GENERATING 3D MODEL FOR FLOOD MANAGEMENT:

HITECH INDUSTRIAL ESTATE, PHRA NAKHON SI AYUTTAYA PROVINCE

Rerkchai Nateenam[1], Chanika Sukawattanavijit[1], and Chittima Ruksa[2]

[1] Geo-Informatics Scientist, [2] Business Development Officer

Geo-Informatics and Space Technology Development Agency (Public Organization)

120 The Government Complex Commemorating
His Majesty The King's 80th Birthday Anniversary, 5th December, B.E.2550(2007)
Ratthaprasasanabhakti Building 6th and 7th Floor,
Chaeng Wattana Road, Lak Si, Bangkok 10210, THAILAND; Tel: +662-141-4589;
E-mail Rekchai@gistda.or.th, chanika@gistda.or.th

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Abstract: The objective of this paper is to study and analyze the cross-section of the lower Chao Phra Ya River's flow pattern and to simulate the flow pattern HAC-RAS model for the flood prevention in Hitech Industrial Estate, Phra Nakorn Si Ayutthaya Province.

The study involves the simulation of flow pattern of the lower Chao Phra Ya River at station S5, C29, and C34, including water surface level and maximum flow rate data of September 2011 into the cross sectional analysis. In order to explain the flow pattern of the river, Manning's Roughness Coefficient of the river (0.04) and river bank (0.05) were used in this step. The river cross-section analysis will provide height surface level of each part of the river, and it will be useful for building of water barrier. Based on the result, Hitech Industrial Estate shall build 4.38 meter high of barrier from water surface level. After the accuracy assessment of flooding model compared with flooded area in 2010, the accuracy is 73%. Moreover, water surface elevation was used for generating of flood map and HAC-RAS model 3 dimensional models generating on Skyline Terrasuit v.5.1. These maps will be useful for flood prevention management.

INTRODUCTION

Flood is a natural disaster that occurs almost every year of Thailand. Since Thailand is located in the monsoon area, sometime it rains a lot in rainy season and the water cannot be drained out in time. There are two types of flood; flash flood and drainage flood. Both types of flood usually happen consequently, especially in the northern and central part of Thailand. This was evident in 2011 mega flooding occurring during monsoon season, on the Chao Phraya and the Mekong River Basin (from late July to 16 January 2012). This disaster is the world's fourth largest damage in terms of rainfall and number of civilians affected.

Seven industrial estates had been shut down since the flood in last year. Hitech Industrial Estate is located in Amphoe Bang Pa-in, Phra Nakorn Si Ayutthaya Province, having 143 factories most being electronic component manufacturer, with some 54,000 workers greatly affected. During flooding period, 15 October -13 November 2011, the water level reached 5 meters at some point and both factories and the workers were greatly affected. Since this industrial estate is located by the Chao Phra Ya River, when the sea level rises it is very risky to be flooded.

HEC-RAS hydraulic model of the US Army Corps of Engineer water resources management. This model can be used to predict water levels each year and map is a useful tool for impacted areas. The result of the model can be shown as a transverse cross section of the river which is clearer and simpler to understand comparing to other

models. Moreover, the cost of implementing HEC-RAS model is not higher than other models but equally effective. In this study, we applied the HEC-RAS model with GIS in order to make the results easier to comprehend. The results were displayed in the form of maps and 3D models to show the actual terrain topography, including built-up areas in Hi-tech industrial estate, as showcase for more effective flood prevention planning in other industrial estates.

OBJECTIVES

1. To study the flow direction of the lower Chao Phraya River by HAC-RAS model
2. To display the result of 3 dimensional HAC-RAS model in Skyline Terrasuit
3. To use the result for planning and preventing flood in Hitech Industrial Estate, Phra Nakorn Si Ayutthaya Province

METHODS AND EQUATION

This paper presents the study and gathering of information for displaying a 3 dimensional water management model from HAC-RAS. The working method is as follows:

