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SMART Saves Kuala Lumpur City Centre From Inundation

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Abstract

The City of Kuala Lumpur has been subjected to major floods since 1926 and after the largest recorded flood in 1971, the Department of Irrigation and Drainage Malaysia (DID) has undertaken various projects to alleviate flooding in the city center. Towards the end of the 20th century, the city center frequently experienced flash floods caused by rainfall of very high intensity and duration. Conventional means to alleviate flooding were not effective, so a radical approach was needed, using a combination of holding ponds and a flood bypass tunnel to divert flow from entering the city center.

This gave birth to the idea of implementing the Stormwater Management And Road Tunnel or SMART as it is commonly called. SMART is a unique and innovative project designed to alleviate flooding in the Kuala Lumpur City centre by transferring excess floodwaters from the upper Klang/Ampang catchment away from the city center besides easing the traffic congestion at the southern main gateway to the city centre. It is the first project of its kind in the world to incorporate a motorway component into a 3km stretch of the 9.7 km long storm water tunnel. It is both a flood relief and road tunnel facility in a single structure.

This paper discusses the role of SMART in reducing flooding at Kuala Lumpur City Center from heavy rainfall in the upper Klang/Ampang catchment during two heavy rainfall events in 2011 and 2012 .

Keywords: *Alleviate flooding, ease traffic congestion, innovative project, Klang/Ampang catchment, flood bypass tunnel.*

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1. Introduction

The Stormwater Management And Road Tunnel (SMART) is an innovative project of the Government of Malaysia which consists of a flood bypass system in combination with regulated release. The main function is to mitigate over-bank flow nearby Tun Perak Bridge located at Kuala Lumpur city center by diverting flood flows from entering the city centre at the Klang/Ampang confluence through a bypass system before finally release it downstream of the city.

SMART system consists of a diversion structure, a holding pond, a bypass tunnel, a storage pond and the Flood Detection System. SMART is designed to provide KL with a Q_{100} protection and this required a very large tunnel with internal diameter of 11.8m. During a Q_{100} peak flow, discharge at the Klang/Ampang confluence is 290 cumecs. Flood flows into the city will be reduced by diverting 280 m^3 of flood discharge at the Klang/Ampang confluence into the Kg. Berembang holding pond and allowing 10 cumecs to pass through into the city. The water will fill the pond and when it reaches a certain elevation, it will spill into the bypass tunnel via the bellmouth weir and then stored in the Taman Desa pond before finally released downstream of the city. The point for release is the Kerayong River, about 1.8 km above its confluence with the Klang River. The release is regulated in order to avoid downstream flooding and this action of regulation and release also helps to reduce the storage that would otherwise have been required. The total storage capacity of the whole system is 3 million cubic meters (0.6 million m^3 in holding pond, one million m^3 in the tunnel and 1.4 million m^3 in storage pond at Taman Desa).

Since flooding can happen about 12 to 18 times in a year, most of the days the tunnel will be dry due to no flood diversion. In order to capitalize this factor and for cost effectiveness, a dual purpose tunnel is designed, to alleviate flooding in the Kuala Lumpur City Center and to ease the traffic congestion problem between Kuala Lumpur City Centre and Southern Gateway at Sg. Besi. Hence the name SMART or Stormwater

Management And Road Tunnel. This dual function is designed so that the tunnel can take in traffic when dry and used for flood discharge when the need arises. This dual function also makes SMART the first project of its kind in the world to incorporate a twin deck traffic component into a 3 km stretch of the 9.7 km long storm water diversion tunnel. For safety reasons, the double-deck allows one directional movement of traffic in the tunnel. The lower deck is designed for city bound traffic and the upper deck for traffic leaving the city.

For the safe and efficient use of the dual purpose, we need a system that can pre-warn the occurrence of floods, namely the Flood Detection System (FDS). FDS involves collection, transmission, processing and analysis of data/information to forecast the storm characteristics which dictates the SMART operation modes.

Since its operation from July 2007 until 2012, SMART has dealt with a total of 203 storm events which comprises of 121 numbers of Mode II events, 77 incidences of Mode III, and 5 incidences of Mode IV events. All these modes require excess flood waters to be diverted into the holding pond. Mode IV events is the most severe mode where the whole tunnel will be used to divert excessive flood waters from entering Kuala Lumpur City Center. Only during the Mode III and Mode IV events that the double deck motorway component will be closed to traffic. Altogether there are a total of 81 numbers of tunnel closures with twelve of these events have diverted more than one million cubic metres of flood waters into the SMART system. Without these diversions, Kuala Lumpur city center would have resulted in very serious flood occurrence. Hence this proved the success of its design based on these twelve events that SMART has handled.

