Development of Flood Hazard Map of Upstream Johor River

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Abstract Flooding has become a common occurrence in Malaysia, occurring every year in many states, particularly during the northeast monsoon. From 1926 until 2013, Johor State, in its most southern portion of Peninsular Malaysia, experienced severe floods. The Johor River watershed, on the other hand, was decimated by floods in December 2006 and January 2007. The floods flooded the relatively extensive catchment of the upstream Johor River, resulting in a substantial volume of discharge. The study's goal was to undertake river modelling and create a flood map for the Johor River upstream. The Johor River is 123 kms long and has a catchment area of 2,636 km. It starts from Mount Gemuruh and travels generally north–south before discharging into the Johor Strait. The data required in setting up this model includes the river spatial and geometrical data, hydraulics and hydrological data. The developing of the river model was starting by collecting data and insert the input data then the river model had been setup. The model had been calibrated and the results had been analyzed. The observed and simulated data have showed a reasonable agreement with the model. With a flood depth of 3.73 m and 100 ARI, Rantau Panjang is the most flooded area. The 100 ARI flood depth at Rantau Panjang is similar to the observed flood depth during the Johor River flood occurrences in 2007. The flood map River modelling can be a highly beneficial option because it is always possible to assess and anticipate with enough data.

Keywords River model · Flood diagram · Catchment area · Hydraulic · Upstream river

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1   Introduction

Flooding is a natural hazard that has always happened in Malaysia. Practically every year in Malaysia, floods occur due to heavy rainfall. The technological innovation of today aggravate this risk. Flood behaviour is changing throughout the last 45 years as the severity and frequency of floods generated by human activities have increased [1]. Flooding affects about 29 000 km^2 (9%) of total land area and more than 4.82 million people (22%), with flood damage estimated at RM915 million per year [2]. Severe weather conditions and frequent floods are caused by the combination of extreme temperatures in equatorial regions, pressure gradients in these locations, and maritime exposure [3]. In Malaysia, there are 189 rivers that flow straight to the sea, 85 of which are prone to flooding [4].

During the floods of December 2006 and January 2007, the Northeast Monsoon, which occurs from December to March, caused significant flooding in various states across Peninsular Malaysia [5]. In four states, namely Johor, Negeri Sembilan, Melaka, and Pahang, these occurrences resulted in millions of dollars in losses and damages [6]. The first wave of floods occurred from December 19th to December 31st, 2006, while the second wave occurred from January 12th to January 17th, 2007. During the floods of December 2006 and January 2007, the Johor River watershed was the hardest hit. The floods flooded a huge area of the Johor River's catchment, which is relatively big.

The average monthly precipitation is 200 mm, however the 2006 storms had a 50-year return period, while the 2007 storms had a 100-year return period [3]. Kota Tinggi town, Kampung Baru Sungai Telor, Kampung Tembioh, Kampung Batu 25, Kampung Sungai Berangan, Kampung Semangar Dalam, Kampung Semangar Luar, Kampung Jawa, Kampung Kelantan, Kampung Sungai Sembilang, Kampung Sungai Sembilang, Kampung Sri Jaya, Kampung Rantau Panjang [5]. The goal of this work is to simulate the Johor River upstream and create a flood map. Johor is a state in Peninsular Malaysia that is located in the south. The Johor River Basin stretches from Tanjung Belungkor, in the state of Johor, to the slopes of Gunung Belumut, east of Kluang, and Bukit Gemuruh, in the north. This basin has a catchment area of around 2,690 km^2 and an upstream catchment area of about 1,130 km^2. The basin is mostly flat, with the exception of the northern and eastern regions, where terrain rises to a height of 500 to 600 mRL in the east and 1010 mRL in the north.

2   Methods

InfoWorks RS features comprehensive solution modelling of open channels, flood-plains, embankments, and hydraulic structures as part of its hydrodynamic modelling programme. The rainfall-runoff simulation is also accessible in complete interactive views of data utilising both event-based and conceptual hydrological approaches, as well as geographical plan views, sectional views, long sections, spreadsheets,

and time-varying graphical data. Any graphical or geographical view can access the underlying data. A sophisticated flood-interpolation model is overlaid onto an imported ground model to provide full flood mapping capability [7].

