ESCAP/WMO
Typhoon Committee

MEMBER
REPORT
MALAYSIA

ESCAP/WMO Typhoon Committee
17th Integrated Workshop
(Video conferencing)
29-30 November 2022

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UNITED NATIONS
Economic and Social Commission for Asia and the Pacific

World Meteorological Organization

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I. Overview of tropical cyclones which have affected/impacted Member's area since the last Committee Session

1. **Meteorological Assessment**

Twenty-five tropical cyclones (TCs) developed over the Western Pacific Ocean, South China Sea and Philippines waters between November 2021 and October 2022. There were eight Typhoon (Ty), six Severe Tropical Storm (STS) and eleven Tropical Storm (TS) observed during that period as shown in **Table 1**. The most active period of TCs formation was between the month of July and October with the month of September recording the highest number of TCs (8). Typhoon Rai recorded the highest maximum wind speed compared to other TCs during the season.

Maritime areas monitored by the Malaysian Meteorological Department (MET Malaysia) for the issuance of marine warnings are depicted in **Figure 1**.

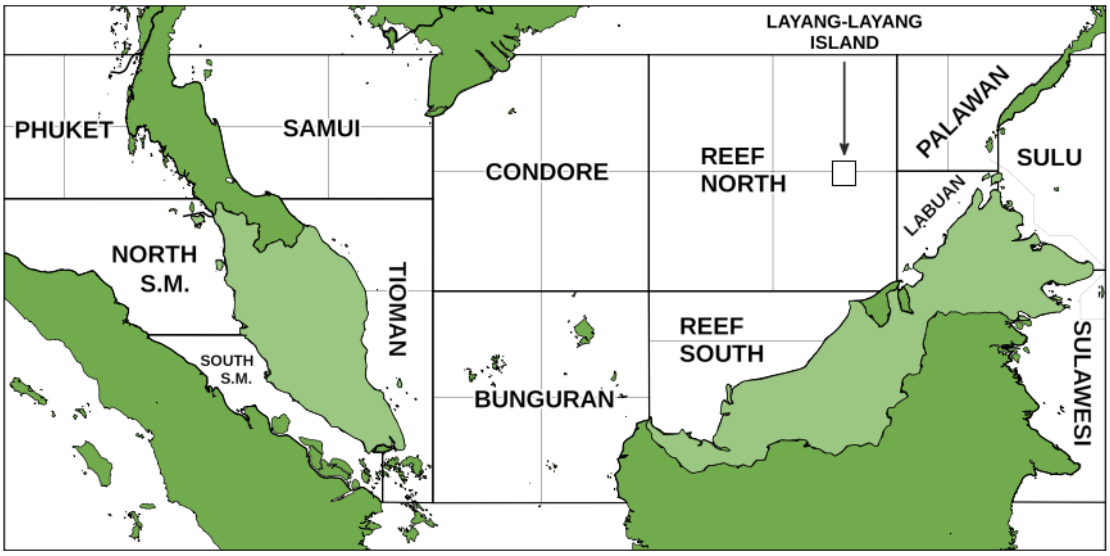

Figure 1: Maritime Area Monitored by MET Malaysia

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Table 1: List of Tropical Cyclone, Classification, Date of Birth and Death of Typhoon and Maximum Winds from November 2021 to October 2022.

No.	Tropical Cyclone	Classification	Date		Max Wind (kts)
			Birth	Death	
1	Nyatoh	Typhoon	28/11/2021	4/12/2021	100
2	Rai	Typhoon	11/12/2021	21/12/2021	105
3	Malakas	Typhoon	6/4/2022	18/4/2022	90
4	Megi	Tropical Storm	8/4/2022	12/4/2022	40
5	Chaba	Tropical Storm	30/6/2022	4/7/2022	45
6	Aere	Tropical Storm	4/7/2022	6/7/2022	35
7	Songda	Tropical Storm	28/7/2022	31/7/2022	40
8	Trases	Tropical Storm	31/7/2022	1/8/2022	35
9	Mulan	Tropical Storm	9/8/2022	11/8/2022	35
10	Meari	Tropical Storm	12/8/2022	15/8/2022	40
11	Ma-on	Severe Tropical Storm	23/8/2022	27/8/2022	60
12	Tokage	Typhoon	23/8/2022	26/8/2022	65
13	Hinnamnor	Typhoon	6/9/2022	7/9/2022	70
14	Muifa	Typhoon	12/9/2022	17/9/2022	80
15	Merbok	Severe Tropical Storm	12/9/2022	16/9/2022	60
16	Nanmadol	Severe Tropical Storm	19/9/2022	21/9/2022	60
17	Talas	Severe Tropical Storm	23/9/2022	24/9/2022	35
18	Noru	Typhoon	26/9/2022	29/9/2022	85
19	Kulap	Severe Tropical Storm	26/9/2022	30/9/2022	50
20	Roke	Tropical Storm	28/9/2022	3/10/2022	45
21	Sonca	Tropical Storm	14/10/2022	15/10/2022	35
22	Nesat	Typhoon	17/10/2022	21/10/2022	75
23	Haitang	Tropical Storm	18/10/2022	19/10/2022	35
24	Nalgae	Severe Tropical Storm	27/10/2022	3/11/2022	60
25	Banyan	Tropical Storm	31/10/2022	1/11/2022	35

The areas affected by TCs near Malaysian waters are listed in **Table 2**. TCs that are located in the vicinity of the South China Sea (SCS) can lead to strong winds and rough seas over the east coast of Peninsular Malaysia and the coastal areas of Sabah and Sarawak. There were six TCs that influenced the weather in Malaysia.

Table 2: Total Number of Area in Malaysia affected by TCs between November 2021 and October 2022