Although SMART is designed to provide Kuala Lumpur City Center with a Q_{100} protection, there are two occasions where SMART has operated above its design capacity, namely on 21st May 2011 and 7th March 2012 and hence saved Kuala Lumpur City Center from submergence. This paper will discuss the role of SMART in reducing flooding at Kuala Lumpur City Center from submergence caused by the heavy rainfall in the upper Klang/Ampang catchment during these two events.

2. HOW SMART OPERATES

2.1 Flood Detection System (FDS)

For the safe and efficient use of the dual purpose, we need a sophisticated and modern system that can provide real time flood forecasting information, known as Flood Detection System (FDS). Components of FDS include data collection system, Modeling system, Gate control system, CCTV monitoring system and Communication system. FDS involves the collection, transmission, processing and analysis of data/information to forecast the storm characteristics which dictates the operation of SMART system.

Data comprises of rainfall and water level and these data will be input in real time to the hydrological and hydraulic modeling software to forecast storm characteristic and predict the operation modes (Mode I, II, III and IV) for SMART system within the first hour of storm.

There are twenty two numbers of rainfall stations in the SMART system that covers Sg. Batu, Sg.Klang, Sg. Ampang, Sg. Bunus, Sg. Gombak and Sg. Kerayong catchments. Out of these, only ten raingauges contribute to the catchment immediately upstream from the tunnel intake, namely the Klang and Ampang catchments. As can be seen in the Figure 1, these ten raingauges are much closer spaced compared to the raingauges in the other catchments, thereby minimizing the probability of non-detection of very small, intense rain storms that may occur in the Klang and Ampang catchments.

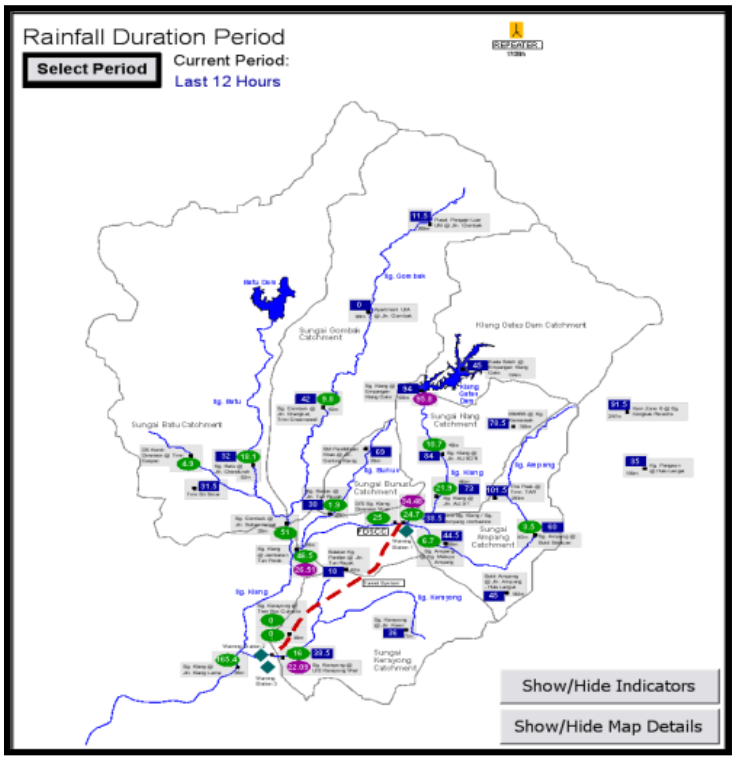


Figure 1 : Location of SMART's Rainfall Stations in Wilayah Persekutuan Kuala Lumpur

The Average Recurrence Interval (ARI) for all rainfall stations was derived from Intensity-Duration-Frequency Curves of JPS Ampang Station No : 3117070.

2.2 Operational Modes of SMART

The objective of implementing these operational modes is to help keep the river stage at the Tun Perak Bridge below the soffit of the bridge and hence prevent flooding in the area.

The SMART system is operated based on the relationship between river discharge at the Klang/Ampang Rivers confluence and the operation status of the motorway. There are four (4) principal modes in the operation of tunnel for the management of flood discharges.

Mode 1 is when the weather is fair with little or no rain and all stormwater flows through the city centre. Diversion is normally not executed as long as the river discharge at the Klang/Ampang Rivers confluence is below 70cumecs. The tunnel will be used for traffic.

Mode II will be activated when moderate rainfall occurs and the flow rate recorded at the confluence of Klang/ Ampang Rivers is between 70-150m^3/s. Only 50m^3/s is allowed to flow downstream and excess water is diverted into the tunnel and confined to the lowest drainage chamber provided in the traffic tunnel. The motorway section is still open to traffic. A set of twin water tight floodgates are installed at either end of the traffic section and is kept shut in order to keep traffic safe in the tunnel.

