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A Study on Drainage Efficiency of Shortcut Canal Project in the Lower Tha Chin River

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Abstract The lower Tha Chin River is often flooded caused by the nature of the river is very meander and its slope is very flat. Flooded water can destroy agricultural areas and habitation which are situated nearby the river bank. Thus, this study aims to apply the hydrodynamic model namely MIKE11 in order to simulate and analyze flow circulation and establish flood mitigation approach for this river. The model calibration and verification were found that the suitable Manning'n values have a range between 0.035-0.062 along each river cross section. These calibrated data has then been applied to the model for flow simulation in a case of the shortcut canal project constructed in the lower Thachin River due to establish flood mitigation approach. It found that the water level comparison between before and after constructed the canal are reduce with a maximum water level around 0.188 meters and an average water level for all section is 0.075 meters. In the lower portion of Thachin River between km.32+000 to km.152+000, water levels are reduced with an average value around 0.120 meters and ranging between 0.007 to 0.188 meters. Regards to the flow rate after constructed the canal, it found that the canal can help to drain river flow to downstream portions with a maximum flow rate around 128.72 m^3/s, a flow rate is increased with an average value around 5.23 m^3/s or 452,000 m^3/day. Regards to the time for drain the peak flood after constructed the canal, it found that the drainage time is reduce with an average value around 1.67 hr. and ranging between 1 to 3 hr. In summary, the shortcut canal project can help faster drainage and mitigate flooding for this river.

Keywords Hydrodynamic Model, MIKE 11 model, Flood Mitigation, Shortcut Canal Project

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1 Introduction

The lower Tha Chin River is often flooded caused by the nature of the river is very meander. This can destroy agricultural areas and home of people which are living in the area are numerous and often every year. Flooding was due in part to changes in land use and upstream areas and the expansion of the urban drainage area is not enough. The growth of the community to make a solid surface, for example, road surfaces, roofs, etc., so that the runoff coefficient increases. Runoff is water that's faster and better. In addition, land reclamation and construction of certain public utilities are affected by drainage.

In addition to the lack of effective drainage flooding in urban areas, the problem is caused by the lack of effective drainage in Tha Chin River too. The drainage in the river has been slow. Due to the lower Tha Chin River has bend very much to make the drainage to the sea is slow. Result of raising the water level to rise, which can cause flooding.

Therefore, this research aims to study the proper drainage of the Tha Chin River by adding shortcut canals to the main areas. And the hydrodynamic model MIKE 11 was applied to the analysis of the flow in the river to study the shortcut canals to alleviate flooding in the basin.

2 Study Area

Study area is the area of the middle and lower Tha Chin River from Pho Phraya regulator Muang Suphanburi down to the mouth of the river Muang Samut Sakhon province, a total distance of 202 km, as shown in Fig. 1 (Nuttawut et al. 2012)

From Fig. 1 it is observed in the lower part of the river is a tributary of the zigzag. The river meanders through the natural drainage will result in slow, causing water levels to rise and cause flooding. Therefore the study was conducted in a short canal in the river bend to reduce the distance and the time to drain the water in the river.

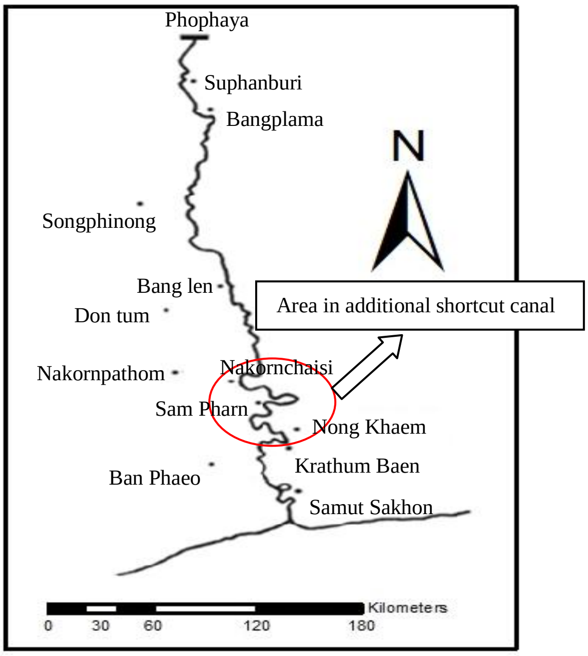

Fig. 1 Map of Tha Chin River in the study

Created by adding the shortcut canal in the Tha Chin River are: 1) Ngew Rai canal, Nakhon Pathom Nakhon Chai Si, 2) Thong Ka nong canal, Nakhon Pathom Sampran, 3) Tha Kham canal, Nakhon Pathom Sampran, as shown in Fig. 2

