Percolation Test Group Project *- hands on applied hydrogeology project lab -*

"PERCOLATION TEST & ENGINEERING REPORT" COURSE GROUP FIELD PROJECT

Maximal 4 group members - Everyone in the group will receive the SAME grade:

Group Member 1 Name:	Contact Info:
	Job Summary:
Group Member 2 Name:	Contact Info:
	Job Summary:
Group Member 3 Name:	Contact Info:
	Job Summary:
Group Member 4 Name:	Contact Info:
	Job Summary:
Overall Grade for Each Group Member	**FINAL GRADE /150**

/30 COMPOSITION & LAYOUT

The REPORT is neat, orderly, and professional. Title page mentions Name, Assignment Name, Course, and Date. Page with group member names and their project contributions is inserted after the title page. Pages are consecutively numbered and carry short title header on each page. The REPORT is typed, and graphics and data are electronically prepared and analyzed. Graphics and data are placed in a coherent form. At least 5 proper formatted citations are included.

30 pts - Everything present and of professional quality 25 pts - One report aspect poor or missing 20 pts - Two report aspects poor or missing
15 pts - Three report aspect poor or missing, generally subpar quality 10 pts - Four report aspect poor or missing, generally subpar quality
5 pts - Five or more report aspect poor or missing, generally subpar quality 0 pts - Missing

/40 WRITING & GRAMMAR - one or multiple point deduction per infraction

Spelling and grammar are correct. Word repetition and use of first person language is avoided. Appropriate and complete language becoming to a professional report is used. Subscripts and superscripts are appropriately used.

/40 EXECUTION, DATA COLLECTION, INTERPRETATION

Appropriate procedural execution of the REPORT is evident from the writing and data. Procedural overview is given. Statements / graphics / charts / tables are factually correct. Units and significant digits are correct. Controls are used whenever possible - data integrity is verified through error calculations. Any inconsistencies are mentioned and adequately explained. Equations used or developed are adequately explicated. Conclusions / discussions follow the evidence and the data matches the conclusions in all aspects.

/40 GRAPHICS, ILLUSTRATIONS, TABLES

Graphical representations and analytical results are appropriate and complete according to the project description. All figures / data tables are captioned. Caption adequately explains graphic / table. All illustrations are electronically prepared. Pictures are clear, of high quality, and with neutral background. Graphs should have a title with appropriate axis and unit labels. Graphic fonts and labels are easily readable. Citation of any source used be included in the caption. Graphics are of adequate size for viewing.

Grading Scale for EXECUTION, DATA COLLECTION, INTERPRETATION & GRAPHICS, ILLUSTRATION, TABLES
40 pts - Everything present and of professional quality 35 pts - One aspect poor or missing 30 pts - Two aspects poor or missing
25 pts - Three aspects poor or missing 20 pts - Four aspects poor or missing, overall subpar quality
15 pts - Five aspects poor or missing, overall subpar quality 10 pts - Six aspects poor or missing, overall subpar quality
5 pts - Much poor or missing, very subpar quality 0 pts - Missing

PROJECT REPORT OVERVIEW:

1. Title Page: Project Name, Author(s), Course
2. Group Member and Project contribution page.
3. Table of Contents
4. Project and procedural overview. Location and soils overview - 1 to 2 paragraphs. Any county specific addendums.
5. Soil Type & Particle Distribution Reconnaissance Analysis
   a. Locate soil data for your specific test location from the Web Soil Survey (WSS) GIS Data Server. See https://websoilsurvey.nrcs.usda.gov/app/ for detail. Summarize the findings in your report.
   b. Results of your rapid soil reconnaissance analysis.
   c. Soil pH
6. Perc Test Procedure and Location of Test Holes Map
   a. Figures: Your location, soils overview, topographic and hole site MAP, including true N and scale.Use appropriate scale for test hole locations (1:100 or 1:50), show any existing structures nearby.
7. Perc Test Results and Tables - Your EXCEL Spreadsheet MPI , K_{sat}, k_f Data Table with explanation
   a. Figures: EXCEL Spreadsheet MPI GRAPH with explanation. Include figure caption. Y-axis: MPI (Minutes per inch drop), X-axis: duration in minutes
8. Your k_f isopleth MAP superimposed on a base map with explanation
   a. Figure: k_f isopleth MAP
9. Septic Field Design, calculations and recommendation
   a. Figure: Drawing of recommended Septic Field Layout. Use appropriate scale.
10. Conclusion Paragraph summarizing results and recommendations
11. Citations - Should be compiled using Zotero (https://www.zotero.org/) Use the United States Geologics Survey (USGS) citation style in your document. You should have a minimum of 5 credible citations.

Printed work MUST BE ELECTRONICALLY PRODUCED! This includes chemical formulas, equations, tables and special characters. Become intimately familiar with these functions in your preferred word processor. Be familiar with placing and sizing visuals into a written document.

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 Geologics 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 Manger 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/cm^3, H_2O, PO_4^{3-}, a_g=9.8m/s^2 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 Accessaries 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 on the client report significantly.

