CIEG 680 Homework #6

1. 8.1. Consider a long, straight, uninterrupted coastline. A single groin is installed as hsown in Figure 8.32.

(a) How will the volume of material deposited updrift of the groin compare with that eroded downdrift of the groin?

The amount of material deposited updrift should be equivalent to the amount of material eroded downdrift.

(b) Develop a convincing argument proving your answer to (a).

Suppose a groin exists at a location x_G along a straight beach. Apply the sand conservation equation from $-x_0$ to x_0, where the distance x0 from the groin is outside the region of the groins influence. The total integral is broken into two parts as

$\int_{-x_0}^{x_G}\left(\frac{\partial Q}{\partial x}+\frac{\partial V}{\partial t}\right)dx+\int_{x_G}^{x_0}\left(\frac{\partial Q}{\partial x}+\frac{\partial V}{\partial t}\right)dx=0$, where Q is the sediment transport rate and V is the volume of sediment.

TERM1: $Q(x_G)=Q(-x_0)-\int_{-x_0}^{x_G}\left(\frac{\partial V}{\partial t}\right)dx$

TERM2: $Q(x_0)=Q(x_G)-\int_{x_G}^{x_0}\left(\frac{\partial V}{\partial t}\right)dx$

Add terms together and set equal to zero as above

$Q(x_G)+Q(x_0)=Q(-x_0)-\int_{-x_0}^{x_G}\left(\frac{\partial V}{\partial t}\right)dx+Q(x_G)-\int_{x_G}^{x_0}\left(\frac{\partial V}{\partial t}\right)dx$ or

$\int_{-x_0}^{x_G}\left(\frac{\partial V}{\partial t}\right)dx=-\int_{x_G}^{x_0}\left(\frac{\partial V}{\partial t}\right)dx$ since the sediment transport rate at x_0 and $-x_0$ are equivalent because they are outside the region of influence of the groin. Thus, the volume deposited updrift is equivalent to the volume deposited downdrift.

(c) Does your answer depend on whether bypassing of the groin occurs? Discuss.

The answer does not depend on bypassing. If sand is bypassed around the end of the groin, it is transported at the same rate on either side. The only way to vary the volumes on the updrift versus downdrift side is to have a gradient in the sediment transport flux. This is not provided by bypassing of the groin.

2. 8.6 The littoral drift rose for a particular area is given in Figure 8.37. Three shore-line segments are separated by Inlets A and B.

(a) Quantitatively describe the sand budget at Inlet A.

The shore-normal for the upper island section is 90º while the shore normal for the central island segment is roughly 120º. Using the littoral drift rose, the positive transport, Q_+ north of the inlet is approximately 1550 L^3/year while the negative transport, Q_- north of the inlet is approximately 600 L^3/year (Where L is either in feet or meters). The respective transport rates on the south side of the inlet are 1500 and 700 L^3/year. Thus, during positive (negative) transport, roughly 50 (100) L^3/year is being deposited into Inlet A. This suggest a total of 150 L^3/year is "lost" to the inlet annually and is likely contained in ebb and flood tidal shoals.

(b) Quantitatively describe the sand budget at Inlet B.

The analysis is nearly identical, except during positive transport north of the inlet, Q_+ = 1500 L^3/year while Q_- = 700 L^3/year. South of inlet B, Q_+ = 1550 L^3/year while Q_- = 600 L^3/year. In this case, during positive (negative) transport, 50 (100) L^3/year are supplied by sediments in the inlet. This suggests a total of 150 L^3/year is supplied by the inlet to the adjacent island segments.

3. 8.9 The littoral drift rose shown in Figure 8.41 is appropriate for an area of interest. The net alongshore sediment transport along the updrift shoreline is 200,000m^3/yr, and the flood tidal shoals of an inlet store 50,000 m^3/yr. The updrift and downdrift shorelines on the opposite sides of the inlet are initially in equilibrium with the waves.

(a) What are the initial orientations of the updrift and downdrift shorelines?

First convert the given transport rates to yards per day. 200,000 m^3/yr = 265403 $yards^3$/yr = 727 $yards^3$/day. 150,000 m^3/yr = 545 $yards^3$/day. A simple sum of the components suggests that the transport downdrift is 150,000 m^3/yr (the 200,000 minus the 50,000 trapped in the shoals). Search the LDR to see where the net transport is 727 $yards^3$/day and 548 $yards^3$/day (Table extracted from LDR).

