TECHNICAL REPORT

Extreme Flood Event:

A Case Study on Floods of 2006 and 2007 in Johor, Malaysia

Submitted by:

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ABSTRACT

Large-scale atmospheric circulations and anomalies have been shown to have a significant impact on seasonal weather over many parts of the world. Malaysia is located in the South East Asia with seasonal monsoons of Southwest and Northeast Monsoons. In December 2006 and January 2007, the Northeast Monsoon had brings heavy rain through series of continuous extreme storms that caused a devastating floods in the northern region of Peninsular Malaysia particularly to Kota Tinggi, Johor. The storms had occurred in two separate phases in late December 2006 and early January 2007 with a total precipitation in four days exceeding twice of the monthly rainfall in which some places recorded a higher number. The 2006 average rainfall return period is 50-years while the later gave more than 100-years return period. The disaster had caused more than 100,00 people evacuated from the residents due to rising flood water. The 2006 flood depth is recorded as 2.3-m and the 2007 flood depths is given as 2.75-m. This study generally analyzed and discussed on both flood events in terms of its maximum precipitation and the causes of the events with a light discussion on general flood management in Malaysia.

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CHAPTER I

INTRODUCTION

Malaysia is situated in Southeast Asia and consists of Peninsular Malaysia from the Asia continents and Sabah and Sarawak in Borneo Island. Located near the equator with higher concentration of solar energy where the Sun's rays strike almost full on all year round and surrounded by the sea, the air is moist and is generally covered with clouds all year round.

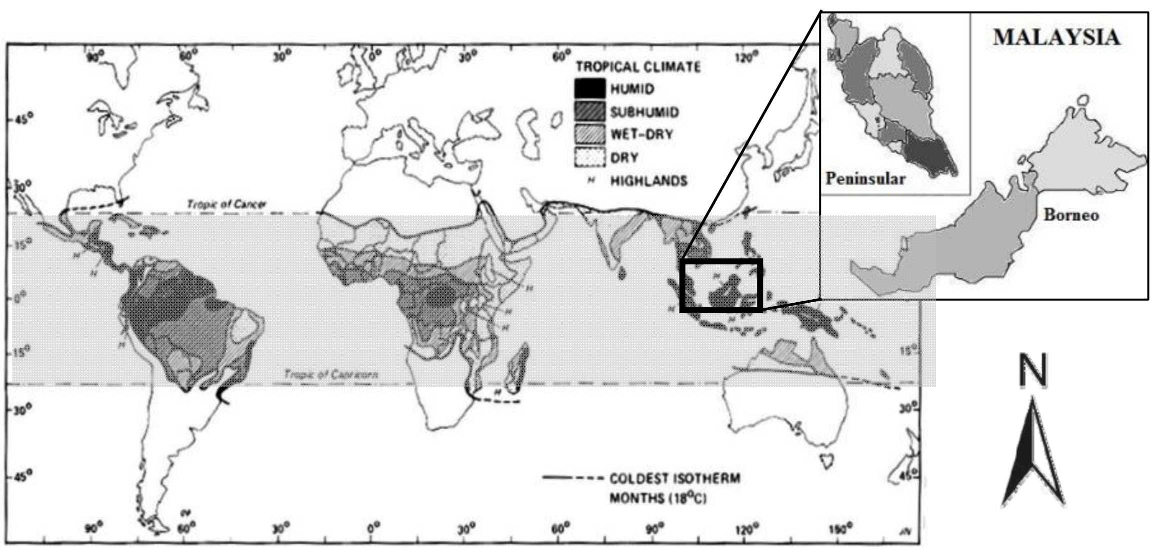


Fig. 1.1: Tropical climate regions map showing Malaysia located in the Far East of Asia

Malaysia is highly influence by the dry and wet monsoons and also the period in between known as the inter-monsoon. The wet monsoon brings heavy, widespread continuous rains while the inter monsoon period usually produce high intensities convectional rains. The combination of the extremes temperature in equatorial regions with the pressure gradients in these areas and the maritime exposure produces extreme weather conditions and the frequent occurrence of floods. There are 189 river systems in the country (89 in Peninsular Malaysia; 78 in Sabah and 22 in Sarawak) flowing directly to the sea of which 85 are prone to frequent flooding. (DID Manual, Vol.1, 2009)

The position of the land and the sea creates the significant pressure gradient resulted in copious rainfall arise mainly from the maritime exposure. The characteristic features of the climate of Malaysia are uniform temperature typically ranging from 75ºF - 86ºF (23°C - 30°C) and the annual precipitation for Peninsular Malaysia is 2500-mm (98-in) while Borneo Island has approximately 3000-mm (118-in) of rain annually. The open water evaporation is ranging from 1600mm-1800mm (63-71 in). The relative humidity defined by the ratio of actual vapor pressure over saturated vapor pressure is exceptionally high about 80% on annual average.

1.1 Overview

In the period of 19-31 December, 2006 and 12-17 January, 2007; Peninsular Malaysia has been hit by series of storm events generated by Northeast Monsoon that caused severe floods in several states located in the lower half of the Peninsular. The 2006 and 2007 events had caused millions of lost and damages in four states namely Negeri Sembilan, Melaka, Pahang and Johor. This study will focus on the flood in Kota Tinggi, Johor that had the most devastating impact with nearly 100,000 people were evacuated to emergency relief centers mainly due to its geographical characteristics and triggers with the inadequate drainage facilities.

1.2 Objectives

The objectives of this study are:

1. Analysis the flood of December 2006 and January 2007 based on precipitation recorded.

2. Flood hazard management in Malaysia

CHAPTER II

LITERATURE REVIEW

The catastrophic flood events are poorly understood due to the fact that the events are intricately responsive to the complex hydrological system that involves the atmosphere, surface, subsurface and the dynamic changes caused by continuous human interventions in nature's processes. This chapter presents brief reviews on the extreme flood modeling and its approaches.

2.1 Diffusive Wave

The diffusive wave equation simplified from the full dynamic wave of St.Venant (1871) equation is the force balance between friction slope, bed slope and pressure gradient neglecting the convective acceleration term and unsteady flow term for local gravitational acceleration.

$$S_f = S_0 - \frac{\partial h}{\partial x} \qquad (1)$$

The diffusive wave simplification of the unsteady, open-channel flow equations is a commonly used approach for flood routing applications and may be considered to be the one that most closely complies with the physics of open-channel hydraulics. (Cappelaere, B., 1997). The simplification however, will subject the resulting predicted quantities such as water depth and discharge in the channel and in the floodplain to risk and uncertainties (Moussa et al., 2009).

Therefore, the choice of the appropriate flood inundation model (Saint-Venant, diffusive wave, kinematic wave, 1D or 2D, etc.) by the modeller, depends on the terms that can be neglected in the full Saint-Venant equations, but also on the availability and the accuracy of input data such as the topography, the hydraulic properties of river reaches and the inundation zone, and the input flood hydrographs. Consequently, the diffusive wave is a good compromise for computation efficiency between the complexity of the complete Saint-Venant equations and the simplified kinematic wave and uniform formulae such as Manning and Chezy (Moussa et al., 2009).

2.2 Flows in Unsaturated Media

Flow in unsaturated zone is complicated because there are generally two fluid phases (air and water) present together. Both the volumetric moisture content (θ) and the unsaturated hydraulic conductivity (K) depends on the pressure head or the capillary pressure, (ψ). The pressure head/moisture content relationship describes how a sample behaves as water is added or removed. As a soil dries out, an increasingly large negative pressure head means that the mostly air-filled system has a large resistance to flow which means small number of hydraulic conductivity, (K). (Schwartz, F.W. and Zhang,H. 2002)

CHAPTER III

SITE DESCRIPTION

Johor is located in the southern region of Peninsular Malaysia and administratively divided into eight districts with Johor Bahru serves as its capital state in highly urbanized setting that connects Malaysia to Singapore as an international business hub and port of entry. The close proximity of Kota Tinggi to Johor Bahru which is approximately 42-km north-east of Johor Bahru had been the main factor contributing to its rapid development as part of the Johor Bahru growth corridor.

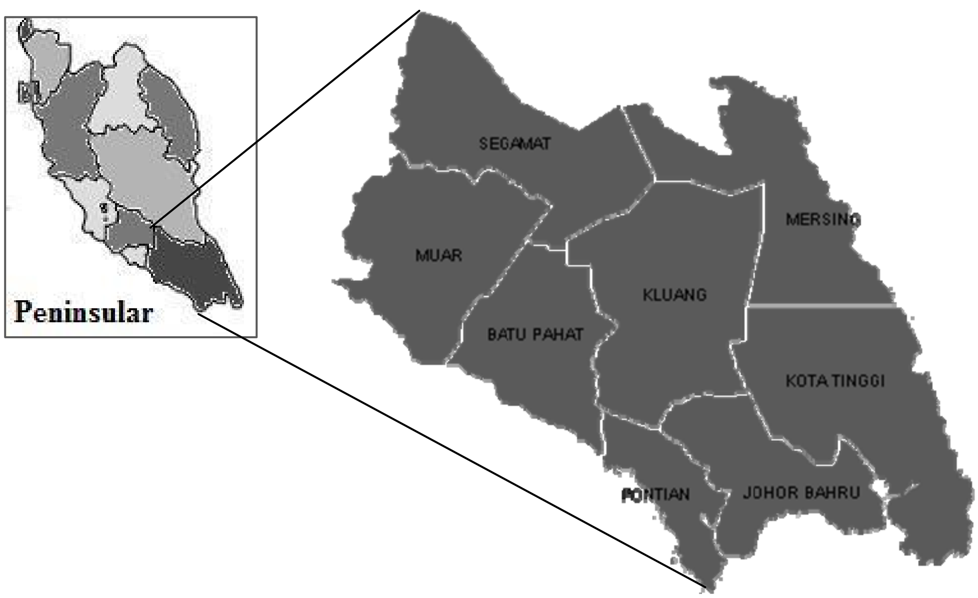


Figure 3.1: Map showing the districts under state of Johor, Malaysia

3.1 Kota Tinggi District

The district of Kota Tinggi is located at the east of Johor state with 65% of its border is surrounded by the sea. Kota Tinggi district have an area of 3,500 km^2 (364,399 hectares) and consists of 10 sub-districts.

Urbanization in this area is growing rapidly focusing in agricultural activities and housing development with population of more than 200,000 people. The administrative town of this district also was named Kota Tinggi. This study will focus in the sub-districts of Kota Tinggi and Ulu Sg. Johor which contributes nearly 70% of the total catchment area for Johor River Basin.

No.	Sub-districts	Area (ha)
1	Kota Tinggi	39,100
2	Ulu Sungai Johor	93,200
3	Tanjung Surat	33,145
4	Pengerang	18,385
5	Sedili Kecil	32,109
6	Johor Lama	20,198
7	Sedili Besar	20,716
8	Pantai Timur	22,787
9	Ulu Sungai Sedili	50,494
10	Kambau	34,245
	TOTAL	**364,399**

Figure 3.2: Map of Kota Tinggi districts with 10-sub-districts. (Majlis Daerah KT)

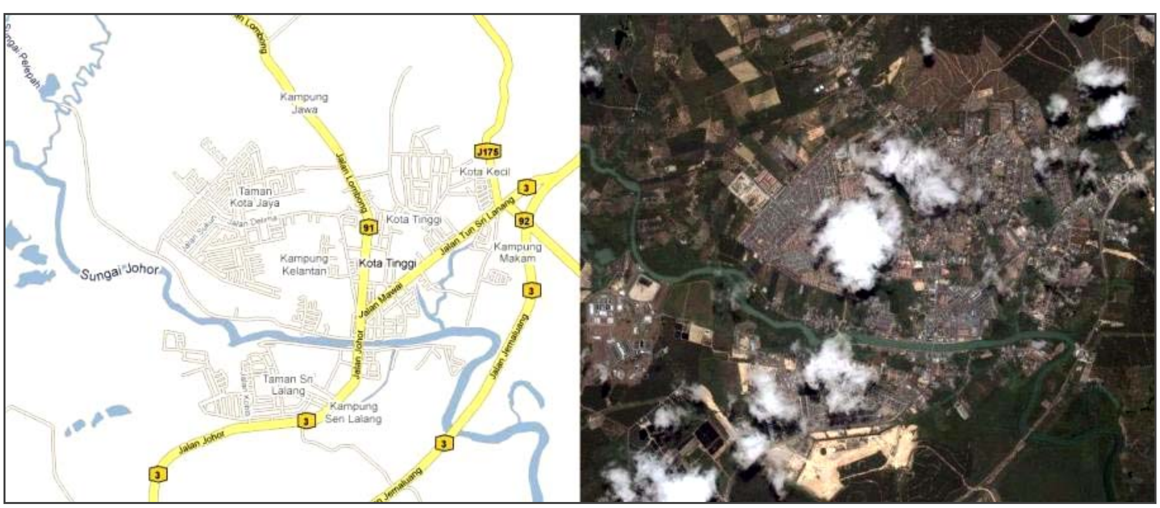


Figure 3.3: Map and aerial view of Kota Tinggi town (Google Maps)

3.2 Wind flow and Monsoon Rain

The rainfall pattern in Malaysia is influenced by two monsoon regimes, Northeast Monsoon and Southwest Monsoon. The shorter period in between the two monsoons is called Inter-monsoon.

Monsoon	**Period**	**Characteristics**
Northeast	November – March	Winds 10-20 knots up to 30 knots during cold surges period affecting east coast area. Heavy rainfall.
Inter-monsoon	April – May October - November	Frequent period of thunderstorm in afternoon and evening hours with heavy rainfall causing flash flood
Southwest	May – September	Winds below 15 knots affecting west coast area. Drier weather.

Table 3.1: Monsoon regimes in Malaysia. (MMD)

Due to the seasonal prevailing winds, the seasonal variation of rainfall in Peninsular Malaysia can be classified to three categories. The east coast will have maximum rainfall in the months of November to January while June and July are the driest months in most areas. The southwest coastal area however, is much affected by early morning "Sumatras" from May to August. October and November are the months with maximum rainfall and February the month with minimum rainfall. The rest of the Peninsula has distinct two periods of maximum rainfall separated by two periods of minimum rainfall. The primary maximum generally occurs in October to November while the secondary maximum generally occurs in April to May. Over the northwestern region, the primary minimum occurs in January to February with the secondary minimum in June to July while elsewhere the primary minimum occurs in June to July with the secondary minimum in February.

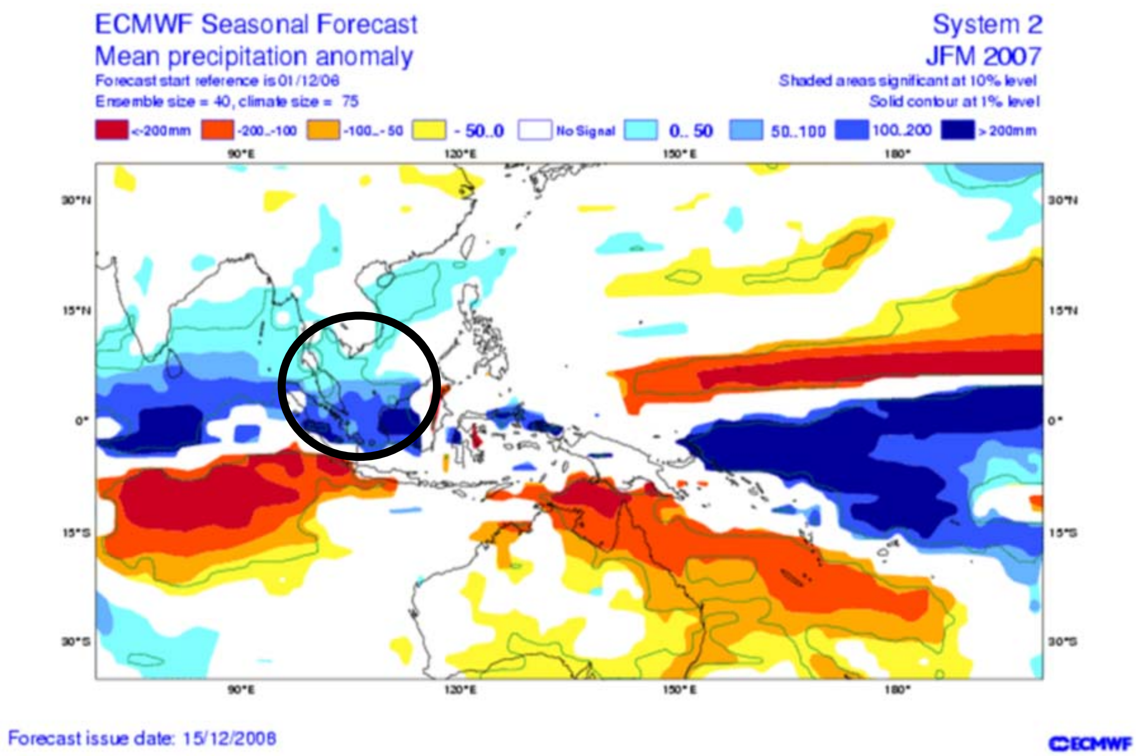


Figure 3.4: Seasonal forecast for January to March 2007 by European Centre for Medium-Range Weather Forecast (ECMWF)

3.4 Soil type

The major soil type in Johor is presented in Figure from Department of Agriculture, Malaysia (DOA).The dominant sol type in Johor is sedentary soils. These soils cover 53% of the total land area in Johor. These soils can be classified under shallow (less than 50 cm), moderately deep (50- 100 cm) and deep soil (more than 100 cm). These soils also occur on different terrain from the relatively flat areas (0- 2 %) to the hilly areas (> 20%). Most of the industrial and food crops in Johor are grown on sedentary soils (DOA, 2002).

