Submarine Groundwater Discharge in the Surf Zone
Stinson Beach, California

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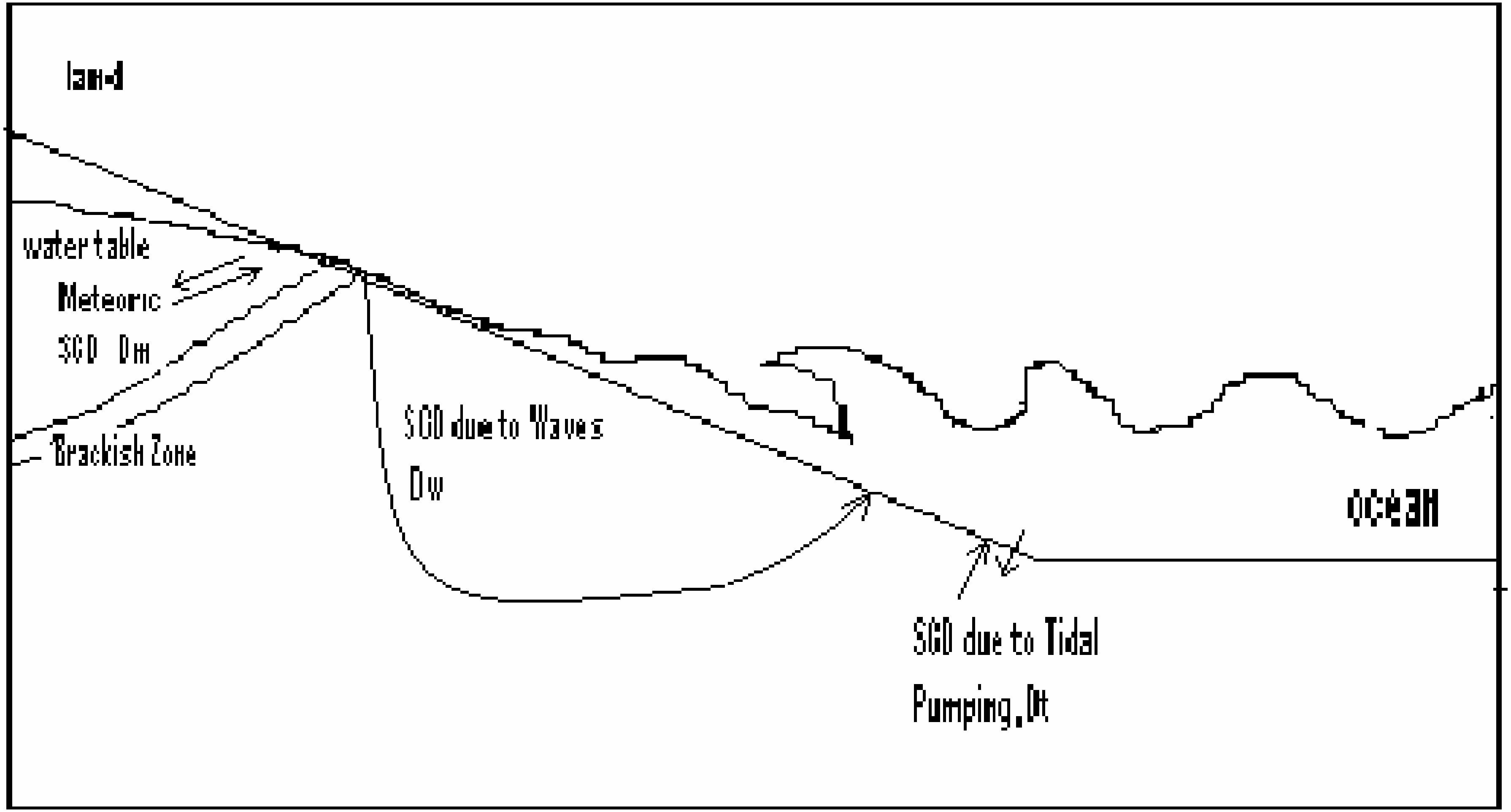
Introduction

- Submarine Groundwater Discharge, SGD-
  - Direct discharge of fresh and seawater water across the sea floor in the coastal zone
  - SGD: Volumetric Flow Rate of Water/ Alongshore Distance, m^3/(min* m)
  - Pathway for transport of nutrients and fresh water into coastal areas
  - Pathway for non-point pollution migration into coastal areas
  - SGD Flow Rate comparable to surficial run-off rates at Huntington Beach

Mechanism for SGD



Mechanism for SGD cont.

