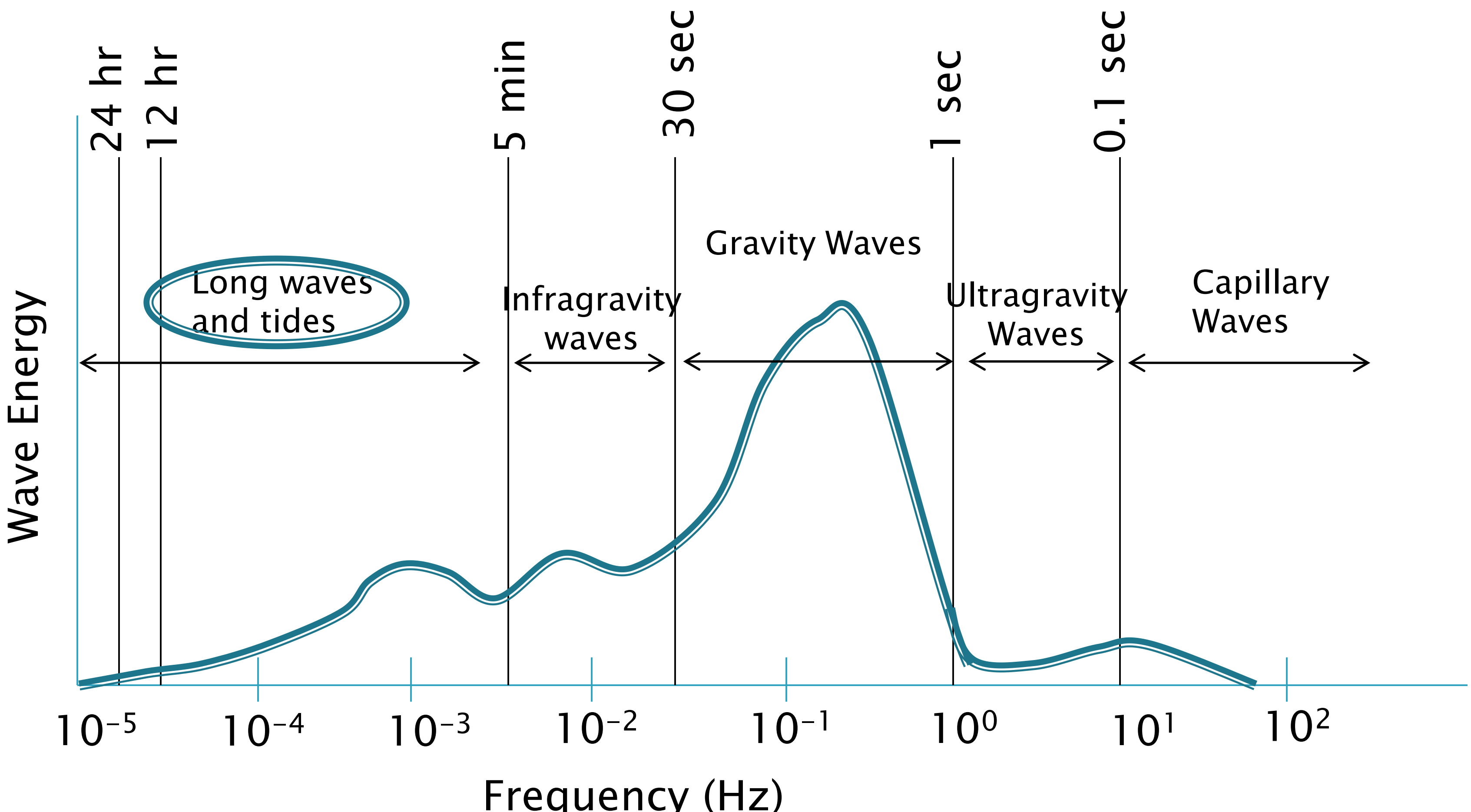
Engineering With Nature

Lecture 5

Goals of Today's Lecture

- Tides
- Beaches
- HW Questions

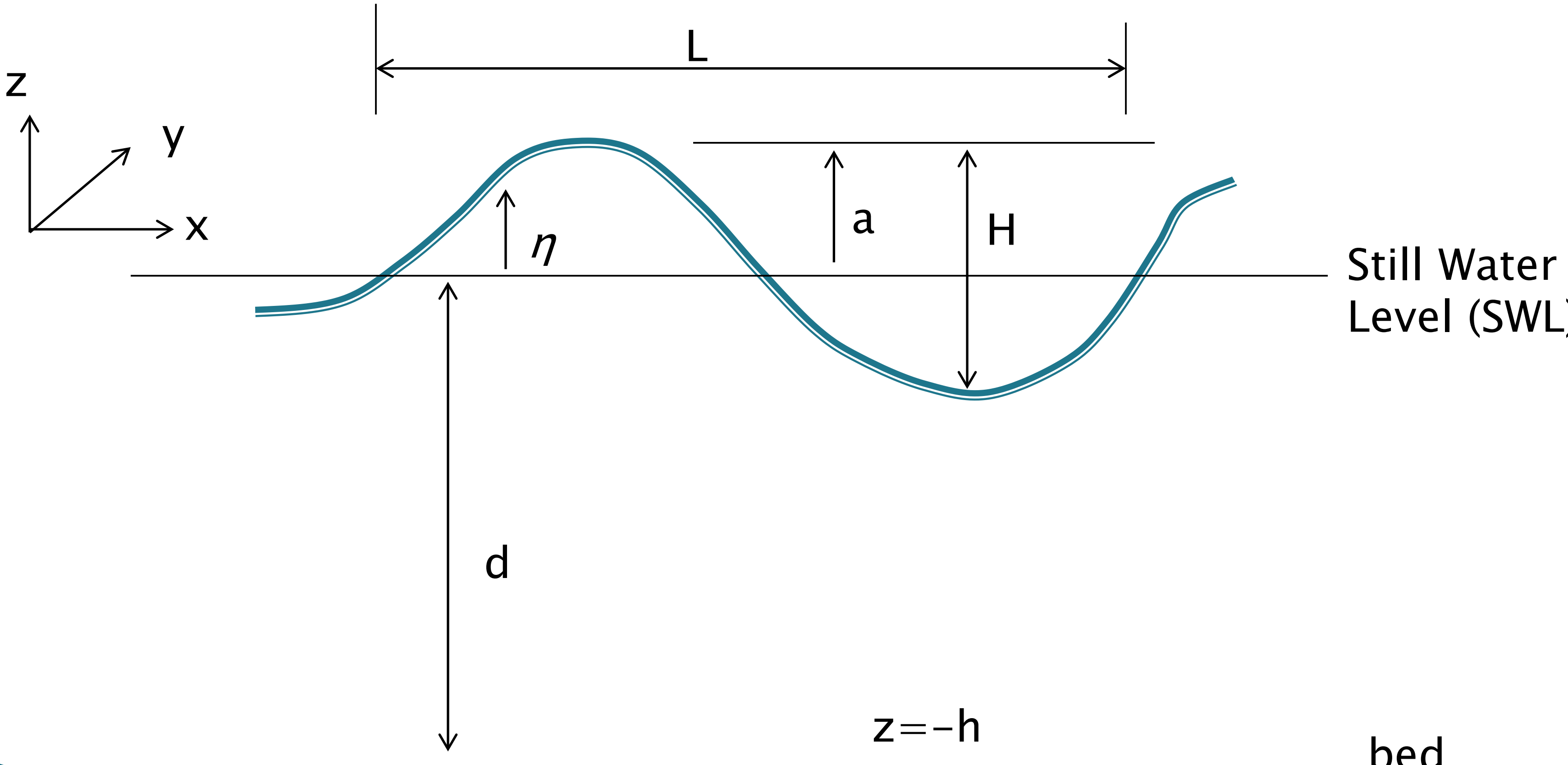
Water Waves



Adopted from Kinsman (1965) "Wind Waves", Prentice-Hall

Waves

Surface gravity waves (water waves) are the fluctuations of the water level.