The Department of Irrigation and Drainage (DID) provided the cross-section profiles of the Johor River sub-basin. There are 21 river cross-section profiles, and the chainages interval used in this study was thousand metres, but smaller intervals down to 250 m were utilised in some areas that are more prone to flooding and more developed to compute the water level and flood map more precisely. Figure 1 depicts the position of 21 cross-sections along Rantau Panjang, which is located upstream of
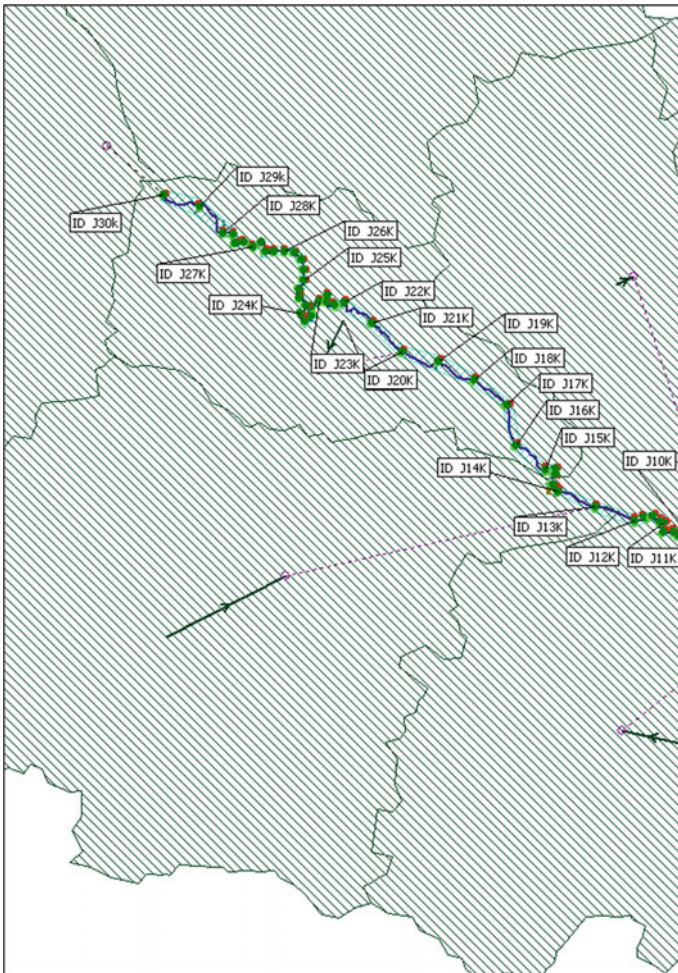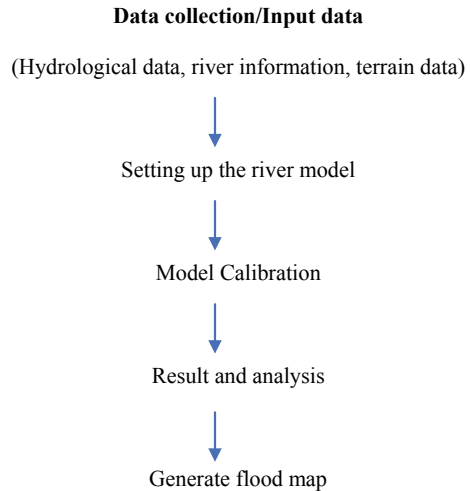

Fig. 1 The cross-sections inserted along upstream Johor River

Fig. 2 Overall methodology
in river modeling

Data collection/Input data

(Hydrological data, river information, terrain data)

Setting up the river model

Model Calibration

Result and analysis

Generate flood map

Sungai Johor. The cross sections were created in AutoCAD format and converted to Shapefiles (SHP) data before being imported into the InfoWorks RS model database.

InfoWorks RS was used to import hydrological data such as streamflow, rainfall, and water level data. A model is built using these data and then simulated for calibration and verification. The input data at the upstream and downstream end points, as well as the tributaries along the upstream Johor River, are known as boundary conditions. The downstream boundary data was based on Seluyut confluence stage data, while the upstream boundary data was based on Johor River discharge data. Figure 2 summarises the procedures involved in modelling the river with InfoWorks RS.

