CHAPTER 2
THEORIES

2.1 Tide

2.1.1Tidal patterns

Tidal patterns are the rise and fall of the water surface caused by the combined effects of the gravitational forces exerted by the Moon and the Sun,and the rotation of the Earth in geometric relationship with locations on the Earth's surface.When the gravitational forces of the Moon and the Sun are perpendicular to the Earth, it causes the bulges to cancel each other. The result is a smaller difference between high and low tides, which is neap tide. And, also spring tides occur when the Earth, the Sun, and the Moon are in a line. The gravitational forces of the Moon and the Sun both contribute to the tides, resulting in the high tides that are very high and the low tides that are very low. Hence, tides can be classified into 3 types (Ghosh, 1998)(Figure 2.1).

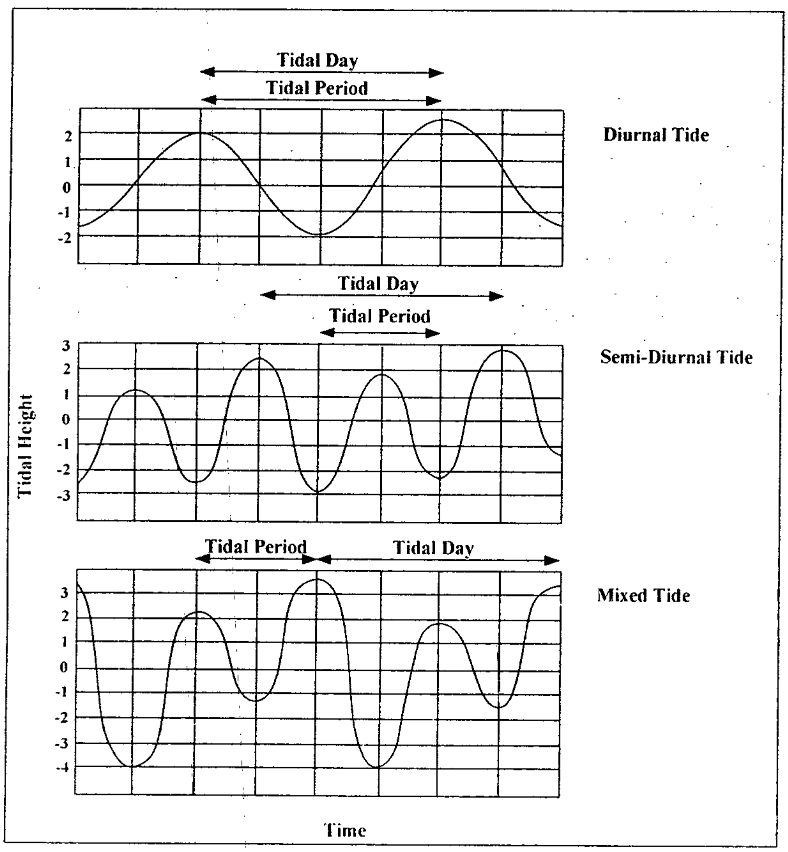

Figure 2.1 Types of tides(Ghosh, 1998).

1) Diurnal tides: whichhave one high and one low water level per tidal day.
2) Semi-Diurnal tides: which have two high and two low water levels per tidal day.
3) Mixed tides:which have two unequal high water levels and two unequal low water levels each tidal day.

The Upper Gulf of Thailand is a semi-enclosed sea located in a tropical zone. It has a square-like dimension with an approximate area of 104 km^2 surrounded by land in all directions, except in the south, which is open to the gulf and causesmixed tides.Thecharacteristic of mixed tide in this area is the semi-diurnal tide dominance because sometimesit has two high and two low waters while one high and one low water per tidal daycan be found in this area also (Thailand Institute of Scientific and Technological Research, 1999).The characteristic ofthe Chao Phraya Basin is flat plan, which cause intrusion of saltwater to inland as interfere drainage into the Upper Gulf of Thailand (Figure 2.2).