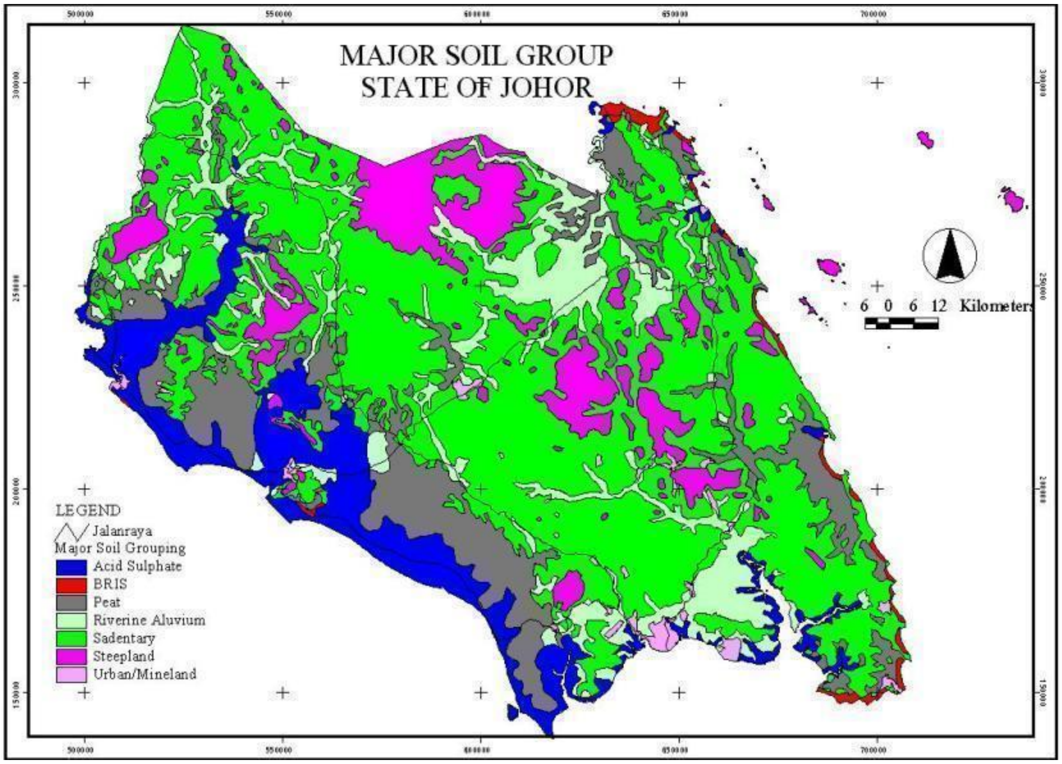


Figure 3.5: Major soil type in Johor (DOA)

3.4 Johor River Basin (JRB)

Johor River is approximately 122.7km long with drainage area of 2,636 km^2. It originates from Mt. Gemuruh and flows through the southeastern part of Johor and finally into the Straits of Johor. The catchment is irregular in shape. The maximum length and width are 80-km and 45-km respectively. About 60% of the catchment is undulating highland rising to a height of 366-m while the remainder is lowland and swampy.

The highland in the north is mainly jungle. In the south a major portion had been cleared and planted with palm oil and rubber. The highland areas have granite soil cover consisting of fine to coarse sand and clay. The alluvium consists of fine sand and clay. The catchment receives an average annual precipitation of 2,470-mm while the mean annual discharge measured at Rantau Panjang (1,130-km^2) has been 37.5 m^3/s during the period 1963-1992. The temperature in the basin ranges from 21°C to 32°C (APFRIENDS).

Location: Central part of south Johor	N 1° 27’ - 1° 49’ E 103° 42’ - 103° 01’
Area: 2,636 km^2	**Length of main stream**: 122.7km
Origin: Mt. Gemuruh (109m)	**Highest point**: Mt. Belumut (1,010m)
Outlet: Straits of Johor	**Lowest point**: River mouth (0m)
Main geological features: Intrusive rocks, quaternary, triassic, permian, cretaceous-jurassic, tertiary	
Main tributaries: Sayong, Linggui, Semangar, Tiram, Layang, Lebam	
Main lakes: Nil	
Main reservoirs: Linggui Dam (impounded in 1993: Malaysia-Singapore Treaty)	
Mean annual precipitation: 2470-mm (basin average)	
Mean annual runoff: 37.5 m3/s at Rantau Panjang (1963-1992)	
Population: 230,000	**Main cities**: Kota Tinggi
Landuse: Urban(5.5%), Forest(16.4%), Oil Palm, Other crops (18.5%), waterbody (0.5%) Swamps(11.6%)	

Table 3.2: Basic Data for Johor River, Malaysia (Catalogue of River, UNESCO)

Johor River or Sungai Johor in Malay language is originated from its source of Sungai Layang-layang and Sungai Linggui/Sayong in the upstream before merging to Sungai Johor and flows down southeast to estuarine of Johor Straits. Downstream major tributaries are Sungai Tiram and Sungai Lebam (DID). The highest elevation in the basin based on the available DEM is 600-m and the lowest point is 4 m. Most of the downstream area is covered with wetlands and swampy area. Generally, Johor River is a meandering channel with most of the areas is prone to have neck or chute cutoff with high sedimentation ranging from suspended, to mixed as well as bedload sedimentation along the reaches.

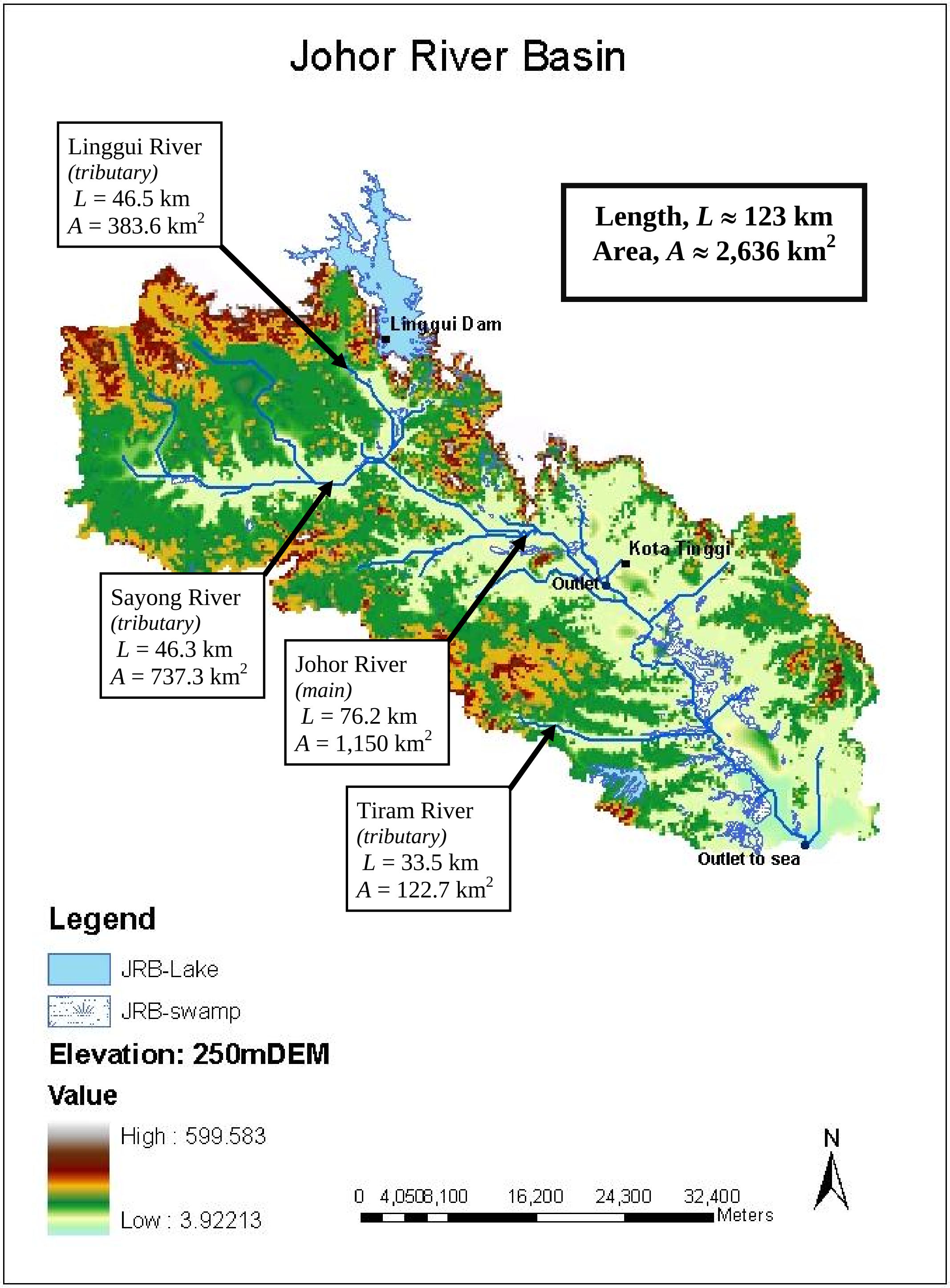


Figure 3.7: Johor river Basin showing main tributaries and basin elevation with the generated GIS flowpath

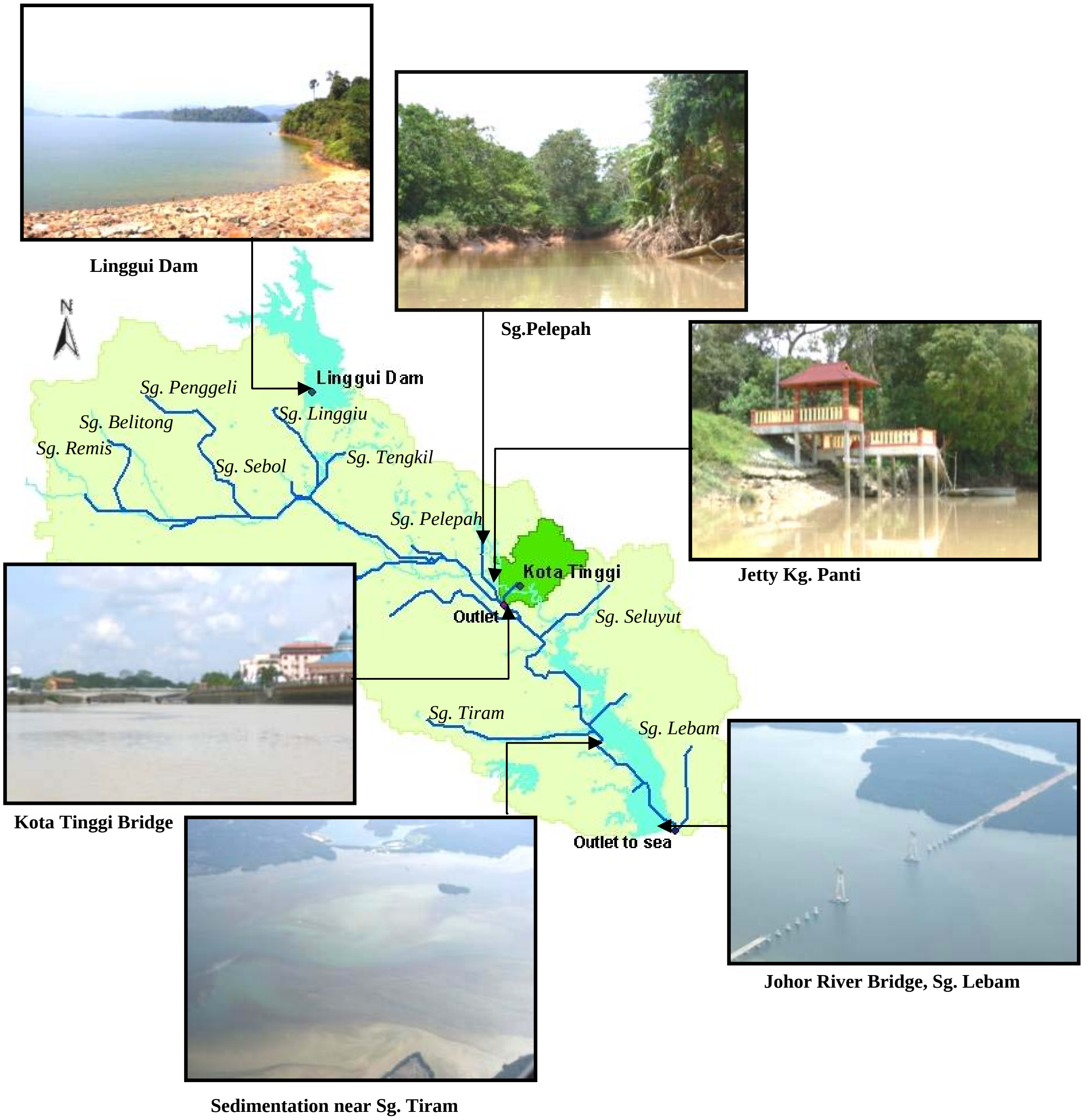


Figure 3.8: Johor River Basin showing the sub-catchment of Kota Tinggi town
(Photo by Yazidtim and tisuisse300, Panaoramio and Robo, http://j-travel.blogspot.com/)

CHAPTER IV

FLOOD OF DECEMBER 2006 AND JANUARY 2007

In December 2006 and January 2007, southern of Peninsular Malaysia has been hit with series of floods with high rainfall recorded. Johor had been affected badly by the storm with the worst case was in Kota Tinggi and Segamat. This chapter will present the general analysis for flood of 2006 and flood of 2007 in Johor focusing on the impact in Kota Tinggi.

4.1 Contributing Storm

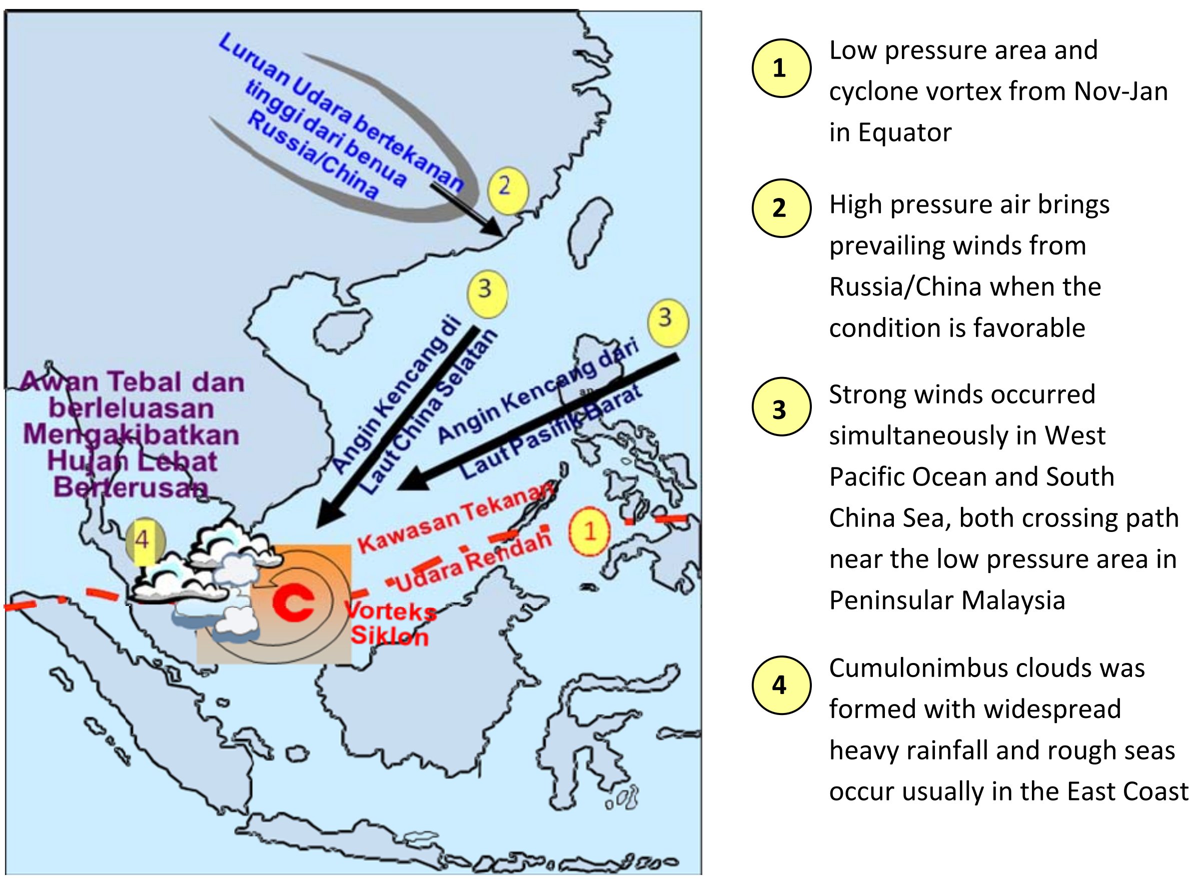


Figure 4.1: Heavy rains caused by the prevailing monsoon (MMD, 2007)

The storms that caused floods of December 2006 and January 2007 was the unusual Northeast Monsoon that blows from South China Sea and West Pacific Ocean. Usually, the Northeast Monsoon brings heavy rain to the upper East Coast area. It is normal for the lower East Coast area to receive heavy rains during the monsoon season, but the December 2006 and January 2007 storms brought extremely high rains. The close occurrence of both storms on widespread area triggered the damages affecting more than 100,000 people and left the Government not completely prepared for such a huge number of victims. .

4.1 Satelite images over Peninsular Malaysia

The ECMWF Seasonal Forecast had published a 100mm – 200mm precipitation anomaly for the Southeast Asia region. The following radar images shows clouds coverage over the northern part of Peninsular including Singapore and parts of coastal area in Central Sumatra.