1. Data Source:

1.1 Topographic map from Royal Thai Survey Department scale 1:50000, series L7018, sheet number 5137III and 5137IV

1.2 QuickBird High-resolution imagery, acquisition date: 3 February 2010 from GISTDA

1.3 Aerial Photo (2003) from Ministry of Agriculture and Cooperatives, scale 1:4000

1.4 Digital Elevation Model 5 meters at the ground from Ministry of Agriculture and Cooperatives

1.5 Building layout of Hitech Industrial Estate from Industrial Estate Authority of Thailand

1.6 Land use map (2010) form Land Development Department

1.7 Daily rainfall – runoff data (2007-2011) and river's cross section from Royal Irrigation Department

2. Research Tools:

2.1 Personal computer and printer

2.2 Software:

2.2.1 ArcGIS 10

2.2.2 Hec-GeoRAS

2.2.3 HEC-RAS 4.1

2.2.4 Erdas Imagine 9.2

2.2.5 Skyline Terra Suit 5.1

3. Methodology (Figure 1.)

3.1 Study on hydraulic data: river cross-section, coordinates/elevation, gauge stations, rainfall-runoff, and river channel.

3.2 Mark points on the river for generating cross-section, compare the accuracy to QuickBird imagery and MOAC DEM.

3.3 Input vector data of river, banks, flow path, DEM, and river cross-section to HEC-RAS for geometry data generation.

3.4 Input derived geometry data from Hec-GeoRAS model, adjust stations and elevation values for steady flow calculation and generate water surface elevation. The water surface elevation will be used for triangulated irregular network generation, then convert into GIS format to be used as a flood map.

3.5 Display 3 dimensional water surface elevations in Skyline Terra Suite, by the following steps:

3.5.1 Prepare Aerial Photo, QuickBird imagery, and auxiliary data

3.5.2 Generate 3 dimensional topographic models in Skyline Terra Suite:

1) Input DEM, QuickBird Imagery, and derive spatial data from HEC-RAS model to TerraBuilder for generating topographic surface

2) Input the result from TerraBuilder to TerraExplorer Pro for building objects, edit graphic data, and create building box for 3 dimension generation

