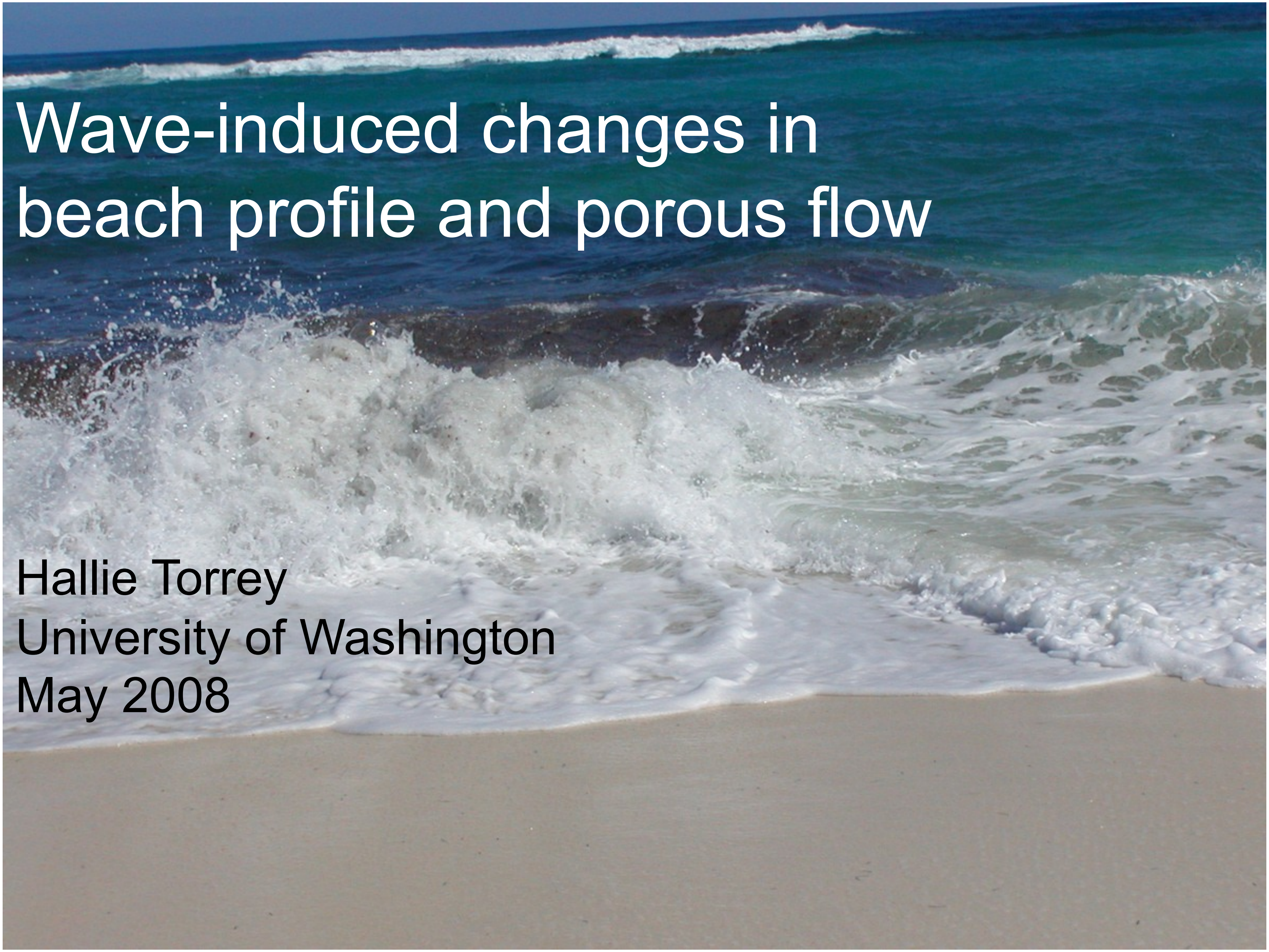
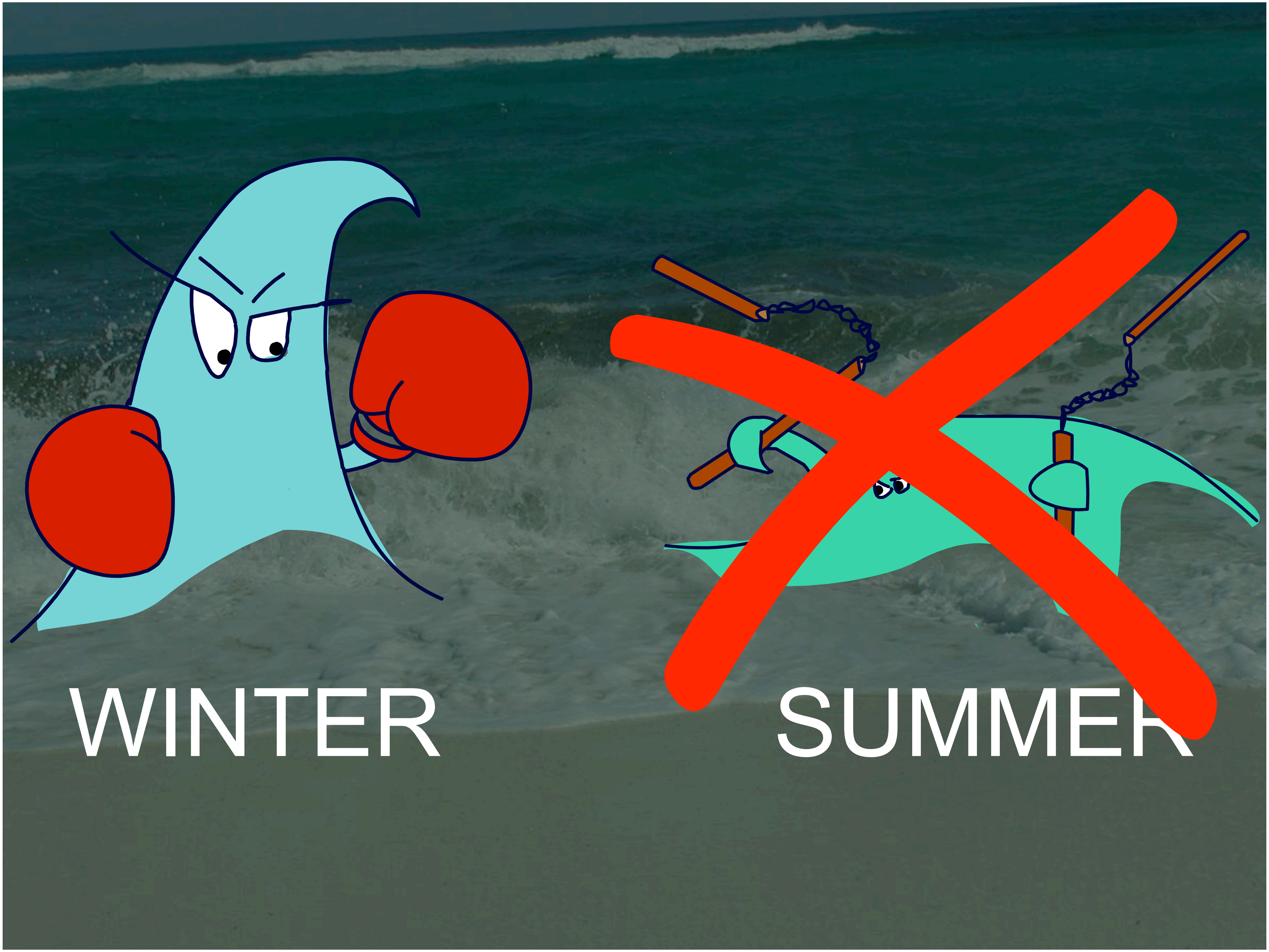
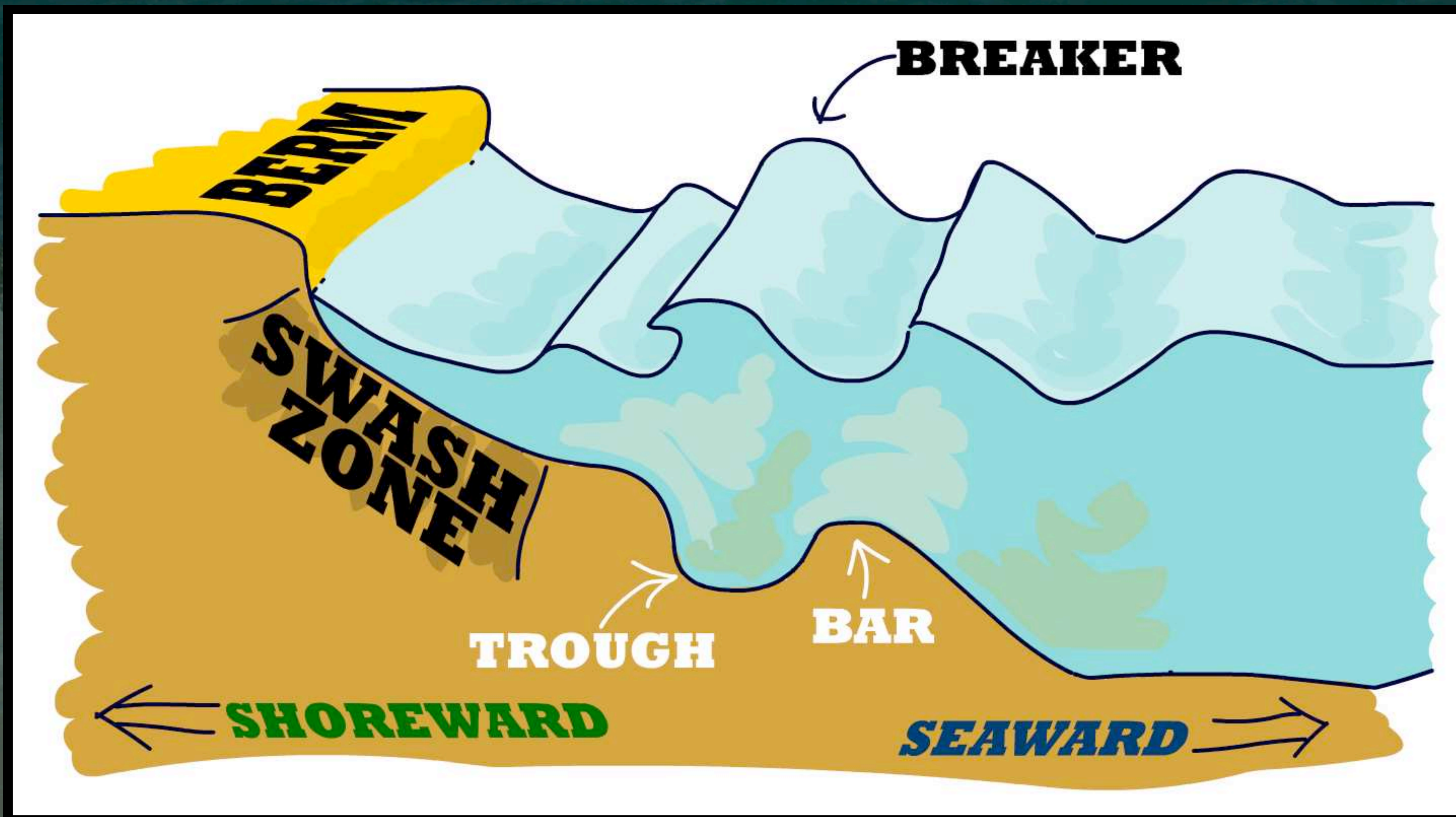
Wave-induced changes in beach profile and porous flow