No.	Tropical Cyclone	Classification	Date		Total No. of Area Affected by TCs
			Birth	Death	
1	**Nyatoh**	Typhoon	28/11/2021	4/12/2021	14 (Condore, Reef North, Layang-Layang, Palawan, Samui, Tioman, Bunguran, Reef South, Layang-Layang, Labuan, Johor, Pahang, Terengganu, Kelantan)
2	**Rai**	Typhoon	11/12/2021	21/12/2021	16 (Condore, Reef North, Tioman, Bunguran, Reef South, Layang-Layang, Labuan, Palawan, Samui, Sulu, Johor, Pahang, Terengganu, Sarawak, Kelantan, Sabah)
3	**Malakas**	Typhoon	6/4/2022	18/4/2022	12 (Condore, Reef North, Reef South, Layang-Layang, Labuan, Sulu, Sarawak, Sabah, Bunguran, Palawan, Samui, Tioman)
4	**Megi**	Tropical Storm	8/4/2022	12/4/2022	13 (Sarawak, Sabah, Labuan, Condore, Bunguran, Reef North, Reef South, Layang-Layang, Labuan, Palawan, Sulu, Samui, Tioman)
5	Chaba	Tropical Storm	30/6/2022	4/7/2022	7 (Condore, Reef North, Phuket, Layang-Layang, Palawan, Labuan, Melaka)
6	Aere	Tropical Storm	4/7/2022	6/7/2022	2 (Phuket, Melaka)
7	Songda	Tropical Storm	28/7/2022	31/7/2022	2 (Phuket, Melaka)
8	Trases	Tropical Storm	31/7/2022	1/8/2022	2 (Phuket, Melaka)
9	Mulan	Tropical Storm	9/8/2022	11/8/2022	7 (Sabah, Phuket, Condore, Reef North, Palawan, Labuan, Layang-Layang)
10	Meari	Tropical Storm	12/8/2022	15/8/2022	-
11	Ma-on	Severe Tropical Storm	23/8/2022	27/8/2022	1 (Phuket)
12	Tokage	Typhoon	23/8/2022	26/8/2022	1 (Phuket)
13	Hinnamnor	Typhoon	6/9/2022	7/9/2022	4 (Phuket, Condore, Reef North, Samui)
14	Muifa	Typhoon	12/9/2022	17/9/2022	4 (Condore, Reef North, Palawan, Phuket)
15	Merbok	Severe Tropical Storm	12/9/2022	16/9/2022	4 (Condore, Reef North, Palawan, Phuket)

17	Talas	Severe Tropical Storm	23/9/2022	24/9/2022	8 (Reef North, Reef South, Layang-Layang, Palawan, Labuan, Sulu, Sarawak, Sabah)
18	**Noru**	Typhoon	26/9/2022	29/9/2022	11 (Sarawak, Sabah, Labuan, Condore, Reef North, Layang-Layang, Palawan, Sulu, Perlis, Kedah, Penang)
19	**Kulap**	Severe Tropical Storm	26/9/2022	30/9/2022	13 (Sarawak, Sabah, Labuan, Condore, Reef North, Layang-Layang, Palawan, Sulu, Perlis, Kedah, Penang, Phuket, Straits of Melaka)
20	Roke	Tropical Storm	28/9/2022	3/10/2022	5 (Perlis, Kedah, Penang, Phuket, Straits of Melaka)
21	Sonca	Tropical Storm	14/10/2022	15/10/2022	7 (Sarawak, Sabah, Labuan, Condore, Reef North, Layang-Layang, Palawan)
22	Nesat	Typhoon	17/10/2022	21/10/2022	4 (Condore, Reef North, Layang-Layang, Palawan)
23	Haitang	Tropical Storm	18/10/2022	19/10/2022	5 (Condore, Reef North, Layang-Layang, Labuan, Palawan)
24	Nalgae	Severe Tropical Storm	27/10/2022	3/11/2022	7 (Condore, Reef North, Layang-layang, Palawan, Bunguran, Reef South, Labuan)
25	Banyan	Tropical Storm	31/10/2022	1/11/2022	7 (Condore, Reef North, Layang-layang, Palawan, Bunguran, Reef South, Labuan)

*Note: Six (6) TCs that influenced the weather in Malaysia appear in **bold** font.*

The tracks of these TCs are depicted in **Figure 2**. Typhoon Rai which was the strongest TC, had the greatest number of affected areas (16 areas).

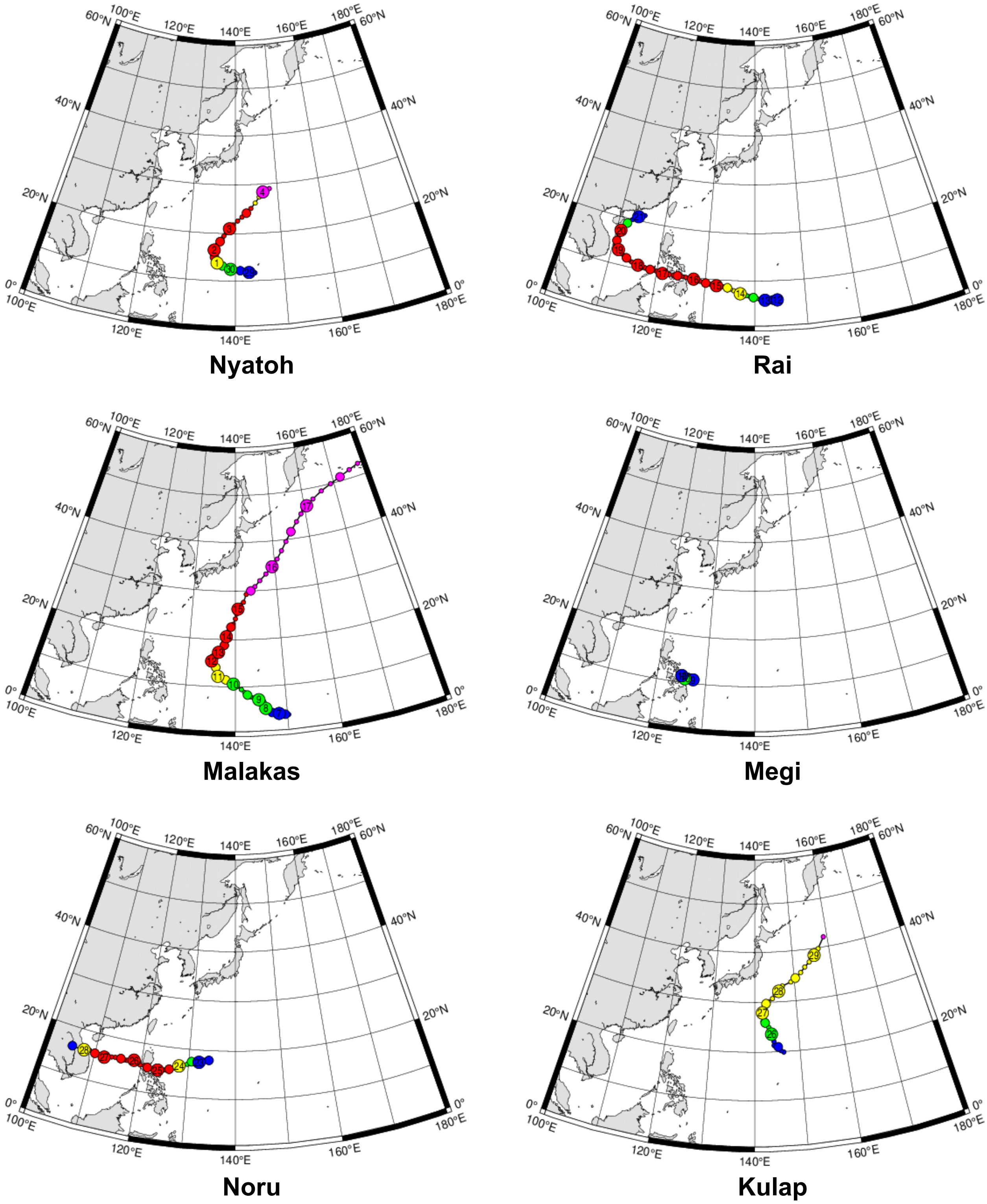
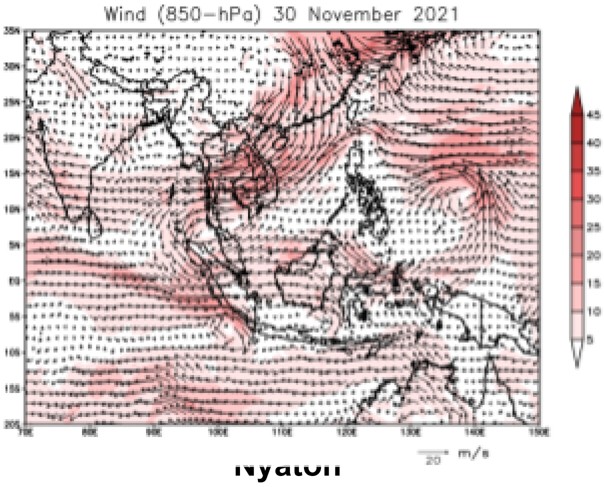
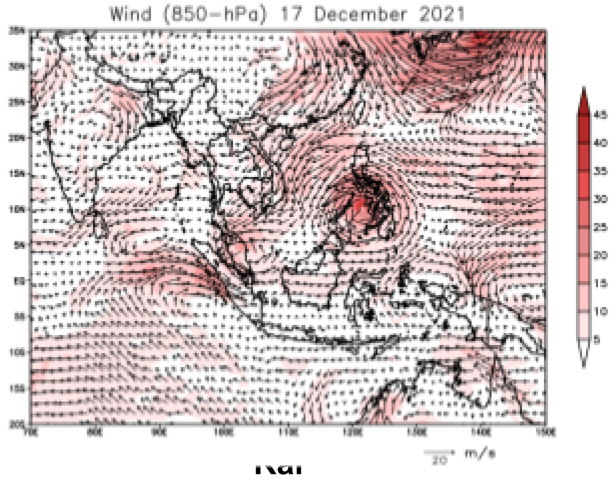