- Hydraulic gradient from water flowing downhill
- Wave and tide pressure gradients in the near coastal zone
- Seasonal flows into and out of the aquifer due to perennial recharge cycles

Three types of SGD

- $D_{SGD} = D_w + D_t + D_m$ (m^3/(min*alongshore dist.))
- D_m, meteroic SGD
- D_w, wave driven SGD
- D_t, tidally driven SGD

What SGD transports

- Nutrients
  - Nitrates, nitrites, ammonia, ortho-phospate, organic carbon
    - Can cause eutrophication, algae blooms
    - Great threat to human health

- Sewage
  - Fecal Indicator Bacteria
  - Pathogens

How to Measure SGD

- Use Radium Isotopes as a tracer for SGD
  - Radium desorbs from sediments at the fresh water, salt water interface
    - Common ion affect
    - Near shore coastal waters have high [Ra]
    - Open seawater has low [Ra]
  - Measure the radioactive decay of ^{223}Ra , ^{224}Ra, ^{226}Ra using a coincidence counter
  - Half Life ^{226}Ra = 1600 years
    - 226Ra is a conservative tracer in the surf zone
  - Half Life ^{224}Ra = 11.4 days
    - Radioactive Decay Important
  - Half Life ^{223}Ra = 3.7 days
    - Radioactive Decay Important

Mathematical Model for the Activity of ^{223}Ra, ^{224}Ra

$$\frac{dA}{dt} = K_h \frac{\partial^2 A}{\partial x^2} - \omega \frac{\partial A}{\partial x} - \lambda A$$

Diffusion Advection Radioactive Decay

- Assume advection can be neglected, steady state

$$A_x = A_o \exp\left[-x \sqrt{\frac{\lambda}{K_h}} \right]$$

- To find K_h: graph ln [A] vs. x (distance from the shoreline)

$$K_h = \frac{\lambda}{m(slope)^2}$$

Mathematical Model for the Concentration of ^{226}Ra

$$\frac{dA}{dt} = K_h \frac{\partial^2 A}{\partial x^2} - \omega \frac{\partial A}{\partial x} - \lambda A$$

Diffusion Advection Radioactive Decay

- Assume advection and Radioactive decay can be neglected, steady state,

$$A_x = A_o + Cx$$

- To find C graph A(Ra^{226}) vs x (distance from the shore) and find the slope

SGD

$$F_{Ra^{226}} = -K_h \frac{dA(^{226}Ra)}{dx}$$

$$A_x(^{226}Ra) = A_o(^{226}Ra) - Cx, \qquad \frac{dA(^{226}Ra)}{dx} = C$$

$$K_{h,Ra^{223}} = \frac{\lambda_{Ra^{223}}}{m\ (slope\ Ra^{223})^2}, \quad K_{h,Ra^{224}} = \frac{\lambda_{Ra^{224}}}{m\ (slope\ Ra^{224})^2}$$

$$F_{Ra^{226}} * Area = Flux\ Cross - shore\ \ Ra^{226}$$

$$D_{SGD} = \frac{Flux\ Cross - shore\ \ Ra^{226}}{A_{beach\ aquifer} * alongshore - dis\tan ce}$$


Stinson Beach Sampling Sites
Sample 100 L at Waist Depth
Sample 100 L at Waist Depth
100 meters
Sample 100 L at Ankle Depth
Sample 100 L at Ankle Depth
Sample 100 L from Pit dug into the Beach
Sample 100 L from Pit dug into the Beach

Sampling

Experimental Goals

- Determine value for SGD, compare to surficial discharge
- Sample Two – Four times/ day at the high-high tide, low-low tide and intermediate tides.
- Sample during a full tidal cycle (two weeks) ie: neap tide and spring tide
- Test to see if timing of nutrient discharge, fecal indicator bacteria levels are related to the daily tidal cycle and fortnightly tidal cycle
- Test to see how discharge of nutrients is affected by seasonal discharge of groundwater
- Data Analysis in Progress

Thank You

GCEP

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