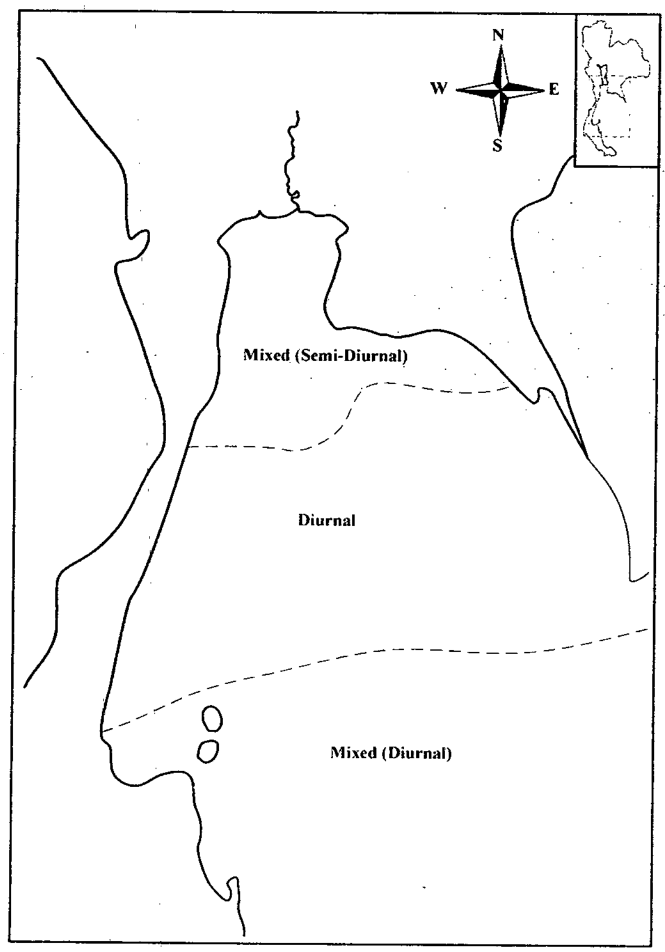

Figure 2.2 Tidal patterns in Gulf of Thailand (Komolmaedhee, 1989).

2.1.2 Tidal in river

Rivers can be characterized by their geomorphology, pattern of salinity stratification and mixing of freshwater and seawater. The interaction between tidal wave propagation and the geomorphology of the river is an important factor for characterizing of river. The river type can be categorized by the balance of estuary convergence and frictional effect. The river is determined by the relative magnitude of influences, which are controlled by numerous physical factors including the river discharge, intensity of tide, tidal current, wind energy, the composition of the sediments, topography and geometric of channel (Woo and Yoon, 2011).

The rise and fall of the water surface at the entrance of the river causes surface gradients. This results in the propagation of a gravity wave into the river. The propagation rate mainly depends on depth of water, in other words, on the tidal range at the mouth. The speed of propagation of waves is different from that of the fluid through which they move. The wave travels with celerity relative to the water depth, as shown in Equation 2.1.

$$c = \sqrt{gh} \tag{2.1}$$

Where, c is celerity (m/s), g is acceleration due to gravity (m/s^2) and h is water depth (m). Another factor of considerable influence on the penetration of the tide is the discharge of the river (Figure 2.3).

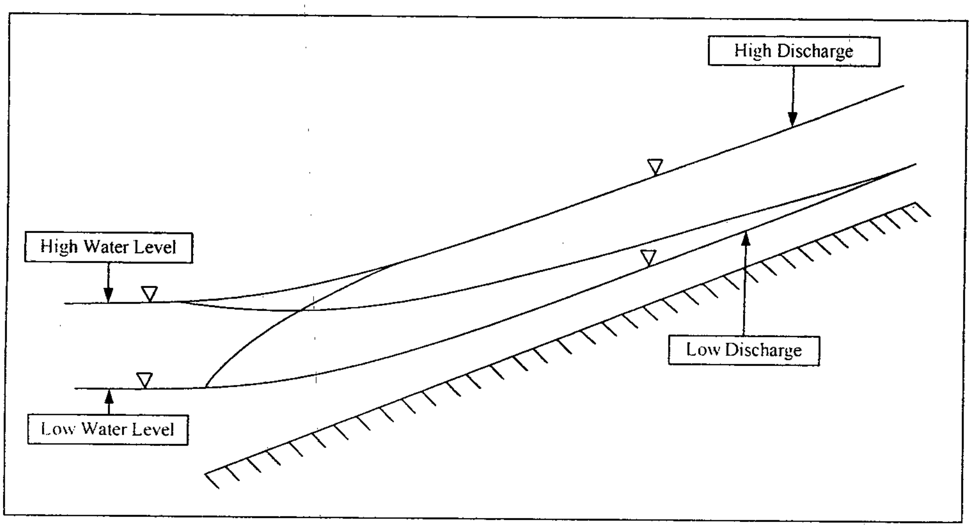

Figure 2.3 Tidal patterns as a function of upland discharge.