3) Display 3 dimensional topographic model in TerraExplorer

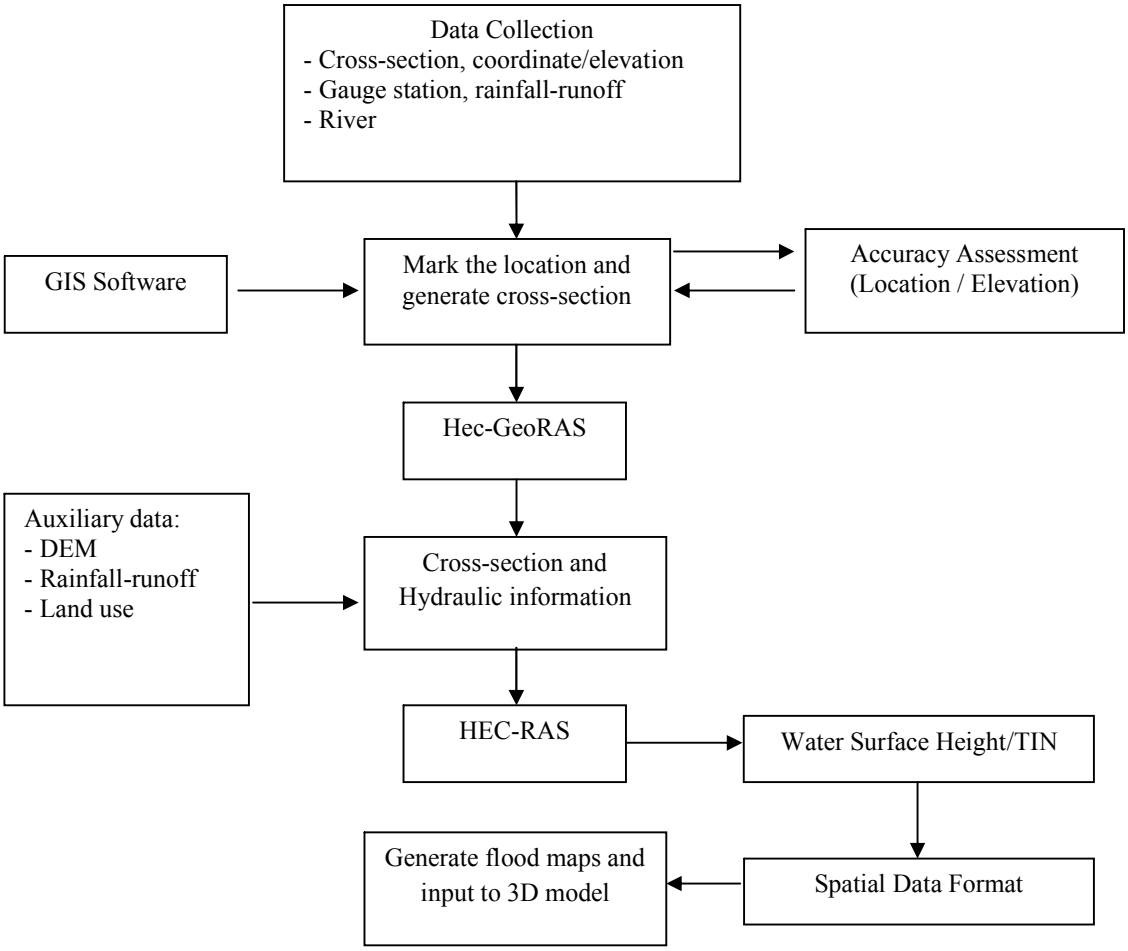


Figure 1: Hydraulic model for water pattern analysis work flow

4. CONCEPTUAL FRAMEWORK

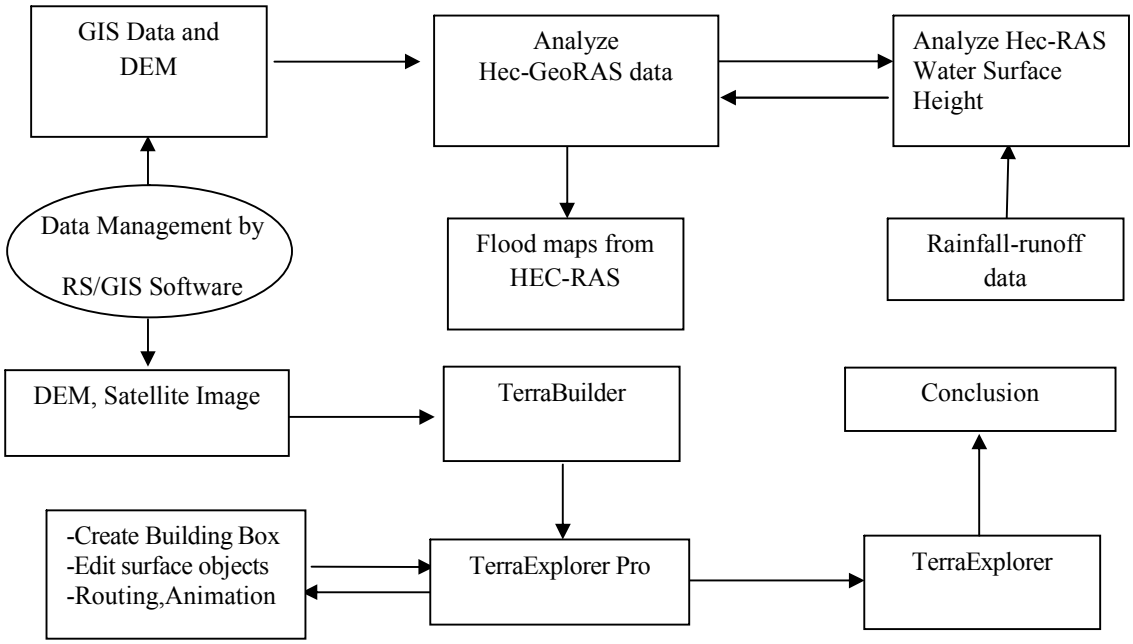


Figure 2: Conceptual framework

STUDY AREA

The flow pattern runs from Chao Phraya River at gauge station C34 and flow pattern runs from Pa Sak River at gauge station S5 C29 (Amphoe Phra Nakorn Si Ayuthaya) to gauge station C29 (Amphoe Bang Sai, Phra Nakorn Si Ayuthaya). The study area (gauge station C34 to C29) is located about 30 km and gauge station S5 to C29 is about 26 km along the river. The flow path covering the study area is shown in Figure 3.