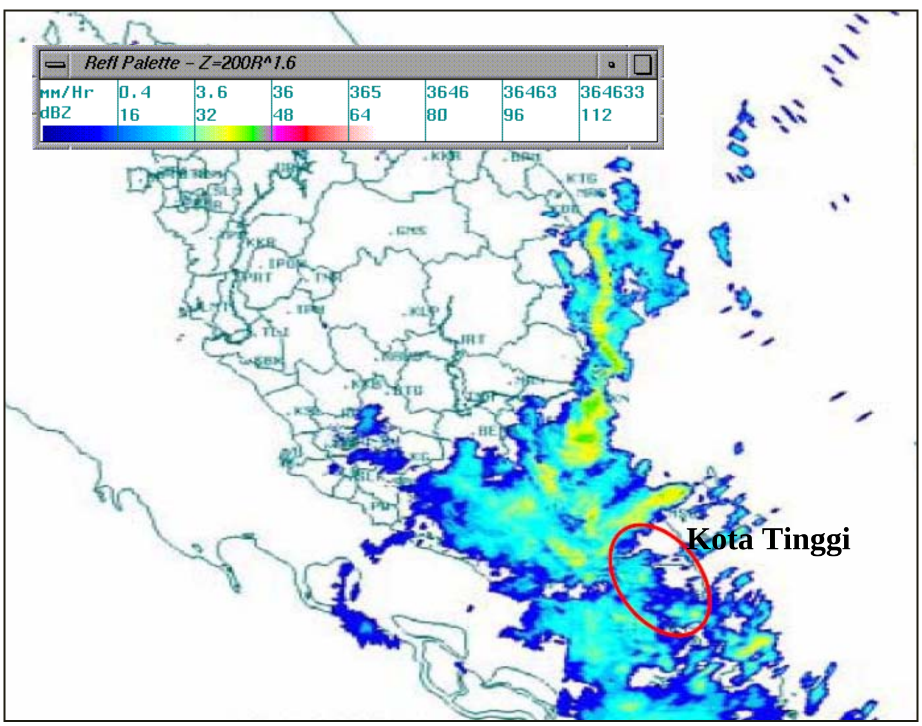


Figure 4.1: Radar image on 19 December 2006

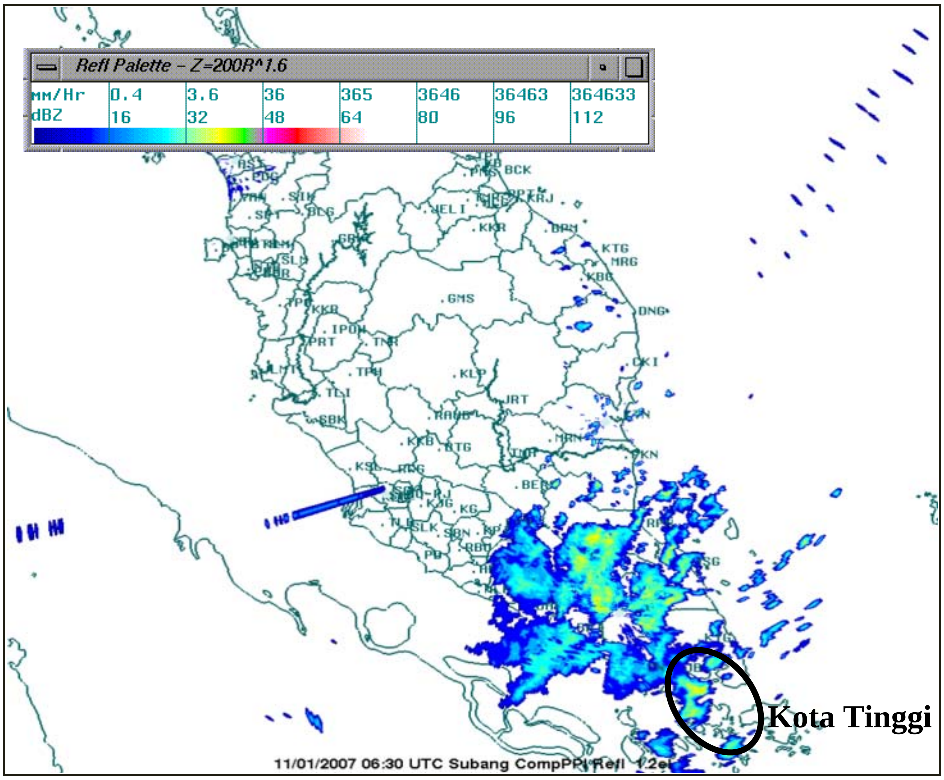


Figure 4.2: Radar image on January 11, 2007 at 2:30 p.m.

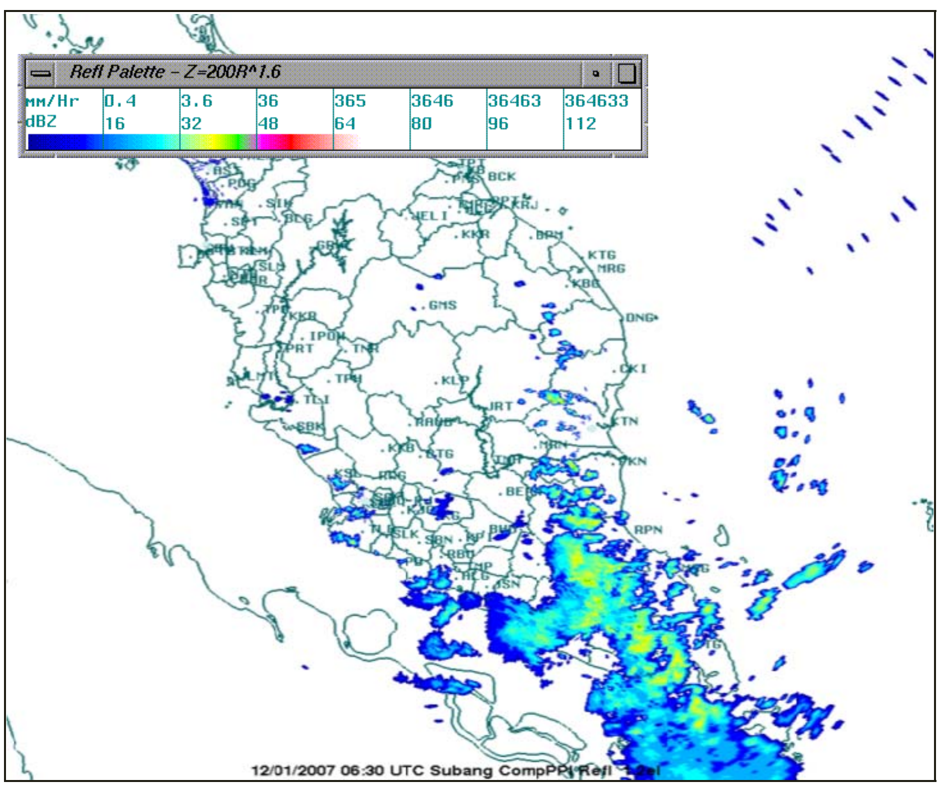


Figure 4.3: Radar image on January 12, 2007 at 2:30 p.m.

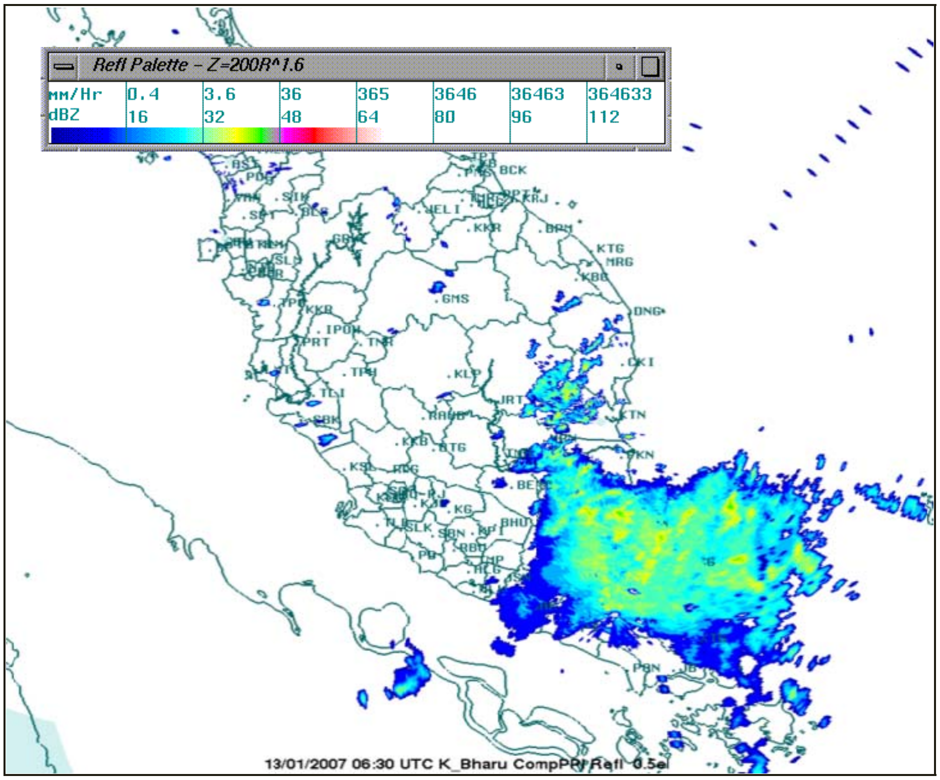


Figure 4.4: Radar image on January 13, 2007 at 2:30 p.m.

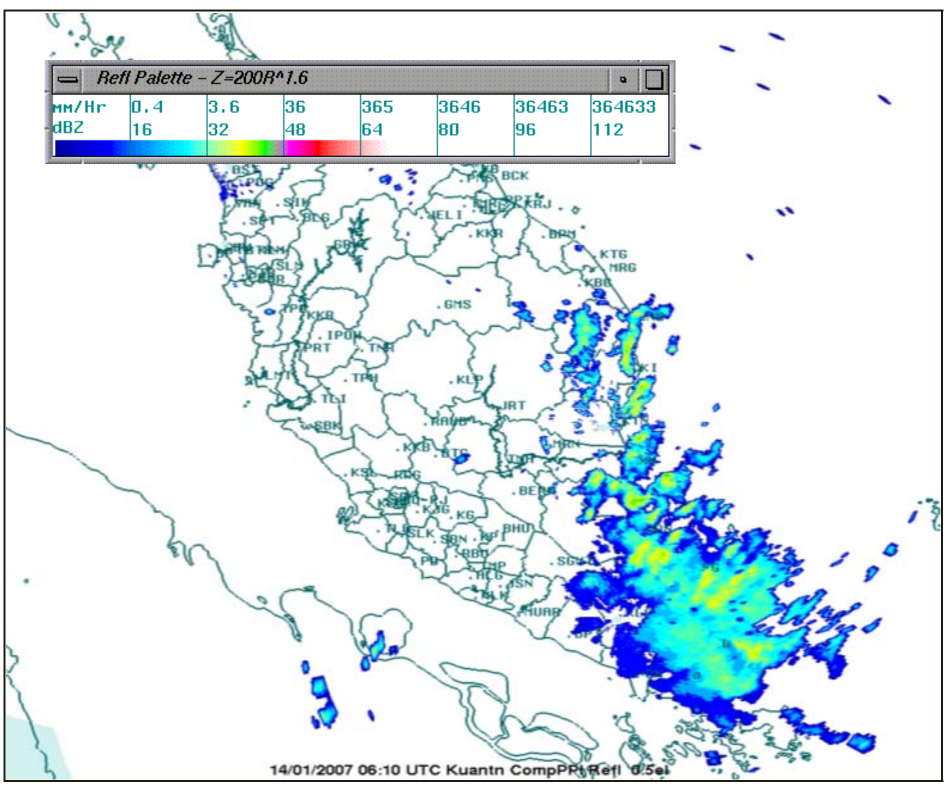


Figure 4.5: Radar image on January 14, 2007 at 2:10 p.m.

4.2 Flood chronology

Kota Tinggi started to receive heavy, widespread rain from the period of five (5) continuous days starting on the 17th to 21st December 2006. Due to the low lying areas of the town and its close proximity to estuaries, the continuous heavy widespread rainfall especially on December 19, 2006 had caused the river rising rapidly and eventually started to fill up the floodplain areas. The inundation period lasted approximately 13 days and the number of victims in Kota Tinggi was 5,243 people. On December 30, 2006, most of the areas had dried out and the relief shelters started to close down by phase. By January 11, 2007, most of the victims have returned to their properties and the condition seems to get better with most of the areas are safe to live. On 11 January 2007, continuous heavy rains started to fall on the state of Johor for another four (4) days until January 14, 2007.

Sun	Mon	Tue	Wed	Thu	Fri	Sat
17	**18**	**19**	**20**	**21**	22	23
24	25	26	27	28	29	30
31	1	2	3	4	5	6
7	8	9	**10**	**11**	**12**	**13**
14	15	16	17	18	19	20

Legend:

Rainy days

Figure 4.7: Kota Tinggi flood chronology of December 2006 and January 2007

4.3 Rainfall Analysis for Flood of December 2006 and January 2007

The 1-day rainfall shows a highest recorded precipitation occurred on 19 December 2006 for the first storm phase and 12 January 2007 for the second phase. The average monthly rainfall is 200-mm. The recorded precipitation yields an unusual high precipitation in a day with the accumulated 4-days total exceeded by almost double the monthly average.

Date	Layang-layang	Ulu Sebol	Bukit Besar	Bdr. Kota Tinggi
17-Dec-06	66 mm	33 mm	29 mm	48 mm
18-Dec-06	52 mm	23 mm	47 mm	43 mm
19-Dec-06	156 mm	189 mm	200 mm	161 mm
20-Dec-06	73 mm	78 mm	69 mm	39 mm
4-days total	**367 mm**	**353 mm**	**345 mm**	**287 mm**

Table 4.1: 1-day rainfall for various stations from 17 – 20 December, 2006

Date	Layang-layang	Ulu Sebol	Bukit Besar	Bdr. Kota Tinggi
11-Jan-07	145 mm	124 mm	147 mm	167 mm
12-Jan-07	135 mm	290 mm	234 mm	122 mm
13-Jan-07	84 mm	76 mm	42 mm	49 mm
14-Jan-07	20 mm	44 mm	35 mm	-
4-days total	**384 mm**	**534 mm**	**458 mm**	**338 mm**

Table 4.2: 1-day rainfall for various stations from 11 – 14 January 2007

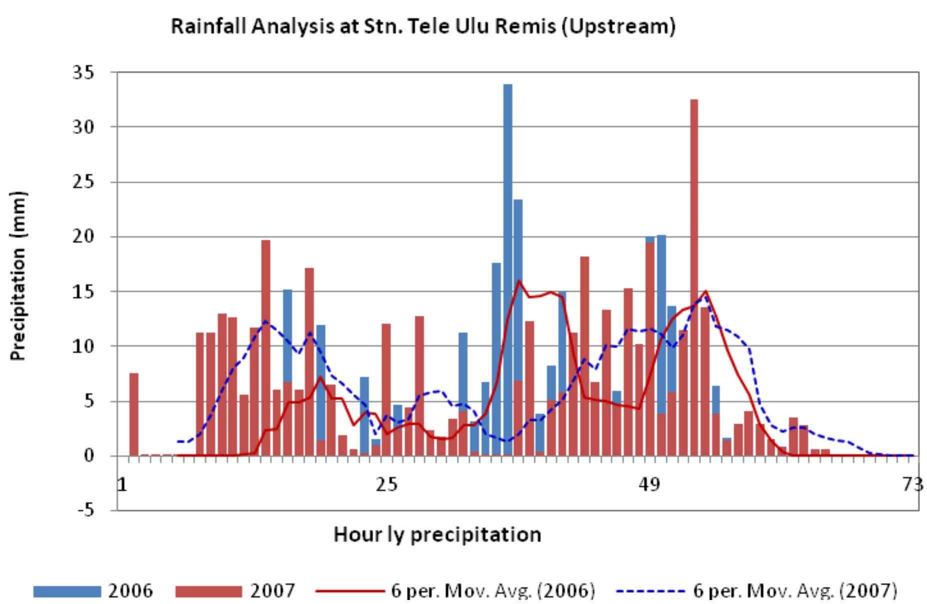


Figure 4.8: Plot of hourly precipitation with a 6-hr moving average shows at least 7mm of rain per hour for the period of 3 continuous days.

24-hr Rainfall – 19 December 2006

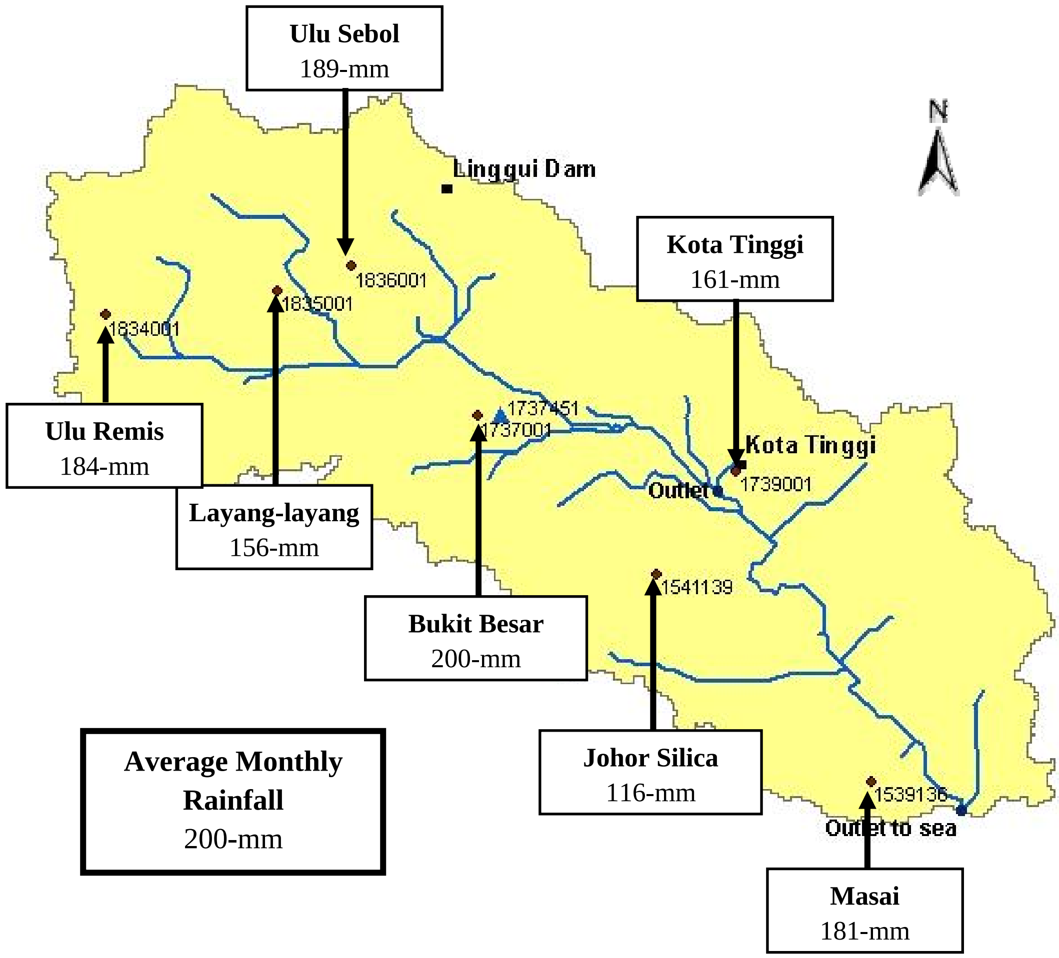


Figure 4.9 shows the 1-day rainfall on December 19, 2006 for selected stations in JRB.