Figure 2: Tracks of six typhoons and tropical storms affecting Malaysia from November 2021 until October 2022. The circled numbers represent the date of occurrence of the typhoons and tropical storms (Source: National Institute of Informatics (NII), Research Organization of Information and Systems (ROIS), Japan http://agora.ex.nii.ac.jp/digital-typhoon/latest/track/)

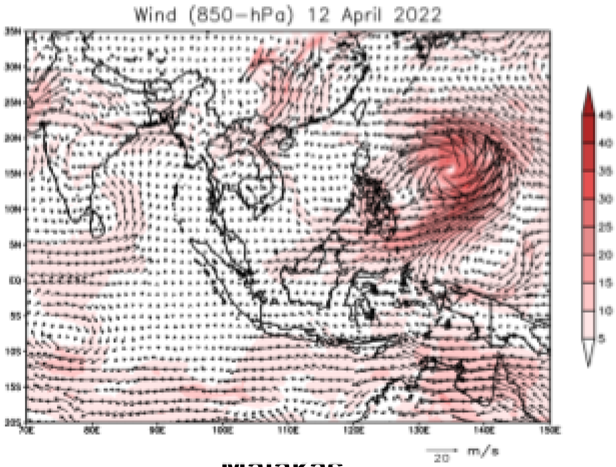
The 850hPa wind circulation derived from ERA-5 during the passage of TCs are illustrated in **Figure 3**.