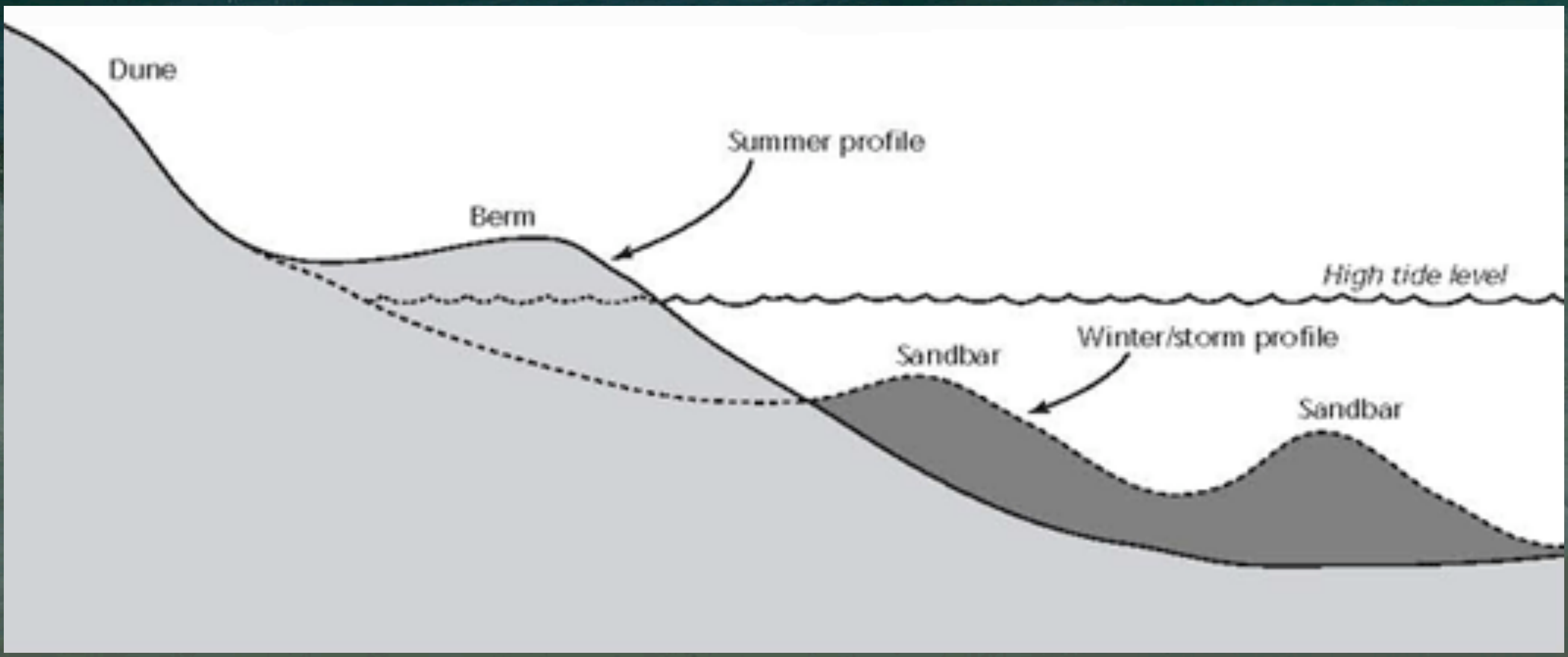
Hallie Torrey
University of Washington
May 2008