When major storm occurs and the SMART Control Centre (SCC) at Kg. Berembang forecasted Klang River discharge exceeds 150 m^3/s at the confluence of Klang / Ampang Rivers, Mode III will be activated. Traffic inside the tunnel will be evacuated and the tunnel will be closed to traffic. A large volume of runoff will be diverted into SMART system to mitigate flooding in city center and only 10 cumecs will be allowed to flow into the city. If the rainfall stops early or due to some circumstances, the traffic tunnel will be re-opened to traffic within 2-8 hours after closure.

If heavy rain storm prolongs, Mode IV will be activated. The flood gates at both ends of the traffic tunnel will be opened and excess flood water will be let through the traffic compartment. The traffic tunnel will normally be closed for 4 days to allow for cleaning, inspection and maintenance works to be carried out before it can be reopened. This will reduce the flood level at Tun Perak Bridge to be below the surrounding ground level of 30 m. Refer to Figure 2 for the four (4) operational modes of tunnel.

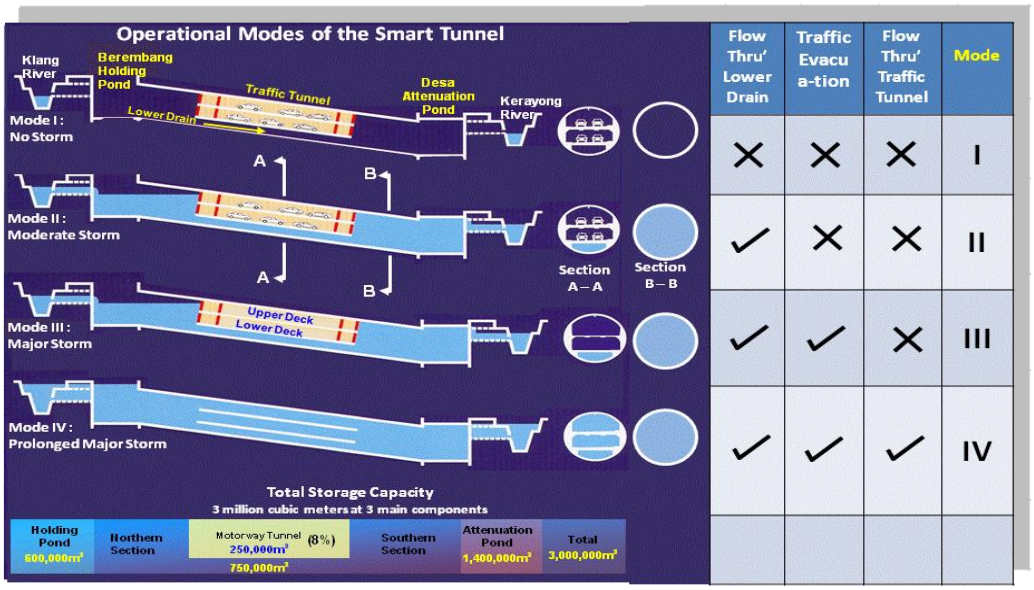


Figure 2: Operational Modes of SMART

3. SMART PERFORMANCE

3.1 Flood Incidences before operation of SMART

The city of Kuala Lumpur (KL) is located at the confluence of the Klang and the Gombak rivers in the Klang River Basin. Founded in the late 19th century, KL has now become Malaysia's largest and most important city. Being the nation's capital city, KL has undergone rapid development. Most of the area has been built-up into township, residential and industrial parks. As a result of the rapid pace of development and its impact on the ground, the existing capacities of rivers in the basin are no longer able to cope with the flood flows from their developing catchments. Flood magnitudes keep on mounting year by year leaving far behind the capability of the city's river and drainage system to cope with it.

KL has experienced seventeen (17) numbers of major flood incidences and the earliest recorded incident is in 1926. The largest in recent history was the flood in 1971, which was widespread and affected not only KL but a few other states in the country. Towards the end of the 20th century, KL has been experiencing flash floods which are quick to

manifest and equally swift to subside. Flash flood is caused by thunderstorm which are localized rainfall of very high intensity (>60mm/hr) and short duration (2-5hours). Table 1 shows the flooding incidences in KL city before SMART starts operation in July 2007. As can be seen from the table, the incidences of flood are becoming more and more frequent towards the end of the 20th century and early 21st century.

PERIOD	INTERVAL (years)	NO. OF FLOOD EVENTS	DATES
Before 1950	-	1	1926
1950 to 1975	16	1	1971
1976 to 1985	10	1	1982
1986 to 1995	10	4	1986, 1988, 1993, 1995
1996 to 2004	9	7	1996, 1997, 30th Apr 2000, 26th Apr 2001, 29th Oct 2001, 11th Jun 2002, 10th Jun 2003
2005 to June 2007	3	3	25th Aug 2006, 3rd Jun 2007, 10th June 2007

Table 1 : Kuala Lumpur flood events in the years before the operation of SMART in July 2007.