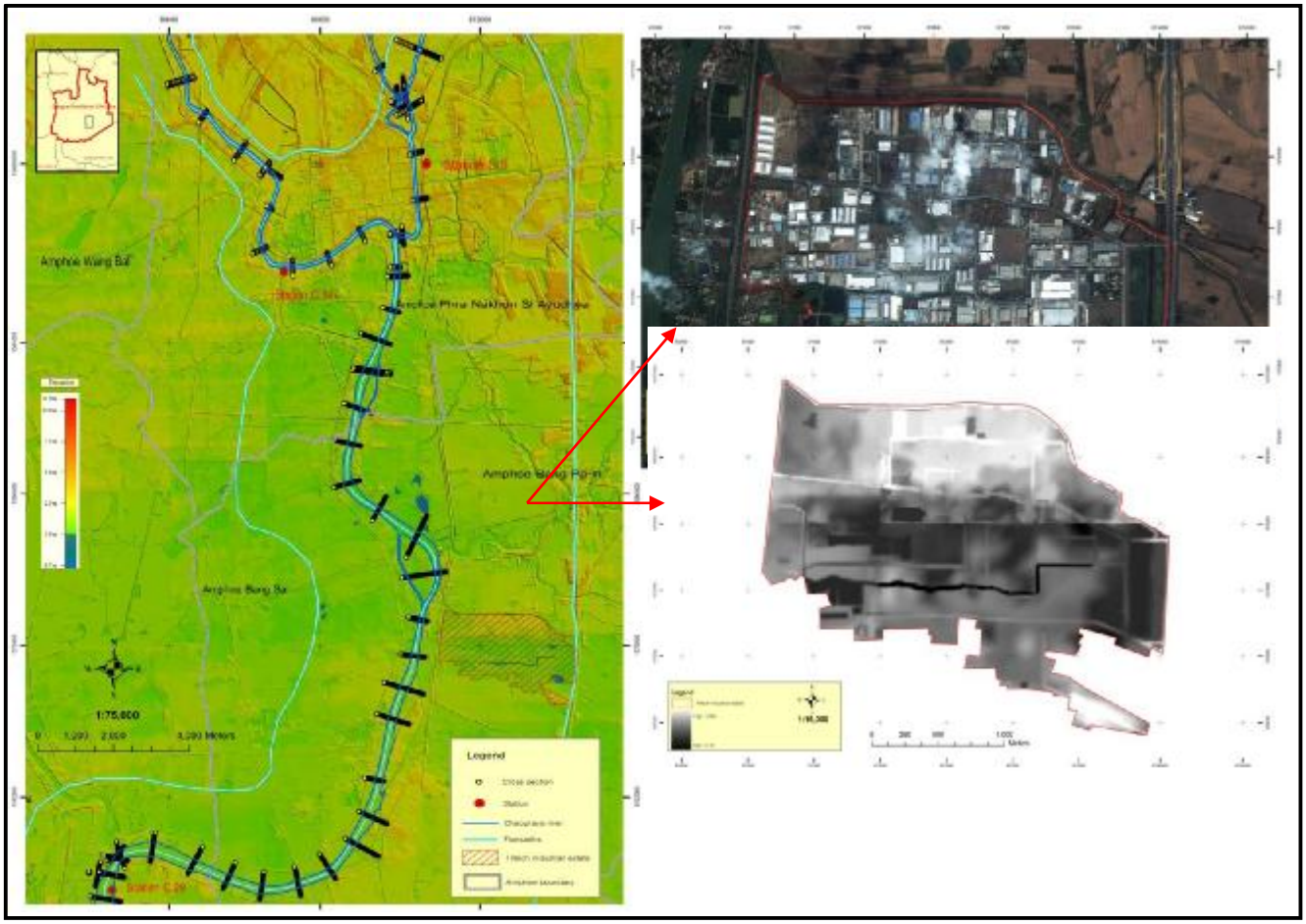


Figure 3: Study Area

RESULTS

1. Geometric Data Preparation by HEC-RAS

Input geometric data (vector of river, banks, flow path, and Xscutlines) to HEC-RAS software and adjust by station value, evaluation value, and Manning's roughness value (river=0.01, and banks = 0.26) to analyze the study flow as in Figure 4.