Orientation º	Q_+	Q_-	Q_{net} ($yards^3$/day)	Q_{net} ($yards^3$/day)
30	1220	1500	-280	-102200
40	1250	1400	-150	-54750
50	1200	1100	100	36500
60	1200	900	300	109500

70	1600	900	700	255500
80	1800	900	900	328500
90	1750	700	1050	383250
100	1700	600	1100	401500
110	1650	600	1050	383250
120	1600	750	850	310250
130	1400	750	650	237250
140	1150	700	450	164250
150	1000	700	300	109500
160	850	700	150	54750
170	800	700	100	36500

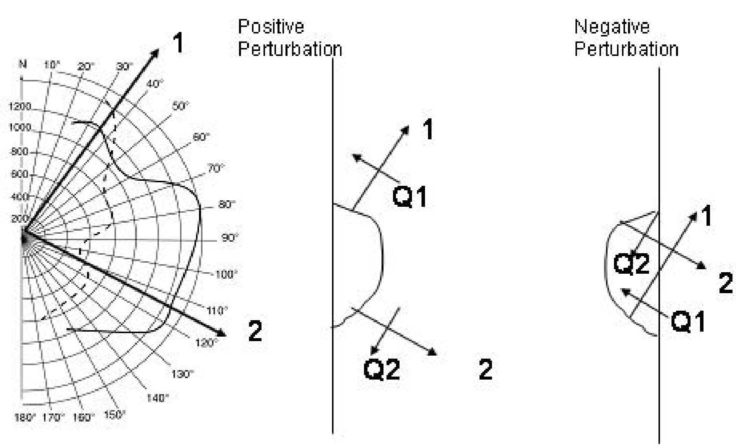
These values are found to be located at shoreline orientations of roughly 70º and 66º respectively. There are also two other shoreline orientations at roughly 127º and 135º respectively but these would suggest the downdrift shoreline being displaced seaward which is not normally the case for inlets.

(b) The equilibrium is altered for navigation by removal of an additional 100,000 m^3/yr (364 yards^3/day) of sand from the inlet. What will be the long-term orientation of the downdrift shoreline?

The sand is removed from the inlet and it is assumed that the sand is not placed on the down drift shoreline. If this is the case, then only 50,000 m^3/yr (182 yards^3/day) is transported along down drift shoreline. By searching through the LDR table, the long-term orientation is found to be roughly 54º.

(c) Is the littoral drift rose stable or unstable? Demonstrate your answer.

Stability of the LDR is found by taking two slices across LDR to see if transport accentuates or nullifies perturbations. In both cases, the LDR tends to smooth out the perturbation, thus the LDR is stable.



Sketch showing tendency to smooth shoreline perturbations based on given LDR.

5. Sediments at 150 m depth require a velocity of 0.05 m/s to be mobilized. Will a 3m, 12s wave cause the sediments to move?

Lets go about this first assuming deep water, then we need to determine a relationship for the bottom velocity as a function of depth (Komar page 163; I think I handed this table out too)

$$u = \frac{H\sigma}{2\sinh(kh)}\cos(kx - \sigma t)$$

only interested in max velocity so set the cos term to 1

$$u = \frac{H\sigma}{2\sinh(kh)}$$

The wave length is obtained from

$$L = \frac{gT^2}{2\pi} = \frac{(9.81)(144)}{6.28} = 225m \rightarrow \quad k = \frac{2\pi}{L} = \frac{6.28}{225} = 0.028$$

Thus,

$$u = \frac{(3)(2*3.14)}{2(12)*\sinh(0.028*150)} = 0.024m/s$$

Sediments will not be mobilized. Note, I think there is a factor of 2 missing from Komar's deep water equation in his table.

A second option is to not assume deep water conditions but a check on the full wavelength equation compared to deep water was 224.7m vs 225m. So it is a fair assumption to assume deep water and we can stop.

6. Komar chap 9 number 4

quartz density is 2650 kg/m^3 while basalt density is 3500kg/m^3.

The transport equation for immersed weight looks like

$$I_\ell = (\rho_s - \rho)g(1-p)Q_\ell$$

take ratio assuming Q and p are constant

$$\frac{(\rho_s - \rho)_{quartz}}{(\rho_s - \rho)_{basalt}} = \frac{(2650 - 1035)}{(3500 - 1035)} = 0.66$$

immersed weight transport is 66 % less for quartz grains. Seems backwards but that is the way it works for these immersed weight calcs since the transport is directly proportional to density and Q.

7. Komar chap 9 number 7

Assume the angle varies from 7+/-2 degrees. If the wave breaker height (assumed Hrms) is 2.5 m then the water depth can be estimated using the spilling breaker assumption. I will assume the ratio is 0.4 rather than the often used 0.78. Thus, the water depth is 2.5m/0.4 = 6.25 m.

Now, $P_\ell = \frac{1}{16}\rho g H^2 C_g \sin(2\theta) = \frac{1}{16}(1000)(9.81)(2.5)^2\sqrt{(9.81)(6.25)}\sin(2\theta) = 30006\frac{N}{s}\sin(2\theta)$

Assuming shallow water since waves breaking.

Now for various breaker angles

Angle (degrees)	Transport (N/s)	Mean (N/s)	Difference (N/s)
5	5210	7241	4062
9	9272		
13	13,154	14,966	3625
17	16,779		