

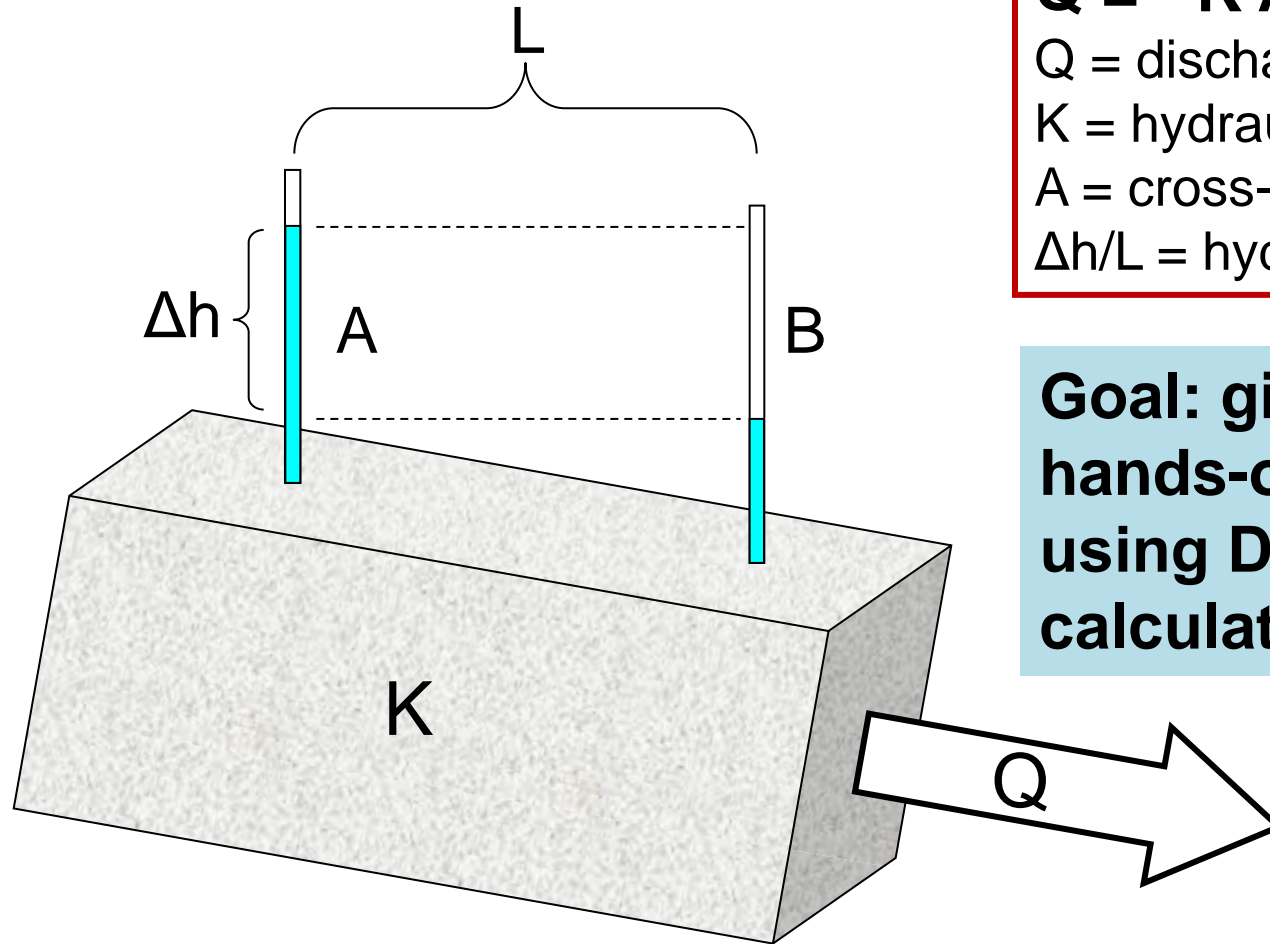
Building aquifers to explore Darcy's Law

Aqueous Systems (ESC 210) – Spring 2012



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Darcy's Law: $Q = -K A (\Delta h/L)$



$Q = -K A (\Delta h/L)$ where
 Q = discharge
 K = hydraulic conductivity
 A = cross-sectional area
 $\Delta h/L$ = hydraulic gradient