The 1-day rainfall in Bukit Besar on 19 December 2009 is equivalent to the average monthly rainfall for the basin. The overall intensities were high throughout the basin resulted in the severe flood disaster since 1948 (58 years). The highest 1-day rainfall for January 12, 2007 was recorded in the upper catchment from Ulu Sebol station given as 290-mm, with 90-mm exceeding the monthly average. The overall basin had received widespread and heavy rainfall.

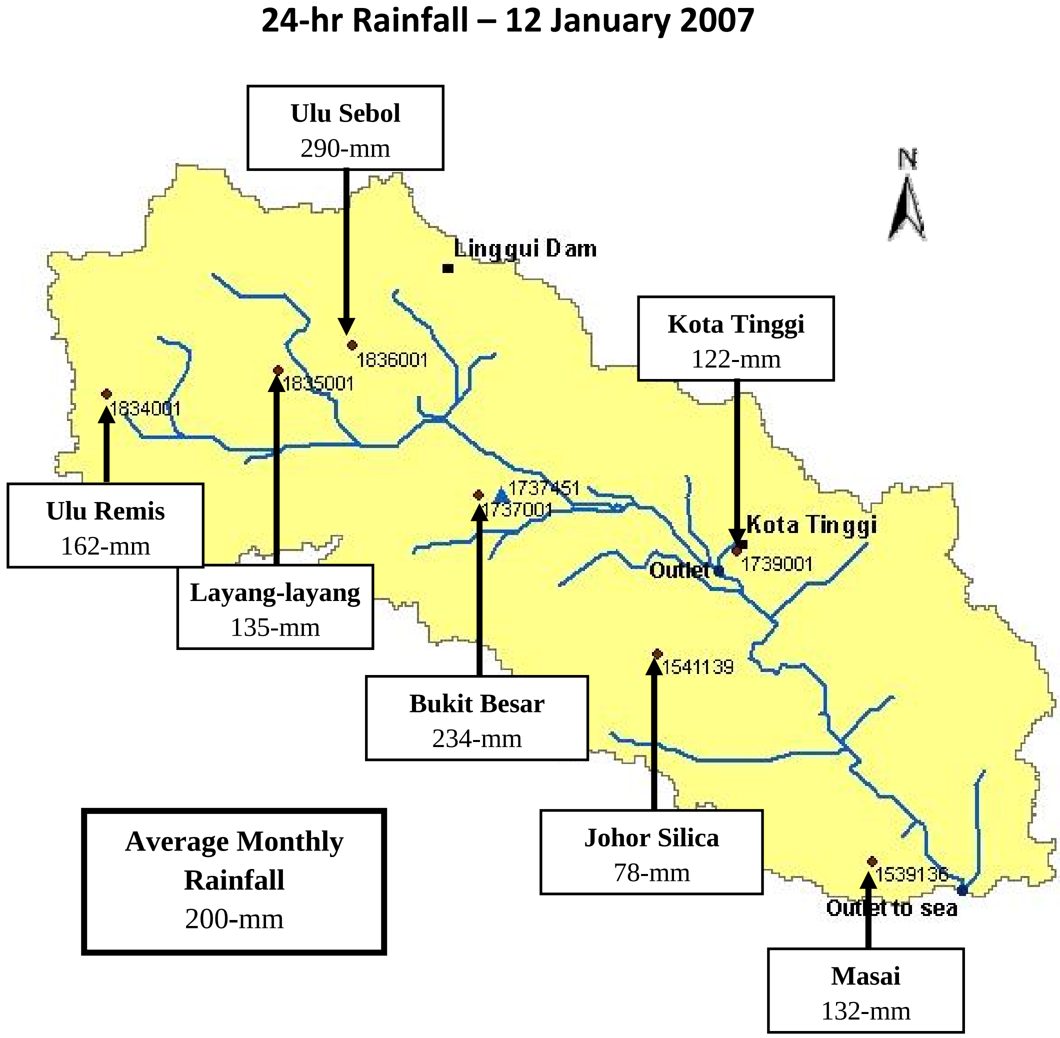


Figure 4.10 shows the 1-day rainfall on January 12, 2007 for selected stations in JRB

4.3.1 Isohyetal Maps

The plotted isohyetal maps for Phase 1 and Phase 2 shows that the Phase 2 gave a wider coverage than December 2006 events. Phase 1 had higher intensities of 700mm in Segamat, Johor. Phase 2 has wide spread rainfall distribution with the same intensities of 400mm throughout the state covering from Segamat, Kluang to Kota Tinggi district which resulted in more severe impact.

No.	Station Name	18/12/06	19/12/06	20/12/06	21/12/06	4-days total (mm)
1	Kg Awat	56	117	124	49	346
2	Buloh Kasap	75	180	138	76	469
3	Segamat	66	239	162	48	515
4	Air Panas	98	477	149	58	782
5	Labis	96	301	130	23	550
6	Kangar Chaah	91	208	70	20	389
7	Sri Medan	44	88	47	4	183
8	K.Penghulu Chaah	103	251	84	9	447
9	Empangan Bekok	68	159	84	2	313
10	SgBekokB77	69	149	92	2	312
11	Bandar Yong Peng	47	153	60	14	274
12	Ladang Chan Wing	92	245	101	2	440
13	Ladang Yong Peng	100	199	81	17	397
14	Empangan Sembrong	120	193	70	23	406
15	Layang-Layang	52	156	94	81	383
16	Ulu Sebol	23	189	108	72	392
17	Bukit Besar	47	197	78	68	390
18	Kota Tinggi	43	161	46	145	395
19	Simpang Renggam	50	84	79	39	252
20	Felda Air Hitam	63	176	89	31	359
21	Kampung Separa	47	193	63	57	360
22	Bandar Kluang	58	251	101	21	431
23	JPSLarkin	80	292	66	23	461
24	Ladang Chaah	95	179	89	10	373
25	Batu Pahat	41	92	34	3	170
26	Empangan Labong	17	249	166	5	437
27	Endau Mersing	8	245	177	0	430
28	Senggaran	56	66	45	7	174

Table 4.3: Rainfall recorded from various rainfall stations in Johor from 18-21 Dec.2006

Table 4.3 and Table 4.4 gives the recorded rainfall data for Johor used to generate isohyetal maps for the 2006 and 2007 flood events.

No.	Station Name	District	11/01/07	12/01/07	13/01/07	14/01/07	4-days total (mm)

1	Kg Awat	Segamat	9	26	13	0	48
2	Buloh Kasap	Segamat	32	33	18	0	83
3	Segamat	Segamat	49	45	39	3	136
4	Air Panas	Segamat	81	204	129	17	**431**
5	Labis	Segamat	70	192	106	16	384
6	Sri Medan	Bt. Pahat	82	147	62	3	294
7	K.Penghulu Chaah	Segamat	79	182	83	8	352
8	Empangan Bekok	Bt. Pahat	85	237	88	52	**462**
9	SgBekokB77	Segamat	99	247	93	32	**471**
10	Ladang Chan Wing	Segamat	110	240	100	19	**469**
11	Ladang Yong Peng	Bt. Pahat	61	136	83	17	297
12	Sembrong Dam	Kluang	78	229	65	11	**383**
13	Sg Sembrong	Segamat	80	207	57	6	350
14	Layang-Layang	Kluang	145	135	84	20	**384**
15	Ulu Sebol	Kt. Tinggi	124	290	76	44	**534**
16	Bukit Besar	Kt. Tinggi	147	234	42	35	**458**
17	Kota Tinggi	Kt. Tinggi	167	122	49	-	338
18	Machap Dam	Kluang	120	163	71	6	360
19	Simpang Renggam	Bt. Pahat	142	119	61	10	332
20	Bandar Kluang	Kluang	121	182	105	16	**424**
21	JPSLarkin	J. Bahru	117	224	6	7	354
22	Batu Pahat	Bt. Pahat	63	120	47	0	230
23	Labong Dam	Mersing	78	50	319	288	**735**
24	Endau Mersing	Mersing	44	33	296	203	**576**
25	Senggarang	Bt. Pahat	18	153	37	0	208

Table 4.4: Rainfall recorded from various rainfall stations in Johor from 11-14 Jan. 2007

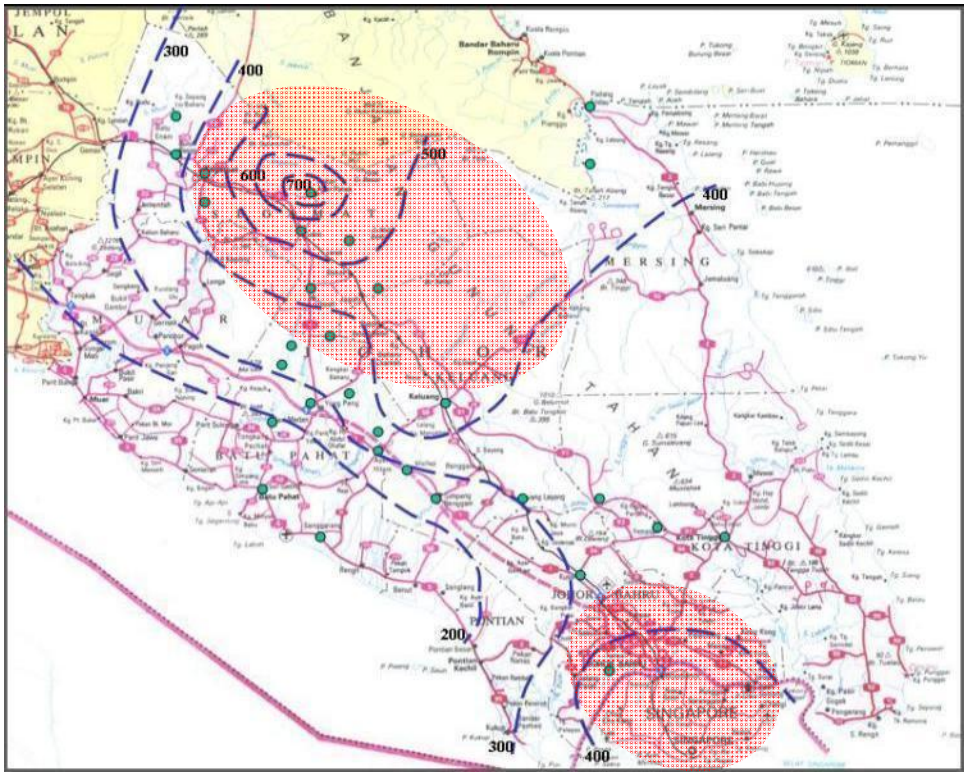


Figure 4.11: Isohyetal map for 3-days precipitation on December 18- 20, 2006

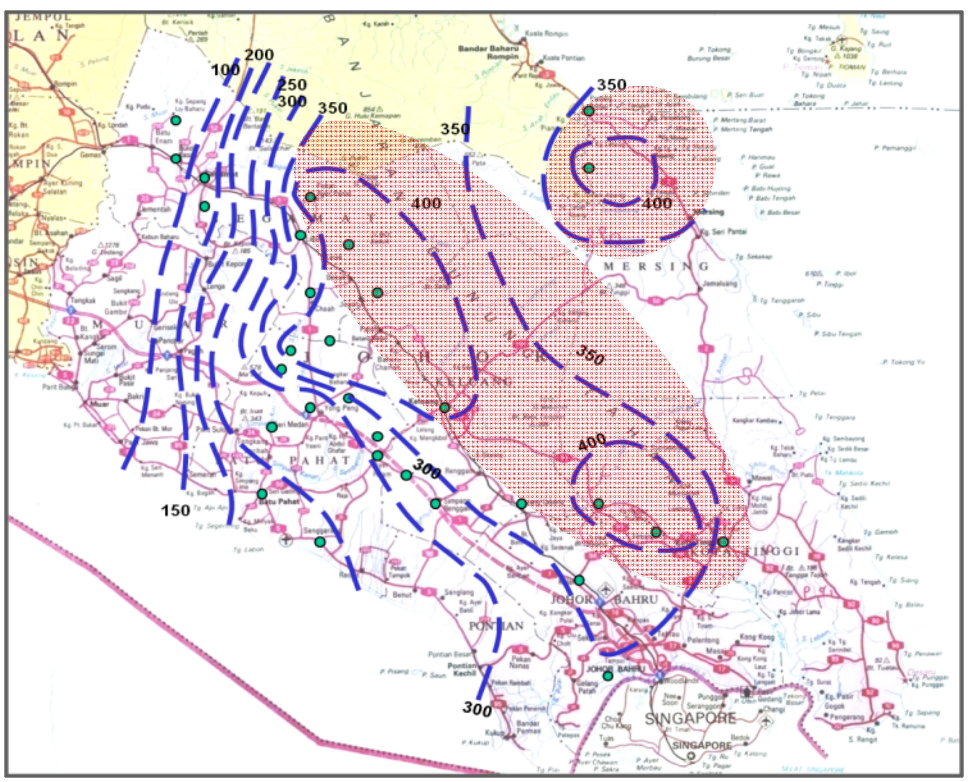


Figure 4.12: Isohyetal map for3-day precipitation on January 11 – 13, 2007

4.3.2 Rainfall Return Period

PHASE 1 : DECEMBER 2006 FLOOD

Rainfall Station	District	Maximum Rainfall (mm)		Return Period (Year)	
		24 hr	48 hr	24 hr	48 hr
Kota Tinggi	Kota Tinggi	184	229	5	2
Bukit Besar		197	307	10	50
Ulu Sebol		279	319	80	60

Note:

24-hr maximum rainfall = 19 Dec. 2006 (16:00 hr) to 20 Dec 2006 (16:00 hr)

48-hr maximum rainfall = 18 Dec. 2006 (16:00 hr) to 20 Dec 2006 (16:00 hr)

Table 4.5: Analysis of rainfall return period on December 2006 flood

PHASE 2 : JANUARY 2007 FLOOD

Rainfall Station	District	Maximum Rainfall (mm)		Return Period (Year)	
		24 hr	48 hr	24 hr	48 hr
Kota Tinggi	Kota Tinggi	205	335	33	> 50
Bukit Besar		199	420	46	> 100
Ulu Sebol		136	473	5	> 100

Note:

24-hr maximum rainfall = 11 Jan. 2007 (09:00 hr) to 12 Jan. 2007 (09:00 hr)

48-hr maximum rainfall = 11 Jan. 2007 (09:00 hr) to 13 Jan. 2007 (09:00 hr)

Table 4.6: Analysis of rainfall return period on January 2007flood

In general, the December 2006 rainfall distribution has a 50-yr return period, which means a 2% probability such maximum precipitation will occur in a year. The January 2007 however gave more than 100-yr return period which means 1% probability of such maximum precipitation will be exceeded in any one year. The 2% probability in a year of 365 days could give a total days that the chances of a 50-yr maximum precipitation could happen for a period of 7 days. The 1% probability give a total days for chances of a 100-yr maximum precipitation could sum up to 3-4 days total. The December 2006 flood of 50-yr maximum precipitation last about a week and the January 2007 flood of more than 100-yr maximum precipitation last about 4 days.

The severity of both floods events were mainly caused by the heavy rainfall from the monsoon. However, the distribution patterns, the duration coupled with the geographical location of the affected area had triggers the impact. The second storm phase had paralyzed the town with the storm distribution is higher than the December events. The previous inundation had increased the soil moisture in the areas to saturation and when the second storm occurred, the mess from the first flood such as debris, trash and sediments eroded from the previous disaster, has not been cleared. These messes caused obstruction to the flow and resulted in more severe flood impact and further destroyed the existing flood destruction.