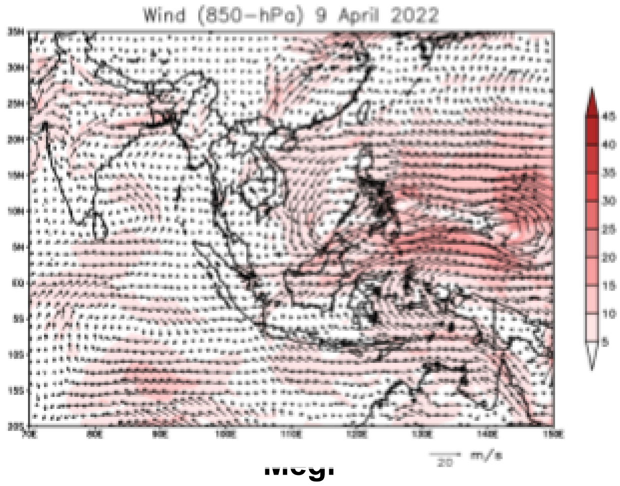
Nyatoh



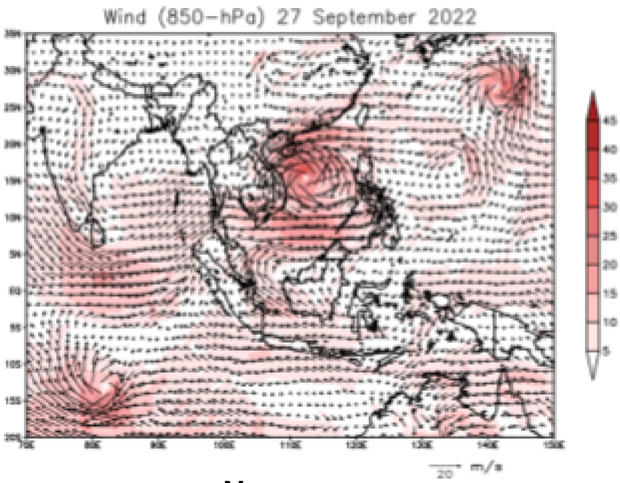
Rai



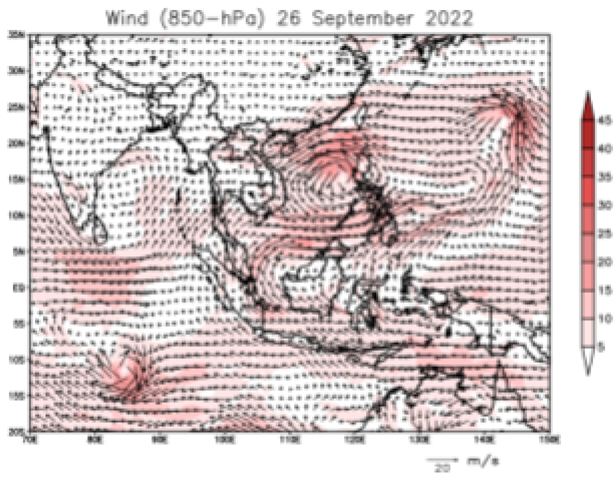
Malakas



Megi

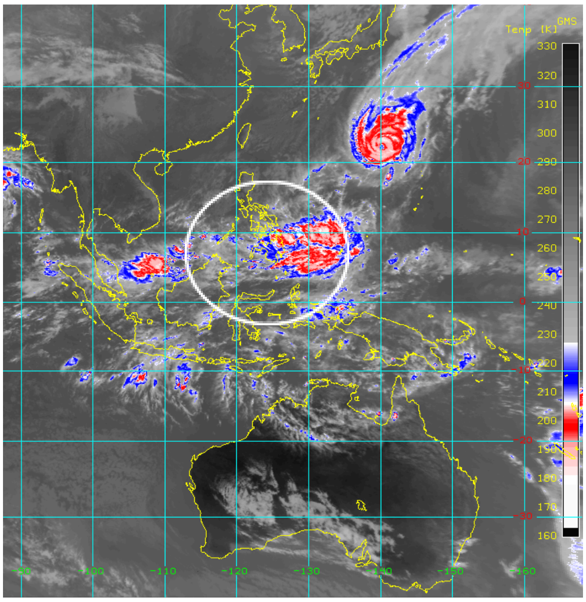


Noru



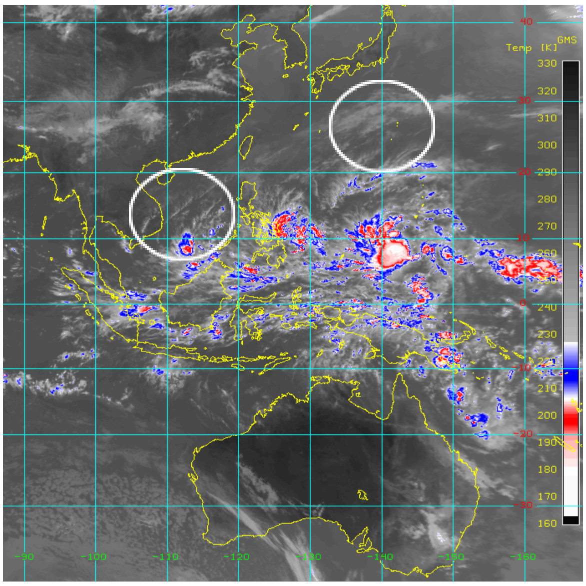
Kulap

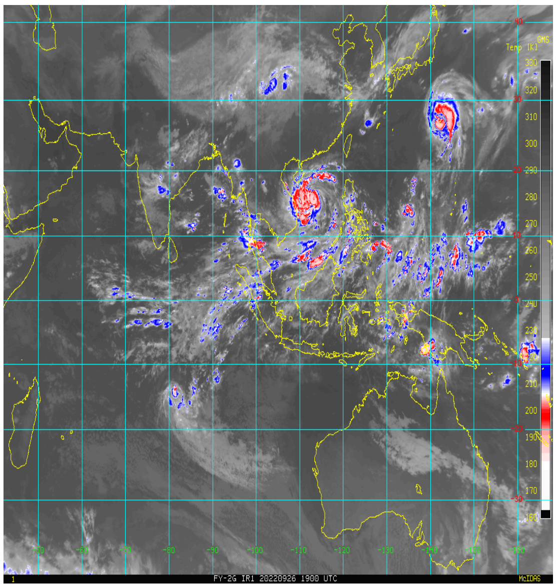
The presence of TCs that coincided with other large-scale synoptic systems such as the cold surge also had profound impact on the Malaysian weather as seen in the case of Typhoon Nyatoh (November 2021) and Typhoon Rai (December 2021). **Figure 4** shows FY-2G satellite imageries during the presence of the six TCs as listed in Table 2. These satellite imageries show the rain cloud clusters that caused heavy and widespread of rain over the Malaysian region.



a) Nyatoh - 3/12/2021

b) Rai - 16/12/2021





c) 9/4/2022 - Malakas and Megi

d) 26/9/2022 - Noru and Kulap

Figure 5 to Figure 8 respectively shows daily accumulated rainfall of the chosen meteorological stations within the northern and east coast of Peninsular and East Malaysia from November to December 2021, April 2022 and September 2022. During Typhoon Nyatoh and Typhoon Rai, accumulated rainfall recorded was above 100mm over the East Coast of Peninsular Malaysia. For TCs developed in April and September 2022, the accumulated rainfall at the selected stations were below 100mm.

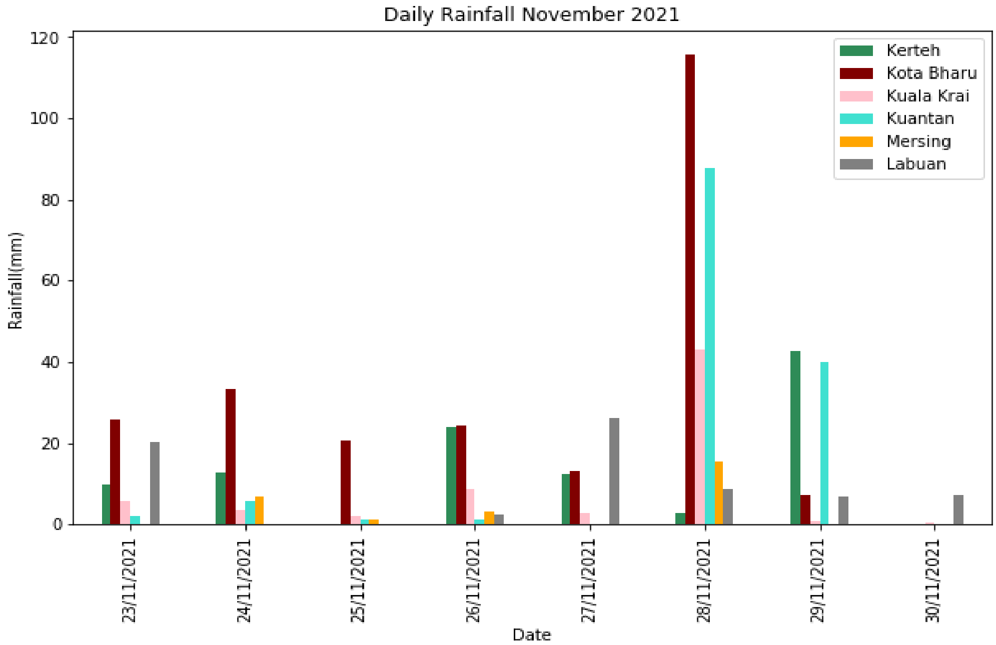


Figure 5: Daily rainfall November 2021 for Typhoon Nyatoh (28/11/2021 - 4/12/2021)

