CHAPTER 3
METHODOLOGY

3.1 Study area

The lower reach of the Chao Phraya River of Thailand was chosen because the Chao Phraya River is the largest river and one of the most important rivers in the central part of Thailand. The Chao Phraya River begins at the confluenceof the Ping and the Nan rivers in NakhonSawan Province(Pak Nam Pho). It then flows southwards for about 372 km from the central plains to Bangkok and the Gulf of Thailand. The cross section of the lower reach of the 112 km of this river is somewhat uniform; with an average width of 400 m and average depth of 9.2 m (Vongvisessomjai and Chatanantavat, 2006). Additionally, Chao Phraya Dam and PasakJolasid Dam are the main discharge controllers to the Gulf of Thailand about 3,000 m^3/s. Furthermore, the characteristic feature of the Chao Phraya basin is a flat plain, which causes an intrusion of saltwater from seainto the river of wet season farther than dry season.In this research three stations along the Lower Chao Phraya River are selected; Bang Sai (Ayutthaya province), Pakkred (Nontaburi province) and Fort Chula (Samutprakan province)which are located at 112 km, 70 km and 2 km from the Chao Phraya Estuary, respectively(Figure 3.1).

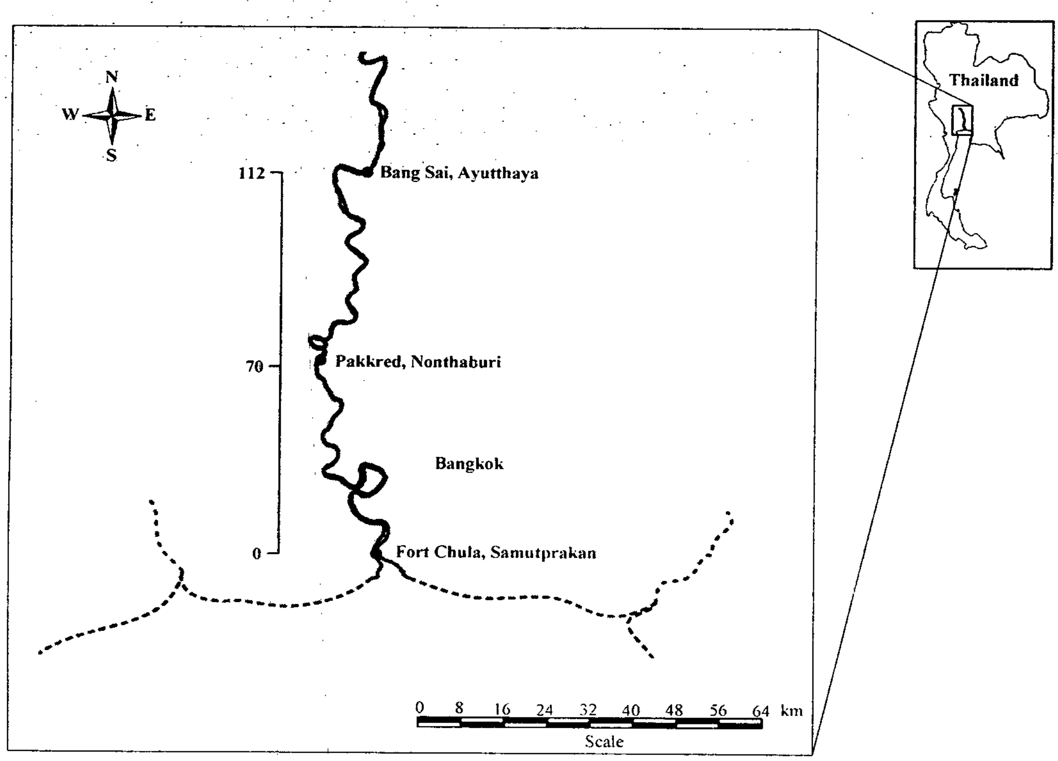

Figure 3.1 Study area.

3.2 Methodology approach

The methods of research (Figure 3.2) and the details of each process can be explained as follows.