Tides

- The rise and fall of the water level, where the amplitude is driven by the gravitational effects of the moon, sun and rotation of the earth
- Tides often the driving factor behind vegetation/habitat types
- Most common datum are the Mean Sea Level, Mean Higher High Water, Mean Lower Low Water.
- Mean Higher High Water is the arithmetic mean of the higher high water heights of tides
- Mean Lower Low Water is the arithmetic mean of the lower low water height of tides
- Mean Sea Level is the arithmetic mean of the water level
- Always check which datum these are in. Most are referenced to a geodetic datum such as NAVD88

https://tidesandcurrents.noaa.gov/datums.html?datum=MLLW&units=1&epoch=0&id=8770475&name=Port+Arthur&state=TX

Tides

- Due to the phases of the moon there are neap tides and spring tides
- Spring tide is the largest amplitude tide that occurs twice each lunar month
- Seven days after the spring tide the neap tide occurs
- Neap tide is the smallest amplitude tide and occurs when the sun and moon are at right angles to each other

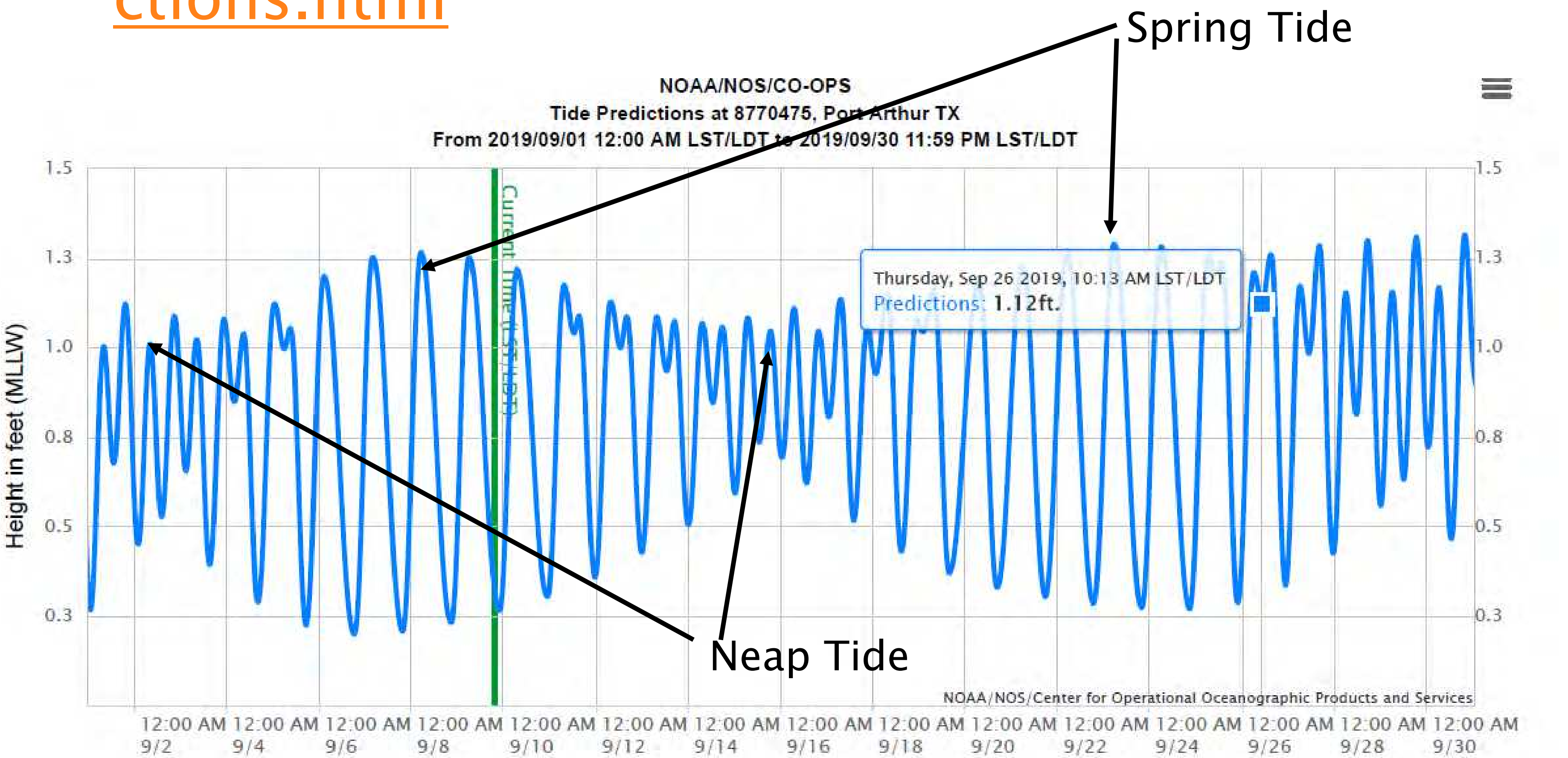
Tides

- Tides are either consider diurnal or semidiurnal
- Diurnal is one low tide and one high tide every lunar day
- Semidiurnal is two low tides and two high tides every lunar day

This map shows the geographic distribution of different tidal cycles. Coastal areas experiencing diurnal tides are yellow, areas experiencing semidiurnal tides are red and regions with mixed semidiurnal tides are outlined in blue.

Tides

- Tidal predictions are available at https://tidesandcurrents.noaa.gov/tide_predictions.html



Tidal Theory

- Modern tidal theory uses tidal constituents to predict the tide.
- 390 constituents have been defined for the gravitation attraction between the earth, moon and sun
- The most important are K_1, O_1, P_1, Q_1, M_2, N_2, S_2 and K_2. The subscript of 1 is for diurnal portions and the 2 is for semidiurnal
- Typically these constituents are placed into a numerical model for accurate predictions of the tides and velocities

http://www.ams.org/publicoutreach/feature-column/fcarc-tidesiii3

Tidal Prism

- Tidal Prism is the volume of water through an inlet/estuary between high and low tide. The simplest calculation for the tidal prism, P, is the surface area of the estuary, A, multiplied by the tidal range, H.
- If there is river inflow, q, subtract this from H*A.
- Ebb Tide occurs during the transition between high and low
- Flood Tide occurs during the transition between low and high