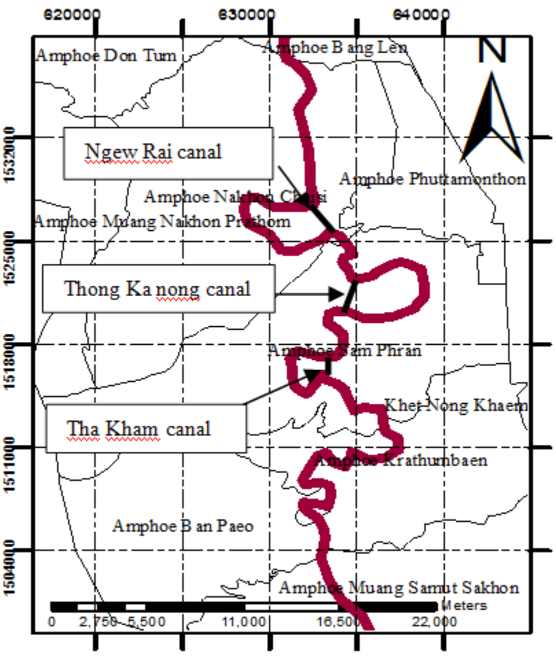

Fig. 2 The proposed shortcut canals in the Tha Chin River

3 Data collection and Model Calibration Indicator

3.1 Data collection

1) Hydrological data, including flow rates, daily water level on the Pho Phraya regulator and at the main regulator in the river as shown in Fig. 3, which was collected in 2007-2008 from the Royal Irrigation Department.

2) The physical characteristics data of the river including a cross-section, which has a total of 209 sections, which was collected in 2002 from the Royal Irrigation Department.

3) Sea level at the mouth of the Tha Chin River in the year 2007-2008, which collected hourly from the Marine Department.

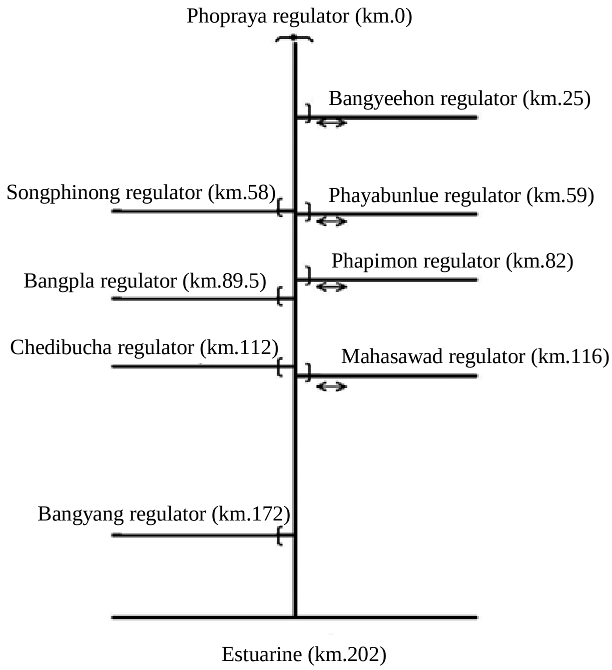

Fig. 3 Main regulator in the Tha Chin River

3.2 Model Calibration Indicator

The calibrated model will be used for statistical comparisons and decisions are represented.

Accuracy is a Root mean square error (RMSE), which is calculated using the equation.

$$RMSE = \sqrt{\frac{\sum (x-y)^2}{n}} \qquad (1)$$

The results of the estimation method, goodness-of-fit with the parameter coefficient of determination (R^2) and Nash coefficient (E) which is calculated using the equation.

$$R^2 = \left(\frac{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)\left(y_i - \bar{y}\right)}{\sqrt{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2 \times \sum_{i=1}^{n} \left(y_i - \bar{y}\right)^2}} \right)^2 \qquad (2)$$

$$E = 1.0 - \frac{\sum_{i=1}^{n}(x_i - y_i)^2}{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2} \quad (3)$$

Where y = the water level of the model (m)
x = the water level of the measurement (m)
$\bar{y}$ = average water level of the model (m)
$\bar{x}$ = average water level of the measurement (m)
i = Sequence data
n = number of data

Acceptable values of the test statistic RMSE and Nash coefficient (E) be the minimum value (close to 0) and the coefficient of determination (R^2) is close to 1 (Nuttawut et al. 2012).