3.2 Overall Performance of SMART

Ever since the SMART system was put into operation on July 2007 until 2012, the system has successfully dealt with a total of 203 storm events, which comprises of 121 numbers of Mode II events, 77 incidences of Mode III, and 5 incidences of Mode IV events. . All these modes require excess flood water to be diverted into the holding pond at Kg. Berembang. Refer to Figure 3 for the SMART operational Modes from 2007 to 2012.

Year 2008 recorded the most numbers of Mode II and Mode III events, while year 2012 recorded the most numbers of Mode IV events. Mode IV is the most severe mode since the whole tunnel will be used to divert excessive flood waters from entering Kuala Lumpur City Center. Mode IV events occurred once in 2008 and 2011 and three times in 2012. This makes year 2012 a very challenging year for SMART Control Centre.

3.3 Tunnel Closure to Traffic

The tunnel is closed to traffic only during Mode III and Mode IV events. According to the Designer's Operation & Maintenance Manual (DOMM), flood diversion process can happen about 12 to 18 times in a year, and on one or two of such events in the year, the use of the full bore of the tunnel becomes necessary for flood control.

Between July 2007 until 2012, altogether there are a total of 81 numbers of tunnel closure, which is within the range of DOMM's estimate. As can be seen in Table 2, most of the tunnel closure for Mode III occurs in the month of April and May, while the most tunnel closure for Mode IV happens in the month of May. Based on these statistics, month of May seems to be a wet and busy month for SMART office.

Month	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Mode III	3	1	7	12	12	3	3	6	7	8	7	8
Mode IV	0	0	1	0	2	0	0	0	1	0	1	0

Table 2 : Operation Modes of SMART according to month (2007 – 2012)

In terms of tunnel closure according to days, weekdays shows a higher number of closure especially on Wednesday and Thursday. Refer to Figure 3 for the percentage of tunnel closure according to days.

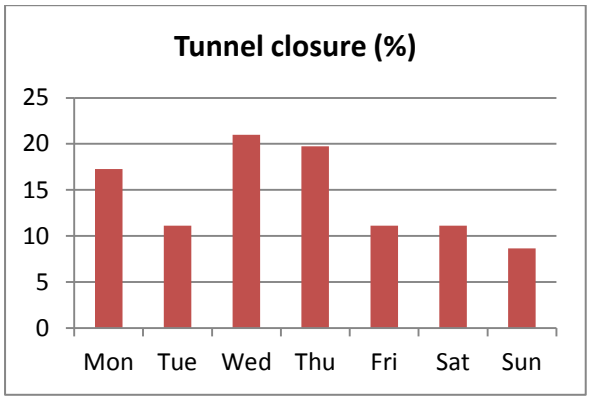


Fig. 3 : Percentage of tunnel closure according to days

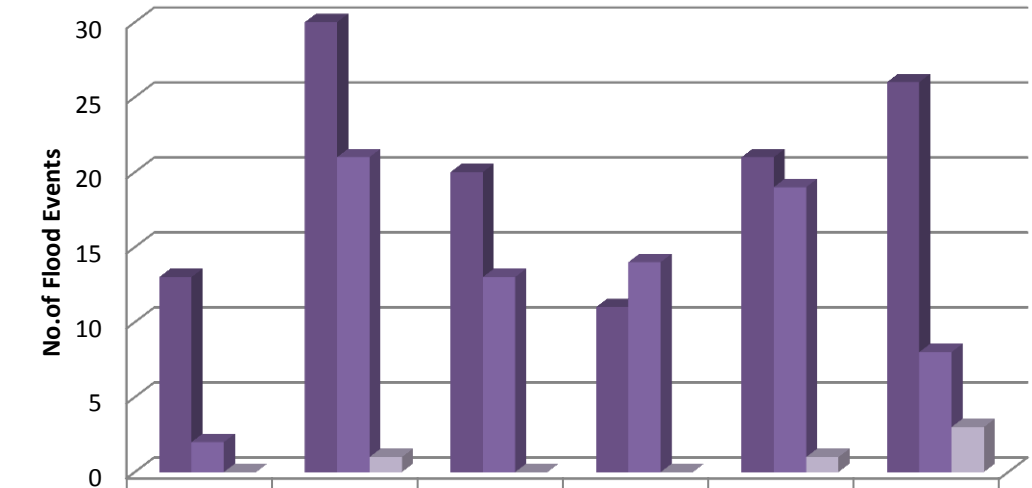
In terms of quantity of volume diverted, from the 203 storm events, each of twelve of these events have diverted more than one million cubic metres of flood waters into the SMART system through the holding pond. If this volume of flood waters not diverted from the city centre, each event would have resulted in very serious flood occurrence in Kuala Lumpur city center. The twelve events are listed in Table 3.