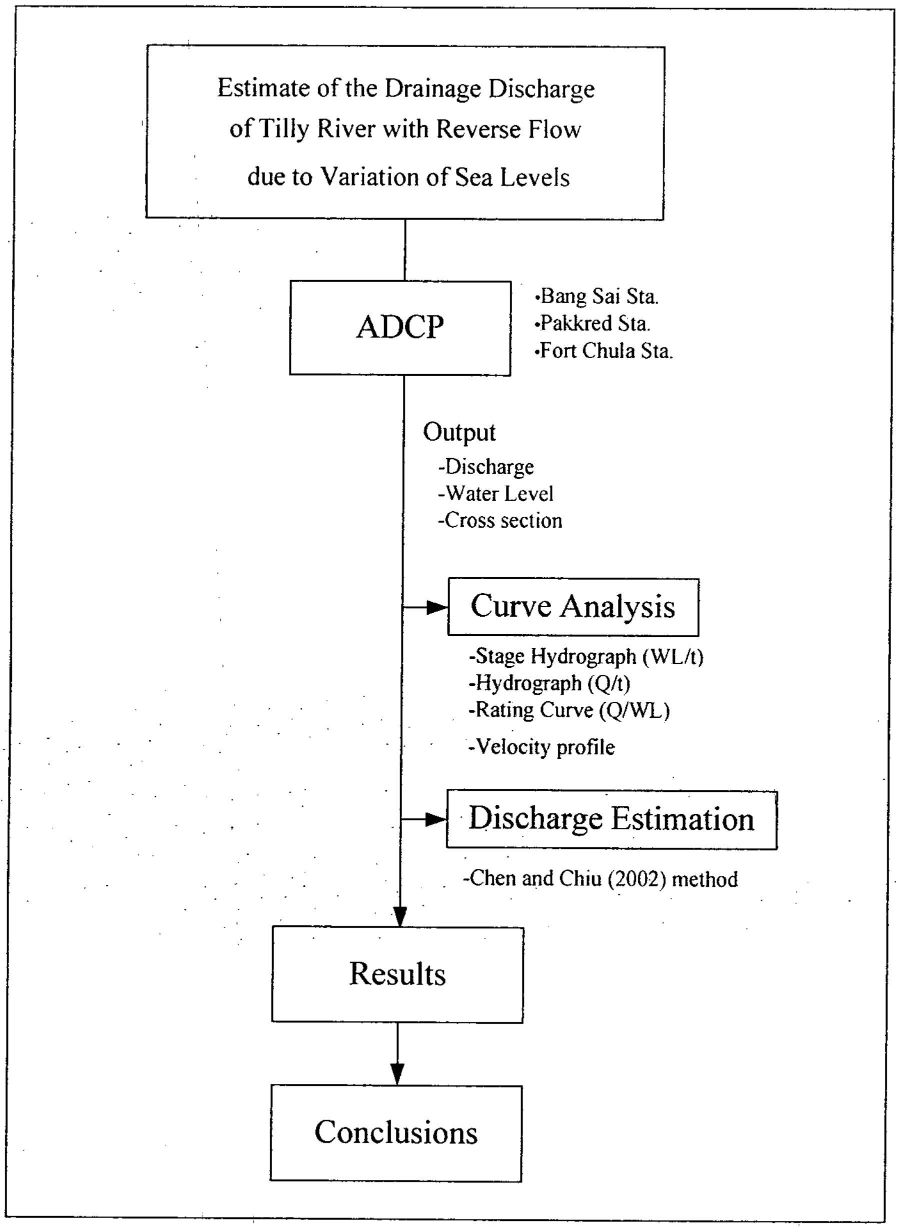

Figure 3.2 Flow chart of research procedure.

The observation data used in this research were discharges, velocities, water levels and cross-sections collected at Bang Sai, Pakkred and Fort Chula stationsby using ADCP for measurement.

1) The important criteria of selection of location and duration

- The total flow was confined to one channel at all stages, and no flow bypassed the location.

- The location of the canal junction was not selected because there was the additional load of discharge.