WINTER
SUMMER

Terminology



Winter vs. Summer



Costa Maya

Florida

North Beach, Ocean Shores

October, 1995

June, 2001

On average…

	Winter	Summer
Height	3 m	1.5 m
Length	180 m	300 m
Steepness = H/L	1/60	1/200
Energy Flux = …	10.26 kW/m	3.31 kW/m

Energy Flux

$= c_g \; (KE+PE)$

	Winter	Summer
Height	3 m	1.5 m
Length	180 m	300 m
Steepness	1/60	1/200

Group Velocity = ½ (Phase Speed in Deep Water)

$= \frac{1}{2} (gL/2\pi)^{1/2}$

WINTER: 8.38 m/s

SUMMER: 10.82 m/s

Kinetic Energy + Potential Energy = $\frac{1}{8} (\rho_0 g H^2)$

WINTER: 1,225 kg/s^2

SUMMER: 306.25 kg/s^2

Energy Flux = $c_g \; (KE+PE)$

WINTER: 10.26 kW/m

SUMMER: 3.31 kW/m

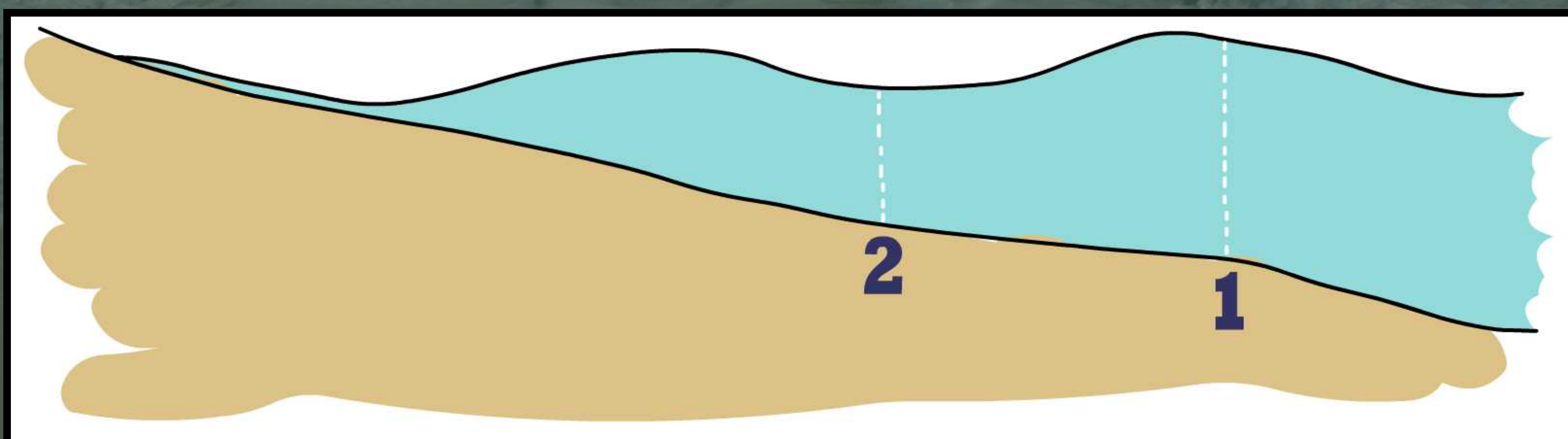
Breaking Waves

For shallow water waves,

$$c_g = c = (gD)^{1/2}$$

As a wave travels, energy flux is constant:

$$E_1 c_1 = E_2 c_2 \qquad {}^{E_1}/_{E_2} = {}^{c_2}/_{c_1}$$



Breaking Waves

CHANGE IN WAVE HEIGHT:

$$E_1/E_2 = c_2/c_1 \rightarrow \frac{1/8\,(\rho_0 g H_1^2)}{1/8\,(\rho_0 g H_2^2)} = \frac{(gD_2)^{1/2}}{(gD_1)^{1/2}}$$

$$\rightarrow \mathbf{H_1/H_2 = (D_2/D_1)^{1/4}}$$

CHANGE IN WAVE STEEPNESS:

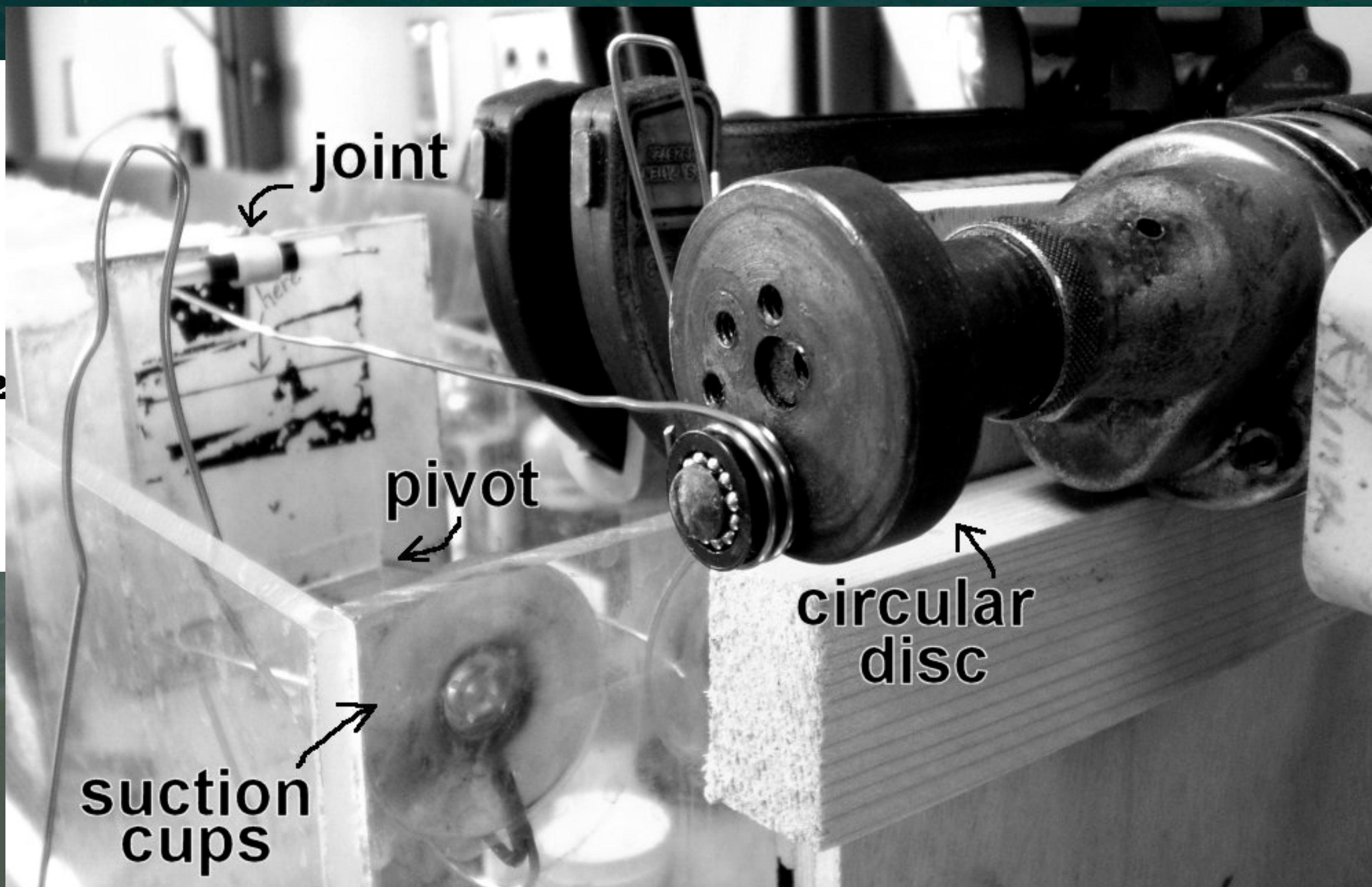
Use dispersion relation:

$$\omega^2 = gD/L_s \rightarrow 1/L_s = \omega/(gD)^{1/2}$$

$$H/L_s \sim D^{-1/4} \cdot \omega/(gD)^{1/2} = \mathbf{D^{-3/4} \cdot \omega/g^{1/2}}$$

MY EXPERIMENT

Apparatus



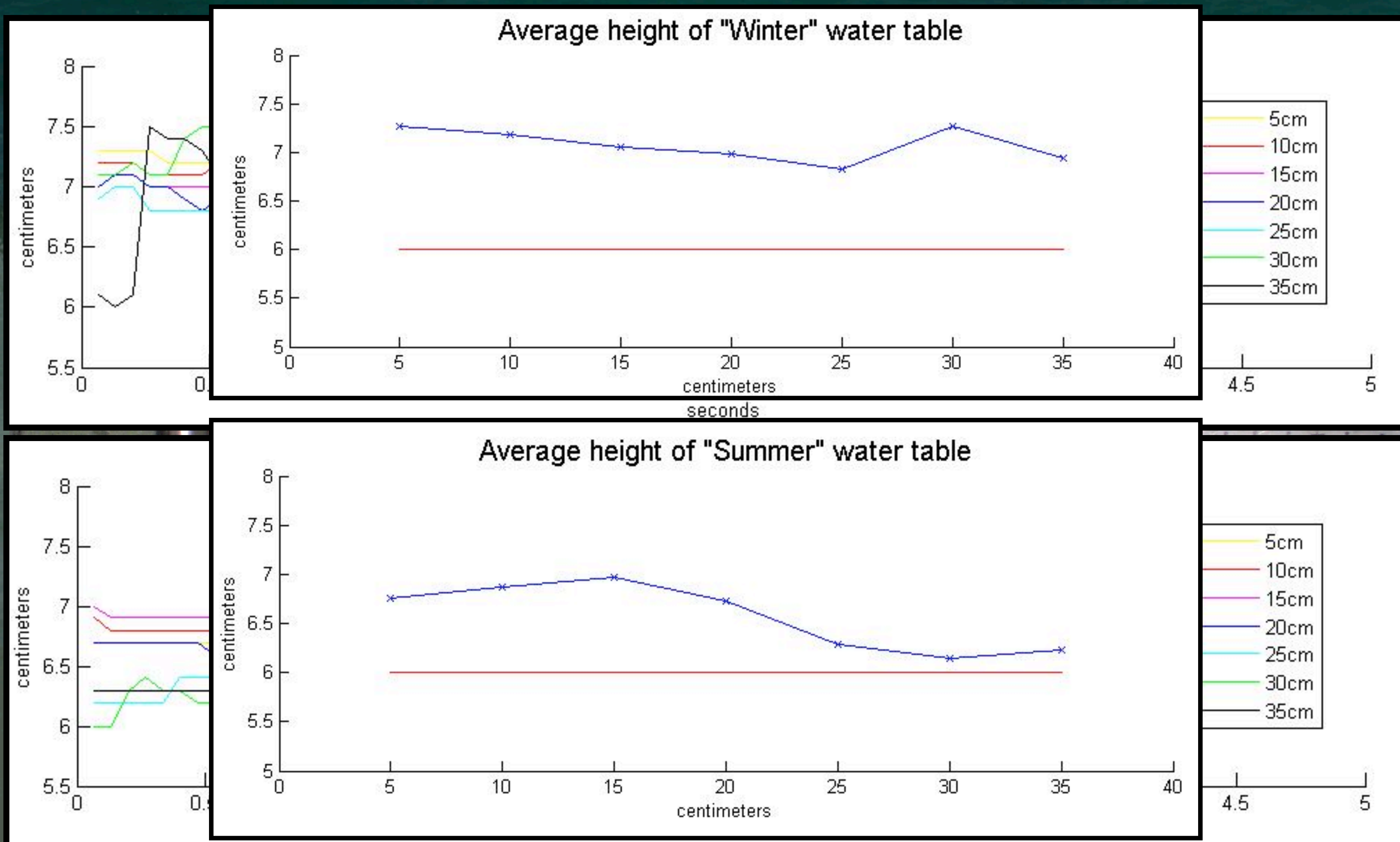
MY EXPERIMENT

Observations

… cue the movies!!!