No.	Date	Day	Quantity of water diverted into SMART system (m^3)	Mode
1	22-Mar-2008	Saturday	1,200,000	III
2	21-May-2008	Wednesday	1,048,320	III
3	4-Sep-2008	Thursday	1,161,450	IV
4	13-Mar-2009	Friday	1,488,930	III
5	19-Sep-2009	Saturday	1,038,850	III
6	24-Feb-2011	Thursday	1,597,259	III
7	19-Mei-2011	Thursday	1,149,584	III
8	21-Mei-2011	Saturday	3,204,967	IV
9	13-Dec-2011	Tuesday	1,159,007	III
10	7-Mar-2012	Wednesday	3,300,000	IV
11	2-May-2012	Wednesday	>1,000,000	IV
12	26-Nov-2012	Monday	>1,000,000	IV

Table 3 : Events with diversions exceeding one million cubic metres of flood waters

4. MODE IV EVENTS.

SMART is designed to provide Kuala Lumpur City Center with a Q_{100} protection and has a storage capacity of 3 million cumecs. There are four modes of tunnel operation and Mode IV is the most severe mode. During a Mode IV event, the full tunnel section will be used for flood conveyance. As can be seen from Fig.4, there are five occurrences of Mode IV events, which occurs on 4 Sept 2008, 21 May 2011, 7 March 2012, 2 May 2012 and 26 November 2012.



	2007	2008	2009	2010	2011	2012
Mode 2	13	30	20	11	21	26
Mode 3	2	21	13	14	19	8
Mode 4	0	1	0	0	1	3

Fig. 4: SMART Operation Modes from 2007 to 2012

However, on 21st May 2011 and 7th March 2012, SMART has diverted more than its design capacity of 3 million cumecs. So SMART has operated above its design capacity and hence saved Kuala Lumpur City Center from inundation. This paper will discuss the role of SMART in reducing flooding at Kuala Lumpur City Center from inundation

caused by the heavy rainfall in the upper Klang/Ampang catchment during these two events.

4.1 Event on 21st May 2011

The month of May 2011 shows a very wet month. There are 6 events which consist of one Mode IV, three numbers of Mode III and two numbers of Mode II. The earliest event occurred on 2nd May at 6.30pm, where we experienced Mode III followed by another Mode III on 3rd May at 4.40pm and then a Mode II in the early morning of 4th May 2011.

Before the occurrence of Mode IV on 21st May 2011, the whole catchment has started to receive light to moderate rainfall on 16th May, 18th May and followed by a heavy downpour in the Klang, Ampang and Gombak catchment on 19th May, which triggers Mode III. During this Mode III event, about 1.15 million cubic metres volume of water was diverted from KL city centre. Two days later, on 21st May, all the six catchments received very heavy rainfall which triggers Mode IV. Table 4 below shows the summary of the six events that occur in May 2011.

Date	Day	Mode II	Mode III	Mode IV	Time	Volume diverted (m3)
2-May-2011	Mon		1		18:31	671,600
3-May-2011	Tues		1		16:39	888,000
4-May-2011	Wed	1			5:36	539,100
12-May-2011	Thursday	1			17:10	24,050
19-May-2011	Thursday		1		18:10	1,149,580
21-May-2011	Saturday			1	18:08	3,204,970
Total						**6,477,300**

Table 4 : Summary of the six events that occurred in May 2011

During Mode IV event on 21st May 2011, Klang and Ampang catchment receive 3 hours of heavy rainfall from 4 pm till 7 pm. The Ampang/Klang average catchment rainfall is 82.6mm (3 hrs 15 min). Mode II operation begins at 6:08 pm and 5 minutes after that it

changes to Mode III operation and Mode IV begins at 8.43pm. After 3.5 hours of diversion, operation was back to Mode I at 9:30 pm. Table 5 shows amount of rainfall collected with Average Recurrence Interval (ARI) and Figure 5 shows the Rainfall Isohyetal map.