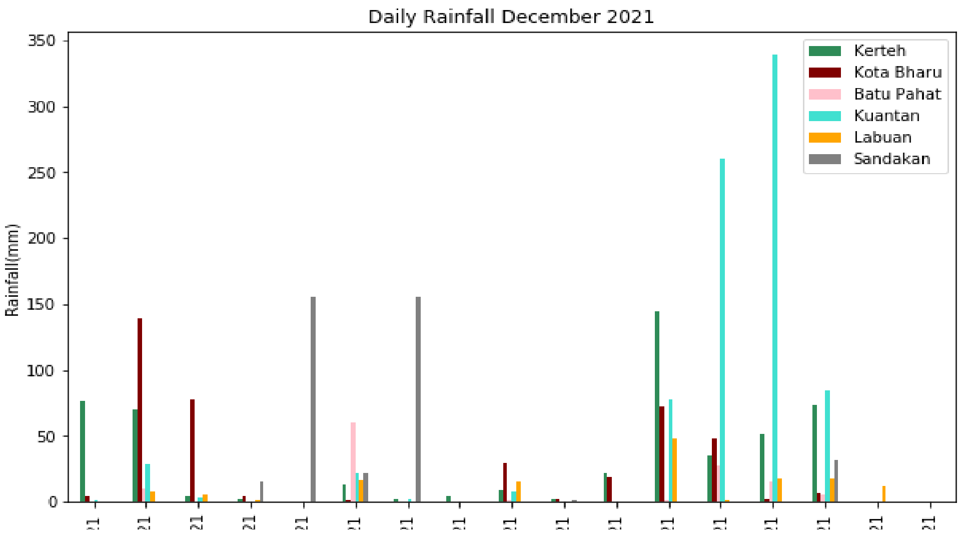


Figure 6: Daily rainfall December 2021 for Typhoon Rai (11/12/2021 - 21/12/2021)

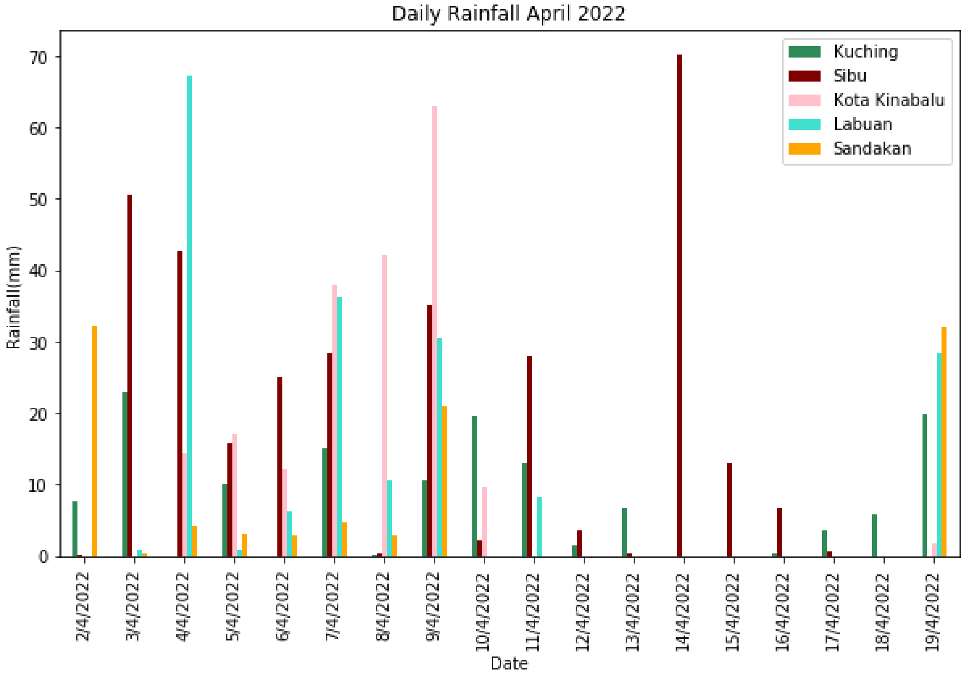


Figure 7: Daily rainfall April 2022 for Typhoon Malakas (6/4/2022 - 18/4/2022) and TS Megi (8/4/2022 - 12/4/2022)

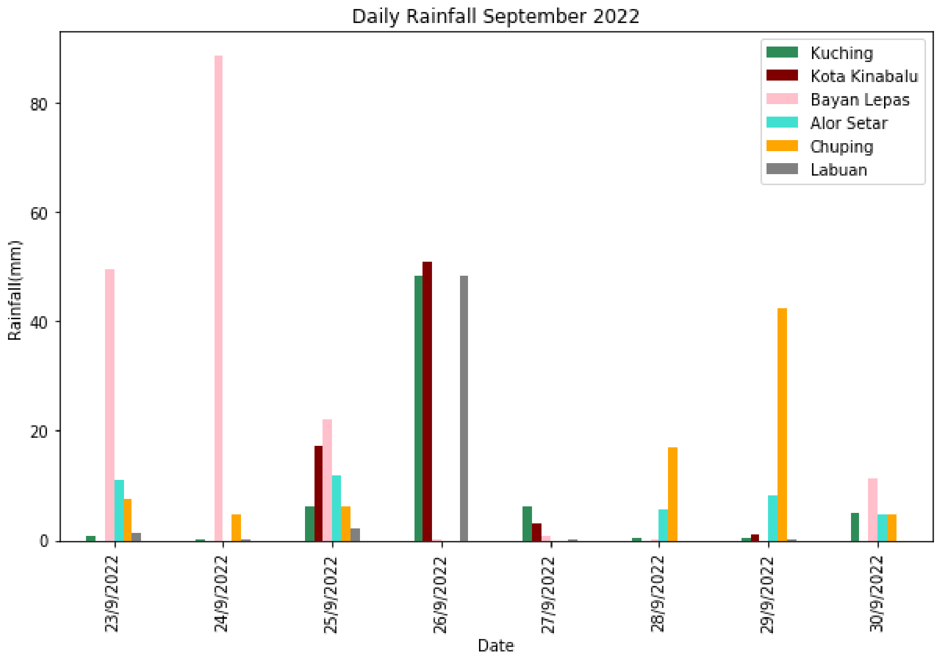


Figure 8: Daily rainfall September 2022 for Typhoon Noru (26/9/2022 - 29/9/2022) and STS Kulap (26/9/2022 - 30/9/2022)