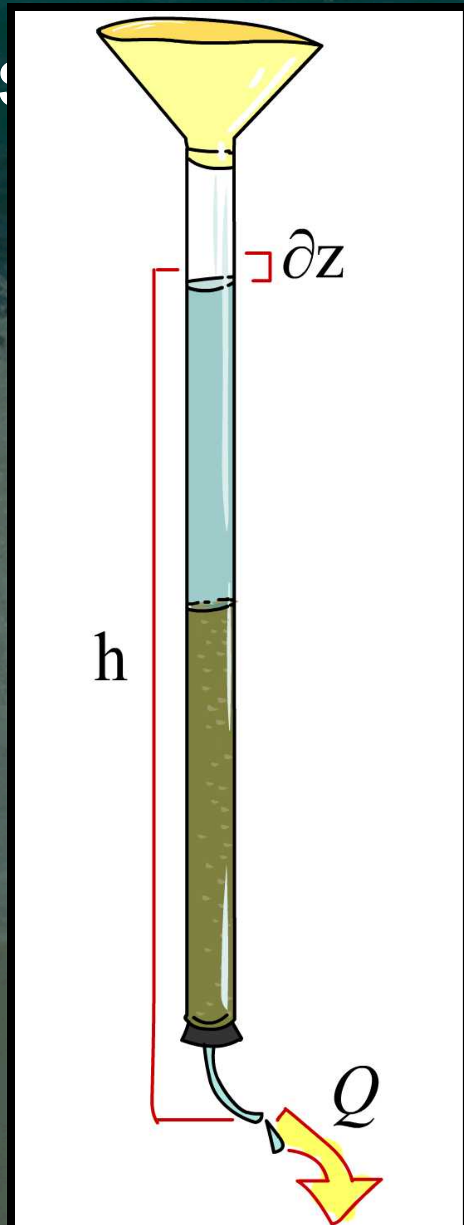
MY EXPERIMENT

Observations



MY EXPERIMENT

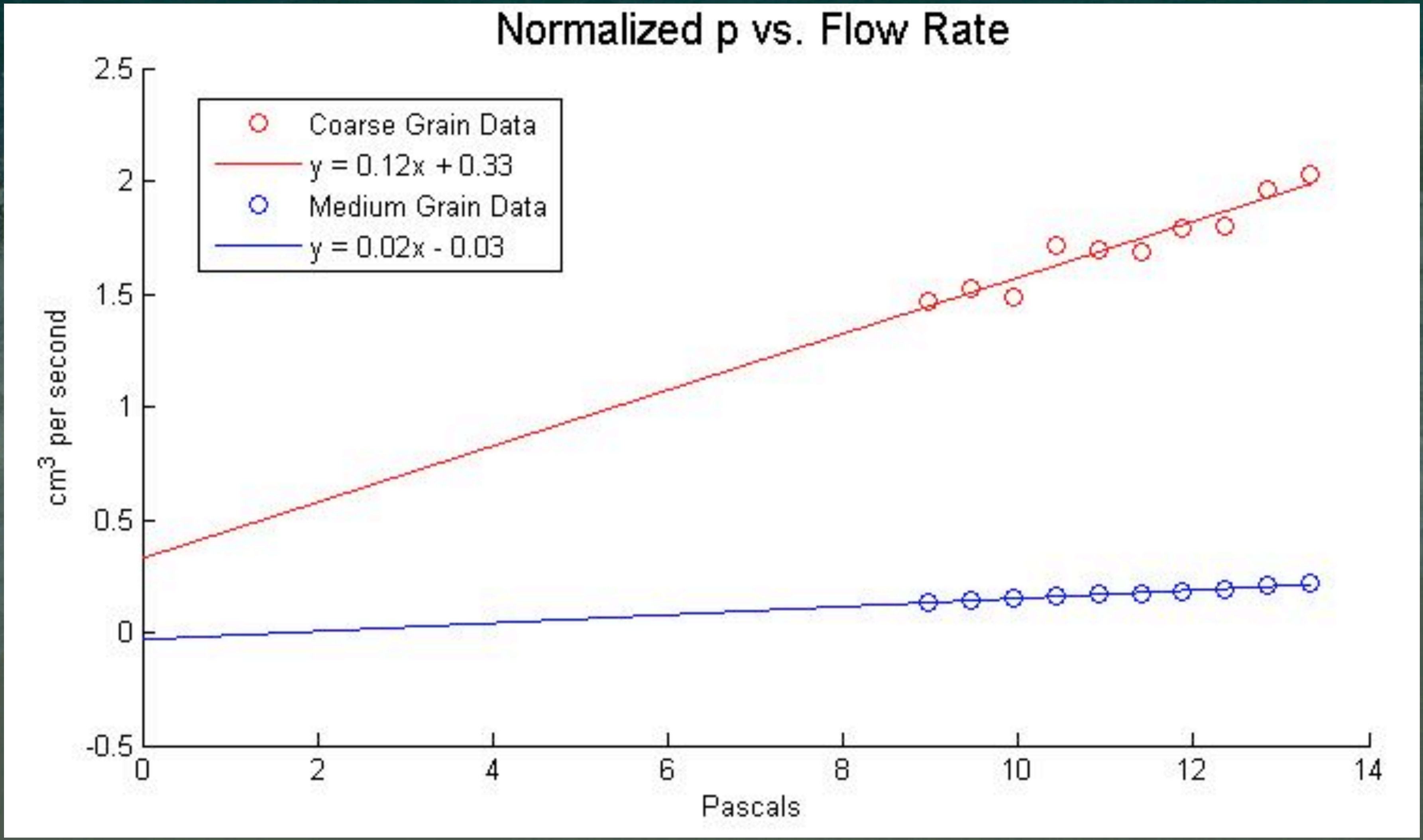
Apparatus



$$Q = G \cdot p$$

MY EXPERIMENT

Observations



Governing Equations

Conservation of Momentum:

$$\vec{u} = K\nabla p = \nabla\Phi$$

Conservation of Mass:

$$\frac{\partial\rho}{\partial\tau} = -\rho\nabla\cdot\vec{u}$$

$$0 = \nabla\cdot\vec{u}$$

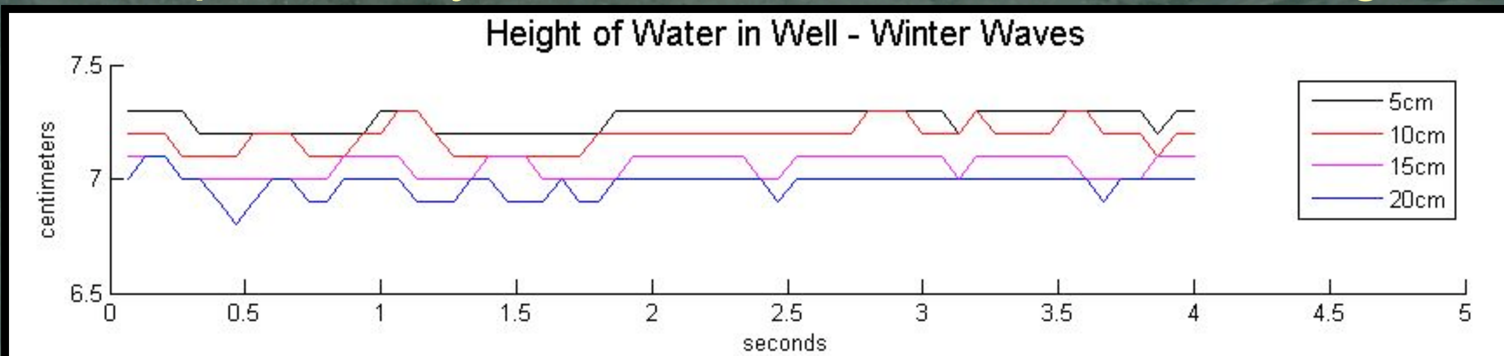
$$\Rightarrow \frac{\partial^2\Phi}{\partial x^2} + \frac{\partial^2\Phi}{\partial y^2} = \nabla^2\Phi = 0$$

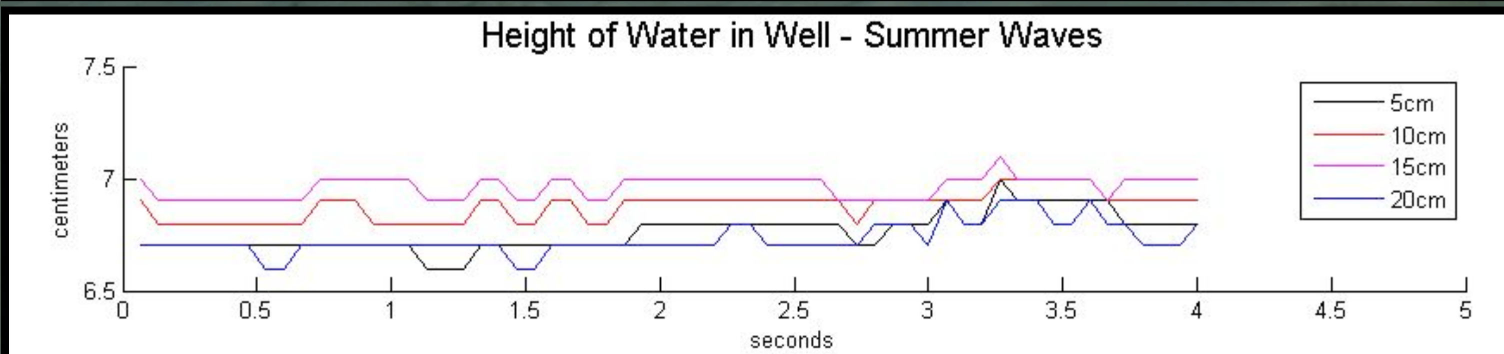
ELLIPTIC!

$$\nabla^2 \Phi = 0$$

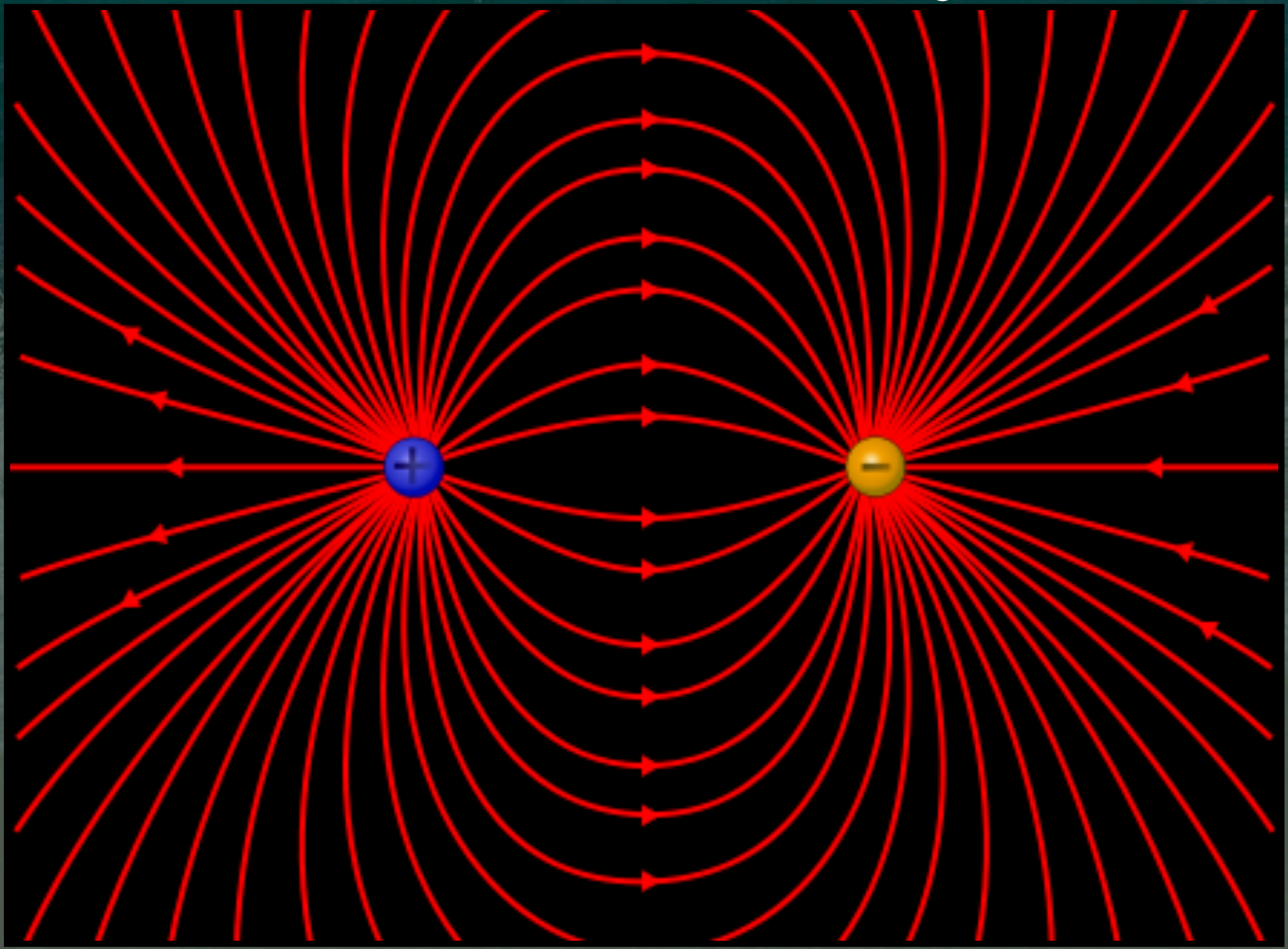
Boundary conditions are periodic.