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 *Fault Counts & Codes*	
Spelling:	| |	The mineral florite has a mohs hardness of four.
incl. capitalization errors & spacing	|	Nicolas Steno_was trained in the classical texts on science.
Grammar:		
incl. punctuation, superfluous	|	Isometric crystals are also isotropic Here light propagates at the same speed.
words, transpositions	| |	Rocks are composed of many ~~many~~ minerals mixed.
Style:		
incl. paragraph,	|*Para.*	... in the geologic sciences.¶Near the end of the 19th a new theory ...
repetitive expressions / words	|||*rep*	... is a light colored mineral. These light colored minerals are often light...
erroneous expression / words,	|	Stalactites hang from the sealing? of a limestone cave.
sub- or superscription,	|*sup*	The density of quartz is 2.65 g/cm3.
unprofessional style,	| |	I was investigating the outcrop with my group.
word insertion	|	Sodium sulfate forms a chalky, ~~incoherent~~ precipitate. *amorphous?*
Sentence:		
incl. grammar,	|	The density of gold is greater then? the density of silver.
run-on,	|	Pyrite has a symmetrical crystal structure, it is cubic.
strings of nouns	| |	Skarn mineral zonation? 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 *Fault Counter & Codes*	
Unclear / erroneous statements	|*unclear, units?*	Mohs hardness of the mineral in question is 16.5.
False / nonsense	||*Nonsense*	~~Glaciation cause severe metamorphism of the region~~

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 <u>no longer acceptable</u>.

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: $F = m \times a = 0.034kg \times 9.8\, {}^{m}/_{s^2} = 0.33\, {}^{kgm}/_{s^2}$

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

Percolation tests (colloquially called perc tests) and associated interpretations are the foundation for the design of private waste disposal systems, but are also important for investigating mine or landfill drainage. Specifically, a percolation test measures the ability of the soil to absorb liquid. In general, sandy soil will absorb more water than soil with a high concentration of clay or where the water table is close to the surface. The results of a percolation test is required to properly design a septic system.

The test could be called a field permeability test and obtained data can actually be used to determine the hydraulic parameters of the soil, such as k_f values. In short, a hole is drilled into the soil and saturated with water. Data is then collected on how quickly this known volume of water dissipates into the subsoil. In general, the rate of drop of the water level is observed by measuring the depth of the water surface below the top of the hole at 1, 2 and 5 minutes after the start of the test and at 5 minutes intervals thereafter. These observations are made until the rate of drop becomes negligible or until sufficient readings have been obtained. While every county and State will have established its own engineering procedures regarding the exact calculations for the length of septic line, depth of pit, etc., the testing procedures usually are similar and follow the outline given above.

In general, jurisdictions are only interested in the data of a steady state condition, when water appears to percolate into the subsurface at a constant rate. This rate is expressed as MPI (minutes / inch) of drop rate and whole home waste disposal systems are designed by interpreting this number. It does work very well as a multitude of installed and functional private sewage disposal systems can attest.

As a hydrogeologist, however, a more thorough data analysis can be performed which may be used to exceed the required interpretation of a certain jurisdiction, but would be a welcomed asset for soil engineers.

YOUR ASSIGNMENT

- ☐ Select a groups and give the instructor the name and contact info of your group members. However, you may work as an individual if desired. Selected a suitable field site (usually Dr.K's property) to dig percolation test holes and do the field study and measurements. You probably will have to visit your site more than once, so plan accordingly!
- ☐ Bring calibrated / charged lab instrumentation and ancillaries to do required on-site testing as required.
- ☐ Collect soil samples from dig site for a quick soil particle size distribution assessment, the Jar Method.
- ☐ Do the perc test as indicated. Record all data.
- ☐ As a group, it might be best to divide the work for data analysis and some additional lab procedures. Do the computations and generate a single professional report per group. Communicate often with your group members. Do NOT postpone until the last minute.
- ☐ Turn in the report by the deadline in CANVAS for grading.

Soil Reconnaissance Testing

MATERIAL LIST - In order to perform the soil test outlined below you will need:

- Sample Bags (e.g. ZipLock)
- pH Meter
- Mason Jar w/ lid
- 5 tablespoons of dishwashing detergent powder
- Graduate Cylinder
- Pycnometer & Scale
- Ruler & Permanent Marker
- Calculator
- DI Water
- Toothbrush
- Large plastic cup(s)

Soil pH Test

Test the soil pH for each test hole using your pH meter:

1. Calibrate pH meter according to manufacturer's instructions before you go into the field

2. Using the test holes used for the perc test, recover a soil sample from a specific depth. Make sure that the soil sample comes from approximate the same depth from each perc test hole.

3a - Place sample into a large plastic cup. Add some distilled or deionized water to dampen and soften the soil sample. Do NOT saturate! Note: Your soil should be soft and pliable enough to press the pH meter sensor tip directly in to the softened moist, soil.

3b - Should the soil prove to be too difficult to dampen or soften, use the slurry method as follows:

3b.1 Break up a representative soil chunk as best as you can and place into plastic up. The finer, the better.
3b.2 Add equal part of distilled or deionized (DI) water to the soil in a 1:1 ratio.
3b.3 Stir the sample well and vigorously for 5 seconds.
3b.4 Let it sit for 15 minutes.
3b.5 Start stirring the sample again after 15 minutes, and take your measurement.

4. When inserting the pH sensor into your sample, allow the reading to stabilize. Record the reading.

5. Clean the pH meter tip carefully and throughly after each test. A toothbrush will come in handy for that. Rinse thoroughly with DI water.

Soil Grain Size Analysis Reconnaissance Test

A soil grain size analysis is usually completed in a soil lab and requires grain size sieves. A summary of a laboratory grain size analytical procedure can be found here:
https://www.geoengineer.org/education/laboratory-testing/step-by-step-guide-for-grain-size-analysis
or here:
https://www.dot.ny.gov/divisions/engineering/technical-services/technical-services-repository/GTM-20b.pdf

We will use a quick reconnaissance method to establish a rudimentary grain size analysis in your home-lab called the JAR TEST as follows:
Credit: https://hgic.clemson.edu/factsheet/soil-texture-analysis-the-jar-test/

1. Remove any debris, rocks, and large organic matter (leaves, sticks, roots, etc.). Break up the soil.

2. Fill the mason jar 1/3 full of the soil to be tested

3. Fill the remainder of the jar with clean water, but leave some space at the top.

4. Add 1 tablespoon of powdered dishwashing detergent

5. Cap the jar and shake vigorously until the soil turns into a uniform slurry.

6. Set on a level surface and time for one minute.

7. Place a mark the outside of the jar, showing the coarse sand layer settled at the bottom of the jar.

8. Leave the jar in a level spot for 2 hours.

9. Mark the top of the next settled layer with the permanent marker. This is the silt layer.

10. Leave the jar on a level spot for 48 hours.

11. Mark the top of the next settled layer with the permanent marker. This is the clay layer that has settled on top of the silt layer.