In most river mouths, the depth of the water is not high, especially at lowtide. This causes considerable friction between the water and the bed, which is most noticeable during the falling tide. This effect can be seen on tide gauge records where the slope of the rising tide will be very much steeper than of the falling tide. Figure 2.4 shows the typical tidal curves for 3 positions in a tidal river. Further, the time of rise from low to high water decreases at points farther inland and will be much smaller than that of the fall. Shallow water effect cause crest of the tidal wave to travel up the estuary much faster than the rough. In some cases, the effect of friction combined with the slope of the bed reaches a critical state at which bores are formed (Ghosh, 1998).

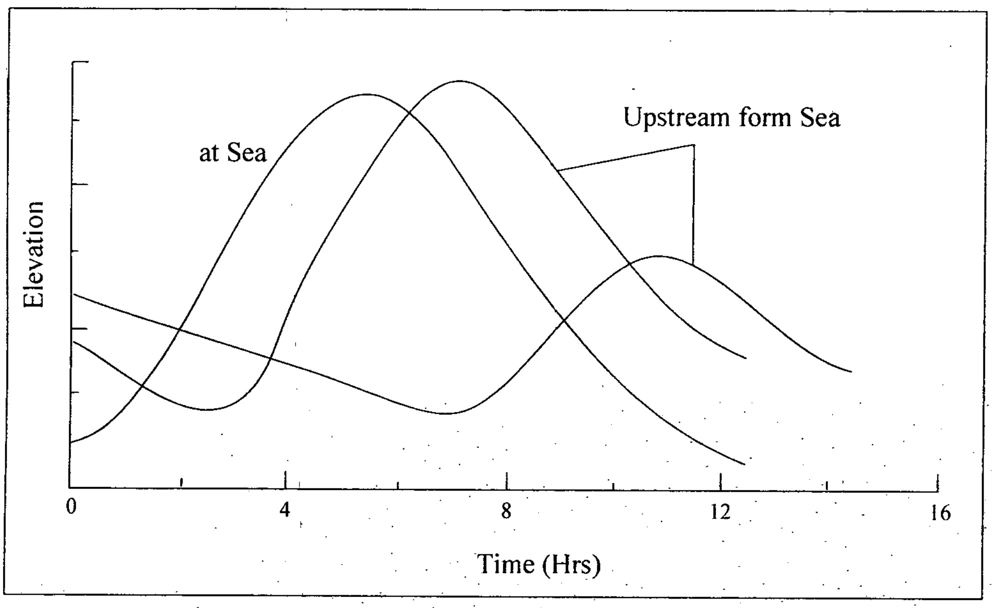

Figure 2.4 Typical tidal curves at any positions.

During an ebb tide, surface gradients are set up at the seaward end, which are initially similar in magnitude to those occurring during the flood tide, but in the opposite direction. As the water level falls, the rate of wave propagation decreases and the influence of the rate of fall of the sea becomes weaker. The ebb flow then becomes a process of drainage under gravity (Ghosh, 1998).

Furthermore, the tides in the Upper Gulf of Thailand mainly come (from tidal propagation) through the Chao Phraya River and also are influenced by the rivers discharges. Moreover, the tidal wave propagation is affected by physical factors which are geometry, bottom topography and river discharge in the Gulf of Thailand. It is important that the interaction of river flow, tide, tidal current and basin morphology determine the type of tidal wave propagation.

2.2 River flow and its effect

2.2.1Flow rate of fresh water

The description of tidal river behavior is concerned with the effects of tidal rises and falls. All tidal rivers are formed by the combined action of tides and river flow.

The equilibrium of a tidal river can only be maintained if the quantities of solid, fresh water and minerals in a solution are "balanced". This requirement of continuity of matter is simple in principle, yet it has a most far- reaching effect on the behavior of tidal rivers. Fresh water entering into a tidal river must leave at the same rate, average over a period of several weeks, if the system is in equilibrium. Rainfall, evaporation and percolation all take part in the process but seldom contributed significantly to the balance of the flow of fresh water, except during times of very low river flow. Water leaving a tidal river eventually mingles with saline water until it can no longer be distinguished from it; but this process is inevitably a gradual one and may still be detected many kilometers offshore of event quite small rivers. The density of coastal waters is noticeably lower than that of the oceans.