Catchment	Rainfall Station	Rainfall (mm)					Total Rainfall			ARI		
		4:00 pm	5:00 pm	6:00 pm	7:00 pm	8:00 pm	1 hr	2 hr	3 hr	1 hr	2 hr	3 hr
Klang Gates	Kuala Seleh @ Empangan Klang Gate	0	15	27.5	3	0	27.5	42.5	45.5	normal	normal	normal
Dam	Sg. Klang @ Empangan Klang Gate	13.5	33	27	1.5	0	33	60	73.5	normal	normal	normal
Klang	IBMBS @ Kg. Kemensah	0	41	39.5	1	0	41	80.5	81.5	normal	3	normal
	Sg. Klang @ Jln. AU 5C/6	0	38.5	56	1.5	0.5	56	94.5	96	normal	8	5
	Sg. Klang @ Jln. AU 3/1	0	58.5	37	1	0.5	58.5	95.5	96.5	normal	9	5
	D/S Sg. Klang/Sg. Ampang Confluence	0	23.5	49.5	1	1	49.5	73	74	normal	normal	normal
Ampang	The Peak @ Tmn TAR	0	29.5	49.5	1	0.5	49.5	79	80	normal	normal	normal
	Sg. Ampang @ Bukit Belacan	0	15.5	59.5	1.5	0.5	59.5	75	76.5	normal	normal	normal
	Bukit Ampang @ Jln Ampang - Hulu Langat	0	13	61	3.5	1	61	74	77.5	normal	normal	normal
	Sg. Ampang @ Kg. Melayu Ampang	0	26.5	51	2	0.5	51	77.5	79.5	normal	normal	normal

Table 5 : Amount of rainfall collected at Klang and Ampang catchment on 21st May 2011with Average Recurrence Interval

The maximum flow recorded near the confluence of Klang/Ampang was 471.83m^3/s and the highest water level recorded in the Holding Pond was more than 38.00 mLSD. Tun Perak Bridge reached its highest water level of 29.42 mLSD at 7:18 pm. This event has diverted a total of 3,2 million cubic metres of flood water into SMART system. If SMART was not built, these huge amount of flood waters could have submerged KL City Centre .

It is interesting to note that during this month alone, the total volume of water diverted into SMART system is 6.5 million cubic metres. So, when Mode IV occurred on 21st May, soil conditions in the Klang /Ampang catchment was already saturated. The maximum flow recorded near the confluence of Klang/Ampang was 471.83m^3/s which had surpassed the Q_{100} peak flow of 290 cumecs, while water level in the Holding Pond was more than 38.00 mLSD and has surpassed its maximum level of 38 meter.

4.2 Event on 7th March 2012

During this event, all the 6 catchments, namely, Klang, Ampang, Gombak, Bunus , Batu and Kerayong received very heavy rainfall since 6:30 pm. The highest rainfall recorded was 237 mm at Sg. Ampang @ Bukit Belacan and the Ampang/Klang average catchment rainfall is 133.2mm. Refer to Table 6 for the total rainfall and ARI while Figure 6 shows the Rainfall Isohyetal map on 7th March 2012 .