Rainfall Station	District	Maximum Rainfall (mm)		Return Period (Year)	
		24 hr	**48 hr**	**24 hr**	**48 hr**
Air Panas	Segamat	158	436	**5**	**>100**
Labis	Segamat	144	388	**3**	**>50**
Segamat	Segamat	63	99	**Normal**	**Normal**
Ladang Chan Wing	Segamat	189	445	**15**	**>100**
Kompleks Penghulu Chaah	Segamat	139	370	**3**	**>50**
Buluh Kasap	Segamat	44	68	**Normal**	**Normal**
Bt.2 Sembrong	Segamat	189	346	**15**	**>50**
Bt.77 Sg.Bekok	Segamat	201	445	**20**	**>100**
Sri Medan	Batu Pahat	170	323	**10**	**>50**
Bekok Dam	Batu Pahat	178	440	**12**	**>100**
Ladang Yong Peng	Batu Pahat	139	282	**3**	**>50**
Simpang Renggam	Batu Pahat	142	261	**3**	**>50**
Batu Pahat	Batu Pahat	63	183	**Normal**	**3**
Empangan Sembrong	Kluang	180	373	**25**	**>50**
Layang-Layang	Kluang	123	318	**3**	**>50**
Empangan Macap	Kluang	176	335	**20**	**>50**
Sg. Mengkibol, Bandar Kluang	Kluang	167	414	**8**	**>100**
Ulu Sebul	Kota Tinggi	136	473	**5**	**>100**
Bukit Besar	Kota Tinggi	199	420	**46**	**>100**
Kota Tinggi	Kota Tinggi	205	335	**33**	**>50**
JPS Larkin	Johor Bahru	156	352	**7**	**>50**
Endau	Mersing	296	499	Normal	**6**

Table 4.7: Analysis of Rainfall Return Period for flood of 2006

Rainfall Station	District	Maximum Rainfall (mm)		Return Period (Year)	
		24 hr	**48 hr**	**24 hr**	**48 hr**
Air Panas	Segamat	535	693	**>100**	**>100**
Labis		320	499	**>100**	**>100**
Segamat		288	447	**100**	**>100**
Ldg Chan Wing		257	395	**100**	**>100**
Kompleks Penghulu Chaah		234	419	**100**	**>100**
Buluh Kasap		241	350	30	60
Ladang Yong Peng	Batu Pahat	209	358	90	**>100**
Bekok Dam	Kluang	183	308	15	**100**
Felda Air Hitam		206	327	30	**100**
Layang-Layang		234	300	60	80
Bandar Kluang		314	403	**>100**	**>100**
Sembrong Dam		193	360	50	**>100**
Bukit Besar	Kota Tinggi	197	307	10	50
Ulu Sebol		279	319	80	60
Kota Tinggi		184	229	5	2
Kg.Separa, Skudai	Johor Bahru	225	298	>50	**>100**
JPS Larkin		321	433	**>100**	**>100**
Endau	Mersing	304	339	5	2

Table 4.7: Analysis of Rainfall Return Period for flood of 2007

4.3.3 Flood Maps

The following Figure 4.16 and Figure 4.16 shows the flood map derived from the rainfall of the 2006 and 2007 events.

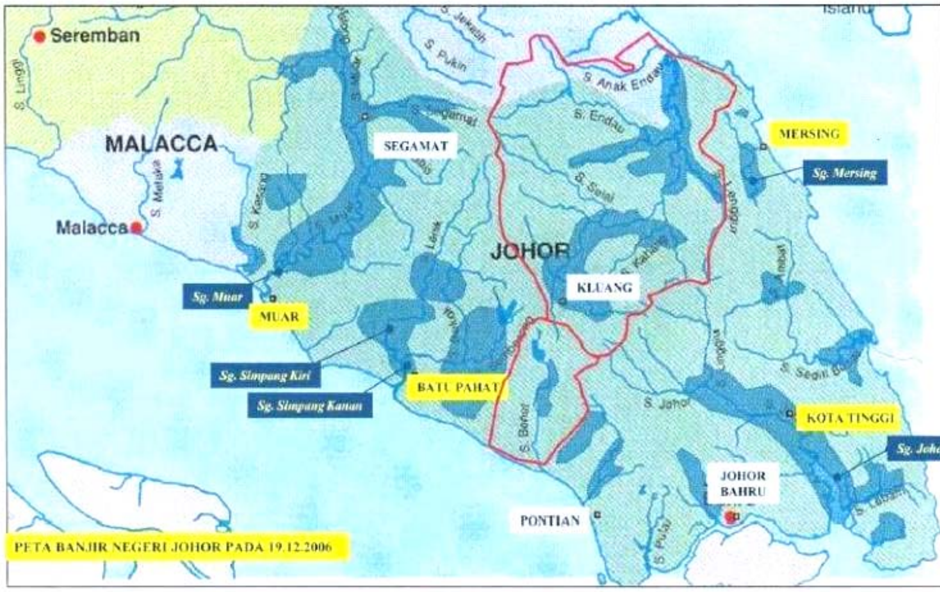


Figure 4.13: Flood map derived from 19 December 2006 floods (DID, 2009)

Figure 4.14: Flood map derived from 12 January 2007 floods (DID, 2009)

4.4 Flow Analysis for Flood of December 2006 and January 2007

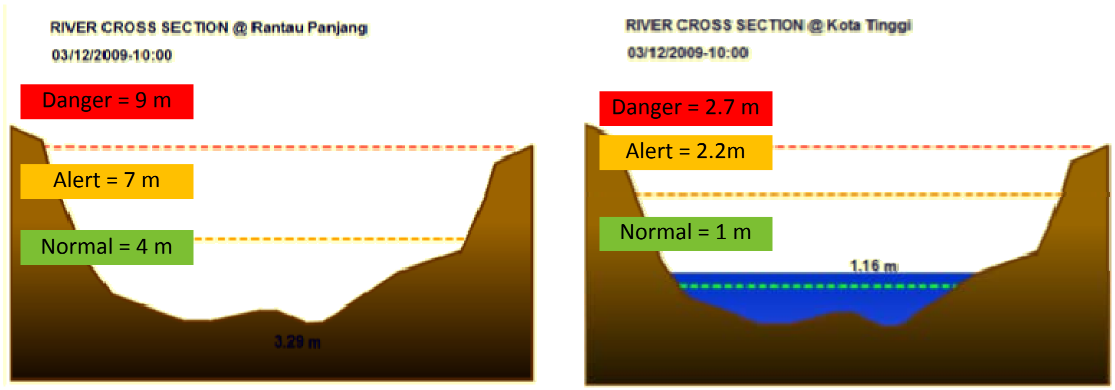


Figure 4.15: Three different levels set for flood management.

Figure 4.12 shows the schematic diagram with three different levels set for flood monitoring and warning. Rantau Panjang station is located in the upper catchment area to cater northwest drainage area with natural drainage setting while Kota Tinggi is located in the city with lined engineered drainage channel to protect the riverbank. The severity of the flood had destroyed most of the stations and data for Phase 2 events could not be recorded for detail study. Both rainfall and water level station at Kota Tinggi were completely destroyed. Figure 4.13 and Figure 4.14 shows the typical cross section for Rantau Panjang Station and the recorded level from December 17, 2006 to December 21, 2006. No data were recorded after the river level reached 10-m deep which possibly caused by the high current that could swept away the instruments or damaged by the floated tree branches. Many data for the second phase of the storm cannot be collected due to damages in the hydrological station from the December flood and funding is prioritized to help the flood victims and other important public utilities and infrastructures.

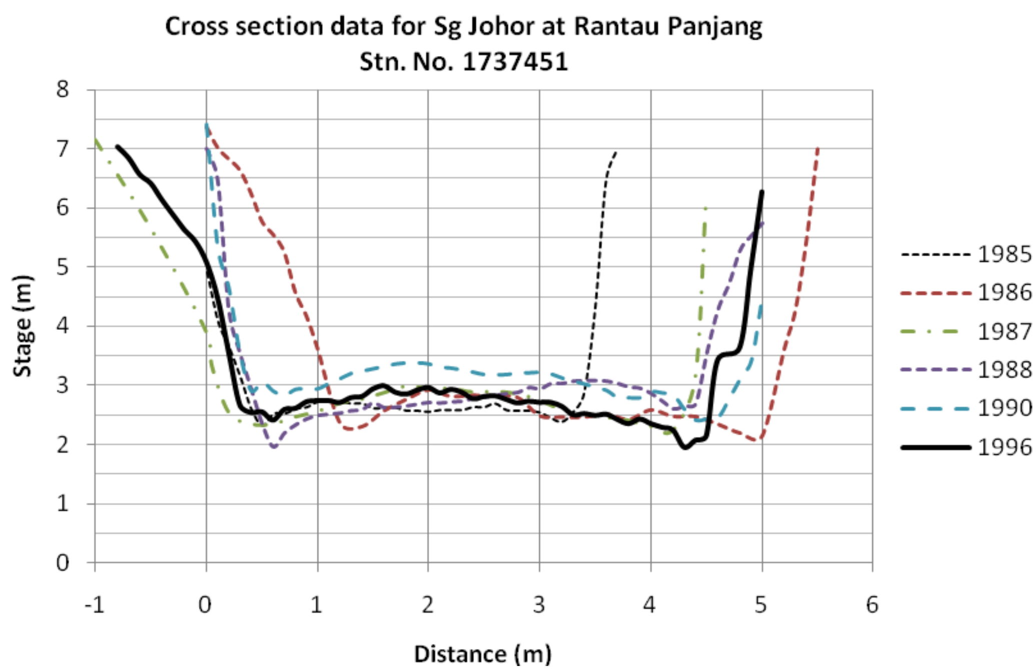


Figure 4.16: Cross-sectional of Johor River at Rantau Panjang depicts a active lateral migration from 1985 -1996

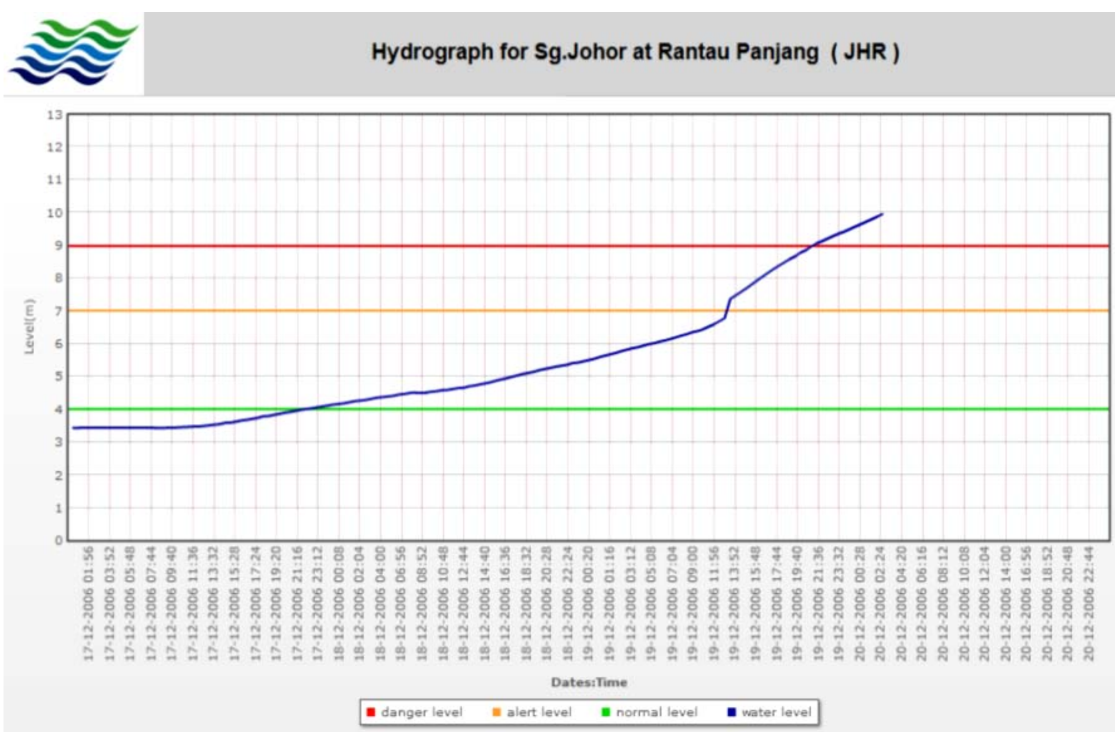


Figure 4.17: Hydrograph of Johor River at Rantau Panjang (1737451). The last data recorded was on Dec. 21, 2006 at 3:00 a.m. before it was destroyed by the flood.

4.4.1 Comparison of December and January Floods

Flood	Maximum River Level (m)	Danger Level (m)	Flood Depth (m)	Flood Depth (ft)
December 2006	5.00	2.7	2.3	7.5
January 2007	5.45	2.7	2.75	9.0

Table 4.8: Comparison of the river stage at station Sungai Johor at Kota Tinggi

Flood	Maximum River Level (m)	Danger Level (m)	Flood Depth (m)	Flood Depth (ft)
December 2006	11.11	9	2.11	6.9
January 2007	12.13	9	3.13	10.2

Table 4.9: Comparison of the river stage at station Sungai Johor at Rantau Panjang

Figure 4.15 shows the tidal effect to Sungai Johor. During the high tides, the typical river level for Kota Tinggi will rise to Alert Level which is about 2.2m and recede to normal level. The continuous rising of river level was worsened when the storms hit during the spring tide with higher rise than usual. During the high tides, the perturbation in the river system had diffused the wave to larger areas and since the slope is relatively flat, the water had nowhere to go and hence the long inundated period.

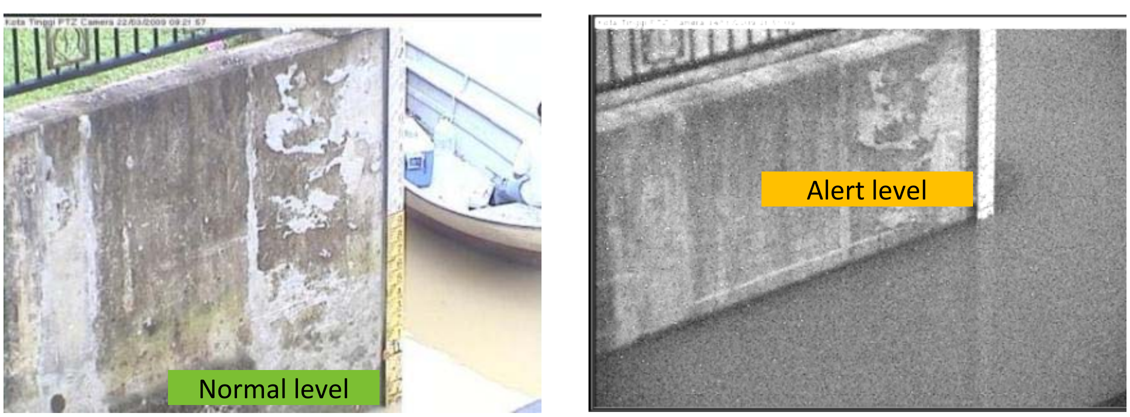


Figure 4.18: Typical normal level during low tides and alert level during high tides

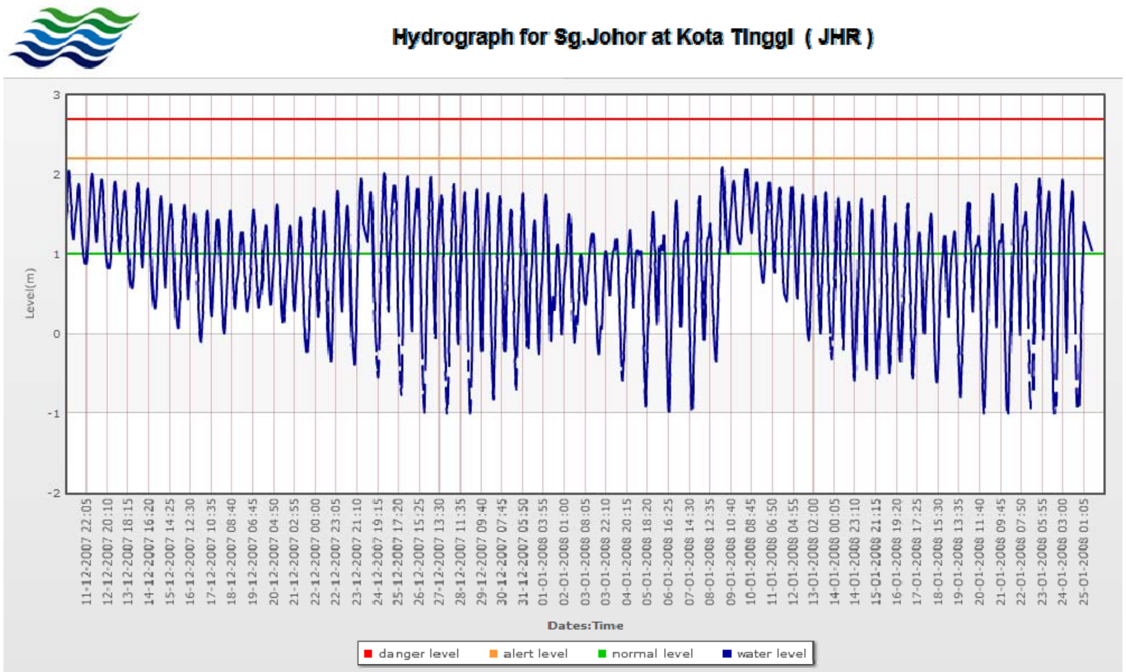


Figure 4.19: Stage hydrograph in normal condition

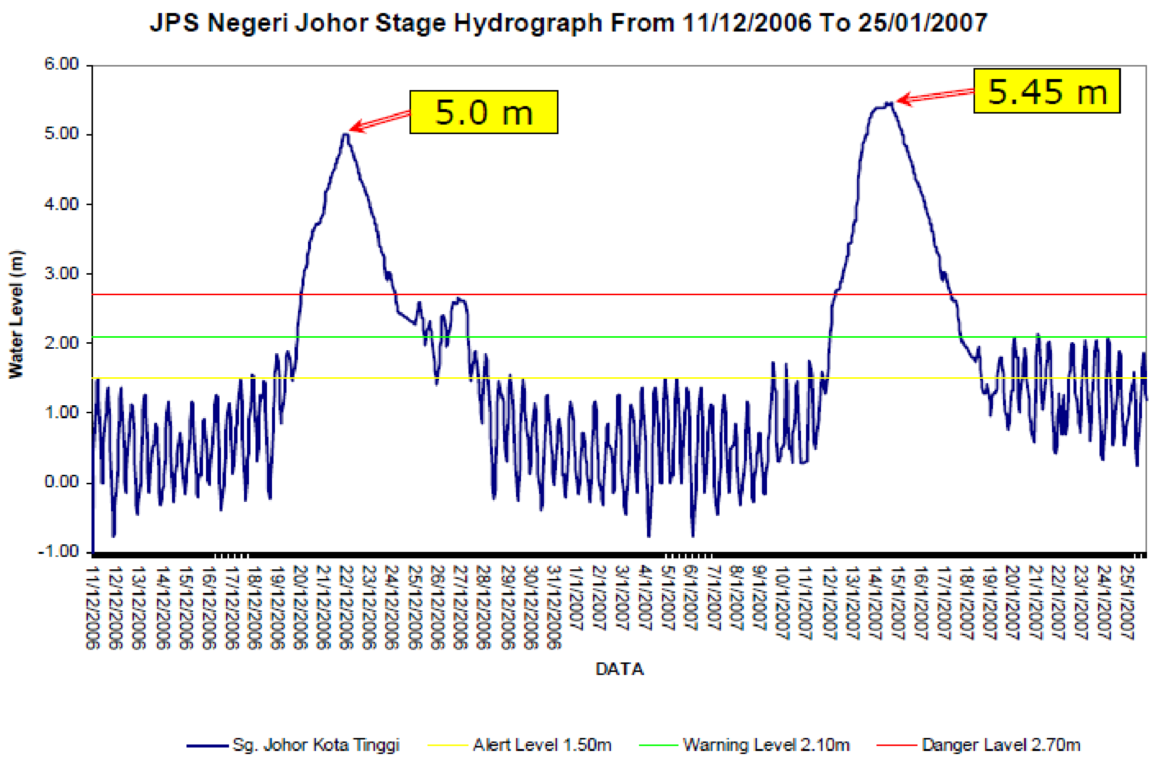


Figure 4.20: Stage hydrograph at Kota Tinggi from December 11, 2006 to January 25, 2007

CHAPTER V

FLOOD IMPACT AND DAMAGES

Flood impact caused by the storm in December 2006 and January 2007 had affected more than 100,000 victims in two separate events. Table 4.8 and Table 4.9 in Chapter IV shows flood depth in the upper stream at Rantau Panjang and in Kota Tinggi both exceeding 6-ft. The flood depth was extremely high with the January flood has higher flood depth about 1-m higher. The standard height for 1-storey building is approximately 10-ft high. The high intensities of the rain had exceeded the maximum capacity of the dam that could help hold some of the excess water. DID have four flood control dams and the Linggiu Dam in Kota Tinggi was contracted to Singapore for the water supply. The flood control dams were designed for 25-year rainfall return period. Both the December 2006 and January 2007 events exceed 25-yrs return period and hence the excess flow must be released for dam safety. The 10-ft flood depth could have been worst without the dams.