12. Using a ruler, measure and record the height of each layer, and the total height of all three layers.

Soil Grain Size Analysis Reconnaissance Test - Graphing and Interpretation

1. Use the soil texture triangle to estimate the soil type for the site. An automated and excel version to plot your results can be found here: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_054167

2. Convert layer thicknesses into percentages (your sum of the % Sand + Silt + Clay should equal 100%)

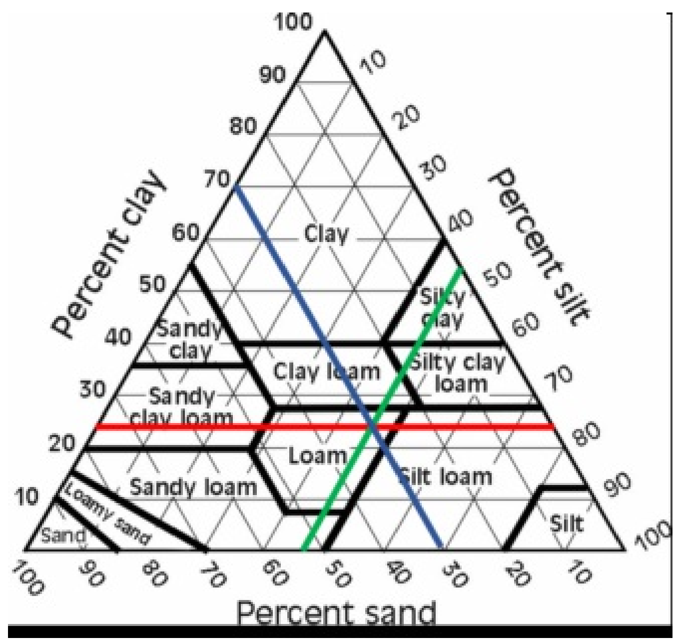
3. Plot the percentages on the soil texture triangle using the Excel template or website mentioned above. You may also do this manually as follows:

   3.a The clay percentages are listed on the left side of the triangle. Lines corresponding to clay percentages extend from the percentages reading left to right (see red line).

   3.b The silt percentage is on the right side, with lines extending downwardly, diagonally right to left (see green line).

   3.c The sand percentage is on the right side, with lines extending upwardly, diagonally right to left (see blue line).

   3.d Track the lines with the percentages measured and find the spot on the triangle where all three lines intersect. The region where these lines intersect indicates the soil type present. The example shown represents a loam soil texture.