Goal: give students a hands-on experience using Darcy's Law to calculate K

Datum level ____

Materials



Materials



Assembly



Assembly



Assembly



Assembly



Assembly



Assembly



Assembly



Assembly



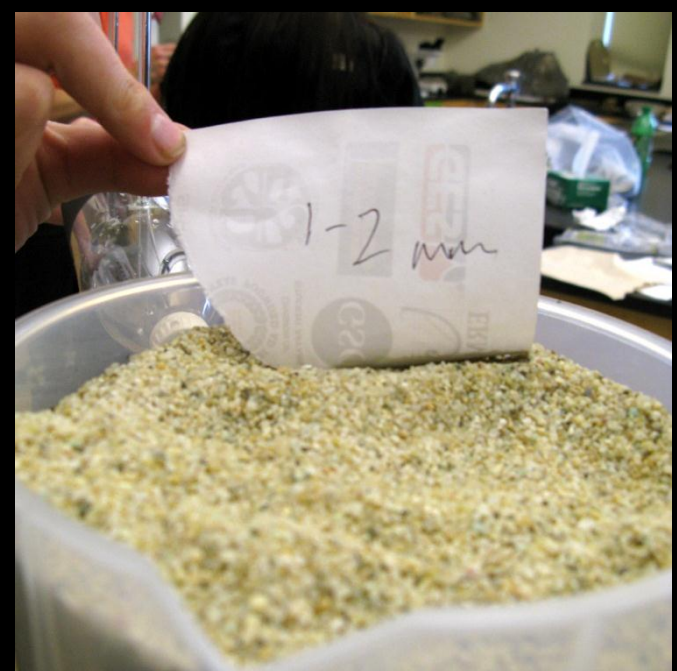
Assembly



Assembly



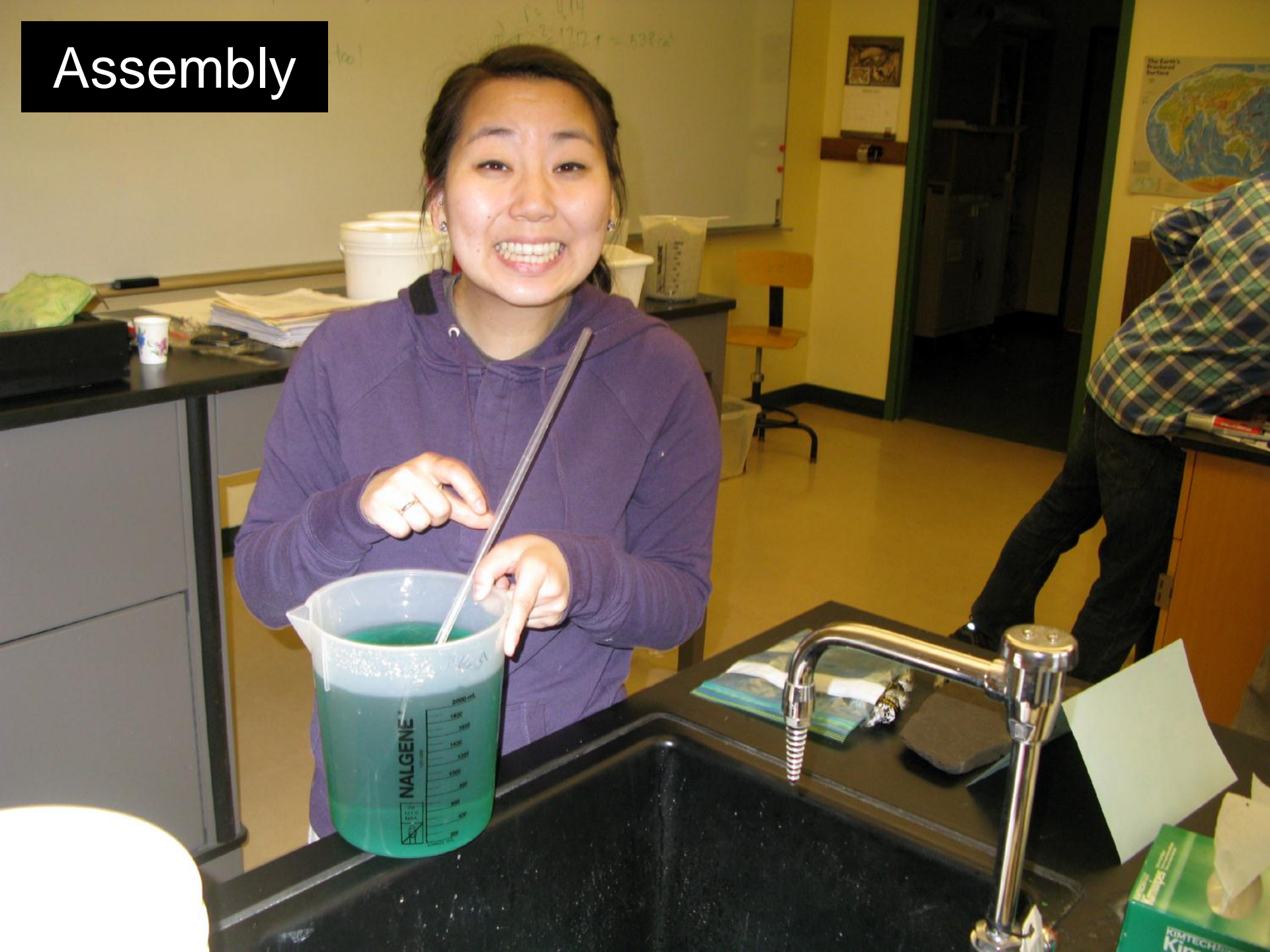
Assembly



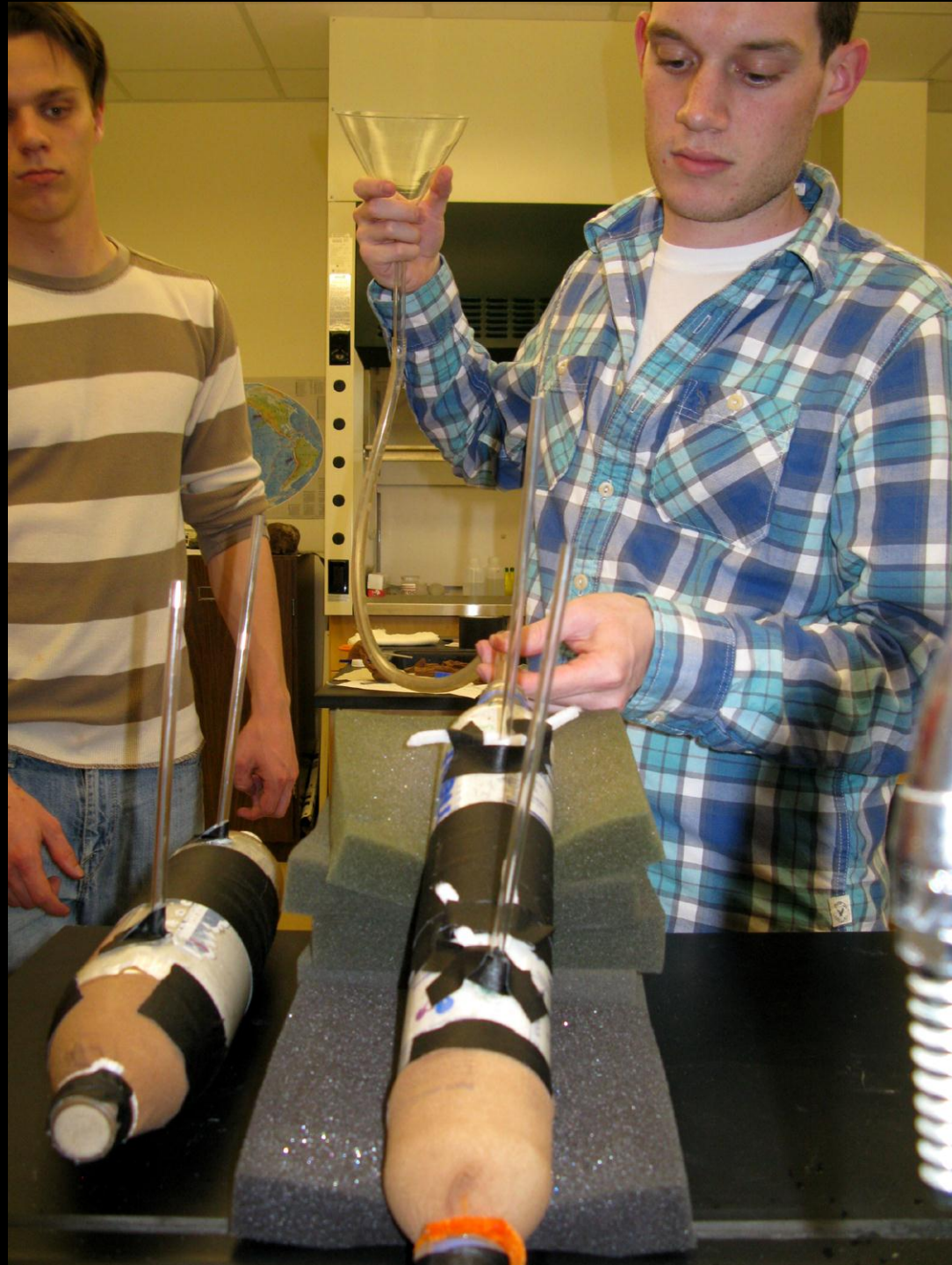
Three grain sizes (sand):
1-2 mm, 0.5-1.0 mm, and
0.25-0.50 mm