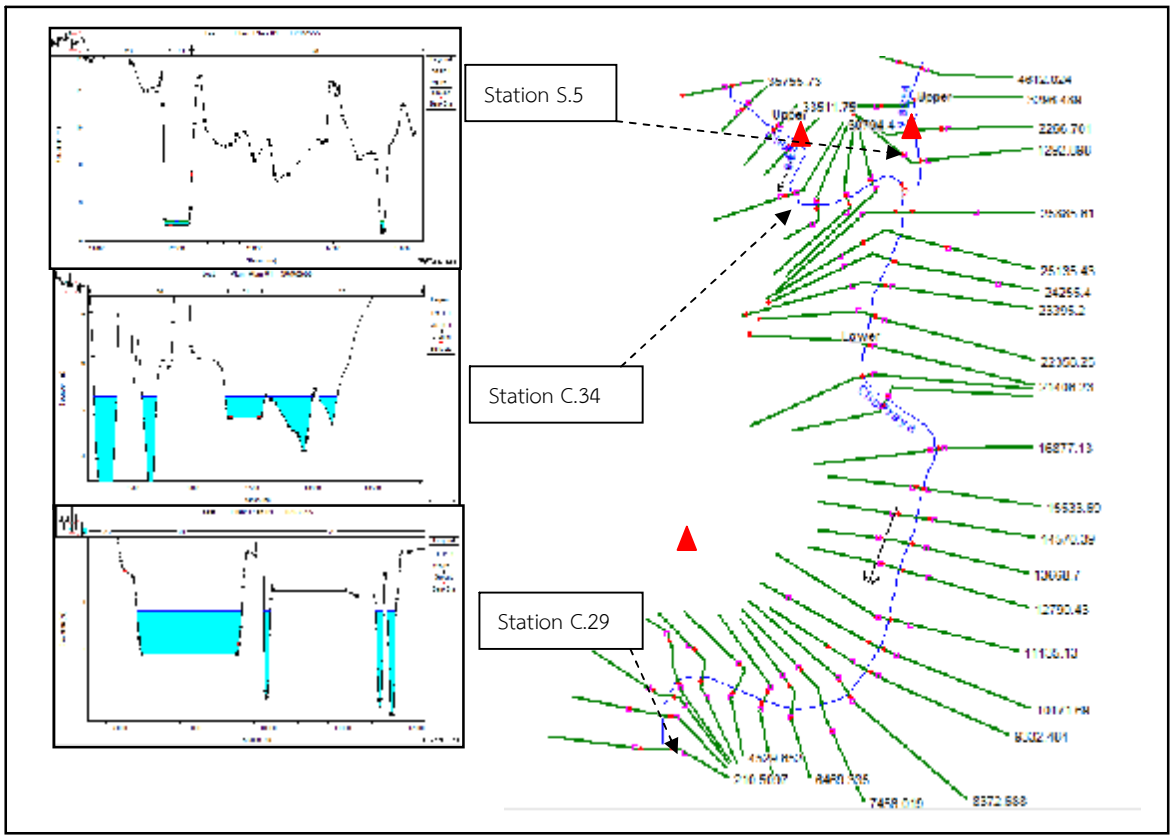


Figure 4: Display of Cross-section Output

2. The river surface levels are calculated by HEC-RAS

HEC-RAS software calculated river surface levels from elevation and flow rate of each river section. It then generates 3D flooded area which is called "RasMapper Model" as in Figure 5.

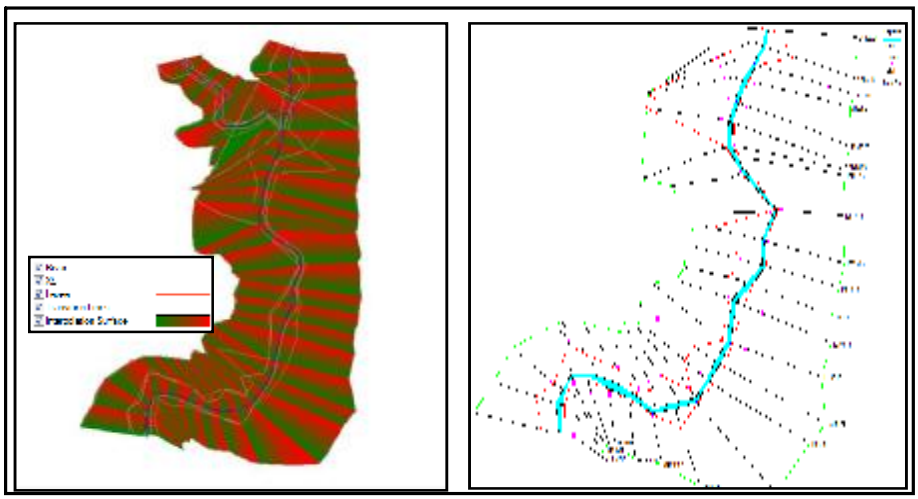


Figure 5: Display RasMapper and flooded area in the form of X-Y-Z Perspective Plot