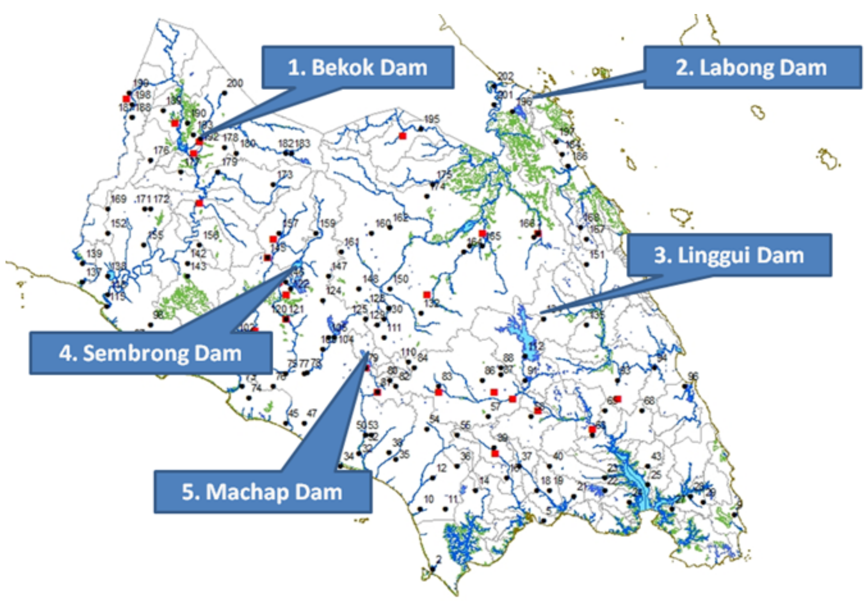


Figure 5.1: Location of the dams in Johor

a) Normal condition

b) Flood on 1968

c) Flood on December 2006

d) Flood on December 2006

e) Flood on January 2007

f) After the flood in normal condition

Figure 5.2 Photos of various flood impact on Kota Tinggi Bridge.
(Photo DID and yazidtim, Panoromio)

The second storm hit on 11 January 2007 with the interval of time of approximately two weeks after the December rains and less than a week after the flood subside. The soil moisture from December flood had not completely dry and the groundwater storage is fully recharge from the previous flood leaving the ground is highly impervious which yields higher flood depth. The photos taken on the affected areas shows most of the first storey building were completely submerged.

a) 21 December 2006

b) 12 January 2007

c) 13 January 2007

d) 19 January 2007

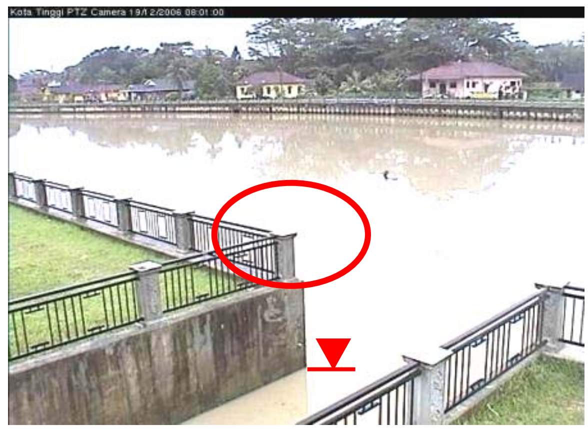
Figure 5.3: Comparison of flood of December 2006 and January 2007 with the past 59 years of flood in January 1948 (Photo DID and yazidtim, Panoromio)

The above photos show the flood level marked in 9 January 1948. The December flood event had reached about the same level on 21 December 2006, about 58 years later while the January flood exceeded the level with an additional depth of 1.5- 2-ft

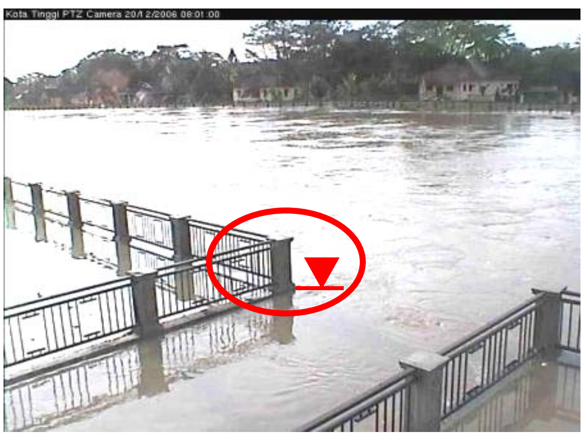
5.1 Damages to Hydrological Station

Rainfall station was installed close to the ground and with the extremely high flood depth most of the sattions has been destroyed. Figure 5.4 shows thechronology of the level rising from 18 December to 21 Decmber 2006. Photo d) taken on 21 December 2006 was the last photo captured before it station was damaged by the flood.

a) 18 December 2006, 2:56 p.m.



b) 19 December 2006, 8:01 a.m.



c) 20 December 2006, 8:01 a.m.

d) 21 December 2006, 8:16 a.m.

Figure 5.4: DID Web camera at Kota Tinggi station shows various river level. tides based on the tidal effect near Johor estuarines downstream

5.2 Damages to Structures

The strong current had swept away structures, eroded the banks causing piles of debris and masses of garbage that clogged and causing the flow obstruction. Many flood structures built to protect public properties and agricultural areas were destroyed and failed to protect the properties on the second storm. Most of the structures were designed to withstand 25-years return period since the area used to be rural with scattered residential. The designed for urban areas is 100-year return period. The January 2007 flood was more than 100-years return period.

a) Flood wall swept away by the current

b) Eroded bank affected the adjacent road

c) A bridge completely destroyed

d) Another bridge also was swept away

Figure 5.5 Pictures of the after effect of flood disaster of 2006 and 2007

During the flood, many structures has been totally submerged and some basic facilities like hospital, police department and fire department also affected. Precautions should be taken seriously when there is inflammable structures or properties around that could cause fire. Unwanted collision during the flood could cause fire. A good example happened in the Fort Collins Flood of 1997 where the train track crossing the creek derailed due to the strong current and causing an explosion to the nearby liquor store causing fire. This is the case where the unexpected could happen during the disasters. The 1997 Fort Collins flash floods claimed 5 fatalities with 54 people injured and 200 homes destroyed and it flooded a creek that you can step over most of the time (Stafford, 2007).

Figure 5.6: A Poudre Fire Authority firefighter stands in the midst of the natural disaster that was the Spring Creek flood in the photo taken July 28, 1997. The trailer park pictured was completely destroyed by the water and flames that occurred.
(Rocky Mountain Collegian, August 2007)

Figure 5.7: Gas station could be exposed to the risk of fire from flood pressure

Figure 5.8: A bursting pipe due to water pressure near Kota Tinggi Bridge. The pressure could easily be approximately 25kPa for flood depth of 2.5m ($P=\rho gh$)

5.3 Damages to Road

The wide coverage of Rubber and Palm Oil plantation contributes to high sheet erosion due to low resistance provided by the almost bare ground. The native plants either a full mature forest or low shrubs which provide high resistance has been replaced with commercial plants for source of income. However, during the flood this plantation area has turned to an open field and caused massive sheet erosion. The plantation has given the space for the floodwater to flow freely with extremely strong currents creating a temporary river to channel the water to lower areas cutting through approximately 1.5m.

a) Strong current in Palm plantation

b) Cutting through the road

c) Public cleared the unstable ground

d) The current broke the accessibility

Figure 5.9: Strong flood current in the low ground resistance of Palm Oil Plantation

5.4 Damages to Private Properties

When disaster strikes, public are the most vulnerable to impact and damages by the disaster. The flood has destroyed many homes and put down businesses causing depression among the victims. Many victims suffered severe trauma due to the properties damage and loss. It is uncommon in Malaysia to insured the properties for natural disasters and the destruction left the victims helpless with insufficient financial supports. The funding assistance from the Government usually is limited due to other needs in refurbishment and major repair of public infrastructures.

a) A house was destroyed and swet away

b) Piles of furnitures swept by the flood

d) Shopping mall and electronic stores

e) Commercial building and apartments

Figure 5.10: Damages to private properties

5.5 Estimated cost of repair

The two main agencies in civil engineering are Public Work Department (PWD) which mainly responsible for public infrastructures such as roads and bridges and Department of Drainage and Irrigation (DID) which is responsible to all structures related to water control and management. PWD estimated cost to repair the road and the bridges was RM147 million (USD43.6 mil.) and DID estimated about RM260 million (USD77 mil.) to replace hydraulic structures.

No.	District	Federal Road (RM)	State Road (RM)	Total Cost (RM)
1	Johor Bahru	1,100,000	6,960,000	8,060,000
2	Muar	2,700,000	9,260,000	11,960,000
3	Batu Pahat	400,000	13,200,000	13,600,000
4	Segamat	7,470,000	800,000	8,270,000
5	Kluang	2,637,000	1,380,000	4,017,000
6	Pontian	80,000	1,000,000	1,080,000
7	Kota Tinggi	8,227,347	0	8,227,347
8	Mersing	4,930,000	0	4,930,000
	TOTAL	**27,544,347**	**32,600,000**	**60,144,347**

Table 5.1: Estimated cost for road repair excluded the emergency road repair and bridges

No.	District	Phase I (RM)	Phase II (RM)	Total Cost (RM)
1	Mersing	1,130,000	1,449,000	2,579,000
2	Batu Pahat	23,436,400	39,886,700	63,323,100
3	Kota Tinggi	2,018,000	38,932,500	40,950,500
4	Kluang	2,104,000	37,600,000	39,704,000
5	Pontian	3,489,900	5,859,420	9,349,320
6	Muar	4,262,500	9,998,500	14,261,000
7	Segamat	27,376,000	1,419,000	28,795,000
8	Johor Bahru	28,797,500	21,800,000	50,597,500
9	Hydrological Station	-	10,000,000.00	10,000,000.00
TOTAL		**92,614,300**	**156,945,120**	**259,559,420**

Table 5.2: Estimated cost for hydraulic structures under DID

5.6 Flood Victims

District	Relief Shelters	Family	Total Victims	Victims by Gender and Age					
				Adult		Children		Baby	
				(M)	(F)	(M)	(F)	(M)	(F)
Johor Bahru	48	2,373	11,724	1,920	1,953	1,021	986	84	83
Muar	126	6,432	30,287	10,471	10,510	3,851	3,521	498	416
Batu Pahat	118	5,419	25,097	7,032	7,225	3,444	3,188	521	388
Segamat	72	2,442	10,286	2,416	3,444	1,209	1,025	179	102
Kluang	70	3,147	13,828	4,423	4,549	1,359	1,803	154	106
Pontian	34	827	3,756	1,197	1,254	622	607	42	39
Kota Tinggi	36	1,165	5,243	1,748	1,811	734	712	125	113
Mersing	10	286	1,297	392	441	202	202	28	32
JOHOR	**514**	**22,091**	**101,518**	**29,599**	**31,187**	**12,442**	**12,044**	**1,631**	**1,279**

Table 5.3: Number of flood victims in **December 2006** flood for State of Johor

District	Relief Shelters	Family	Total Victims	Victims by Gender and Age					
				Adult		Children		Baby	
				(M)	(F)	(M)	(F)	(M)	(F)
Johor Bahru	43	3,133	15,229	2,347	2,069	1,087	1,037	93	145
Muar	26	979	4,233	1,357	1,391	652	689	86	58
Batu Pahat	164	12,704	55,282	18,814	19,118	7,888	7,414	1,267	948
Segamat	34	2,314	8,748	3,132	3,157	1,186	1,055	140	107
Kluang	59	4,737	19,210	6,335	6,365	2,259	2,014	237	189
Pontian	37	1,339	5,583	1,934	2,000	741	764	85	59
Kota Tinggi	44	2,488	11,482	3,867	3,845	1,516	1,421	260	222
Mersing	20	1,053	4,517	1,495	1,591	665	590	92	101
JOHOR	**427**	**28,747**	**124,284**	**39,281**	**39,536**	**15,994**	**14,984**	**2,260**	**1,829**

Table 5.4: Number of flood victims in **January 2007** flood for State of Johor

Number of fatalities until January 17, 2007 = 15 confirmed (DID,2007)

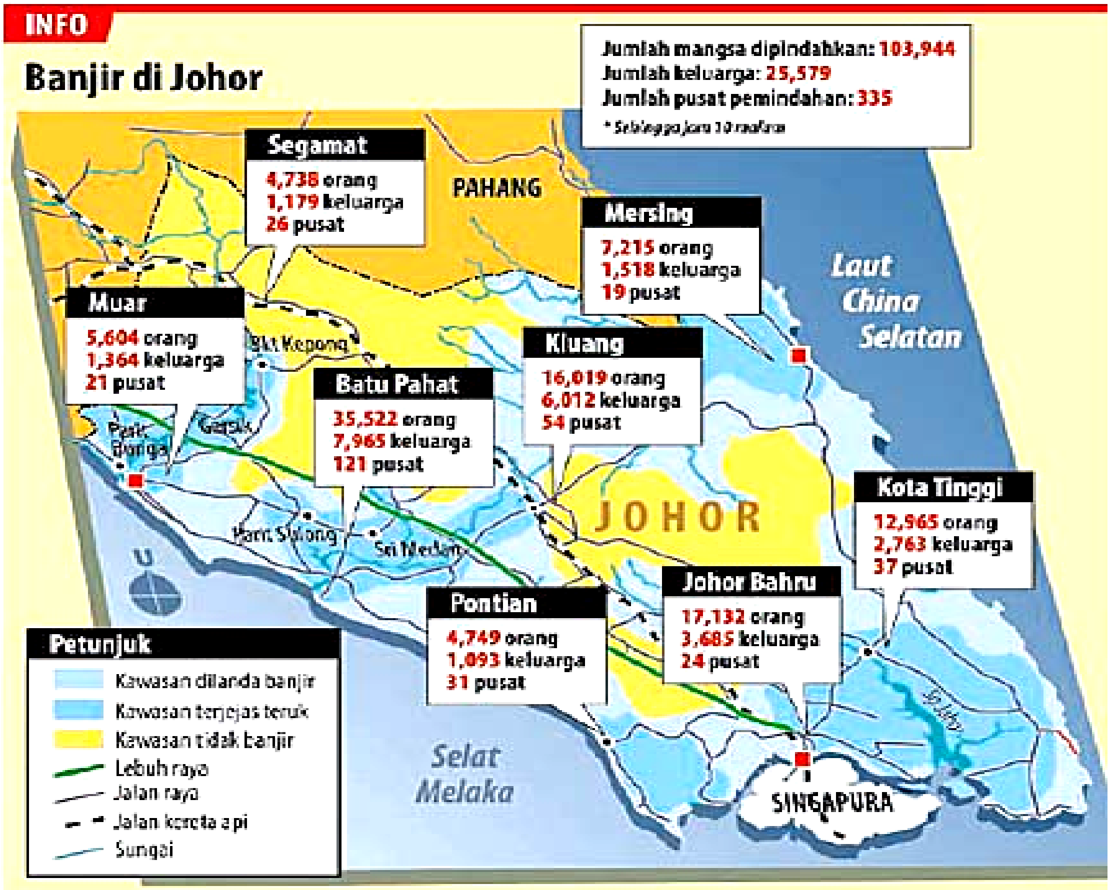


Figure 5.11: Number of victims on the December 2006 Flood

CHAPTER VI

FLOOD HAZARD MANAGEMENT IN MALAYSIA

> *"Better decision-making, improved planning, effective risk management, innovation in development and environmental protection activities – these are the human activities that can reduce the vulnerability of communities. To this end, risk assessment and disaster reduction should be integral parts of all sustainable development projects and policies."*
>
> *Kofi Annan, United Nations Secretary-General*
> *http://www.unwater.org/downloads/wwdr2_ch_10.pdf*

Flood hazard management is one of the most important fields that incorporate the engineering principles, theories and design as well as environmental protection and planning measures within the floodplain and flood prone areas adjacent to. In principle, the objective of flood hazard management is to minimize the impact of flood disasters to people and property through emergency preparedness. The approaches include but not limited to curative measures, preventive measures and flood emergency response.