- The river bed was not subject to scour and deposition.

- The durations of the neap tide and the spring tide were selected because they we able to demonstrate the effect clearly. The measurement covers the time series of water levels in 24 hours for investigation of its characteristic. The time series can be divided into 4 periods: A falling water level, B minimum water level, C rising water level andD maximum water level (Figure 3.3). The timetable for field measurement as shown in Table 3.1.

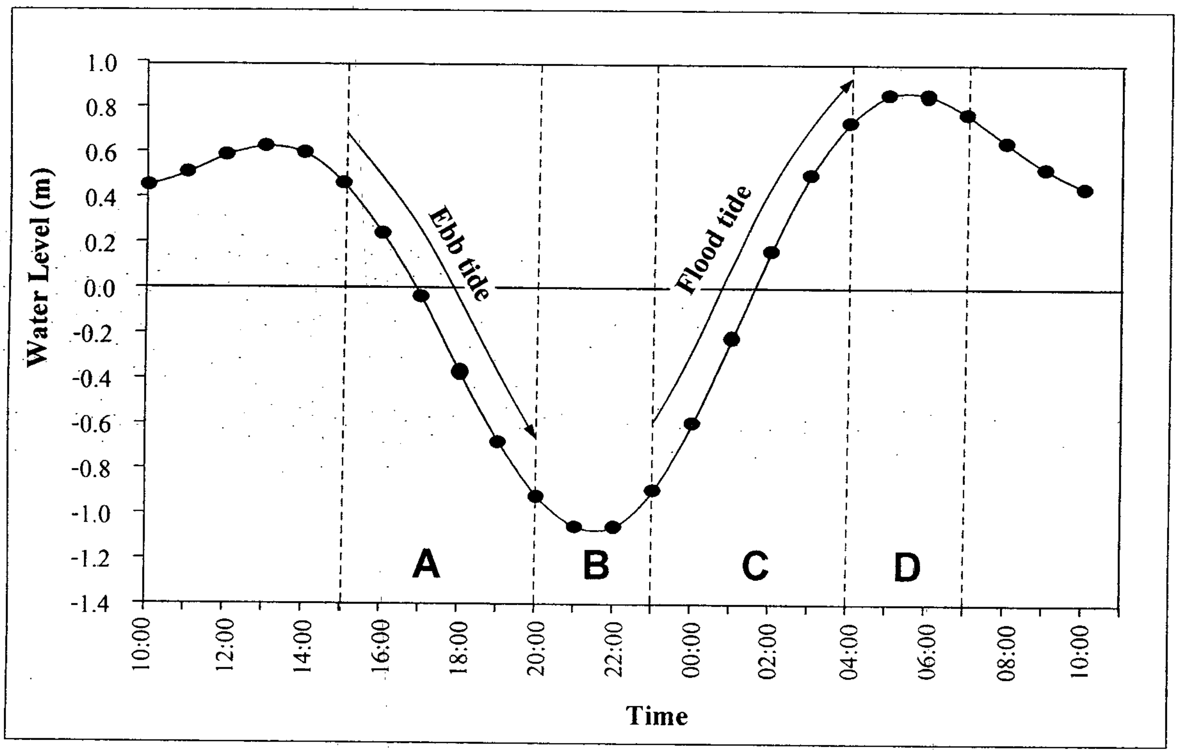

Figure 3.3 Example of time series of water level in 24 hours at any location.

Table 3.1 Timetable of field measurements in 2012.

Durations / Stations	June	July		August		September		October
	Neap Tide	Spring Tide	Neap Tide	Spring Tide	Neap Tide	Spring Tide	Neap Tide	Spring Tide
Fort Chula		-	-	3-4*	7-8*	-	8-9	13-14
Pakkred		-	-	-	-	15-16	22-23	-
		-	-	-	-	29-30	-	-
Bang Sai	27-28	18-19	25-26	1-2	-	-	-	-

* Data incompleted (only discharge available)

2) Equipment for data collection

The equipment used for data collection were of 2 types: staff gauge for measurement of water level and Acoustic Doppler Current Profiler (ADCP) for measurement of current velocity, discharge and cross-sectional area. The details of each equipment are as follow;

2.1) Staff gauge

The staff gauge was used to measure the water level of river. The water level is the elevation of the water surface above the datum (Figure 3.4).The water level can be determined continuously (hourly water level) manual by observer direct reading staff gage in unit of meter above mean sea level (m, MSL). The water level data is used for many purposes such as:the stage-hydrograph, rating curve and effective zero areaof estimation cross-sectional area stepin estimation discharge section.