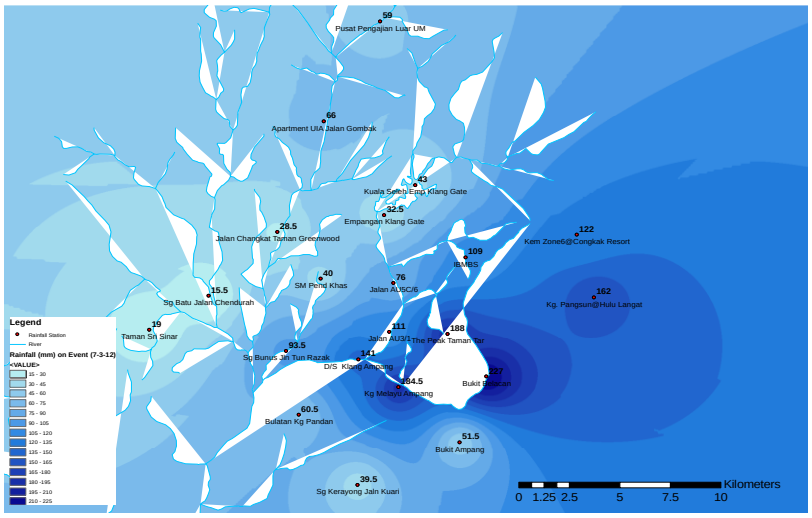


Figure 6 : Rainfall Isohyetal map on 7th March 2012 for Sg Klang catchment

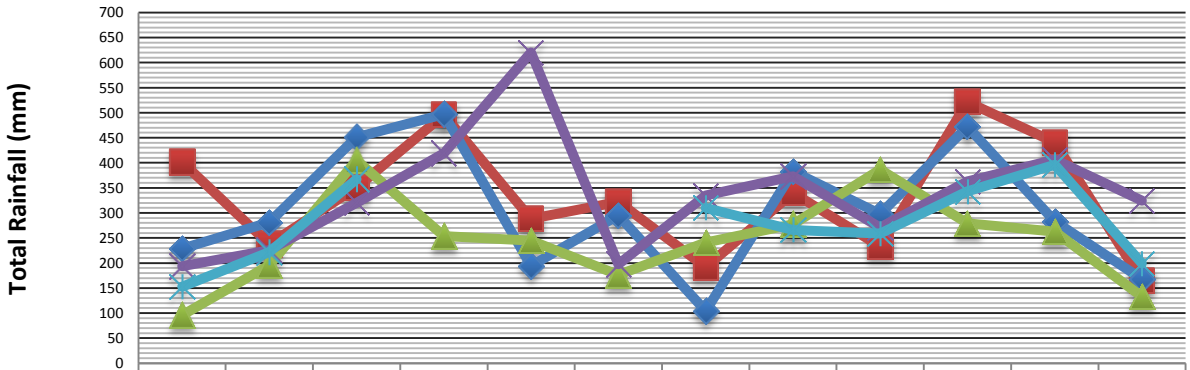
Mode II started at 7:33 pm followed by Mode III ten minutes later when the discharge at the confluence of Sg Klang/Sg. Ampang has increased from 78.25 m^3/s to 192.80 m^3/s during the 10 minutes duration**.** The highest discharge recorded at the Klang/Ampang confluence was 473.5 m^3/s / which has surpassed the Q_{100} peak flow of 290 cumecs.

The water level at Holding pond has surpassed its maximum level of 38 meter at around 9:05 pm and starts to overspill the banks which resulted in 0.6 m flooding at areas surrounding the SMART Stormwater Control Centre (SCC).

Water level at Tun Perak bridge has overtopped its banks (30.24 m) at 9:34 pm with the highest level recorded was 30.37 m. Total volume of water diverted into holding pond is approximately 3.3 million m^3 . SMART had once again saved KL City Centre from inundation.

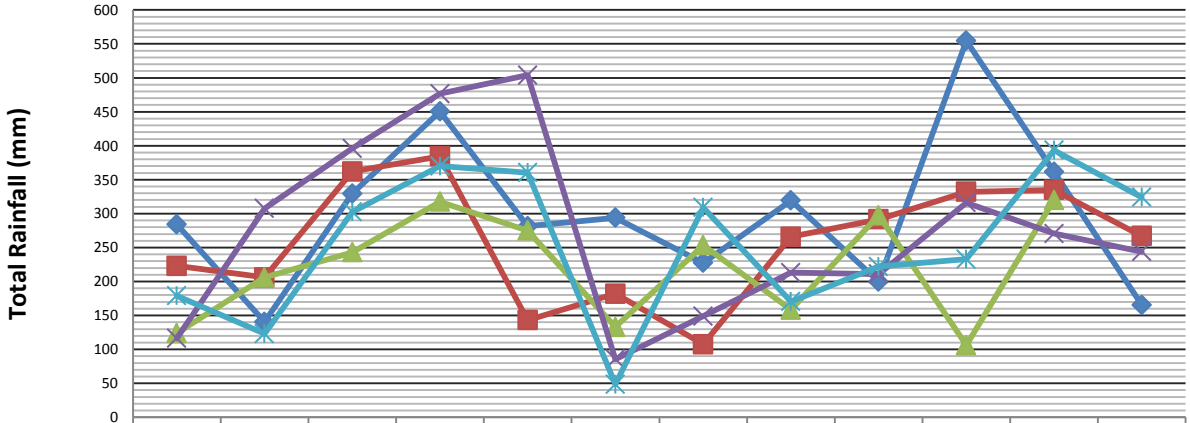
During this event, four (4) numbers of rainfall stations have exceeded the 100 ARI design rainfall and the discharge at the Klang/Ampang confluence has surpassed the Q_{100} peak flow of 290 cumecs. Within four hours of rainfall, these stations have contributed more than 50% of rain collected in a month. For rainfall station at Sg. Ampang @ Bukit Belacan, it contributed 61.2% of the total rainfall in March 2012, Sg. Ampang @ Kg Melayu Ampang contributed 61%, d/s of Sg.Klang/Sg. Ampang confluence contributed 53.2% and The Peak @ Taman TAR contributed 51.9%. Refer to Figure 7 till Figure 10 for the monthly rainfall from year 2008 till 2012 for the four rainfall stations.

Fig 7: Total Monthly Rainfall of Sg. Ampang @ Bukit Belacan Rainfall Station from 2008 - 2012