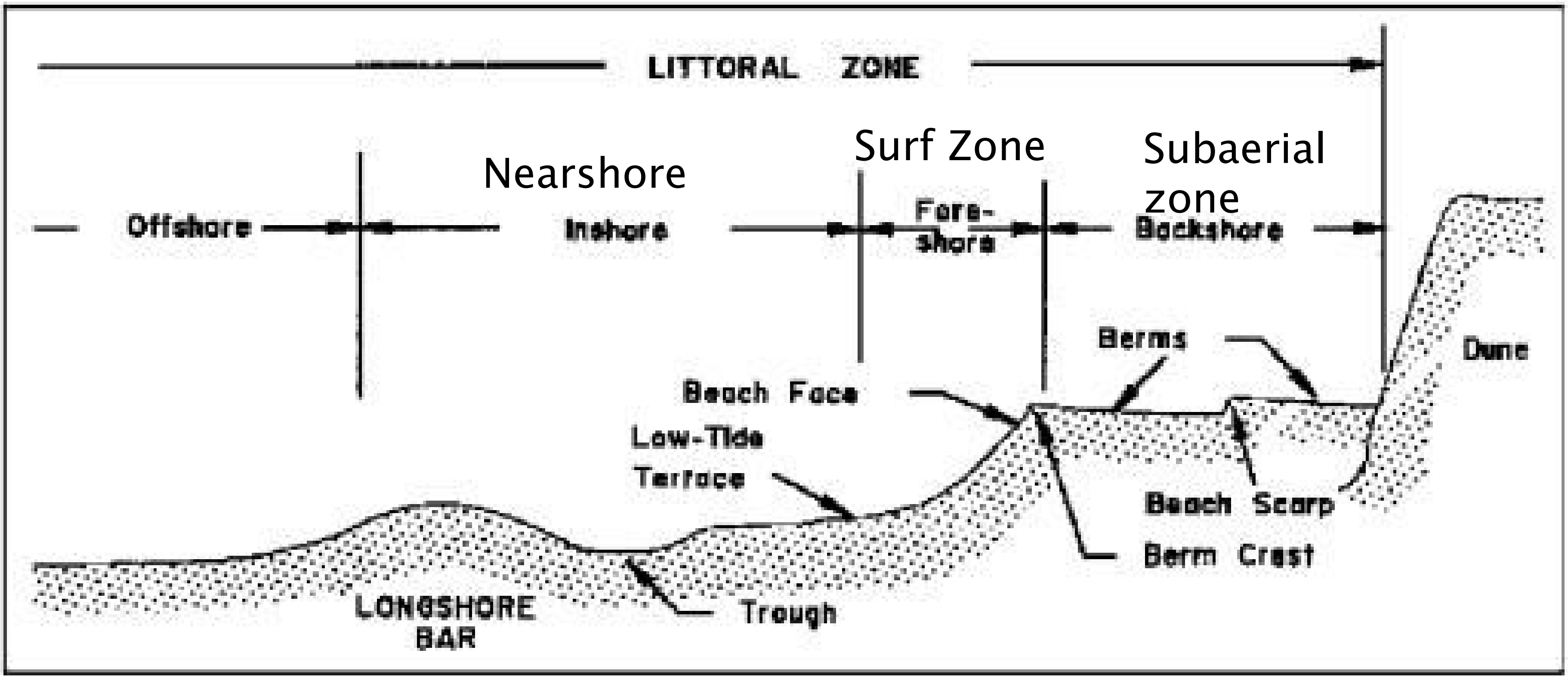
Tidal Prism

- The tidal prism can be changed by
  - Shoreline Structures
  - Dredging
  - Flood Structures
- Additionally changes in the tidal prism can influence the equilibrium depth through an inlet
- Predicting the changes to a tidal prism are typically done with a numerical model

Tides and Vegetation

- The water levels influence the vegetation type
- Example:
  - *Halodule beaudettei* – Shoal Grass (1 to 3 feet deep)
  - *Spartina alterniflora* – Cordgrass (grows in low marsh)
  - *Spartina Patens* – Salt hay (grows in upper marsh)
- If you are targeting a particular type of marsh you need to consider both your design elevation and tidal range.

Beaches


LITTORAL ZONE
Surf Zone
Subaerial zone
Nearshore
Offshore
Inshore
Fore-shore
Backshore
Berms
Dune
Beach Face
Low-Tide Terrace
Beach Scarp
Berm Crest
LONGSHORE BAR
Trough

Important Beach Concepts

- Sandy beaches can be defined by equilibrium beach profile where

$h=A*x^{(2/3)}$ where h is the water depth (m), x is the distance offshore from the (m), and A is sediment scale parameter ($m^{(1/3)}$)

- This definition is not perfect as it cannot account for offshore bars and has a infinite slope at x=0