2. **Hydrological Assessment**

a) **Flood scenario in Malaysia**

Malaysia recorded 1057 flood incidents in 2021 which is increase about 188 flood events compared to 2020. The 10 years trend shows the flood events increase significantly from 90 flood in 2012 to 1057 in 2021. Details annual flood record since 2001 shows in **Figure 9**. The monsoon floods that occurred in December 2021 hit 11 states and it has had a very bad impact to the country. Study carry out by the Department of Statistics Malaysia has found out that in year 2021, floods have killed 56 people and displaced more than 70,000 people. Losses due to floods reached RM 6.1 billion which is detail loss for each category shows in **Table 3**;

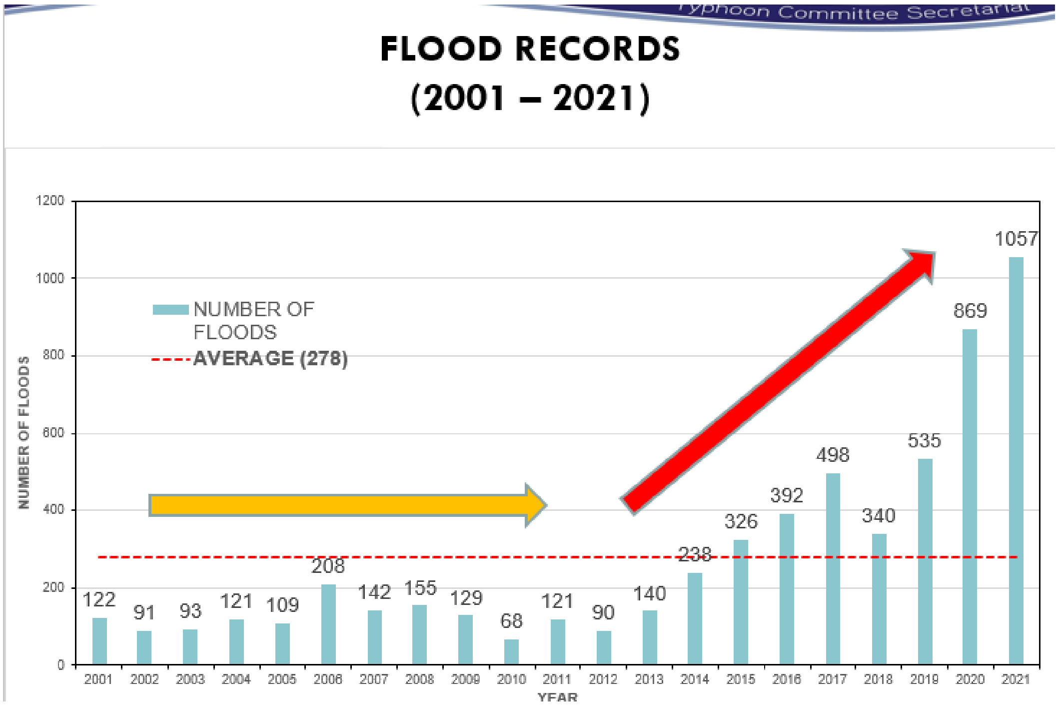


Figure 9 : Annual flood record since 2001 until 2021

Table 3: Category of flood loss in 2021

Category	**Loss (RM)**
Public Assets and Infrastructure	2.1
Vehicles	1.0
Manufacturing	0.9
Living Quarters	1.6
Agriculture	0.09
Business Premises	0.5
Total	**6.19**

During the monsoon flood that occurred on 17 to 30 December 2021, Klang Valley experienced extremely worse flood events particularly on 17 to 19 December 2021. Klang Valley that located in the west coast of Peninsular Malaysia normally facing the flash flood, however since the Typhoon Rai hits East Peninsular Malaysia and suddenly passing the Titiwangsa Range and collide with low pressure system at Klang Valley. The situation has caused very heavy rainfall that lead to the extreme flooding at many places in Klang Valley of Kuala Lumpur and Selangor.

Figure 10 shows the location of Klang Valley and **Figure 11** and **Figure 12** showing the flood images on 18 December 2021 at Selangor and Kuala Lumpur.