3. The river surface level results from HEC-RAS model in each period

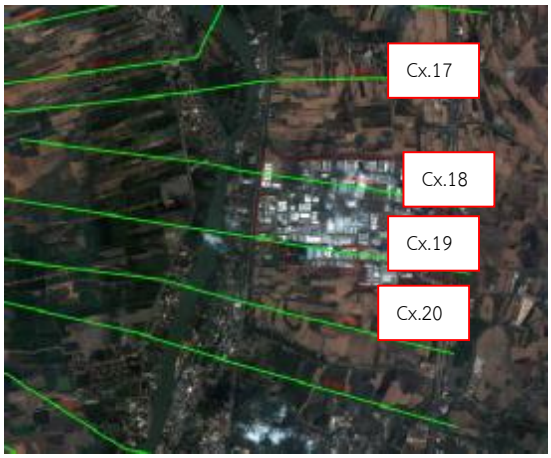
3.1 HEC-RAS software calculated river surface level from elevation and flow rate of each river section, then generated 3D flooded area which is called "RasMapper Model" as in Figure 6.

3.1.1 Upper Chao Phraya River: calculated river surface level is higher than the normal level, the highest difference is 4.26 meters, average is about 2.77 meters, and total flow rate is 1,141 m^3/s.

3.1.2 Lower Chao Phraya River: the length along the area is about 24 km. The calculated river surface level is higher than the normal level, the highest difference is 4.68 meters, average is about 3.49 meters, and total flow rate is 2,980 m^3/s.

3.1.3 Upper Pa Sak River: calculated river surface level is higher than the normal level, the highest difference is 4.45 meters, average is about 3.57 meters, and total flow rate is 983 m^3/s.

3.2 The result of flow pattern analysis shows the river level at each cross-section and the highest water surface level in Hi-tech Industrial Estate (Figure 4). It shows the water overflowed into the left side of the river bank when it reached 2.56 meters, and 3.16 meters on the right side of the river bank.



Cross section	left river bank m(msl)	right river bank m(msl)	Highest water level m(msl)	Overflow at left river bank m(msl)	Overflow at right river bank m(msl)
Cx.17	2.87	3.24	5.66	/	/
Cx.18	3.24	2.14	5.55	/	/
Cx.19	1.99	2.19	5.57	/	/
Cx.20	3.90	2.01	5.46	/	/

Figure 6: The river level at each cross-section and the highest water surface level in Hi-tech Industrial Estate

4. The result of flood boundary and flood maps

The result from HEC-RAS Model shows the flooded area covering about 61.9 sq.km. (38178.1 Rai). The average of flood surface level is about 2.62 m. in the entire area and 2.14 m. in Hi-tech Industrial Estate area. Mass of water mass started to overflow into the west and north barriers, and the whole industrial estate was totally flooded as in Figure 7.