4 MIKE 11 Hydrodynamic model

In this study, a mathematical model MIKE 11 is the historical model developed by DHI Water Environment and Health, to be used in the calculation of the one-dimensional flow in the river. The model is physical base model and the input data consists of a river network, cross section, water level or flow rate of the initial boundary conditions. The mathematical equations used to calculate the water level (H) and flow rate (Q) is in the river.

$$\frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} = 0 \quad (4)$$

$$\frac{\partial Q}{\partial t} + \frac{2Q}{A}\frac{\partial Q}{\partial x} + \left(g\frac{A}{B} - \frac{Q^2}{A^2}\right)\frac{\partial A}{\partial x} + gA\left(S_f - S_0\right) = 0 \quad (5)$$

Where Q = flow rtae (m^3/s)
A = cross section (m^2)
t = time (s)
x = distance (m)
B = canal width (m)
g = gravity acceleration (m/s^2)
S_f = energy slope (h_L/L)
S_0 = canal slope

The equations such as equation Non-linear Second Order Partial Differential Equation solver is used to compute numerical methods (Numerical Analysis) and Finite Difference Method for Solving the above equation (Nuttawut et al. 2012).

5 The results of model calibration.

To model and analyze the flow of water necessary to start from the calibrated model to determine the coefficient of roughness the river or Manning's n appropriate to the selected position is used to calibrate the three positions are with the Bangyeehon regulator (km.25) to represent the upstream river, the Phapimol regulator (km.82) to represent the middle river, and the Mahasawat regulator (km.116) to represent the downstream river. Which is results of the calibration for each position regulator is determined from the roughness coefficient at different the river. The upper of river is the steep terrain above the bottom of the river. The roughness coefficient upstream is lower than downstream.

To calibrate the model, the Bangyeehon regulator try to start the river roughness coefficient from 0.030 to 0.045, as shown by the comparison in Table 1 and Fig. 4, the position of the Phapimol regulator are beginning to experiment the river roughness coefficient from 0.035 to 0.05, as shown by the comparison in Table 2 and Fig. 5, where the Mahasawat regulator are beginning to experiment the river roughness coefficient from 0.045 to 0.07, as shown by the comparison in Table 3 and Fig. 6.

Table 1 Result comparisons of the calibration model at the Bangyeehon regulator.

Manning's coefficient (n)	Performance indicates		
	Coefficient of determination (R^2)	Nash coefficient (E)	RMSE
n=0.030	0.7944	0.7475	0.4923
n=0.033	0.7914	0.7782	0.4614
n=0.0350	0.7889	0.7860	0.4533
n=0.0375	0.7853	0.7834	0.4560
n=0.040	0.7814	0.7691	0.4708
n=0.045	0.7728	0.7116	0.5262

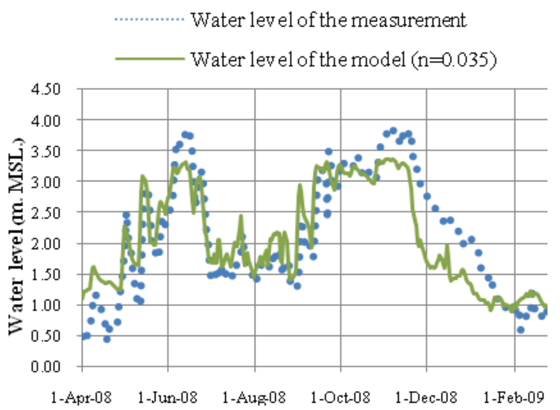

Fig. 4 Water level comparisons at the Bangyeehon regulator n=0.035

Table 2 Result comparisons of the calibration model at the Phapimol regulator

Manning's coefficient (n)	Performance indicates		
	Coefficient of determination (R^2)	Nash coefficient (E)	RMSE
n=0.035	0.5939	0.5916	0.2351
n=0.0375	0.6256	0.6185	0.2272
n=0.04	0.6509	0.6352	0.2222
n=0.045	0.6939	0.6456	0.2190
n=0.0475	0.7119	0.6379	0.2213
n=0.05	0.7276	0.6207	0.2266