The inevitable movement of fresh water away from the tidal river into the sea is accompanied by the movement of saline water, which must be replaced if equilibrium is to be maintained. In such a situation, the exact quantity of salts entrained with fresh water, and removed from a given region in unit time, must be replaced by an equal influx of water and dissolve salts. Because there is a small increase of density with salinity at a particular temperature, the fresh water move on the surface away from the river mouth whereas the saline water moves towards it near the sea bed.

2.2.2 Density gradients

Within the tidal river, the effect of density gradients is considerable. It has already been shown that there is a tendency for the net landward movement of sediment to occur over the middle reaches because flood tidal velocities are stronger than those of the ebb tide. Superimposed on this effect, the density difference between the water from the seaand fresh water from rivers causes net land movement of water near the river mouth bed, and a compensating seaward movement near the water surface. This can cause finesediments to be carried landward in suspension to a point of zero net movement, which is near the landward limit of density gradients (Figure 2.5).

Water is predominantly fresh upstream of this point. When river flow is high, this position of zero net movement is moved seawards, and conversely, when the flow is small, it moves landwards.

The effects of density gradients on the flow in a tidal river depends on the level of turbulence that occurs. If turbulent mixing is so intense that there is only a small difference in density over the depth at any point, there must be a horizontal gradient of density ranging from 1000 kg/m^3 at the upper tidal limit to the density of sea water (~ 1026 kg/m^3) at some distance offshore. The horizontal force due to such a density gradient increases with depth below the surface and is always directed in the direction of decreasing density. This gives rise to a small landward force that is zero at the surface and reaches maximum at the bed. At low flow rates mixing between fresh river and sea water occur at the narrow interface between the layers. Some sort of mixing will occur at the interface and to maintain the equilibrium landward movement of saline water in the lower layers will result. This can be explained as follows (Figure 2.6).