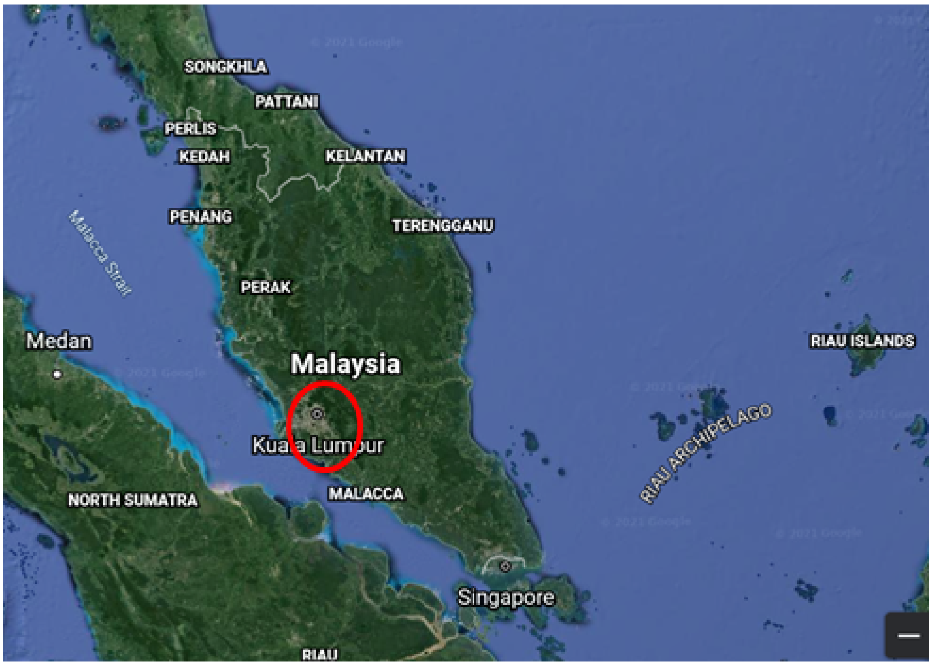


Figure 10: Location of Klang Valley involved Kuala Lumpur and Selangor

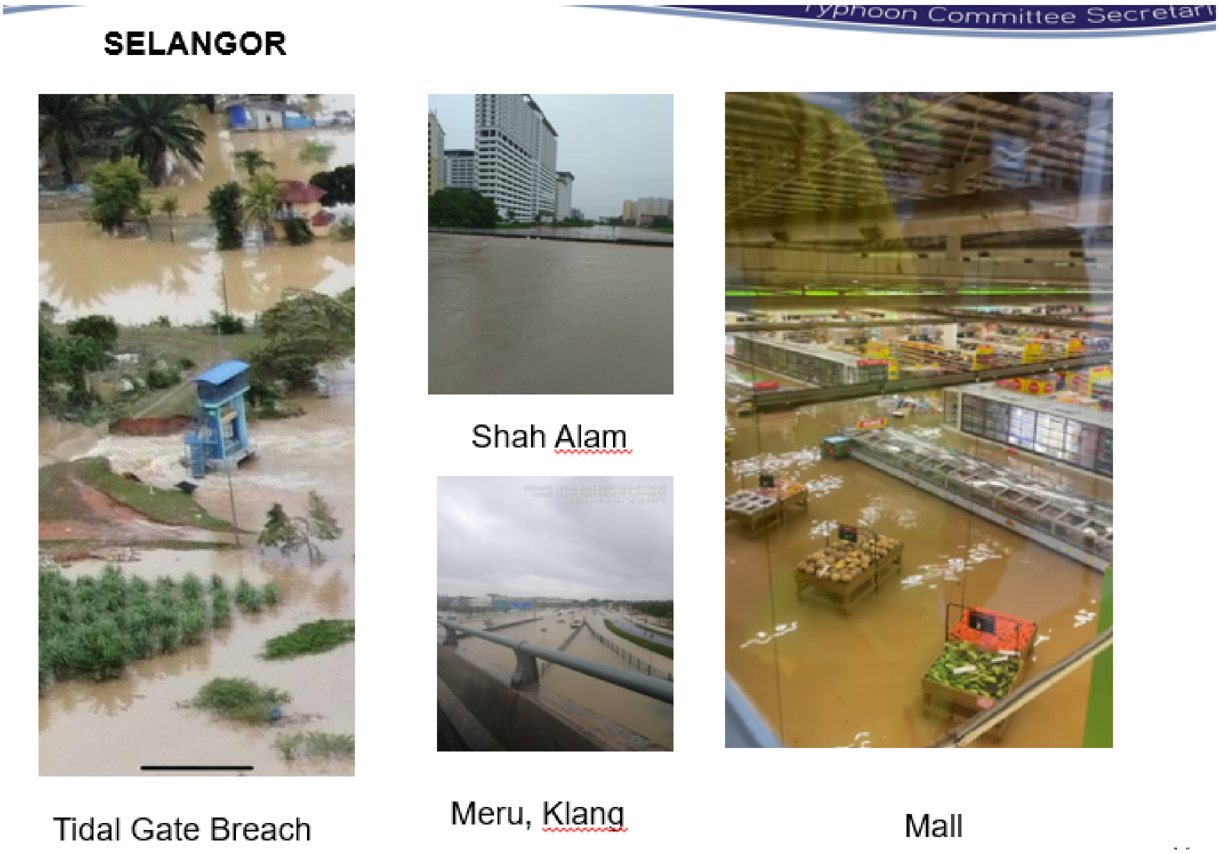
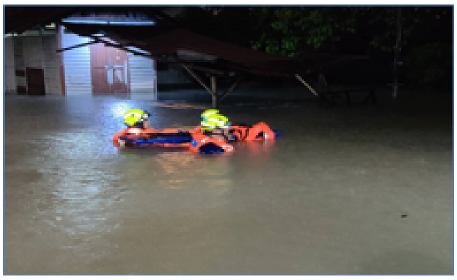


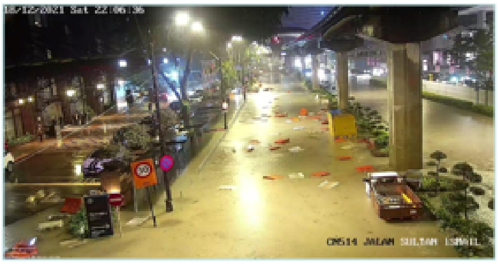
Figure 11: Flood images at the State of Selangor (18 December 2021)

KUALA LUMPUR

Dataran Merdeka, Kuala Lumpur



Kg. Periuk, Kg. Baru



Jalan Sultan Ismail/Sheraton Hotel (CCTV DBKL)

Jalan Sultan Azlan Shah/Bank Rakyat (CCTV DBKL)

Figure 12: Flood images at the State of Kuala Lumpur (18 December 2021)

During the 17-19 December 2021 flood event in the Klang Valley, rainfall data showed very high intensity at most stations. The highest rainfall depth was 356mm in a 24-hour period at Ladang Pulau Carey which equates to over 100 years return period. **Table 4** shows almost all rainfall station recorded very heavy rainfall, with 13 locations in Selangor had more than 100 years ARI. Meanwhile, 2 stations in Kuala Lumpur shows rainfall depth above 100 years ARI at Sentul and Ladang Edinburgh as shown in **Table 5**.

Although worse flood occurred in Klang Valley, other location in Malaysia also experienced the flood especially in east coast of Peninsular Malaysia such as Pahang, Terengganu and Kelantan. At the same time, the heavy storm also occurred over several areas in the west coast of Peninsular Malaysia, that has resulted a series of flash floods in Kedah, Penang, Perak and Selangor.

Table 4: Rainfall intensity for the State of Selangor in 2021

RAINFALL RETURN PERIOD (ARI) FOR THE STATE OF SELANGOR
DURATION (17 DEC 2021 TO 19 DEC 2021)

3 district of Selangor show above 100yrs ARI:
1. Hulu Langat
2. Klang
3. Kuala Langat

Daerah	Nama Stesen	15 mins		30 mins		1 hour		3 hours		6 hours		12 hours		24 hours	
		Rainfall (mm)	ARI	Rainfall (mm)	ARI	Rainfall (mm)	ARI	Rainfall (mm)	ARI	Rainfall (mm)	ARI	Rainfall (mm)	ARI	Rainfall (mm)	ARI
H. Langat	Batu 12	49.5	12	90	63	113.5	58	155.5	77	192.5	>100	193.5	64	200.5	41
Klang	P/A Pandamaran	104	>100	152.5	>100	177	>100	220.5	564	265	>100	270.5	>100	272	>100
Klang	Kg. Delek	68.5	>100	107.5	>100	131.5	>100	186.5	190	256	>100	264	>100	265.5	>100
Klang	Kg. Rantau Panjang	42.5	7	56	4	76	5	150.5	60	221.5	>100	230	197	230.5	>100
Klang	Selat Muara	138.5	>100	173	>100	201.5	>100	241	828	289	>100	294.5	>100	316.5	>100
Klang	SMK Raja Lumu	100	>100	141.5	>100	152.5	>100	190.5	237	233.5	>100	238	>100	243.5	>100
Klang	Telok Gong	91.5	>100	112	>100	122.5	83	138	31	177.5	64	208	94	227	>100
K. Langat	Ladang West Pulau Carey	98	>100	156	>100	222	>100	248	1119	277	>100	318	>100	356.5	>100
K. Langat	Bt. 7 Sijangkang	99.5	>100	158.5	>100	186.5	>100	215.5	492	233	>100	238	>100	294	>100
K. Langat	Bukit Changgang	44	9	56.5	5	89	18	120.5	22	153	43	156.5	26	236.5	>100
K. Langat	Pekan Banting	75	>100	101	>100	132	>100	179	308	187.5	>100	190.5	>100	204	>100
K. Langat	RS Batu 8	113.5	>100	172	>100	205	>100	237.5	808	255.5	>100	261.5	>100	289.5	>100
K. Langat	TKPM Sg. Kelambu	57	47	75.5	32	124.5	>100	188.5	331	205.5	>100	208	>100	227.5	>100