Is the periodicity “felt” INSTANTLY within the region?

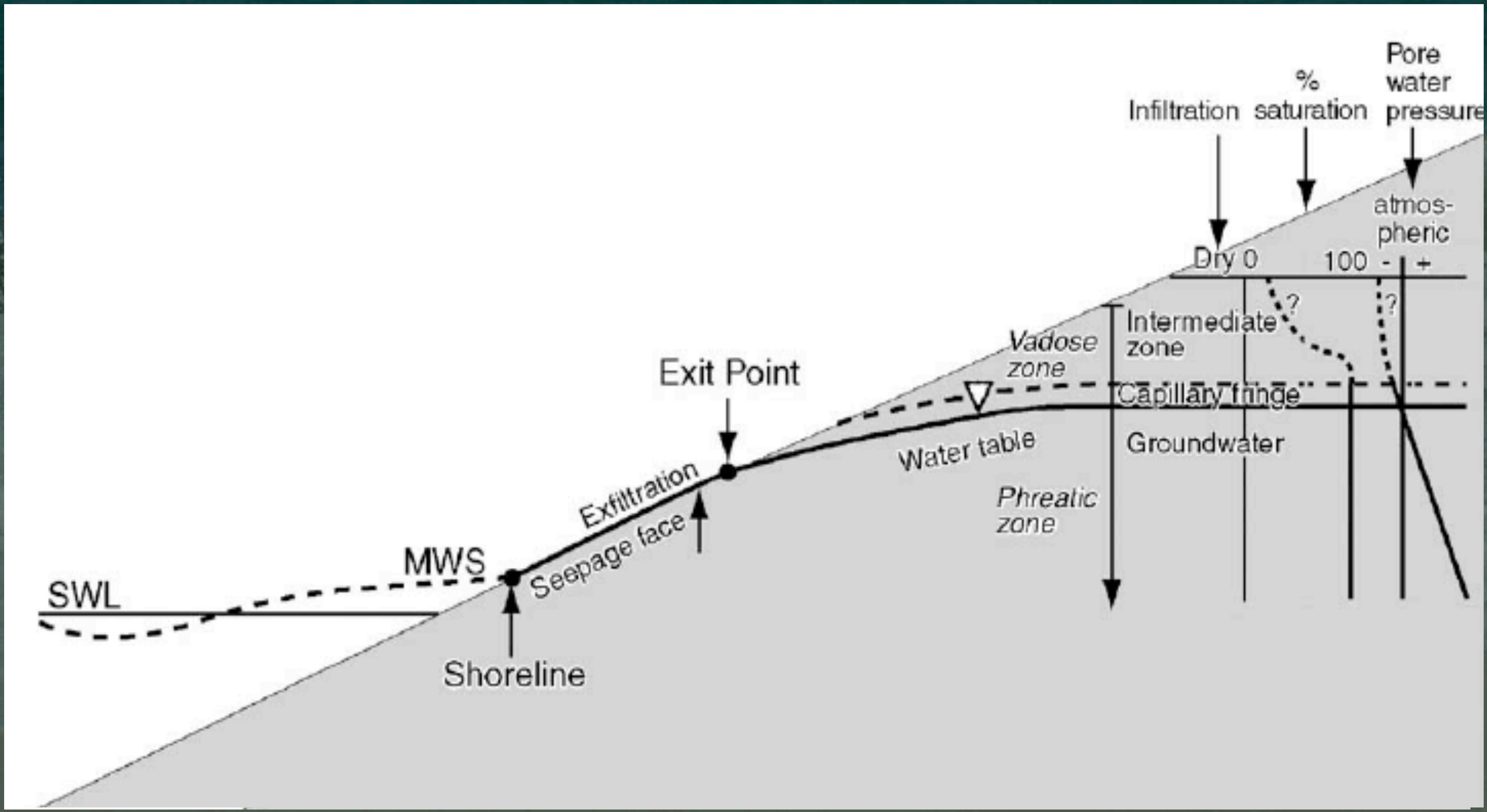




Ohm and Darcy



So-and-so said…*



* Consider it paraphrasing.

So-and-so said…*

"Use the Boussinesq equation!"