6.1 DID Roles in Flood Management

Department of Irrigation and Drainage Malaysia (DID) is the lead Government agency responsible for flood management in Malaysia. DID was formed in 1932 providing services in engineering designs and management for agricultural areas during British colonialism. In 1971, following big floods in Kuala Lumpur, the function has been expanded to include urban and rural areas. Since then, DID have expanded its roles and growing strongly in the water resources management. Today, DID roles and responsibilities encompass hydrology, river management, flood mitigation, coastal management and stormwater management.

Figure 6.1: Kuala Lumpur Flood of 1971 (DID)

Figure 6.2: Kuala Lumpur Flood of 1971 (DID)

6.2 Risk Management and Uncertainty Concept in Disaster Management

Classical definition of risk, *R* is defined as the probability of the event exceeding the certain limit proportional to its impact and consequences, *C*.

$$R = P(X > x_d)C$$

The risk can be redefined when a certain protection is imposed to minimize the consequences which decrease the vulnerability, *V*. A system with the 100% effective protection will have zero vulnerability and therefore the risk will be in complete control.

$$R = P(X > x_d)(1 - P_i)C$$

where,
R = *Risk*
P = *Exceedance probability (disaster)*
P_i = *Exceedance probability (protection breach)*
C = *Consequences*

In principal, risk management comprises of determination of threats, mitigation of vulnerabilities and minimizing the consequences. The threats here can be translated into many possibilities based on the subject of interest which in this case will be flood and its chain impact. Vulnerability is subject to infrastructures like building, hospital or dam which will be most vulnerable to the threats. The consequences involves losses and damages in economic, social, political stability and environmental aspects..

Over the long term, flood damages are mitigated through flood-risk management, which relies on estimates of the risk of flooding (Morss et al.) and the risk analysis are subjected to uncertainty. The estimation evidently has several uncertainties that could be due to measurement errors, sampling errors, parameter uncertainties or many other contributing factors intrinsically as well as extrinsically. Flood risk management is simply the art of protection by planning to manage and minimize the existing flood risk. The operational structures of risk management involves several stages described by Eikenberg, 1998 .

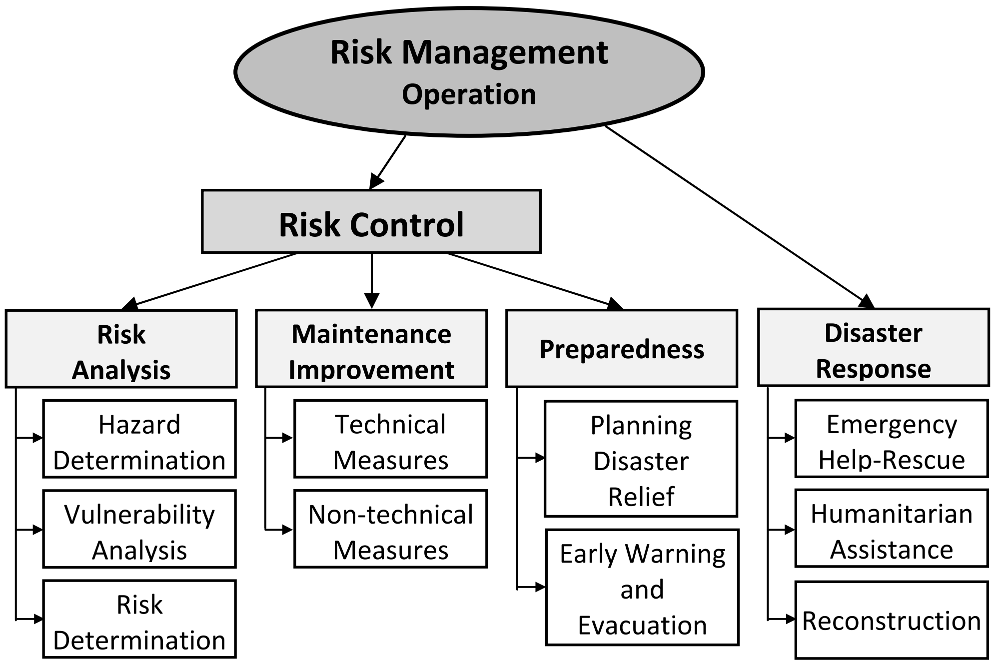


Figure 6.3: Operational risk management, adapted from Eikenberg (1998), (Plate, 2002)

6.3 Flood Management Approaches

DID has been long known to focus on structural flood mitigation measures over the past 40 years in the form of installation of structural works to tackle the most vulnerable areas within the limited floodplain corridors . The physical approach however is inadequate due to the rapid urbanization within the river corridors which resulted in the increasing number of illegal settlement along the river reserves. In the year 2000, with more awareness on the importance of flood management and more funding from the Federal government, DID has broaden its approaches to be more environmental friendly. The introduction of Urban Stormwater Management Manual (*MASMA*) marked the new era for better stormwater management in Malaysia by regulating that the post excess flow of a new development should be equal it's pre-condition by application of retention and detention ponds.

Figure 6.4 : Typical retention pond built in the residential areas (DID, 2005)

Figure 6.5 : Typical retention pond built for recreation (DID, 2005)

Over the years, with better funding and investment, DID has managed to developed better Flood Forecasting and Warning System (FFWS) to serve the public in vulnerable areas and those who will directly or indirectly possible to the risk. Today, the FFWS encompasses the traditional telemetric siren in the high risk areas to mobile text messages. In 2003, DID have started the construction of Stormwater Management and Road Tunnel (*SMART*) to minimize the flood impact to its capital city, Kuala Lumpur which located in the confluence of two rivers. SMART was built to mitigate the flow from the northeastern catchment by diverting large volumes of flood water from entering this critical stretch via a holding pond, bypass tunnel and storage reservoir. The tunnel is designed to divert the excess flow during the storm and as traffic bypass during the normal conditions.

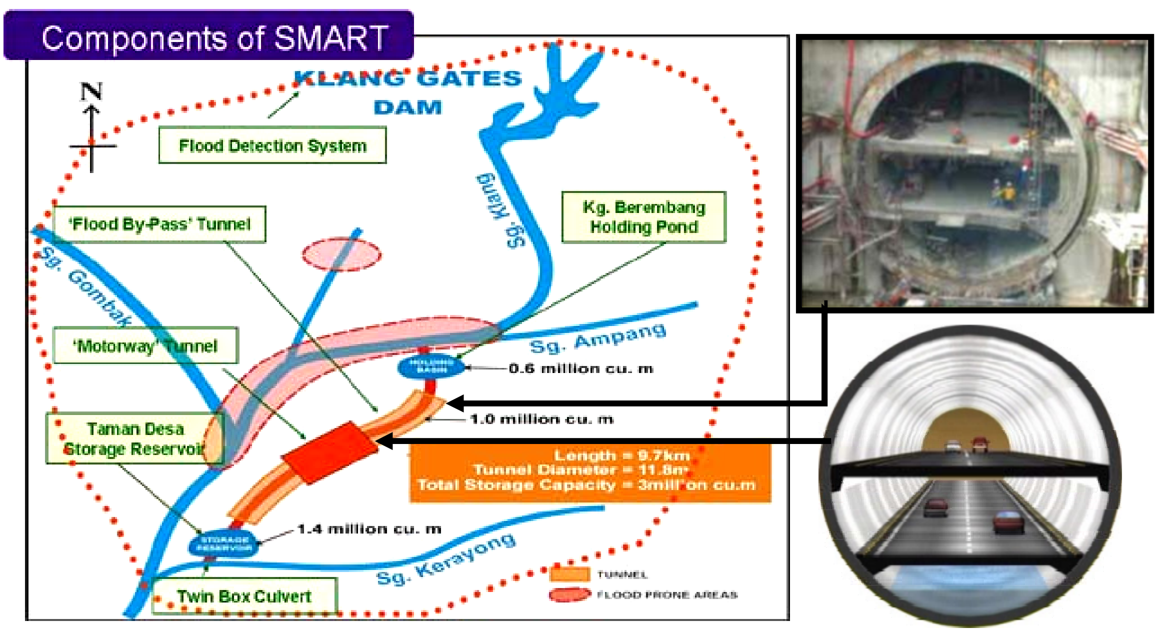


Figure 6.6: Flood management in urban areas (DID, 2007)

The introduction to urban rainwater harvesting system for buildings and small communities promotes public participation and increase the public awareness on flood risk and environmental conservation. More study and funding are also allocated to produce flood hazard mapping and flood risk map to areas with high risk of flood. The recent design of flood mitigation structures has comprises more environmental friendly approaches to incorporates the biodiversity in the ecosystem by restoration and rehabilitation approaches rather than the hard engineering approaches. The combination of engineering and preservation of natural zones towards more balance approaches is known as Integrated Flood Management (IFM)

6.4 Integrated Flood Management (IFM)

The 2006 and 2007 Floods in Malaysia had given a new definition for flood preparedness and emergency in the improvised approach known as Integrated Flood Management (IFM). IFM is a new concept as opposed to the traditional flood management measures that focus only on reducing flooding and reducing the susceptibility to flood damage. IFM is the process of promoting an integrated approach to flood management incorporated into the Integrated Water Resources Management (IWRM) aimed at maximizing benefits from the use of floodplains without compromising on sustainability of the vital ecosystems (DID Manual, Vol. 3, 2009). Global Water Partnership (GWP) defined IWRM as a process which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital eco-systems.

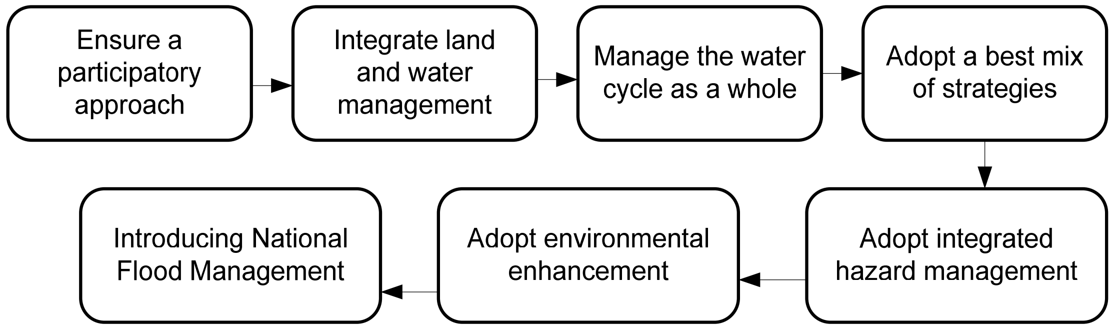


Figure 6.7: Schematic Diagram of Components of Integrated Flood Management

The IFM is defined as a process that promotes an integrated, rather than fragmented, approach to flood management. It integrates land and water resources development in a river basin, within the context of integrated water resources management (IWRM), and aims to maximize the net benefit from floodplains and to minimize loss to life from flooding.

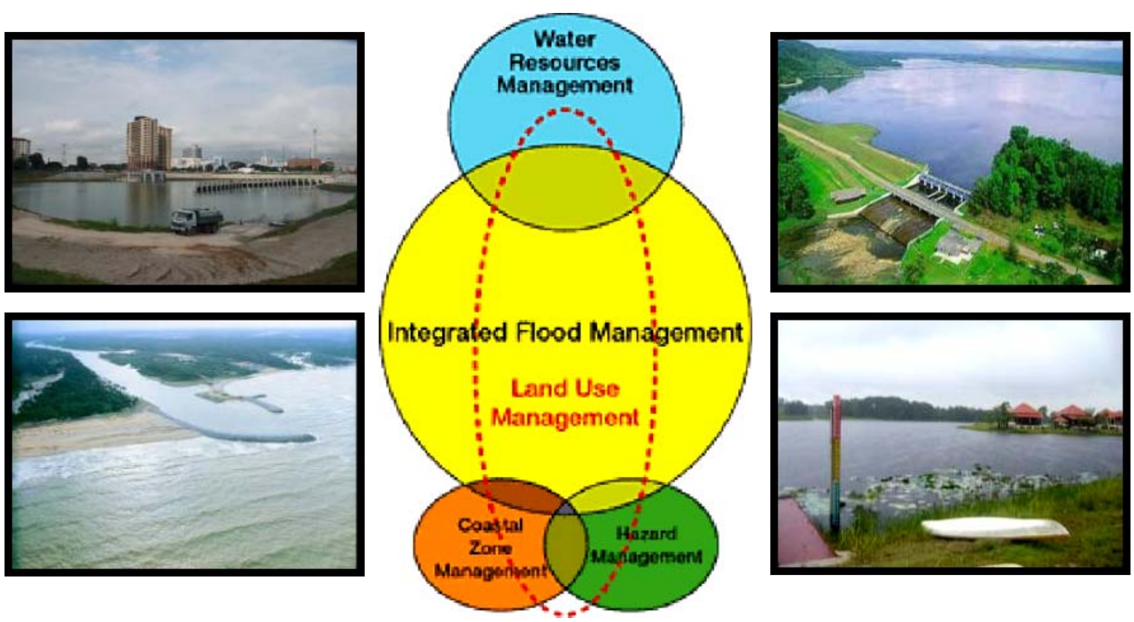


Figure 6.8: Integrated Flood Management (IFM)

6.5 Structural Measures

Structural measures in flood management system refers to a choice of solution to flood problems and issues by installing structures and implementing physical improvement works directly related to the cause of flooding (DID Manual, Vol. 1, 2009). This approach is the most preferred approach by the engineers and also known as the hard engineering approach. The structures are rigid to the ecosystem but usually design to tackle and solve the pressing problem to save human and valuable properties.

The following are the curative measures approach in Malaysia flood mitigation structures:

i.) Regulate Water Level:
~ *Barrage, tidal gate, flap gates, lock*

ii.) Store and controlled release of flood water:
~ *Dam, reservoir, detention and retention ponds, bund, inlet and outlet and spillway*

iii.) Improve flow efficiency and controlled flows:
~ *River channelization, improvement works, flood wall, weir, control gate, culverts*

iv.) Re-route the flood flow:
~ *River diversion, diversion channels, flood bypass (open channel and tunnel), intake structures, bridge and culvert*

v.) Forced removal (non-gravity flow) of excess water:
~ *Pumps, pump house, inlet and outlet structures*

vi.) Delineation and separation:
~ *Polder, ring bund, linear bund*

a) Tidal barrage

b) Tidal gates

c) River channelization and levee

d) Flood wall along the channel

e) Pumping stations

f) Debris removal system

Figure 6.9: Examples of the structural approaches in Malaysia

Figure 7.9 depicts the engineered approaches with usually involves expensive funding and can only be provided by the government or through collaboration projects with private funding known as Public Finance Initiative (PFI) through Public-Private Partnership (PPP).

6.5.1 Traditional structures control

The early settlements of Malaysia were concentrated in the riverine and coastal areas where source of water is near and abundance and the only means of transportation is accessibility through waterways which is the rivers. Traditional houses were built elevated to adapt the natural flood occurrences. The indigenous houses in Borneo islands and Malay houses had been built to adapt the lifestyle living in the floodplains.

Figure 6.10: Traditional Kedah house (Kedah Public Library)

Figure 6.11: Traditional raft house in Rompin with sampan or Malay canoe (UUM)

Figure 6.12: Modern stilt house (DID, 2007)

However, due to modernization of lifestyle and rapid development, the preferences for elevated houses are replaced with modern building and in urban areas with multi-level apartments and condominiums. Over the years, the change in landuse has contributed to more severe floods impact and damages that affect the urbanized areas worst than the rural. The traditional of elevated and floating houses should be taken into considerations for future residential designs in flood prone area. Netherlands with its ultra sensitive to climate change and rising sea levels had designed modern floating houses to adapt with the increasing sea levels and instead of driving out the water, they blend in their lifestyle with nature.

Figure 6.13: Flood impact in elevated houses and modern houses (DID, 2007)

6.6 Non-Structural Measures

In the light of the event, the Government had a first-hand experience on massive flood responses that involve three states simultaneously to help public coping with disaster. Guidelines, manuals as well as rules and regulations has been reviewed and refine. The public as well as insurance provider could see the benefits for natural disaster insurance to protect the properties. Following the events, the public awareness on flood risk had increased and public become more alert on the risk living on the floodplain and perhaps could see why earlier settlements built the house on silt. The advantage of the awareness to DID is that it helps to justify the pending approval proposing the needs to gazette the floodplains and riparian zones along the river corridor which is often be seen as a commercial opportunity to some private organization.

Non-structural measures for flood mitigation involves planning, programming, setting policies, coordination, facilitating, rising awareness, assisting and strengthening the society to face the threats and impacts of floods. It also covers educating, training, regulating, reporting, forecasting, warning and informing those at risks including insuring, assessing, financing, relieving and rehabilitating (DID, 2009).

In general, non-structural measure is any approach that not involving the construction of the physical measures. The non-structural measures usually is used to complement the limitation by structural measures by means of legal agreement, guidelines, laws and regulations, policies or simply by training and awareness through educational programs in multiple level based on the target groups. Manuals such as Urban Stormwater

Management Manual (MSMA) and Erosion and Sediment Control Plan (ESCP) are developed to regulate the development in the watershed as part of IWRM and IRBM.

The following are the non-structural measures in Malaysia:

i.) Floodplain management

ii.) Flood hazard mapping

iii.) Landuse Planning and Zoning

iv.) Flood Proofing

v.) Flood Forecasting and Warning System

vi.) Flood Response

vii.) Flood Damage Assessment

viii.) Flood Insurance

Following the disaster, the urgencies to generate Flood Hazard Mapping (FHM) becomes pertinent as the insurance coverage plan will be based on FHM. Before this, locals are skeptical about having their properties insured for natural disaster as this means paying additional expenses. However, with the level of severity that occurs especially in the low-lying areas, the insurance might be a good option. The FHM is useful for the authorities to map out the emergency response for relief shelters and improve flood preparedness. The map will act as a tool to guide any future development in the flood prone areas and the necessary measures to control the risk.