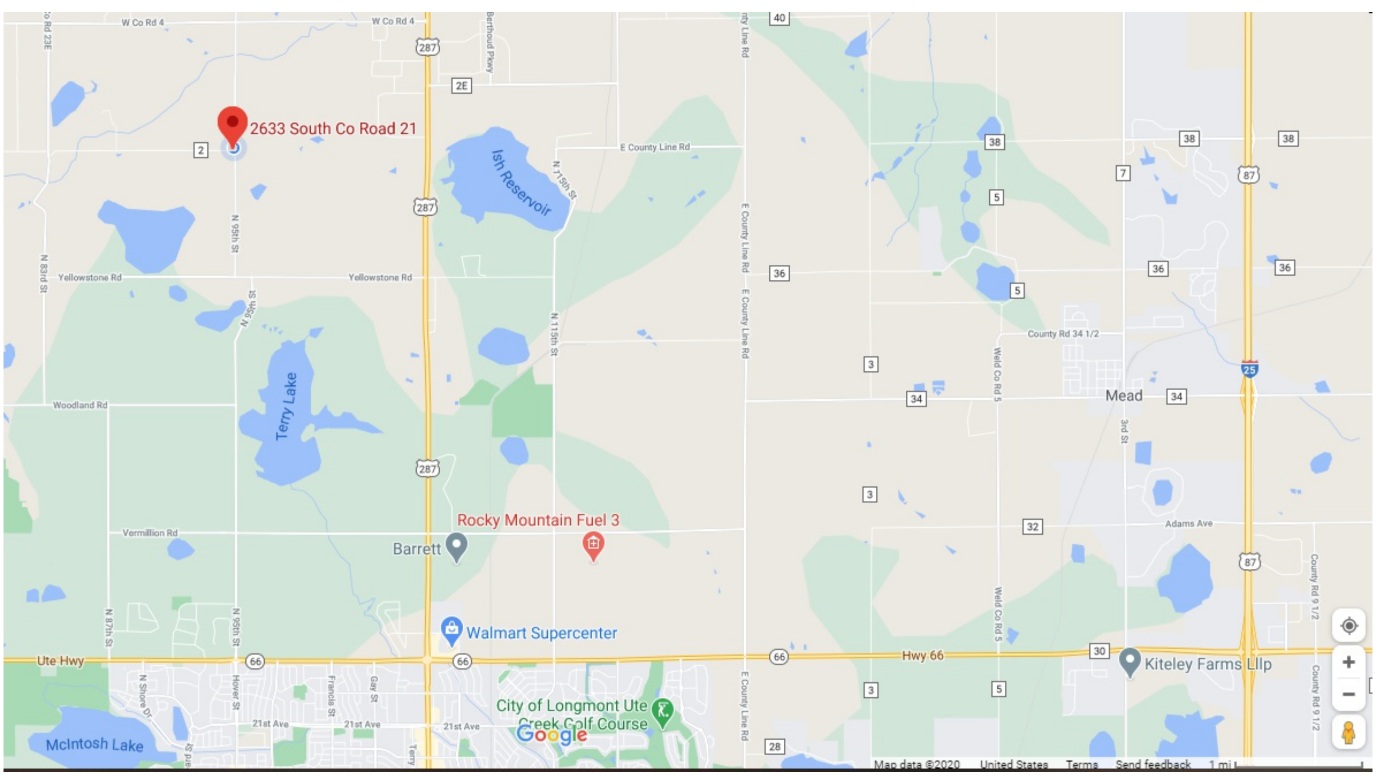


The Percolation Test

You will need to travel to the test site to do the tests and collect the samples. If one or more of your group members are unable to field travel, please video record or stream your site visit activities to share with your group members. The following visits and time estimates are recommended. You may also combine certain visits:

Trip	Itinerary	Time
Visit 1	Site Visit: Familiarize yourself with the test site and walk through with Dr.K. Mark your location (you may want to bring ground spray paint or survey flag markers). Collect Map points with cell phone GPS. Surface Mappuing.	Estimated on-site time: 2 - 4 hours
Visit 2	Hole digging and prep: Lots of physical activity using post hole diggers to excavate your test holes.	Estimated on-site time: 2 - 4 hours
Visit 3	Presoak test holes for 24 to 48 hrs. This visit must happen a day (or two) BEFORE the actual perc test “Visit 4".	Estimated on-site time: 1hour ... However, you may have to come back after a few hours to check and refill the test holes as needed.
Visit 4	The Percolation Test Day	Estimated on-site time: 2 - 4 hours

Dr. K’s Property is located at **2633 South County Road 21, Berthoud, CO 80513**
Please schedule Visit 1 in advance!

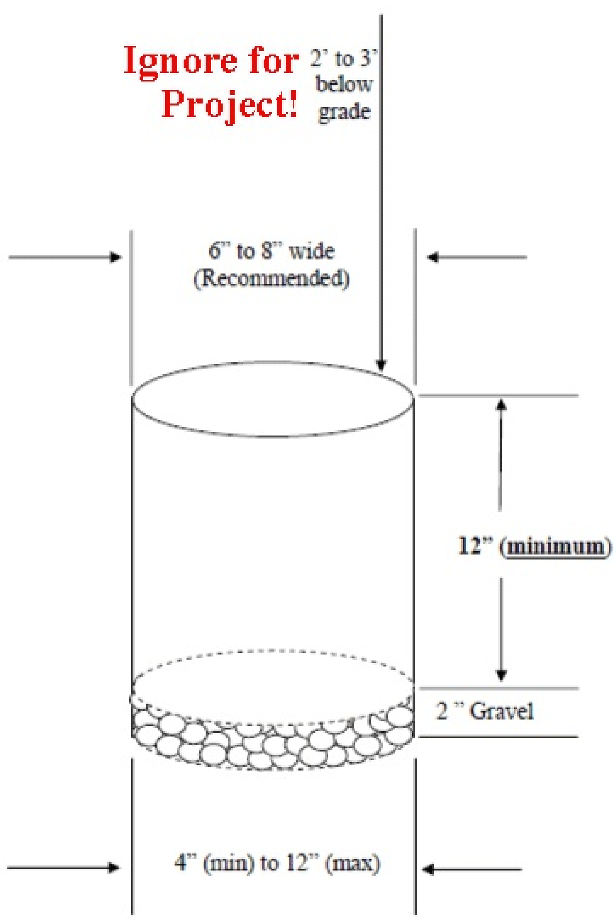


MATERIAL LIST - In order to perform the percolation test outlined below you will need:

- Dr. K's property
- Post hole digger (available from Dr.K) ... I also have a motorized one if you feel comfortable running power tools
- Bag of coarse gravel
- (3) yardsticks or other long poles or a water depth level meter. I have one but may need to be shared with other groups if working on the same day.
- Timing Device (watch with second hand or stop watch)
- Knife
- Note Paper / Recording Table(s)/ Field Notebook
- Sample Bags
- Cell phone with GPS logger
- Tape Measure
- Measuring Instruments for field work
- Lots of CLEAN, CLEAR water. Also available from Dr.K but you may have to carry it to your testing site.
- 1 ½' to 2' piece of wood
- Possibly some screws and screw driver
- Look for additional COUNTY REQUIREMENTS: Larimer County

GENERAL OVERVIEW

LOCATION OF PERCOLATION TEST HOLES - The percolation(perc) test holes shall be spaced uniformly over the proposed soil absorption (leach field) site. **A minimum of three(3) test holes are required.** More than 3 are preferred. Location of holes are to be shown on a location field map.



TEST HOLE PREPARATION - Test holes that are 4 to 12 inches in diameter (6" to 8" recommended) shall be dug or bored to the proposed depth of the leach field (typical depths are 30 to 42 inches or 2' to 3' below grade). *In case of digging problems we willl use an alternate depth of 12in (1 foot). See figure.* The side walls shall be vertical and a natural soil surface (one which is not smeared from digging) shall be exposed by scraping the sides and bottom of the test hole with a sharp pointed instrument (knife). Any loose material shall be removed from the test hole and 2 inches of coarse sand or gravel placed in the bottom of the test hole in order to prevent scouring and sealing before the water is poured in. Make sure the top of the gravel layer is LEVEL since it will be the base for your water level measurements with a ruler.

