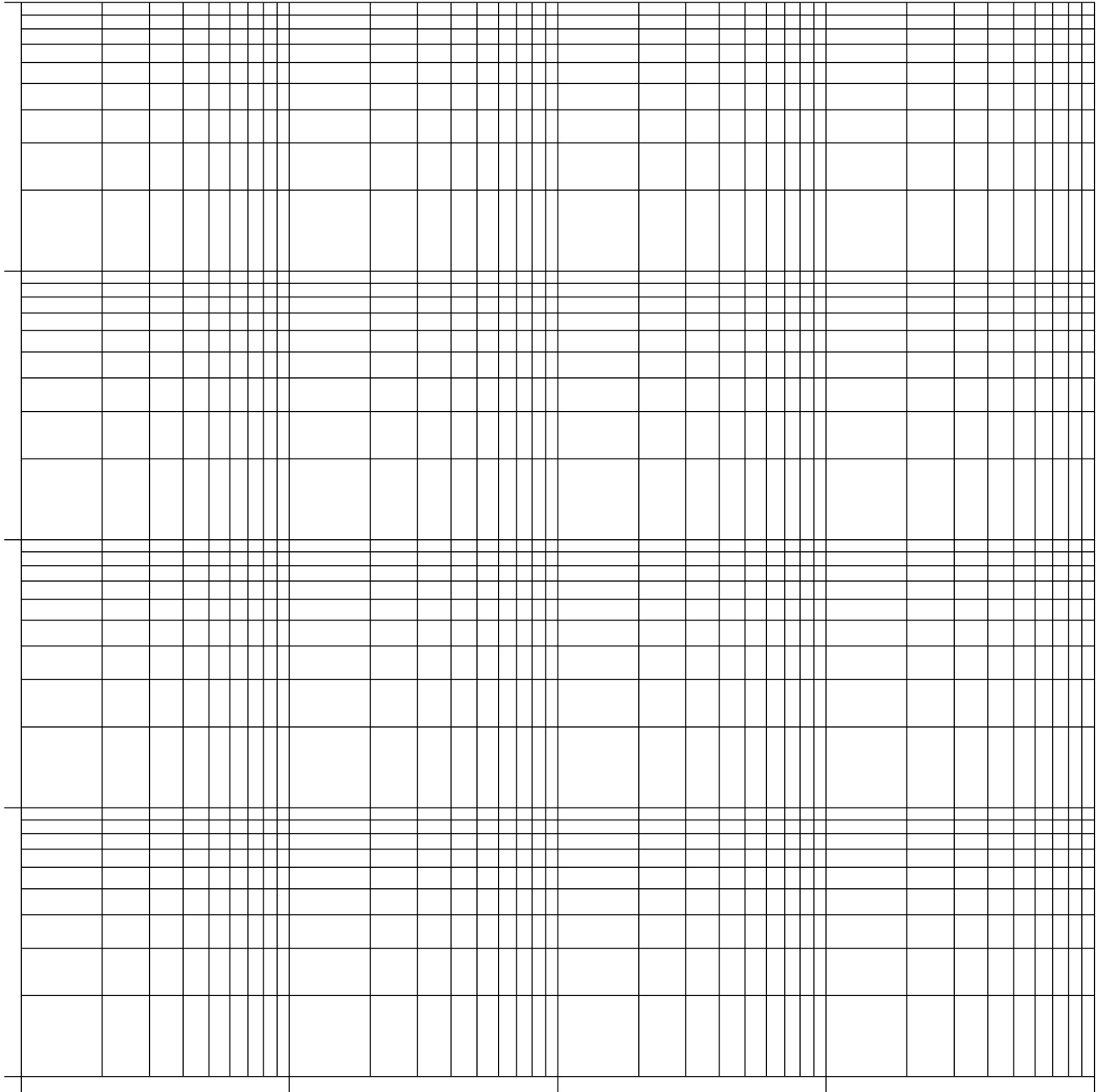




THEIS METHOD - CONFINED AQUIFER PUMPING -PUMPING DATA GRAPH

Either complete the graph below create your own version. **IMPORTANT: Physical size of both graph papers MUST BE THE SAME, including same scalar and number of log cycles!**

t vs Δh





Only turn in the [LAB4: CONFINED AQUIFER PUMPING RESULTS](#) page for grading after completion.