Figure 3.4 Staff gauge at Bang Sai Station.

2.2) Acoustic Doppler Current Profiler (ADCP)

The principle of an Acoustic Doppler Current Profiler (ADCP) is the Doppler shift to measure currents in the ocean, rivers or estuaries. An ADCP can calculate current velocity, direction of the current, the depth of the water column, cross-sectional area and discharge. This instrument can be placed on the river bed, attached to a buoy, or mounted on a boat.

The ADCP works by sending out high frequency pulses at a constant frequency into the water. As the sound waves travel, they ricochet off particles suspended in the moving water, and are reflected back to the instrument. Due to the Doppler effect, sound waves bounced back from a particle moving away from the profiler have a slightly lowered frequency when they return. Particles moving toward the instrument send back higher frequency waves. The difference in frequency between the waves the profiler sends out and the waves it receives is called the Doppler shift. The instrument uses this shift to calculate how fast the particle and the water around it are moving as shown in Figure 3.5. A disadvantage of ADCP is, therefore, if the water is very clear, the pings may not hit enough particles to produce reliable data.

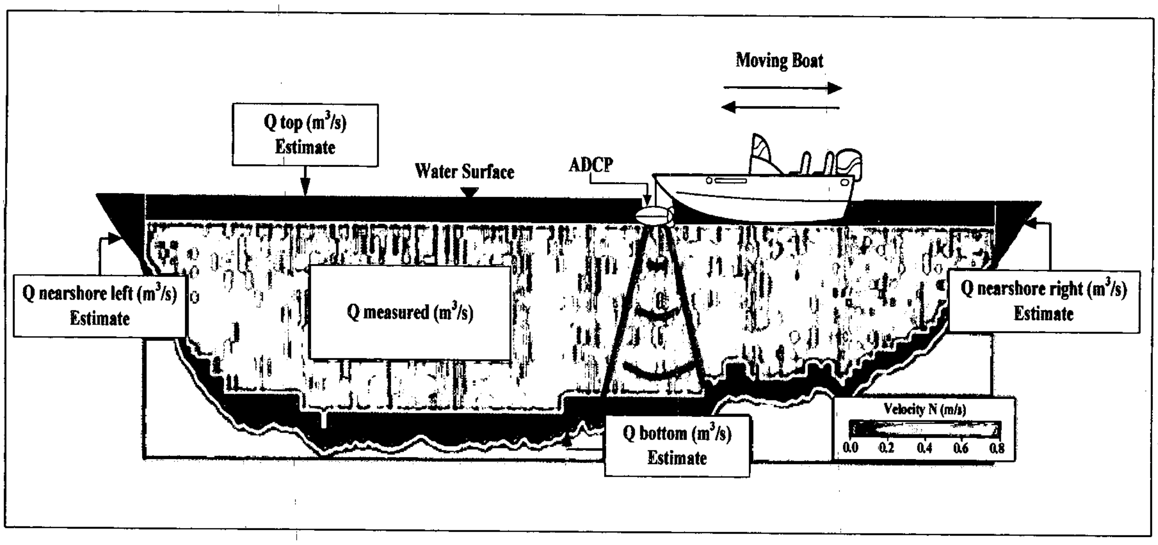

Figure 3.5 Acoustic Doppler Current Profiler (ADCP).