Nevertheless, in most rural areas where the locals barely make a decent living, the Government should improve flood protection infrastructure and imposes soft-engineering measures such as flood retention pond, swales and other environmental friendly designs.

Some percentage of lands could be allocated for recreation parks and natural areas that will be a multi purpose infrastructures. The natural area preserved along the river could be transformed to a wetland that eventually will enrich the local plants and wild habitat and improve the quality of the environment. During the wet season, this areas could soak up the water and provides additional storage and hence minimizing the flood impact without sacrificing the environment. There are many succesfull rehabilitation measures that could be adopted to suit Malaysian climate and rainfall pattern. These measures should be studied and altered to meet local environment and conditions. A pilot project could always be carried out in order to find the BMPs in dealing with extreme tropical floods. The best way is to figure out the underlying source such as lack of control in landuse development such as mining activities in the rivers, housing development in the floodplain without providing ample storage for excess water or inadequate drainage infrastructures in the floodprone areas.

6.7 Flood Response and Emergency

The operation of the flood response and emergency involves three levels in Malaysian governmental system which is federal, state and district. All the committees are directly under the office of Deputy Prime Minister manage through Department of Security. In the federal level, CCDNR is chaired by Deputy Prime Minister and hence the committee members consists of secretary general, inspector general of police, army general, finance minister, national unity and social development minister and head department from relevant agencies like DID, Malaysian Meteorological System, Department of Mineral and

Geosciences etc. In general, all public defense and public works agencies are involves in all level.

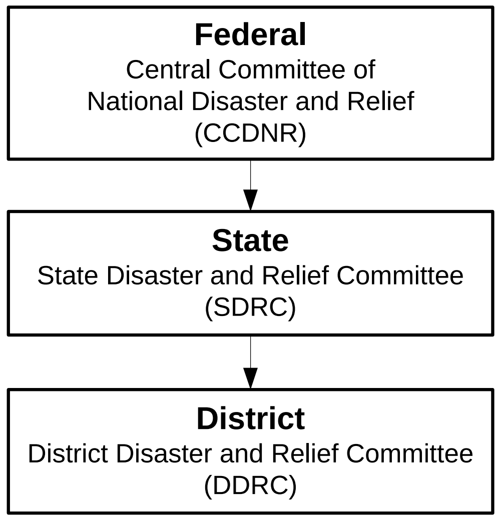


Figure 6.14: Structure of National Disaster Management

The DID Headquarters Operation Room will start operating once the river level exceeds the danger level. Otherwise, the situation can be controlled by State level. However, in higher risk areas such as in the east coast of Peninsular Malaysia, the Flood Operation Room in Ampang, Kuala Lumpur will be operating 24-7 in the monsoon seasons.

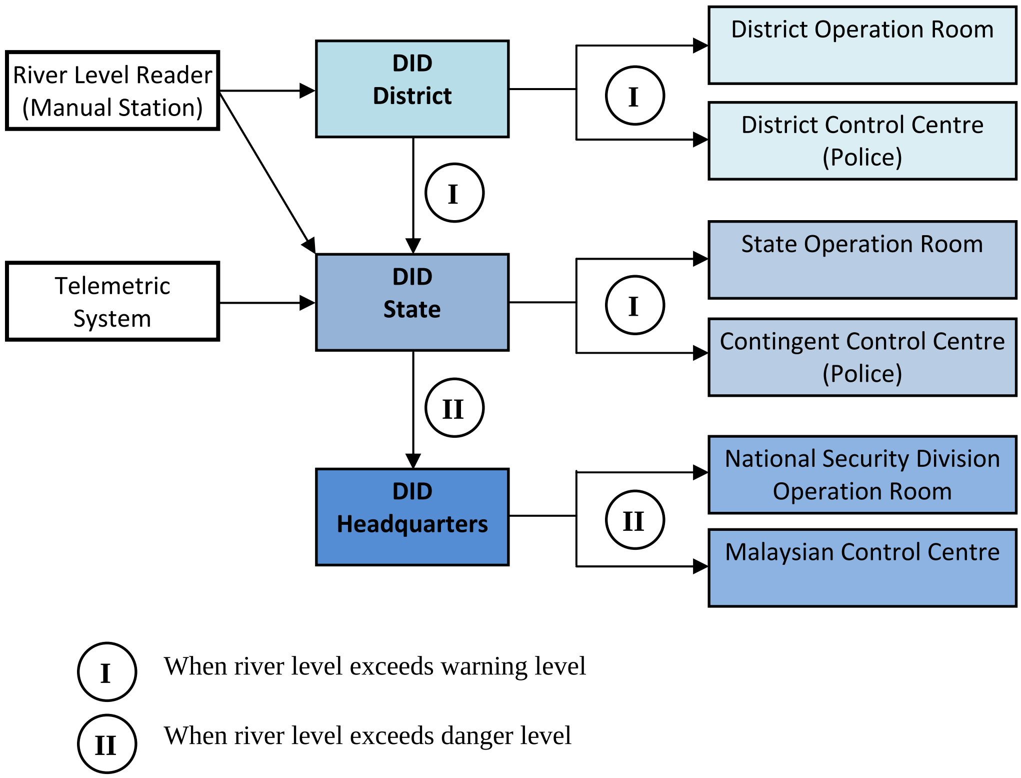


Figure 6.15: DID standard operation on dissemination of current river level information

Figure 6.16: Flood Emergency Response leads by the Army and Public Defense Services were out to rescue the victims. Some of the residents will not leave the house in early stages of the flood and many insist to stay and protect their properties.

The Army helped with the food distribution   Food storage and basic needs for the victims

Figure 6.17: Flood Emergency Response leads by the Army and Public Defense Services

6.8 Other Control Systems

In lights of the 2006 and 2007 floods, other critical areas should be looked into thoroughly to minimize the impact of the disaster to public properties as well as private properties. There are many places that is still open for improvement to impose regulations and control . There are newer technologies as well in Information Technology (IT) to provide state of the art tools to assist the overall management systems.

6.8.1 Protection of Agricultural Zones

The January 2007 floods had destroyed acres of agricultural areas including rubber and palm oil plantation, fisheries and husbandry in the form of profit loss, physical damages and soil fertility due to erosion from the strong current. Department of Agriculture Malaysia had reported loss of RM30 million for Johor flood alone. Rubber Industry Smallholders Development Authority (RISDA) had allocated the financial aid to help farmers replanting with RM7000/acre of loss for rubber and RM4500/acre of loss for Palm Oil. (DID, 2007)

Figure 8.4: Areal view of the inundated Palm Oil Plantation in Johor.

Figure 8.4 shows the needs to protect plantation areas in order to minimize the flood impact and protect the future generated profit from the plants. One of the easy low-cost measures is by providing detention pond for flood storage or swales along the plantation boundary to store some excess water. In general, business driven activities usually will disregard the allocation of land for flood storage while they can utilize the land for profit. However, providing a detention pond for flood storage could save millions and with the current depressing climate, this measure should be taken into considerations. Other approach is constructing flood levee or permeable areas for underground storage.

6.8.2 Sand Mining Control

One of the majopr issues in flood control management is the regulation in sand mining. A good example is the sand mining procedures in Fort Collins along the floodplain. In some suitable location, the floodplain usually have the same sand distribution that could be used for constructions material. Instead of mining in the channel that could caused chain reactions in the river system such as channel degradation, high turbidity due to sedimentation,bank erosion and many other issues, mining on the floodplain in a control techniques could save the river system as well as providing the source to construction materials for the industry. The authorities in Malaysia should look into this approach which proved to be succesfull in the United States. FEMA introduced the zone along the streamline as Erosion Hazard Zone located in the floodplain areas. The concept is as long as it is erodible, with certain requirements, it is fine to excavate and mine the sand in that zone, because it will be eroded eventually so a control mining with the right techniques will minimize the impact to the river system.

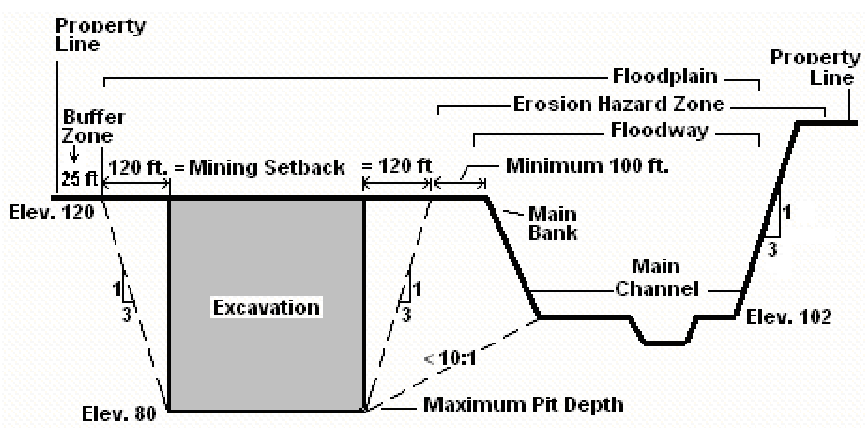


Figure 8.1: Floodplain excavation pit geometry for streamlined floodplain use with permit. Pit is 40 ft deep. (FCD Maricopa, 2004)

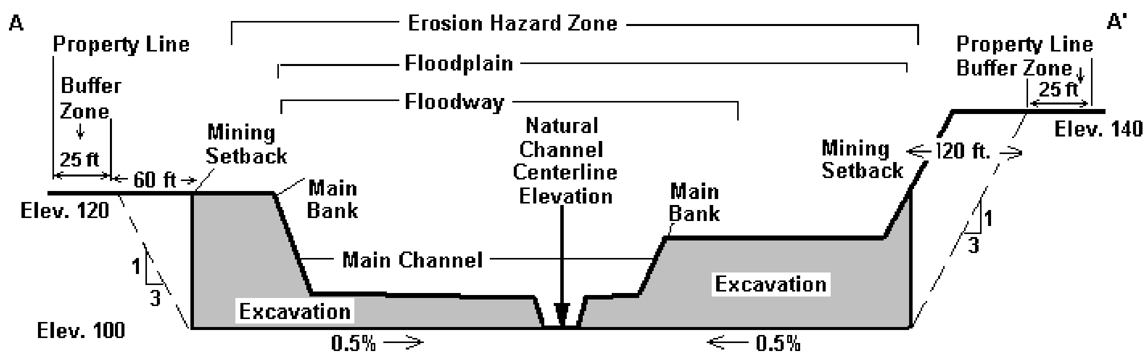


Figure 8.2: Main channel and floodway excavation geometry for streamlined floodplain use permits. Plan view is shown in Figure 8-3. This pit is 20 feet deep (Elev. 120 – Elev. 100). The shaded area marked "Excavation" is the area that can be mined under the streamlined permit process. Material may not be excavated from areas outside the shaded zone unless an engineering analysis is submitted. (FCD Maricopa, 2004)

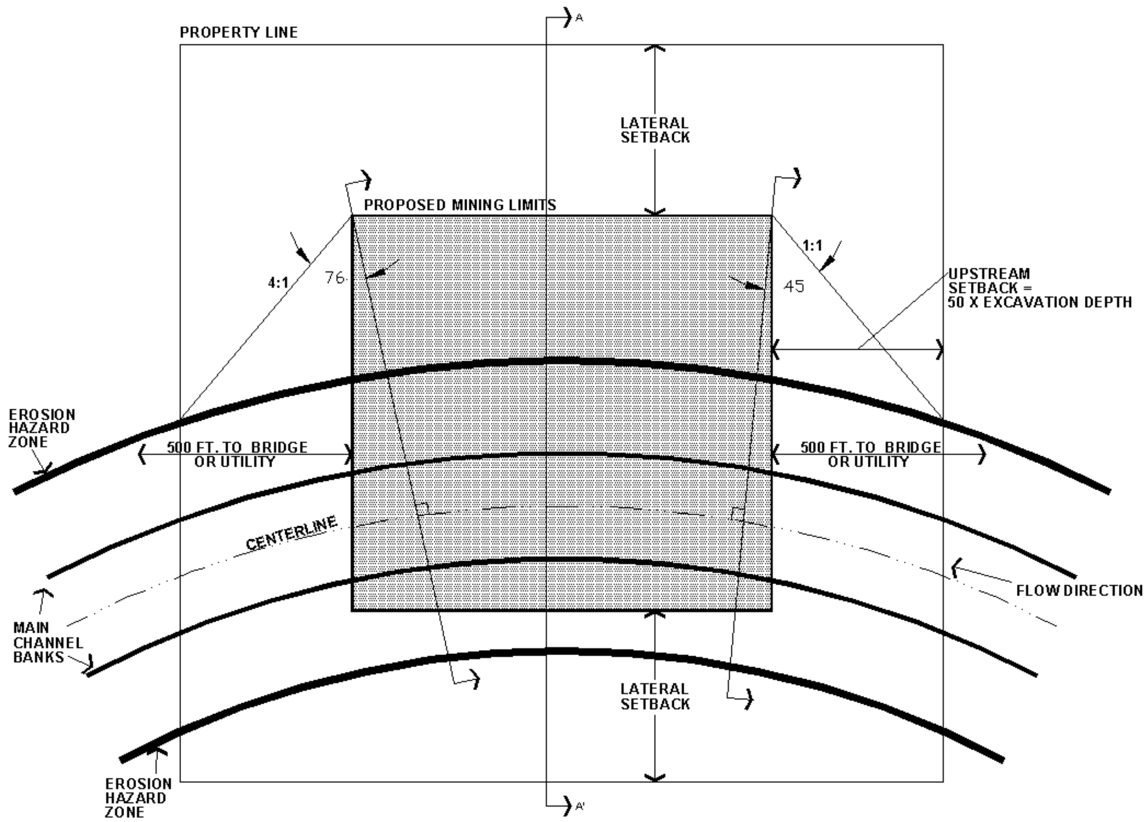


Figure 8.3: Upstream and downstream setbacks from property lines for excavations that extend outside the erosion hazard zone. (FCD Maricopa, 2004)

CHAPTER VII

SUMMARY

Monsoons and the atmospheric circulations coupled with anomalies could bring extreme precipitation events and caused devastating floods to the tropical regions. These catastrophic flood events are poorly understood due to the fact that the events are intricately responsive to the complex hydrological system that involves the atmosphere, surface, subsurface and the dynamic changes caused by continuous human interventions in nature's processes. Many researches are carried out to understand the monsoon effect to flood disaster. (M.A. Makagonova and Garnet, E.R. & Khandakar, M.L.)

In December 2006 and January 2007, the Northeast Monsoon had brings heavy rain through series of storms that caused a devastating floods in the northern region of Peninsular Malaysia particularly to Kota Tinggi, Johor. Kota Tinggi is located at the east of Johor state with 65% of its border is surrounded by the sea in low-lying setting with an area of 3,500 km^2. Kota Tinggi is part of the Johor River drainage area which has a total drainage area of 2636 km^2 drains out to Johor Straits. The catchment receives an average annual precipitation of 2470-mm and the annual discharge measured upstream has been 37.5 m^3/s.

The storms that caused floods of December 2006 and January 2007 was the unusual Northeast Monsoon that blows from South China Sea and West Pacific Ocean. The 2006 storms brought a total of 287-mm of rain in four (4) days recorded in Bandar Kota Tinggi and the 2007 brings a total of 338-mm. The highest total for 2006 was recorded near

Layang-Layang with a total of 367-mm and the 2007 was recorded in Ulu Sebol for 534-mm total. The average monthly precipitation is 200-mm. The 2006 gave an average of 50-years return period while the 2007 storms gave an average of 100-years return period. The flood depth caused by the 2006 storms was 2.3-m (7.5-ft) with highest level recorded by the station is 5.0-m. The bankfull level is 2.7-m. The 2007 highest level is recorded as 5.45-m with 3.13-m (9.0-ft) exceeding the bankfull level.

The flood disaster had caused 101,518 evacuees for the whole state of Johor and about 5,243 victims in Kota Tinggi alone. The second phase of the flood had higher victims with a total of 124,284 in which Kota Tinggi alone was evacuating a total of 11,482 victims. The number of fatalities reported for both storms until January 17, 2007 was 15 confirmed. Victims were placed in schools and public hall with basic facilities that were brought in later by the military and NGO's organization such as Red Cross.

Many public and private properties had been destroyed by the flood. Most of the loss in private property is not insured as flood insurance is not a common practice in Malaysia. The total cost of repair reported by Department of Drainage and Irrigation Malaysia for irrigation structures, pumps, gates, jetty, hydrological stations and others was estimated about RM260 million (USD77 mil.) while Public Works department estimated about RM147 million (USD43.6 mil.) for roadwork and bridges. There were other report of damages that is not included in this report estimated by the hospitals, municipal counties and many other government agencies.

In light of the event, the government tried to find new ideas and approaches to better manage the flood disaster in order to minimize the impact. The new concept was introduced known as IFM, an Integrated Flood Management, which is another sub-division from the larger concept of Integrated Water Resources Management (IWRM). The idea is not to focus only in the hard-engineering approaches like building more flood walls, or flood structures but also to emphasize on the developing public awareness through policy and regulations. It also improves the public information dissemination through a new technology in flood warning system and faster information technology like the text messaging system to public cell phones as additional tools to the conventional siren. The existing structural measures approaches are still relevant but the design has been improved to couple with the information technology to fully utilize both systems for public benefits.

Other issues which are critical to flood risk are the agricultural zone and also the practice of local construction companies in sand mining. The agricultural zone usually don't have a sufficient flood protection as no human being is in higher risk in those areas however the damage to the agricultural zone such as paddy field, livestock and shrimps farm could risk food supplies to human. The sand mining has been proven to destabilize the river system and risk the flood downstream or erosion problem in the upstream.

In conclusion, a flood event can cause series of destruction which is caused by series of factors which human should learn to interact well with the system so that both can thrive and survive in this dynamic and highly sensitive system.

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