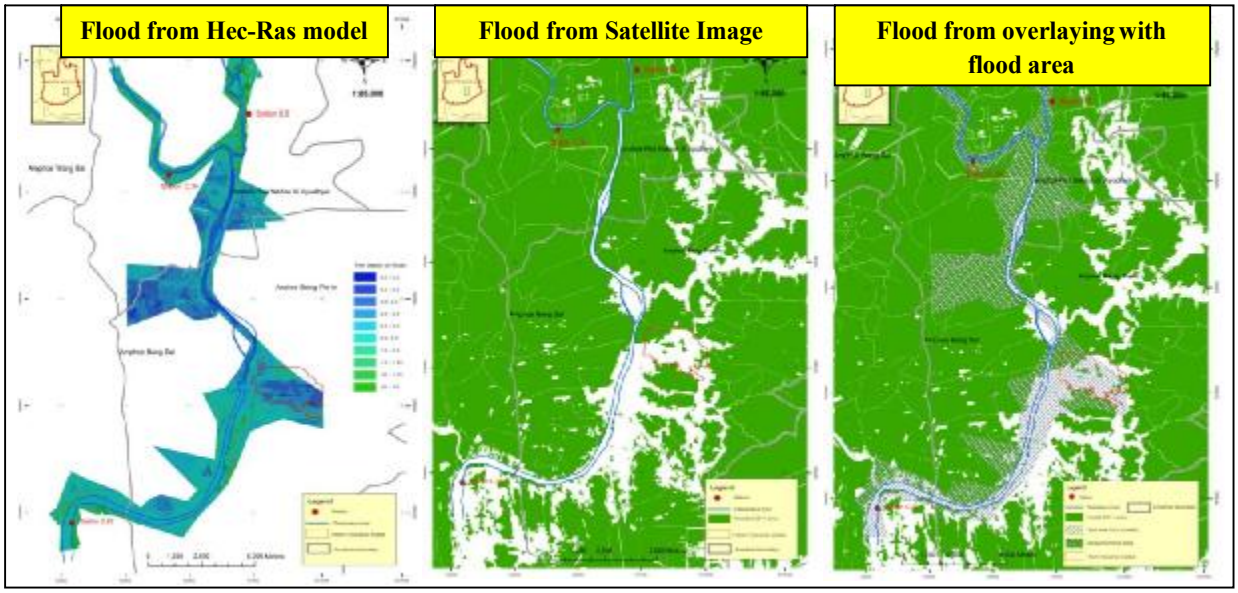


Figure 7: Display of flood maps

The flooded area from HEC-RAS model covers 61.9 sq.km(38,178.10 Rai) while the satellite image shows only 40 sq.km (25,011 Rai) were flooded and the resulting overlay showed that the water mass in Hi-tech Industrial Estate area covers 64.62 percent of the entire estate as in Figure 7.

5. To display the HEC-RAS model and 3D display in Hitech Industrial Estate

5.1 Hitech Industrial Estate is located in Amphoe Bang Pa-in, Pra Nakorn Si Ayuthaya Province with the total area of 2,868 Rai and one meter elevation above mean sea level. The result from HEC-RAS model shows 2595.87 Rai of flooded area or 90 per cent of Hitech Industrial Estates was flooded whereas from satellite image it shows only 672 Rai or 23.4 per cent as in Figure 8. The average water surface height is 2.14 meter.