PRESOAKING - **PRESOAKING IS ABSOLUTELY REQUIRED** in order to get valid percolation test results. The purpose of presoaking is to have the water conditions in the soil reach a stable condition similar to that which exists during continual wastewater application in a leach field. The minimum time of presoaking varies with soil type and soil conditions, but must be sufficiently long so that the water seeps away at a steady rate. Filling the hole several times during a 24 to 48 hour period and/ or overnight soaking are excellent methods. Determining the appropriate percolation test procedure will aid in ascertaining additional presoaking and hole preparation procedures.

DETERMINATION OF APPROPRIATE PERCOLATION TEST PROCEDURE

1 Fill the percolation hole with water to a depth of 12 inches over the gravel or top of the hole. Insert plastic ruler to gravel depth and record starting position.

2 Determine the time needed for the water to seep away completely. This is done by filling the presoaked test hole completely with water (as instructed under 1) and determining if the water seeps away in 10 minutes or less.

2.1 **IF** water remains in the percolation hole after 10 minutes, proceed with the (A) SLOW PERCOLATION TEST PROCEDURES.

2.2 **IF** water has completely seeped away after 10 minutes, proceed with the (B) FAST PERCOLATION TEST PROCEDURES.

(A) SLOW PERCOLATION TEST PROCEDURES

1 Make sure the test hole is properly presoaked by maintaining at least 12 inches of water over the gravel in the hole for 4 hours and then refilling the hole preferably for an overnight soaking. Let the hole sit for not less than 16 hours or more than 30 hours to allow swelling of clay systems to occur during this period. Your SLOW PERCOLATION TEST PROCEDURE must begin no sooner than 16 hours and no later than 30 hours after the end of the 4-hour soaking period.

2 To start the test, fill the percolation hole with water to a minimum depth of 12 inches or top of hole over gravel.

3 Immediately insert ruler vertically to touch gravel and record water height starting level AND starting time. *Hint: You may want to move ruler around and take a few measurements to see if your gravel is level. It might be best to anchor the ruler into a vertical position. This can be done by screwing the ruler to a perpendicular mounted 1 ½' to 2' piece of wood and laying / clamping the wood piece across the hole, keeping the ruler stationary and perfectly vertical in the test hole.*

4 Measure the drop in the level of the water at 30-minute intervals, for a total of 4 hours. If the first 6 inches of water seeps away in less than 30 minutes, the interval between measurements must be reduced to 10 minutes and the length of the test must be reduced to 1 hour. Make sure to record times and measurements.

5 Fill the hole to a maximum depth of 6 inches over the gravel as often as necessary to prevent the hole from becoming empty. Make a note in your recording.

6 The amount of the drop in the level of the water during the last interval must be used to determine the percolation rate, except that if two successive measurements do not vary more than 1/16th of an inch, the test may be stopped and the percolation rate may be determined.

(B) FAST PERCOLATION TEST PROCEDURES

1 Make sure the hole is properly presoaked as per instructions above.

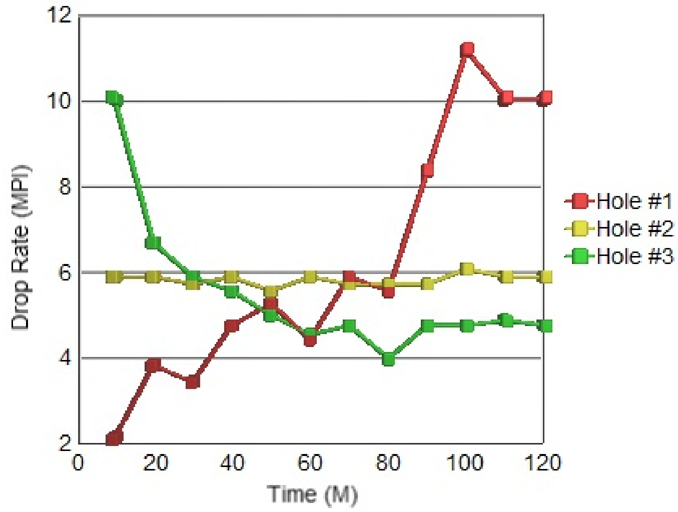
2 Fill the percolation hole with water to a level that is no more than 6 inches over the gravel. Immediately insert ruler vertically to top of gravel and record starting height and starting time. *Hint: You may anchor the ruler as per instruction 3 under Slow Percolation Test Procedure.*

3 Measure at 10-minute intervals, how much the water drops over the next 60 minutes. If 6 inches of water seeps away in less than 10 minutes, a shorter interval between measurements must be used. Don't forget to record water levels an times.

4 Refill the hole as necessary to prevent all water from seeping away. The level of the water must never exceed 6 inches in depth over the gravel. Proceed with refill and measurements until your water level drop rate is