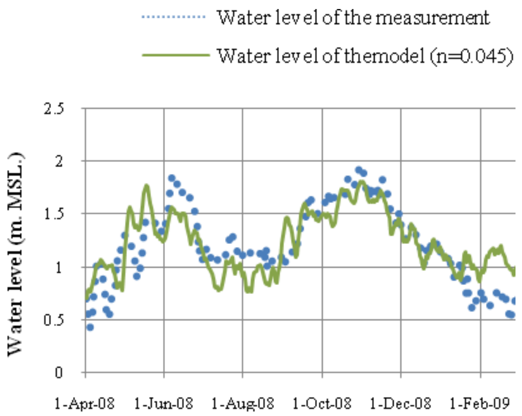

Fig. 5 Water level comparisons at the Phapimol regulator n=0.045

Table 3 Result comparisons of the calibration model at the Mahasawat regulator

Manning's coefficient (n)	Performance indicates		
	Coefficient of determination (R^2)	Nash coefficient (E)	RMSE
n=0.05	0.5625	0.3542	0.1886
n=0.058	0.6009	0.4039	0.1812
n=0.06	0.6087	0.4082	0.1805
n=0.062	0.6159	0.4089	0.1804
n=0.065	0.6255	0.4029	0.1813
n=0.07	0.6381	0.3716	0.1860

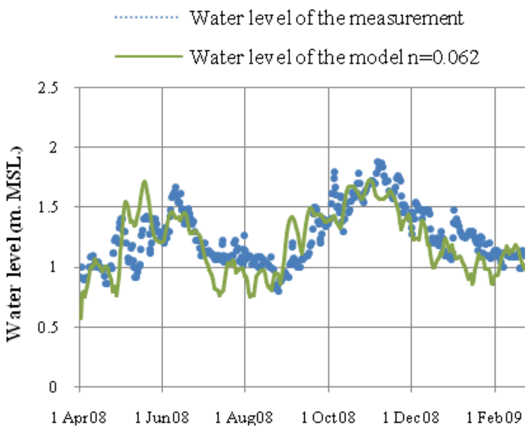

Fig. 6 Water level comparisons at the Mahasawat regulator n=0.062

The results of the comparison, as shown above to determine the best roughness coefficient of the river is found, the river or the Bangyeehon regulator has roughness coefficient of 0.035, Phapimol regulator has roughness coefficient of 0.045 and the Mahasawat regulator has roughness coefficient is 0.062, which is the best channel roughness coefficient is corresponding with the real nature of the river as well. Because to the nature of the lower river is very meanders. It made to the flow is not convenient and it made to water level in the river high. This resulted in the roughness coefficient of the river increased from upper part to lower part of the river.

6 Effect of proposed shortcut canal to help alleviate flooding.

Flood events from the past to present have resulted in damage to both life and property are numerous. Therefore, in order to minimize the damage of flood has been proposed canal shortcuts in the river by the design of the canal shortcuts such as a trapezoid with width surface canal 150 meters deep 10 meters wide the bottom canal 50 meters in the all position, as shown by the shortcut canal in Fig. 7.

The study found that when compare water level of the Tha Chin River before and after the shortcut canal in the river. The water level has decreased maximum 0.188 meters and average 0.075 meters. Area of the Tha Chin River from km.32 +000 to km.152 +000 the water level has decreased average 0.120 meters and the water level decline is in the range of 0.007 to 0.188 meters, as shown in Fig. 8 and Table 4.

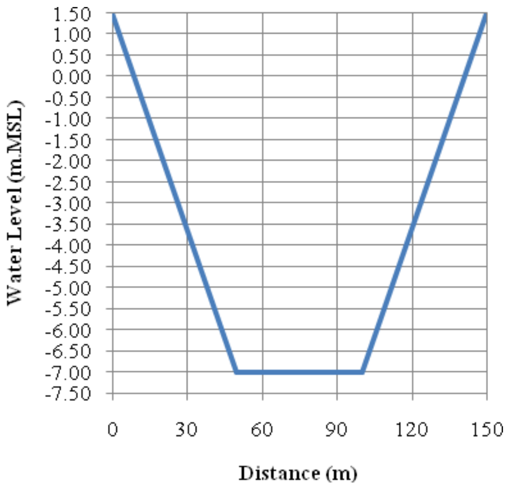

Fig. 7 The cross-section of shortcut canal used in the study.

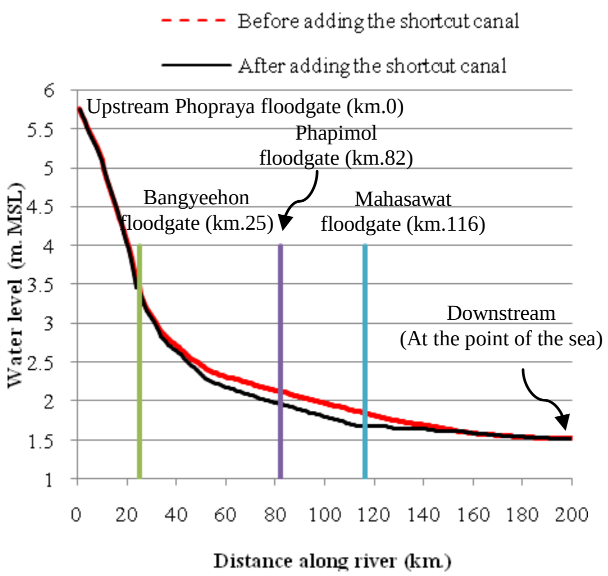

Fig. 8 Water level comparisons in the Tha Chin River before and after constructed the shortcut canal.