Assembly



Assembly



Running the experiment



Running the experiment

Saturating the aquifer



Running the experiment



Teamwork required



Running the experiment

We measured discharge for 60 seconds and marked h in both piezometers



<http://www.youtube.com/watch?v=6uBxKZusOYg&feature=plcp>

Running the experiment

We needed longer piezometers
with filters on their bottom ends



<http://www.youtube.com/watch?v=s7YyBHJE4SU>

Calculating K, the hydraulic conductivity

Rough calculations done on the board –
reasonable K values!

$$K = \frac{Q}{\frac{\Delta h}{L} \cdot A} = \frac{486}{\frac{5.7}{15} \cdot 54} \approx \frac{486}{17} \approx 28.4 \cdot \frac{1}{60} \approx 0.5$$

$C = \pi D$ Cherry Pi delicious

$$A = \pi r^2$$

$$K = \frac{Q}{\frac{\Delta h}{L} \cdot A} = \frac{61}{\frac{12}{18} \cdot 53} \cdot \frac{61}{35} = 1.73 \cdot \frac{1}{60} \approx 0.03$$

Apple PIs are too! 0.50mm
Standard 7mm
Pis 0.25-0.50mm

$$Q = K \cdot \frac{\Delta h}{L} \cdot A$$

$$\#2 \quad C = \frac{26.0}{\pi} = 8.28$$

$$r = 4.14$$

$$A = \pi r^2 = 17.12 \pi = 53.8 \text{ cm}^2$$

$$Q = K \cdot \frac{\Delta h}{L} \cdot A = \frac{62 \text{ cm}^3}{\frac{8}{15} \cdot 28.7 \text{ cm}^2} \approx 4 \frac{\text{cm}}{\text{min}} \cdot \frac{1 \text{ min}}{60 \text{ sec}} \approx 0.066 \frac{\text{cm}}{\text{s}}$$

Calculating K, the hydraulic conductivity

Final calculations done in Excel

	A	B	C	D	E	F	G	H	I	J	K	L
1	Lab 13 - Data		Darcy's Law: $Q = KiA$ or $Q = -K A (\Delta h/L)$									
2												
3	Apparatus #	Packing material size	Q (ml/min)	Q (cm ³ /s)	A (cm ²)	h1	h2	Δh (cm)	L (cm)	Δh / L	K (cm/s)	
4	1	0.25-0.50 mm	62	1.03	28.7	27.7	19.7	8	15	0.53	0.07	
5	2	1.0-2.0 mm	486	8.10	53.8	27.5	21.8	5.7	18	0.32	0.5	
6	3	0.50-1.0 mm	61	1.02	52.9	36	24	12	18	0.67	0.03	

Sheet1 Sheet2 Sheet3

Ready Artesian sand geysers - YouTube - Mozilla Firefox 120%

Calculating K, the hydraulic conductivity

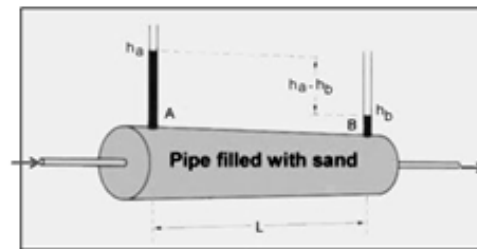
Lab 13 – Darcy tube
ESC 210 - Spring 2012

Name _____

Making a Darcy apparatus

Introduction

We are going to build one or more working models of an apparatus with which to explore Darcy's Law ($Q = K_i A = -KA (\Delta h/L)$). We want to end up with something like this:



Once we have constructed the apparatus and determined A and L, we will run water through it and measure head difference and discharge, then calculate hydraulic conductivity for the packing material.

Methods - Describe what we did.

Results - Report what happened.

Discussion - What worked, what didn't work, what we learned, how we could improve this.

Lab handout

Conclusions

- Design and engineering process required extensive problem-solving and collaboration (good!)
- Components of Darcy's Law went from abstract to concrete for students (good!)
- Calculated K values were reasonable – exciting bonus!
- Will definitely do this again



Cutting Edge Workshop
Teaching Environmental Geology
Montana State University
Bozeman, MT
June 2-7, 2012