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Percolation Test Calculations												
2													
3	Hole #1				Hole #2				Hole #3				
4	Time (Min)	Water Level (in)	Refill Level (in)	Drop (MPI)	Time (Min)	Water Level (in)	Refill Level (in)	Drop (MPI)	Time (Min)	Water Level (in)	Refill Level (in)	Drop (MPI)	
5	0	11.75			0	11.00			0	12.00			
6	10	7.10		2.15	10	9.30		5.88	10	11.00		10.00	
7	20	4.50	11.50	3.85	20	7.60	11.25	5.88	20	9.50	11.50	6.67	
8	30	8.60		3.45	30	9.50		5.71	30	9.80		5.88	
9	40	6.50		4.76	40	7.80		5.88	40	8.00		5.56	
10	50	4.60		5.26	50	6.00		5.56	50	6.00	12.00	5.00	
11	60	2.35	11.50	4.44	60	4.30	11.50	5.88	60	9.80		4.55	
12	70	9.80		5.88	70	9.75		5.71	70	7.70		4.76	
13	80	8.00		5.56	80	8.00		5.71	80	5.20		4.00	
14	90	6.80		8.33	90	6.25		5.71	90	3.10		4.76	
15	100	5.90		11.11	100	4.60		6.06	100	1.00	11.25	4.76	
16	110	4.90		10.00	110	2.90		5.88	110	9.20		4.88	
17	120	3.90		10.00	120	1.20		5.88	120	7.10		4.76	
18													

constant. If water continues to all seep away in ten (10) minutes or less, this indicates that the soil is excessively permeable and the site is unsuitable for a standard subsurface disposal system. *However, for this project, continue with the percolation test calculations as outlined anyway.*



PERC RATE CALCULATION & GRAPHING - After the water level drop rates have stabilized in all of the test holes the test is completed and you can commence with the data analysis. Use EXCEL Spread Sheet or similar software to REPORT RESULTS, do your CALCULATIONS and GRAPH RESULTS.

$PercRate = \frac{Time(\min)}{Drop(in)}$ Percolation Rates are expressed in minutes per inch (MPI). To calculate the perc rate for each test hole measurement, divide the time interval by the drop in inches.

A sample EXCEL spreadsheet suitable for reporting results is shown here.

The perc rate is literally the inverse of the saturated hydraulic conductivity of the soil K_{sat} which would by expressed in distance/time, such as m/s. In other words, PercRate = $1/K_{sat}$ and
$K_{sat} = 1/PercRate$

The next step is to graph your results. This is done by plotting the time since beginning of perc test on the x-axis nad the drop rates in minutes per inch (MPI) on the y-axis. Again, you should use your EXCEL software to do the graphing. Please chose XY-scatter plot from the graphing menu to arrive at your correct results. The Example given here is representative of what will be expected from you.

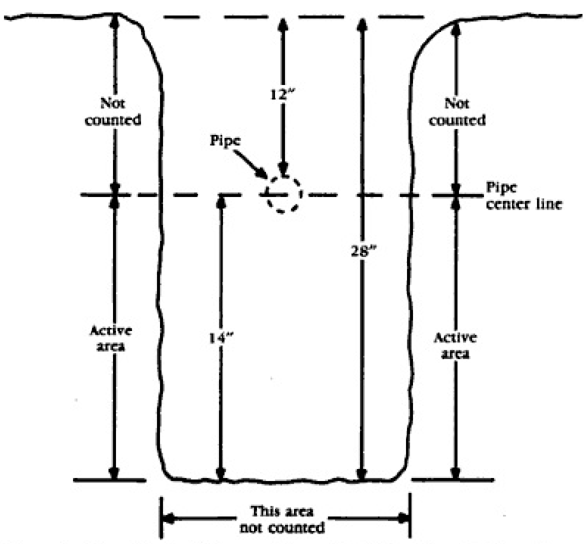
Once the graph is completed, the perc rate can be interpreted from the plotted data. The final rate is the flat curve on the graph, where it parallels the x-axis.

(A) Graphical Solution - Draw a straight line on the x-axis parallel to the graph, averaging the horizontal point distribution. The intersect of this line with the y-axis is your perc rate.

(B) Mathematical Solution - Use only those data points from the flat end (parallel to x-axis) of the graph and calculate the averages. In the sample graph, Hole #1 would include data from 100 - 120 minutes, Hole #2 ALL the data, and Hole #3 the 90 - 120 minute data range.

If the perc test data agrees among the test holes, the overall FIELD PERC DROP RATE can be calculated by averaging the above estimated perc rates from each hole. If perc data varies, a field map showing the various perc zones should be completed from the test data and additional holes and test might need to be performed.

SEPTIC SYSTEM DESIGN STANDARDS



Measuring the active (useful) area of the walls of a leach trench. The active area in this example is 2 times 14 inches for every foot of trench length, or 2.4 square feet per foot.

Septic System Design Standards are based on the perc rates measured. The following form from a Nevada Engineering firm will give you an idea about the requirements for designing a septic system. For our project you may chose your own house size (number of bedrooms). Follow the calculations for design standards presented on the next page.

The engineering term "effective sidewall" is defined in the graphic to the left. It is literally the depth below the drain tile multiplied by two. Usually the area is filled with gravel or river pebbles of 3/4" size. For the system you are required to design for the project, use an active side wall depth of less than 1 foot, but greater than 4". That is, you will be filling the septic trenches in your design with a layer of gravel less than a foot thick. *Hint: The calculations on the next page already include the multiplication by 2. So don't multiply twice!*

Why sidewall?
Think about the hydraulic conductivity test from Lab 2. Here percolation was related to the diameter of the soil sample, because the sidewalls in your experimental tubes were impermeable plastic. In real life application, however, the sidewalls are also active percolation areas where liquid can permeate into the subsurface, not just the area at the bottom.

The decision to include the sidewall area in the leach field calculation and design depends on the soil drainage. If the soil drainage is rapid, then the sidewall is less effective, since most of the drainage will be vertically downward. In these cases the sidewall is ignored and only the bottom area of the septic trench is included in the design.

If the percolation rate is slow, the sidewall area becomes more and more "effective" in allowing the effluent into the subsurface. In these cases the sidewall area is included in the septic design. In certain clay type soil, the fissile nature of shale is considered to have a higher percolation rate horizontally along the shale layers than vertically through the shale. In a sense, my percolation becomes ANISOTROPIC. Here the included sidewall percolation is of utmost importance because it is assumed that most of the percolation will occur sideways. In many such applications the bottom area is not even considered.