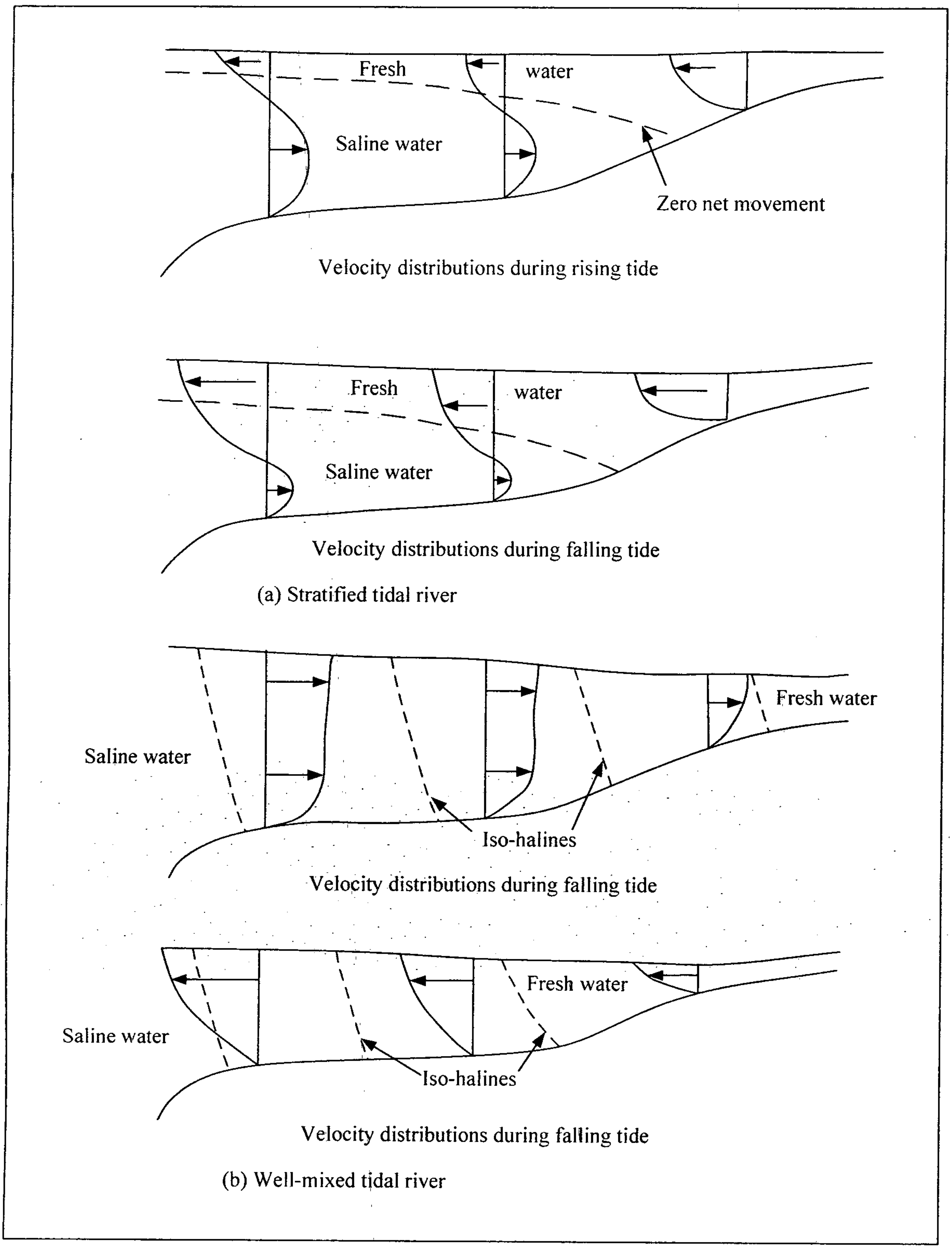

Figure 2.5 Distributions of velocity over depth in typical stratified and well-mixed tidal rivers.

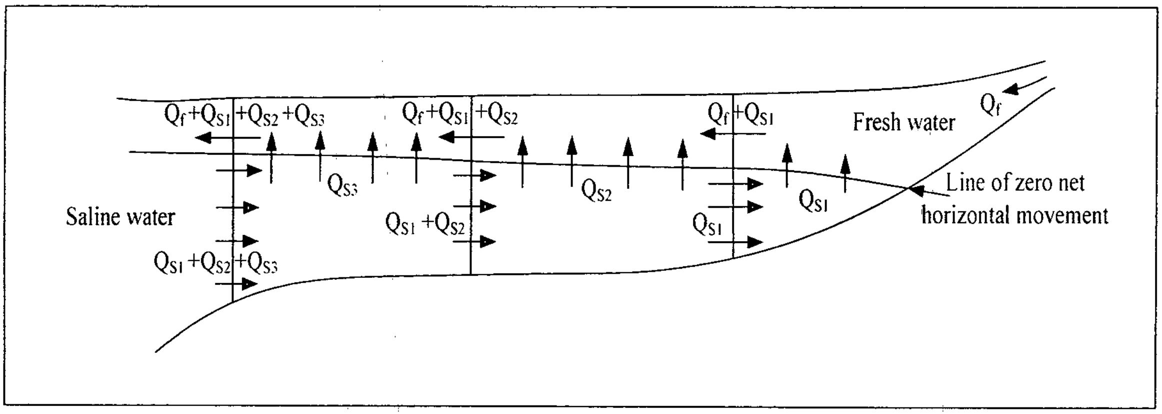

Figure 2.6 Effect of entrainment on rates of flow in the stratified tidal river (McDowell and O'Connor, 1977).

If there is a fresh water flow $Q_f$into the channel and as result there is a landward flow of Q_s in any part of the cross-section, then there must be seaward flow Q_f+Q_sin the remainder of the cross-section. Similarly for salt the net flow for equilibrium at any section must be zero.

Stratified flow occurs in tidal river that have weak tidal action; that is, tidal river with small tidal range and/or steeply sloping beds, which means small tidal storage volume. It can occur during neap tide in tidal river there are partially mixed. Conversely, well-mixed tidal river have high tidal activities.

Based on the degree of stratification, attempts have been made to classify tidal rivers. Harleman (1966) proposed the numerical value of the river mouth number asEquation 2.2 to determine the degree of stratification.

$$\text{River mouth number} = \frac{(P_t) \times (F_0^2)}{Q_f \times T} \qquad (2.2)$$

A large value indicates well-mixed tidal river where P_t is the volume of tidal prism, defined as the volume entering the mount of the river during rising tide:Q_f rate of inflow of fresh water. T is the tidal period. F_0 is Froude number $U/\,(gh)^{1/2}$ where U is the maximum flood tide velocity average across the mouth; and h the depth below mean water level at the mouth of the river (Ghosh, 1998).