3   Result and Discussion

The flooding region in the Johor River upstream stretches from around Bukit Gemuruh to Rantau Panjang. Figure 3 depicts the maximum and lowest water levels (blue lines) for 100 ARI in Rantau Panjang. The flood will occur when the maximum water level exceeds the river's left and right banks. In longitudinal section view, the high-water level along the upstream Johor River can be seen, as depicted in Fig. 4. The water level for the whole stretch of the river is depicted in this diagram. The simulated water level is on top, while the riverbed is on the bottom. Flooding will occur in any section when the water level is greater than the bank level.

The observed data for water level and discharge has been calibrated. Table 1 summarises the flood events with various ARI. The table shows that there is no flooding occurrence in Rantau Panjang for the return time of 2 ARI, but the flood depths for 50 and 100 ARI are relatively high, with 3.5 and 3.73 m, respectively.
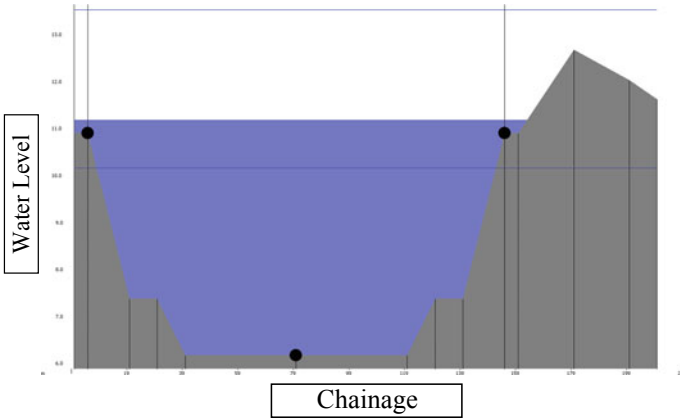
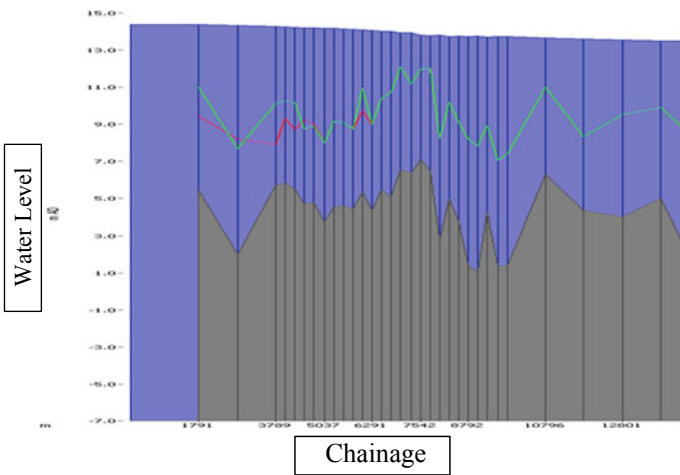**Fig. 3** Rantau Panjang cross section

Fig. 4 Longitudinal section for Rantau Panjang

Table 1 Water level and flood depth for Rantau Panjang with different ARIs	ARI	Rantau Panjang		
		2	50	100
	Max. River Level (M)	8.10	12.50	12.73
	Danger Level (M)	9	9	9
	Flood Depth (M)	No flooding	3.5	3.73

Rantau Panjang lies in the upper catchment region, with natural drainage, to serve the northwest drainage area from Semangar. The 100 ARI flood depth for Rantau Panjang (3.73 m) is close to the observed flood depth during the Johor River flood occurrences in 2007, which was 3.13 m. The flood danger map will make the region where the inundation area is determined more visible. Figure 5 depicts flood hazard maps for 2, 50, and 100 ARI.

4 Conclusions

- Finally, during seasons of severe rainfall, numerous locations in Rantau Panjang, which is upstream of the Johor River, flood several times a year.
- Rantau Panjang has the greatest flood depth of 3.73 with 100 ARI, making it the most flooded location.
- The flood depth of 100 ARI for Rantau Panjang is near to the observed flood depth for the 2007 flood events in Johor River.
- River modelling may be a highly beneficial option because assessment and prediction are always possible with enough data.
- Results showed that InfoWorks 1-Dimensional model is computational efficiency, ease of parameterization and easy representation of hydraulic structures in dealing with flows in large and complex networks of channels on the surface.

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