Practically, the sidewall area is the HEIGHT of the gravel bed below the perforated sewage drainpipe. In the design in this practical assignment use a gravel thickness between 4 inches and 0.99 feet. Which depth to pick? A deeper gravel bed will likely result in shorter overall distribution line length but may cost the client more in gravel purchase. A shallower gravel height might be cheaper but may also increase the size of the septic field because a longer line distribution length will be required. As a rule of thumb, if the available area for the septic field is large, use smaller sidewall or gravel depth. If the area is small, go with a deeper sidewall or gravel depth.

For this project you may chose (design) your own sidewall depth as long as it is between 4 inches and 0.99 feet. However, remember that your septic field design must fit into the allotted property area after your calculations are complete. If it does not fit, redesign with a greater sidewall depth.

Calculating Size of System

NOTE: The system is sized based on tank size, perc rate and effective depth.

Number of Bedrooms	Minimum Liquid Capacity of Tank (in gallons)
3 or less	1,000
4	1,200
5 or 6	1,500
More than 6	150 gallons for each additional bedroom must be added to 1,500 gallons.

Percolation Rate	Design Application Rate (gallon/square foot)
0-10	1.6
11-15	1.3
16-20	1.1
21-25	1.0
26-30	0.9
31-40	0.8
41-50	0.7
51-60	0.6

Example of how to size your system

Step 1 – Choose tank size based on number of bedrooms.
Step 2 – Use the slower percolation rate to determine gallon/square foot design application rate.
Step 3 – The absorption area is calculated by dividing the capacity of the septic tank by the design application rate as follows:

4 bedroom house = 1,200 gallon tank
Perc rate of 23 minutes = 1
1,200 by ÷1 = 1,200 square feet

Step 4 – Multiply the effective sidewall by 2, maximum depth is 4', 4 x 2 = 8.
Step 5 – Determine the required length by dividing the required absorption area by the effective sidewall as follows:

1,200 square feet ÷ 8 (depth of trench multiplied by 2) = 150 lineal feet.

Step 6 – Maximum length of leach line is 110 feet. A minimum of two trenches, 75 feet long with 4 feet of aggregate beneath the distribution lines, is acceptable.

Enter your calculation below:

Number of Bedrooms_________Tank Size________ Perc Rate _______

Tank Size ________ ÷ Design Application Rate__________ = _________

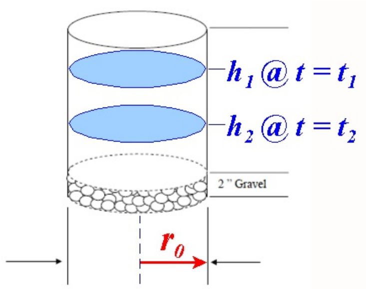
Sidewall depth X 2 = _________ Number & Length of lines ___________________

Or Number of Infiltrators used______.

ADDITIONAL HYDROLOGIC INTERPRETATION

While K_{sat} can be calculated from 1/PercRate, actual k_f values can be computed as follows from the collected percolation data. This is basically the same as a Falling Head Permeameter, but with sidewall percolation.

$$k_f = \frac{2.3\pi r_0}{5.5(t_2 - t_1)} \log \frac{h_1}{h_2}$$



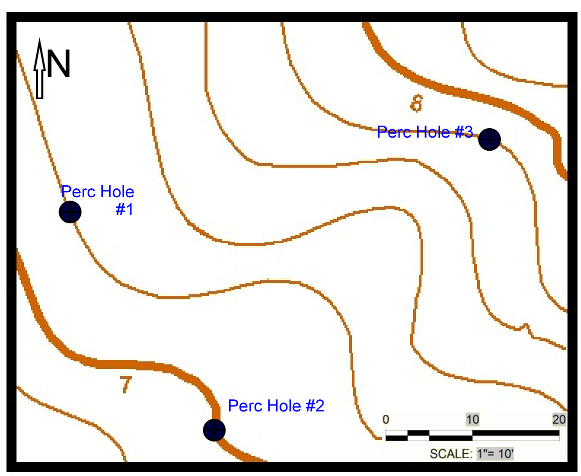
Please indicate both values in your write-up. For your own understanding (NOT part of write up, try to explain why both of these values might be different)

LOCATION MAP & K_F ISOPLETHS

Video Instructions can be found here:
https://web.microsoftstream.com/video/cfa59e68-c8e1-44d0-9638-152ec1e7bee3

You are required to construct a map showing the k_f contours of the subsurface in the area of your proposed septic leach field. The map should show a topographic map of the surface with the locations of the test holes and other structures (such as houses). Make sure you provide a scale for your map. Google Maps is an excellent starting point, but remember: Your map will be a very Small Scale map probably on the order of 1" = 25ft or 1:300. You may have to enlarge the map and then redraw your section of interest. Your completed map should fit on a regular letter sized page. Do not forget to indicate true North on the map. To locate your exact test holes, use a landmark starting point and a tape measure. You should be able to transfer the test hole locations onto your map.

Step #1: Create a contoured elevation base map as explained! For those needing basic information on how to created contoured elevation maps, the following exercise with included video link from GEL1010 - Introductory Geology explains the basics:
https://www.earthscienceeducation.net/PUBS/LAB%20EXERCISE%2013.pdf
Note: Since the area of interest will most likely be fairly flat, your contour interval will most likely be in 1/10th of feet or inches.