Depth of Closure

- The depth of closure is the depth at which sediment motion doesn't occur
- The depth of closure is dependent on the wave height, wave period and sometimes sediment grain size
- Over five popular depth of closure equations

Hallermeier (1981) Eq. 2_Inner DOC	$d_l = 2.28H_e - 68.5(\frac{H_e^2}{gT_e^2})$
Hallermeier (1981) Eq. 6_Inner DOC Simplified	$d_l = 2\bar{H}_s + 11\sigma_s$
Hallermeier (1981) Eq. 7_Outer DOC	$d_i = (\bar{H}_s - 0.3\sigma_s)\,\bar{T}_s(\frac{g}{5000D})^{0.5}$
Birkemeier (1985)_Eq. 2	$d_l = 1.75H_e - 57.9(\frac{H_e^2}{gT_e^2})$
Birkemeier (1985)_Eq. 3	$d_l = 1.57H_e$

H_e =	$\bar{H}_s + 5.6\sigma_s$
T_e =	Period associated with H_e
$\bar{H}_s$ =	mean significant wave height
σ =	Standard deviation of $\bar{H}_s$
$\bar{T}_s$ =	Mean period associated with $\bar{H}_s$
D =	Grain size

http://wis.usace.army.mil/

http://cirp.usace.army.mil/products/depth-of-closure.php#

Beach Retreat

A simplified model (for high level evaluation) for beach retreat, R, given a change in sea level rise, S. (Bruun, 1962)

$$R = SL/(h+B)$$

Where S is the sea level rise, L is the distance to the equilibrium depth, h is the depth of closure, and B is the height of the beach elevation or dune crest