The river drainage after adding the shortcut canal is to help a good drainage. The flow rate of the canal shortcuts has maximum 128.72 cubic meters per second or increase an average of 5.23 cubic meters per second, about 452,000 cubic meters per day, as shown in Fig. 9 and Table 4. For the time to drainage of the flood wave after a short canal project has fallen average 1.67 hour and in ranged 1 to 3 hours.

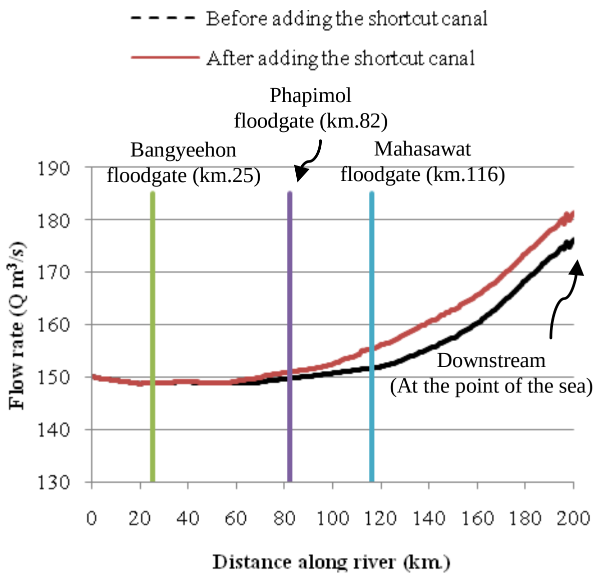

Fig. 9 Flow rate comparisons of the Tha Chin River drainage before and after construct shortcut canal

Table 4 Comparison of the effects of changes in water levels and flow rates after a short canal project.

Distance (km.)	**water level decrease (m)**
0+000 to 23+070	0.00-0.026
23+070 to 43+000	0.026 - 0.081
43+000 to 63+000	0.081 - 0.140
63+000 to 111+940	0.140 - 0.188
111+940 to 125+000	0.188 - 0.098
125+000 to 149+000	0.098 - 0.027
149+000 to 201+000	0.027 - 0.00
Average	0.075

Distance (km.)	**Difference of the flow rate (m^3/s)**
0+000 to 54+480	0.00 – 0.012
54+480 to 67+500	0.003 - 0.877
67+500 to 78+500	0.877 – 1.169
78+500 to 101+500	1.169 – 1.915
101+500 to 127+500	1.915 – 4.469
127+500 to 155+500	4.469 – 5.299
155+500 to 200+500	5.299 – 5.064
Average	5.23

7 Conclusion

The study of river flow would be necessary to calibrate the model to determine the roughness coefficient of the river. The analysis of calibration model was found in the upstream river; at the Bangyeehon regulator have the roughness coefficient Manning'n 0.035, in the middle of the river at the Phapimol regulator have the roughness coefficient

Manning'n 0.045 and the lower part of the river at the Mahasawat regulator have the roughness coefficient Manning'n 0.062, which gives the best statistics determination in along the river. Which is the best channel roughness coefficient is corresponding with the real nature of the river as well. Because to the nature of the lower river is very meanders. It made to the flow is not convenient and it made to water level in the river high. This resulted in the roughness coefficient of the river increased from upper part to lower part of the river

Due to the nature of the lower Tha Chin river is very meanders, the water is going to be slow, so it offers the shortcut canal in the lower Tha Chin River to improve performance of the drainage. After adding the shortcut project the result in improved drainage from km.32+000 to km.152+000 with an average water decrease of 0.120 meters and in the range of 0.007 to 0.188 m.

The drainage in the river after add the shortcut project, the project contribute to the good drainage. The drainage has maximum rate of discharge of the canal shortcuts to 128.72 cubic meters per second, or will increase an average of 5.23 cubic meters per second, about 452,000 cubic meters per day. For the time to drain of the flood wave after the shortcuts found to have decreased an average of 1.67 hours and in the range 1 to 3 hours, so the canal shortcuts that a good drain and has contributed significantly the flood in the Tha Chin River.

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