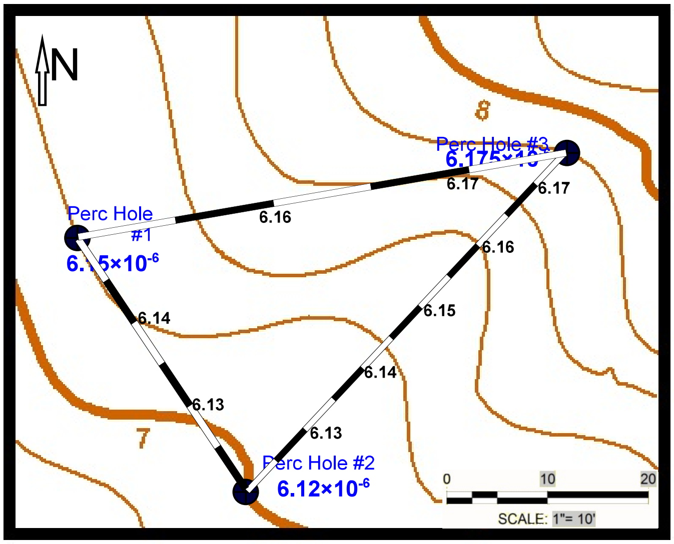


Step #2: Indicate the position of your perc test holes on your base map. Include a North arrow and the map scale on your base map. This map should look similar as the one in the example to the right.

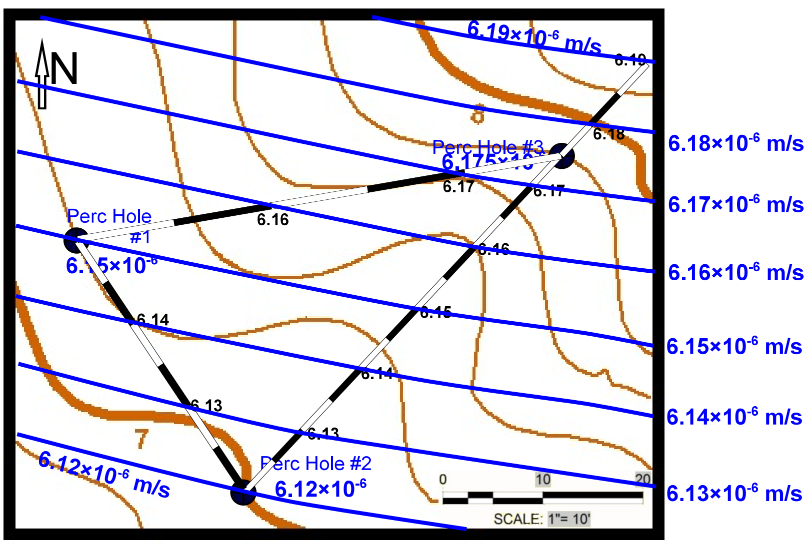
Step #3: Copy your calculated k_f values next to each respective perc hole on the map.

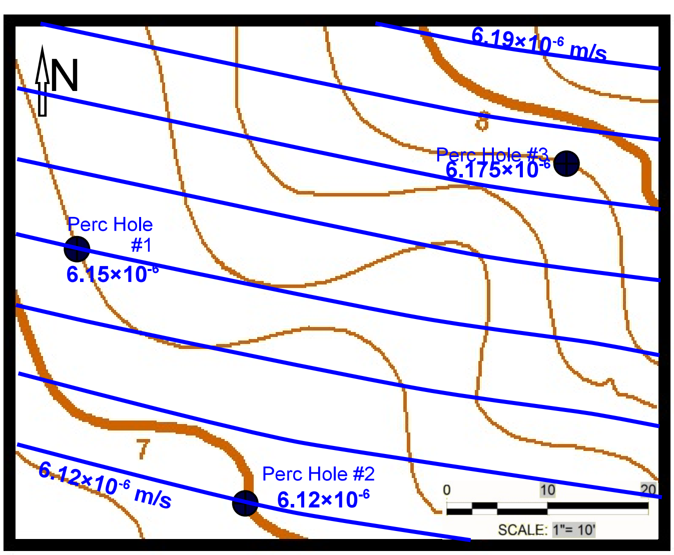
Step #4 Add more k_f data points onto your map through interpolation. Fetter (2001), section 3.12, p. 107, 108 explains isopleth construction for Hydraulic Gradients and well set-ups. You can modify the approach slightly in order to construct the k_f isopleths from your test hole data and to show hydraulic conductivity gradients. The method is also explained in the graphics below and in the following video:

Adding more k_f data points through interpolation



Drawing the k_f isopleths contours through the additional interpolated data points!





Remove construction lines for final product k_f isopleth map.

Superimposed on this base map are the k_f isopleths indicating changes in hydraulic conductivity. Usually soils are heterogenous enough to show slight differences.

PERCOLATION TEST REPORT

A Percolation Test Report is a professional write-up to be submitted to the health department and the client requesting the percolation test to be performed. It should include some suggestions for septic field design and sizing. It also includes all graphs and data tables. The actual report does NOT include handwritten field notes.

LARIMER COUNTY SOIL & SITE EVALUATION REQUIREMENTS

https://www.larimer.org/sites/default/files/uploads/2017/lcdhe-site-and-soil-evaluation.pdf
https://www.larimer.org/sites/default/files/uploads/2018/lcdhe-larimer-county-owts-2018_0.pdf
https://www.larimer.org/health/clean-air-water-and-soil/septic-systems-owts/septic-permit-instructions

BOULDER COUNTY ONSITE WASTEWATER TREATMENT REQUIREMENTS

https://assets.bouldercounty.org/wp-content/uploads/2017/02/owts-regulations-boco.pdf
https://www.bouldercounty.org/environment/water/septicsmart-understanding-onsite-wastewater-treatment-systems/