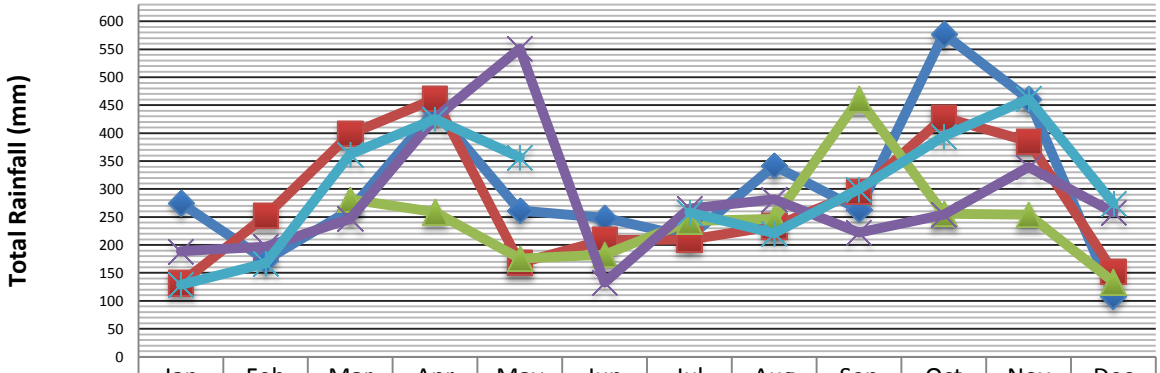
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	401	237.5	351	496	288	322	192	340	233.5	521	441	165
2009	229	281	451	497	194.5	295	104	383	297.5	472	283	168
2010	96	195.5	405	253.5	244.5	176.5	241	277	386.5	279	262.5	133
2011	193.5	225.5	320	419	620.5	197.5	334.5	373	271	363	406	324.5
2012	153	221.5	367.5				310	265.5	259	343	396	199.5

Fig 8 : Total Monthly Rainfall of Sg. Ampang @ Kg. Melayu Ampang Rainfall Station from 2008 - 2012



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	284	140.5	329.5	450.5	281.5	294	227.5	319.5	200	554.5	361.5	165.5
2009	223	206	362	384.5	143	182	107.5	266	291.5	332	335	267
2010	124	206	243	317.5	275	133	253.5	158.5	297.5	106	320	
2011	116.5	307.5	396	476.5	504	85.5	149	213	211	316	270.5	244
2012	179	123	302.5	370	360.5	48.5	309	170.5	222	233	393.5	324

Fig 10 : Total Monthly Rainfall of The Peak @ Tmn. TAR Rainfall Station from 2008 - 2012



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	274.5	173	262.5	440.5	261.5	248.5	214	342	263.5	577.5	461	108.5
2009	131.5	252	398.5	461.5	168	209	209.5	233.5	295	428	385.5	152.5
2010			281.5	259	175.5	182.5	242.5	246.5	461	256	254	134
2011	189	197	247	427	551	133	265	281.5	222	254	339.5	258
2012	129	167	362.5	425.5	356.5		258	221	300	394.5	461.5	274.5

Table 7 shows a summary of data for the four Mode IV events that occurs on 21st May 2011, 7th March 2012, 2nd May 2012 and 26th November 2012.

	28th May 2011	7th March 2012	2nd May 2012	26th Nov 2012
Areal rainfall (mm)	82.6	133.2	71.55	72.9
Holding Pond Initial level (m) Highest level (m)	 29.8 >38	 32.11 >38	 29.93 36.89	 29.45 > 38
Mode 2	1808	1933	1422	1548
Mode 3	1813	1943	1430	1620
Q at confluence (m^3/s.)	471.83	473.52		
Vol. diverted (m^3)	3.2 million	**3.3 million**	> 1 million	> 1 million
Duration of diversion	3 hrs 30 min	2 hrs 49min	4 hr 17 min	4 hr
Tun Perak level (m)	29.42	30.37	29.1	28.9
Attenuation pond Initial level (m) Highest level(m)	 19.9 26	 20.05 25.75	 20.25 24.72	 19.98 24.35

Table 7 : Summary of data for the four Mode IV events

5. CONCLUSIONS

The dual function of the Stormwater Management And Road Tunnel provides a uniquely innovative solution to two serious situations faced by Kuala Lumpur's city dwellers, flood and traffic congestion. SMART will relieve Kuala Lumpur city from devastating floods that create chaos during periods of heavy rainfall and from the frustration of traffic congestion at the southern main gateway to the city centre.

Since the SMART system was put into operation on July 2007 to 2012, the system has successfully dealt with a total of 203 storm events, which comprises of 121 numbers of Mode II events, 77 incidences of Mode III, and 5 incidences of Mode IV events. From these 203 events, twelve events involved the diversion of more than one million cubic metres of flood waters into the SMART system. If these flood waters were not diverted from the city centre, each event would have resulted in serious flood occurrence in Kuala Lumpur City Center. SMART had in fact saved Kuala Lumpur City Centre from 12

potentially serious floods with the flashpoint being the overflow of the Klang River at Tun Perak Bridge.

Although SMART has been designed to mitigate floods up to the 100-year event level with a Q_{100} peak flow discharge at the Klang/Ampang confluence of 290 cumecs, most of the Mode IV events, especially on 28th May 2011 and 7th March 2012 has gone beyond the 100-year event limit. Considering the amount of flood water that has been diverted from flowing into the city, SMART has undoubtedly saved the Kuala Lumpur City Centre from inundation due to flood.

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