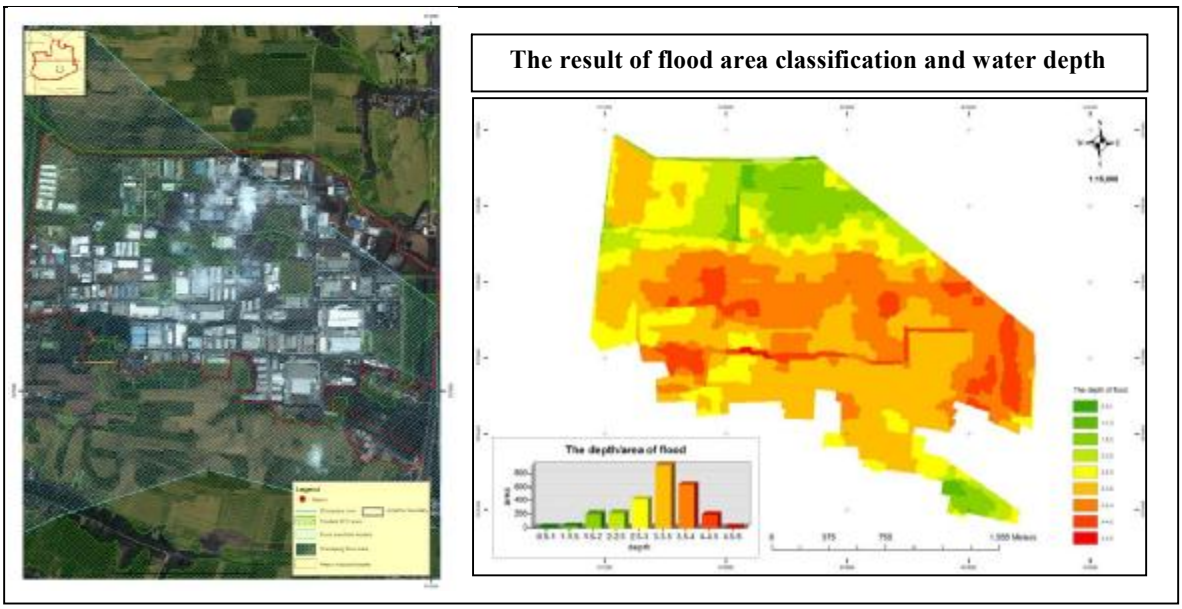


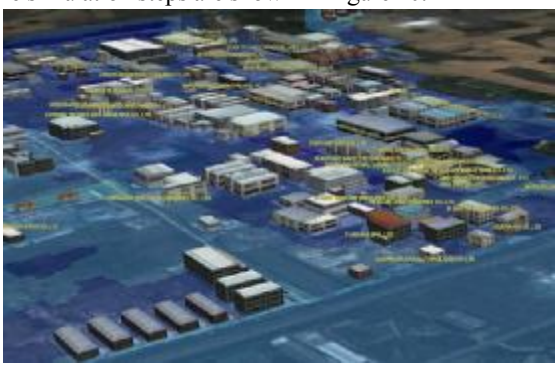
Figure 8: Display of flood characteristics in study area

5.2 To create flood risk area in 3D models as shown in Figure 9 using Skyline software with flood data generated from HEC-RAS models and other relevant data.

Figure 9: 3D display

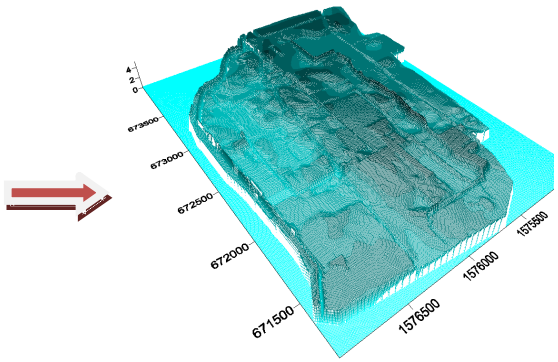
RECOMMENDATION

The knowledge of geo-informatics, hydrology, and engineering should be combined with the barrier layout information from Industrial Estate Authority of Thailand (IEAT) for flood protection plan in Hitech Industrial Estate. According to IEAT, the prevention measures at this industrial estate were taken up by lifting the west barrier up from 2.5 to 5.4 meters and the width widen from 4 to 5 meters with and the roads on the east, north, and south being lifted up to 4.5 meters also. The simulation steps are shown in Figure 10.

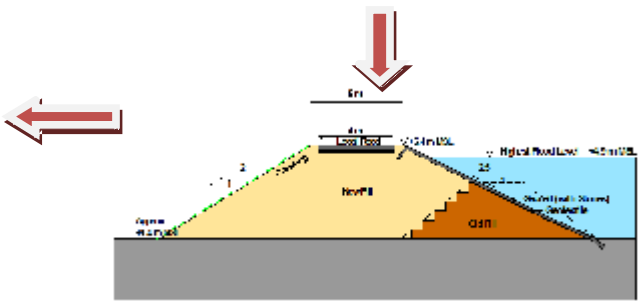


Flooded area

Flood Protection area



Geo-informatics & Hydrological Models



Engineering

Figure 10: Flood Management

CONCLUSION

The calculated river surface level of the upper Chao Phraya River during flooding is higher than the ground level at the banks. The non-flooding average height is 2.77 meters, with the highest point at 4.26 meters, and the flow rate is 1,141 m^3/sec. The average water surface level of lower Chao Phraya River is 3.49 meters, the highest at 4.68 meters, and the flow rate is 2,980 m^3/sec. The average Pasak River's water surface level during flooding is 3.57 while the highest is 4.45 meters, and the flow rate is 983, m^3/sec. Since of river surface level during flooding is higher, it makes the river overflow to both sides of the bank and this reach up to 2.14 meters in Hitech Industrial Estate area. Based on the result of this study, in order to safeguard the estate, the barrier should not be lower than 3 meters high. However, the accuracy of the result compared to actual flooded area in 2011 was 64.6 per cent.

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