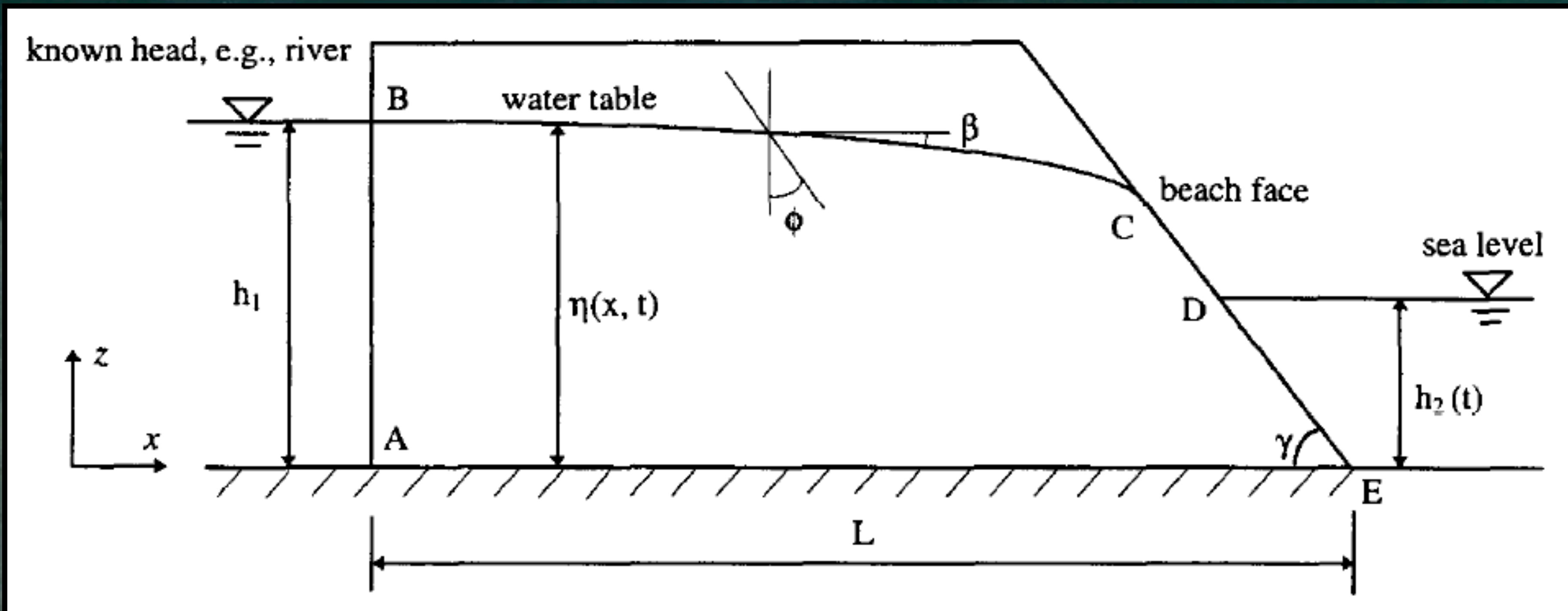
$$\frac{\partial h}{\partial t} = \frac{K}{s}\frac{\partial}{\partial x}\left(h\frac{\partial h}{\partial x}\right)$$

"Assume the Dupuit-Forchheimer approximation!"

* Consider it paraphrasing

So-and-so said…*

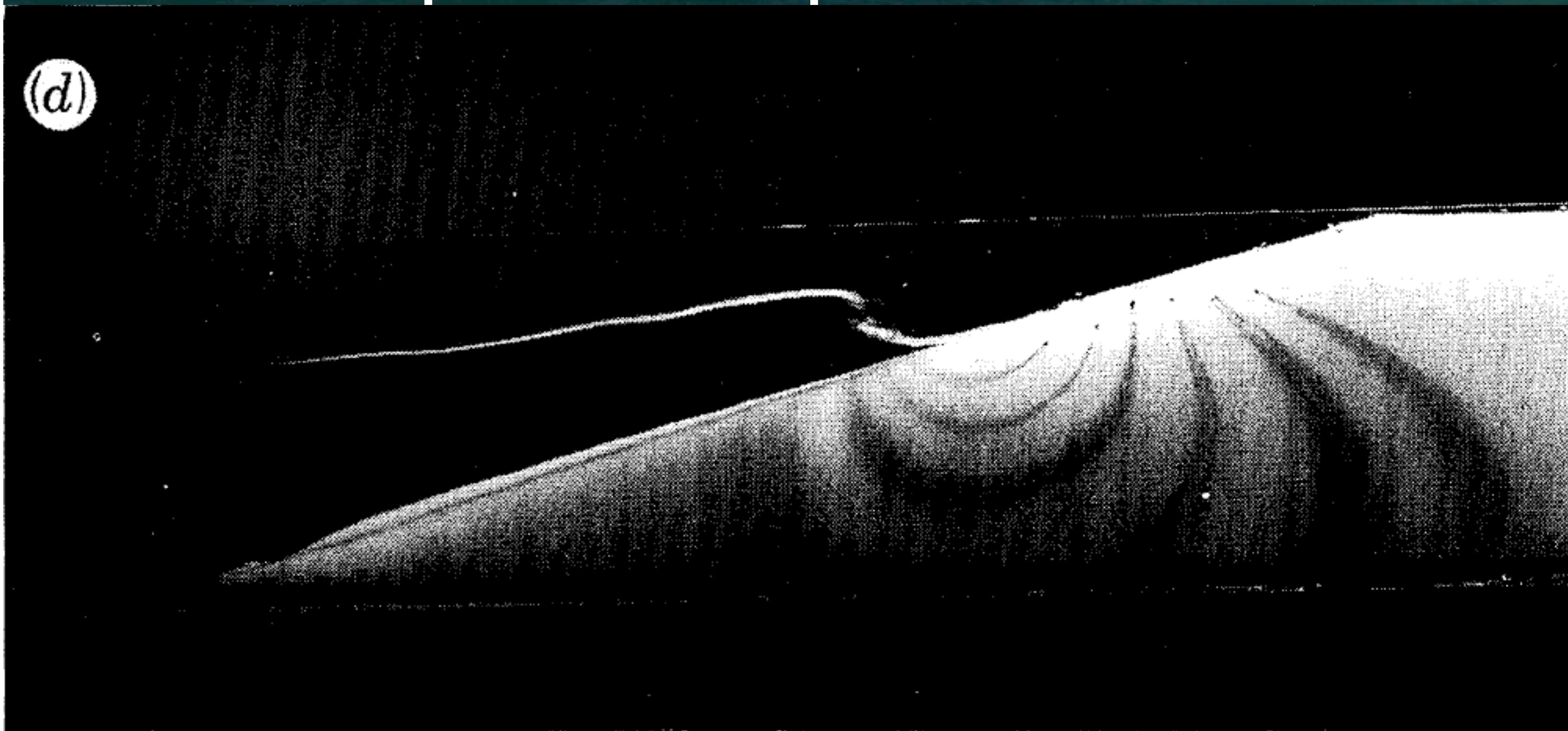
"Solve Laplace's Equaion!"



* Consider it paraphrasing.

So-and-so said…*

“Solve Laplace’s Equaion!”



* Consider it paraphrasing.

References

[1] Cardenas, M. Bayani and J.L. Wilson, "Exchange across a sediment-water interface with ambient groundwater discharge." Elsevier Ltd (Copyright 2007)

[2] Cardenas, M. Bayani and J.L. Wilson, "Hydrodynamics of coupled .ow above and below a sediment-water interface with triangular bedforms." Elsevier Ltd (Copyright 2006)

[4] Komar, Paul D., Beach Processes and Sedimentation. Prentice Hall, Inc, Englewood Cli¤s, New Jersey, 1976

[8] Turner, Ian L. and Gerhard Masselink, "Swash in.ltration-ex.ltration and sediment transport." Journal of Geophysical Research, 103 (1998), No C13, pp 30,813-30,824

Plus more!