A river's discharge, or volumetric flow rate, is a measure of the amount of water that passes through a cross-section of the water body per unit time.The ADCP is subjected to operational limitations that directly influence the quality of discharge measurements. One of these limitations is the inability of an ADCP to collect data from all areas of the river'schannels. Unmeasurable areas include top, bottom, and side or nearshore subsections. Therefore, the total flow rate (Q_{total}) can be expressed in Equation 3.1(Sontek, 2010).

$$Q_{Total} = Q_{Measured} + Q_{Bottom} + Q_{top} + Q_{Nearshore\ Left} + Q_{Nearshore\ Right} \quad (3.1)$$

The details of the discharge calculation of each region are as follows:

- Measured Discharge ($Q_{measured}$) can be calculated by Equation (3.2) and Equation (3.3).

$$Q_i = X_i \Delta t D_a \quad (3.2)$$

$$Q_{Measured} = \sum_{i}^{N} Q_i \quad (3.3)$$

Where$i$ is the bin number, Q_i is the discharge in the i^{th} bin, D_a is the depth cell size, N is the number of ensemble and Δt is the time between the last good and the next good ensemble.

- Nearshore Discharge ($Q_{nearshore}$) can be calculated by Equation (3.4).

$$Q_{Nearshore} = C V_{ms} L d_m \quad (3.4)$$

Where C is the coefficient (0.35 for triangular, 0.91 for rectangular shape),V_{ms} is the mean water velocity in the first or the last segment, L is distance from the shore to the first or the last segment specified by the user,d_m is the flow depth of the first or the last segment.

- Bottom discharge (Q_{Bottom}) and Top discharge (Q_{Top}) can be estimated by the power method proposed by Chen (1991) who proposed the theory of power laws for flow resistance, as depicted in Equation (3.5).

$$\frac{u}{u*} = 9.5\left(\frac{z}{z_0}\right)^b \quad (3.5)$$

where$u$ is the velocity at distance z from the bed, z is the distance to the channel bed, $u*$ is shear velocity, z_0 is the bottom roughness height, and b is equal to 1/6 (Simpson and Oltmann, 1993).

3) Curve analysis

The observational data obtained from the ADCP instrument, such as discharge, velocity, water level and cross-sectional area, which were analyzed to determine the relationship of each parameter is variation with time, for instance stage-hydrograph, discharge-hydrograph, loop rating curve and velocity profiles, were relate between water level and time, discharge and time, water level and discharge, and water level and velocity, respectively.

4) Discharge estimation

Chen and Chui (2002) proposed a method for estimating the discharge on tidal the effect based on constant ratio of mean to maximum velocity. This method is applied from the velocity area principle.The method of discharge estimation can separate into 2 parts; mean velocity estimation and area estimation. The observation data used for discharge estimation separated into 2 groups; 80% of all used for calibration and 20% for verification.

The calibration and verification of the discharge equation are testing the equation efficiency. This test is the comparison of equation results with observed data performed by the statistical approach. The statistics values that use to perform the equation development are following;

4.1) Root mean square error (RMSE)

The RMSE used to assess the performance of the equation, by measuring the differences between the values estimated by the equation and the values actually observed. RMSE measures the closeness of the estimated and observed discharges. The smaller RMSE is, the better the performance of the efficient method. That given by:

$$RMSE = \sqrt{\frac{\sum (Q_{obs} - Q_{est})^2}{n}} \qquad (2.6)$$

Where Q_{obs} is observational data, $Q_{est}$is estimated data and $n$is the number of data point.

4.2) Coefficient of determination (R^2)

R^2 is the value of the linear relationship between 2 data sets explained by a linear regression. The coefficient of determination ranges from 0 to 1and measures successfully the relationship between 2 data sets. In other words, it reflects the linear relationship between simulated results and observed data. It is defined inEquation 2.7.

$$R^2 = \left(\frac{n\sum xy - \left(\sum x\right)\left(\sum y\right)}{\sqrt{\left(\left[n\sum x^2 - \left(\sum x\right)^2\right]\left[n\sum y^2 - \left(\sum y\right)^2\right]\right)}} \right)^2 \qquad (2.7)$$

Where y is the estimated results, x is the observed data, and n is the number of data points.