Table 5: Rainfall intensity for the Kuala Lumpur Federal Territory in 2021

RAINFALL RETURN PERIOD (ARI) FOR THE STATE OF KUALA LUMPUR
DURATION (17 DEC 2021 TO 19 DEC 2021)

2 Rainfal station recorded above 100 yrs ARI ; Sentul and Ladang Edinburgh

Daerah	Nama Stesen	6 hours		12 hours		24 hours	
		Rainfall (mm)	ARI	Rainfall (mm)	ARI	Rainfall (mm)	ARI
Gombak	Empangan Klang	121	6	147	9	174.5	14
Gombak	Gombak KM. 11	138.5	14	164.5	16	172	8
Gombak	Gombak Barrage	148.5	41	173.5	58	176.5	34
Gombak	Kg. Sg. Tua Batu Dam	99.5	3	135.5	12	146	10
Gombak	Gombak Simpang 3	140	28	169.5	49	181.5	40
Gombak	Empangan Batu	102	3	135.5	11	145	9
Gombak (WPKL)	Gombak KM. 16	103.5	4	136	11	165.5	22
Gombak	Pulau Kuala Seleh	91	2	118	4	148	10
Hulu Langat	Lembah Jaya	135	15	151.5	15	197.5	36
Hulu Langat	Pandan Indah	116.5	5	132.5	6	153.5	8
Kuala Lumpur	Jinjang	164	67	189.5	80	191.5	42
Kuala Lumpur	Jln. Tun Razak (Sg. Bunus)	168.5	63	189	65	191	35
Kuala Lumpur	Sentul	200	>100	233	>100	235.5	>100
Kuala Lumpur	Kolam Takungan Batu	172.5	76	196.5	85	197.5	44
Kuala Lumpur	Kg. Berembang (SMART)	164	53	176.5	41	183	26
Kuala Lumpur	Leboh Pasar	136.5	16	157.5	19	160.5	11
Kuala Lumpur	JPS Wilayah	151.5	32	174.5	39	177	21
Kuala Lumpur	Ladang Edinburgh	173	78	206.5	>100	207	60
Kuala Lumpur	Air Panas	149.5	29	169	31	173.5	18
Kuala Lumpur	JPS Ampang	132.5	12	149.5	14	156	10
Kuala Lumpur	Lembah Keramat	112.5	4	132	6	170	16
Kuala Lumpur	Kg. Cheras Baru	122	7	138.5	8	145	5

b) **National Flood Forecasting and Warning Programme (Program Ramalan dan Amaran Banjir, PRAB)**

Since 2015, Malaysia is developing a Flood Forecasting and Warning System namely Program Ramalan dan Amaran Banjir, PRAB throughout the country. The 15 years project (2015-2030) aims to provide 7 days in advanced monsoon flood forecast and early warning flood forecast 2 days in advanced to the flood related agencies and public. PRAB consists of components to develop flood forecast modeling system at 74 river basin throughout the country and currently 25 river basin have been completed and ready for operational as shown in **Table 6**. Besides, PRAB also involved construction hydrological telemetry stations which included parameter of rainfall, water level, streamflow, soil moisture and evaporation. The numbers of siren and camera system will be installed at few locations especially in flood prone area. The non-structure elements that related to public awareness have been carried out to provide basic knowledge on flood forecast and warning. The awareness programme involved many parties such as flood related agencies, student at school and higher education, villagers, local leader, non-government organization and others.

Table 6 : List of river basins with National Flood Forecasting and Warning System (NAFFWS)

No.	**State**	**River basin**
1.	Perlis	Sg. Perlis
2.	Kedah	Sg. Kedah
3.	Kedah	Sg. Muda
4.	Kedah	Sg. Melaka at Langkawi
5.	Pulau Pinang	Sg. Juru
6.	Pulau Pinang	Sg. Perai
7.	Pulau Pinang	Sg. Jawi
8.	Pulau Pinang	Sg. Pinang
9.	Perak	Sg. Kerian

11.	Perak	Sg. Perak
12.	Johor	Sg. Johor
13.	Johor	Sg. Mersing
14.	Johor	Sg. Endau
15.	Pahang	Sg. Rompin
16.	Pahang	Sg. Pahang
17.	Pahang	Sg. Kuantan
18.	Terengganu	Sg. Kemaman
19.	Terengganu	Sg. Dungun
20.	Terengganu	Sg. Paka
21.	Terengganu	Sg. Terengganu
22.	Terengganu	Sg. Setiu
23.	Terengganu	Sg. Besut
24.	Kelantan	Sg. Kelantan
25.	Kelantan	Sg. Golok

3. **Socio-Economic Assessment**

Despite the fact that there were no TCs that directly impacted Malaysia, the monsoon floods that occurred in December 2021 has had a very bad impact to the country. Study carry out by the Department of Statistics Malaysia has found out that in year 2021, floods have killed 56 people and displaced more than 70,000 people and the losses due to floods reached RM 6.1 billion.

4. **Regional Cooperation Assessment**

Typhoon information issued by the Regional Specialized Meteorological Centre (RSMC) – Tokyo Typhoon Centre and JTWC as well as numerical weather prediction products of European Centre for Medium-Range Weather Forecasts (ECMWF) and Japan Meteorological Agency (JMA) are used in analysis and forecasting of weather during a typhoon passage close to Malaysia.

II. Summary of Progress in Priorities supporting Key Result Areas

1. Addition of 3 New Radar Observation Sites in Malaysia for Monitoring Severe Weather

MET Malaysia enhanced its radar observation network with the addition of 3 new radars to improve the coverage for severe weather monitoring. They are X-Band radar with Doppler capability and equipped with Wind Shear Detection Systems (WSDS). The new radars are strategically located to overcome blockage due to terrain.

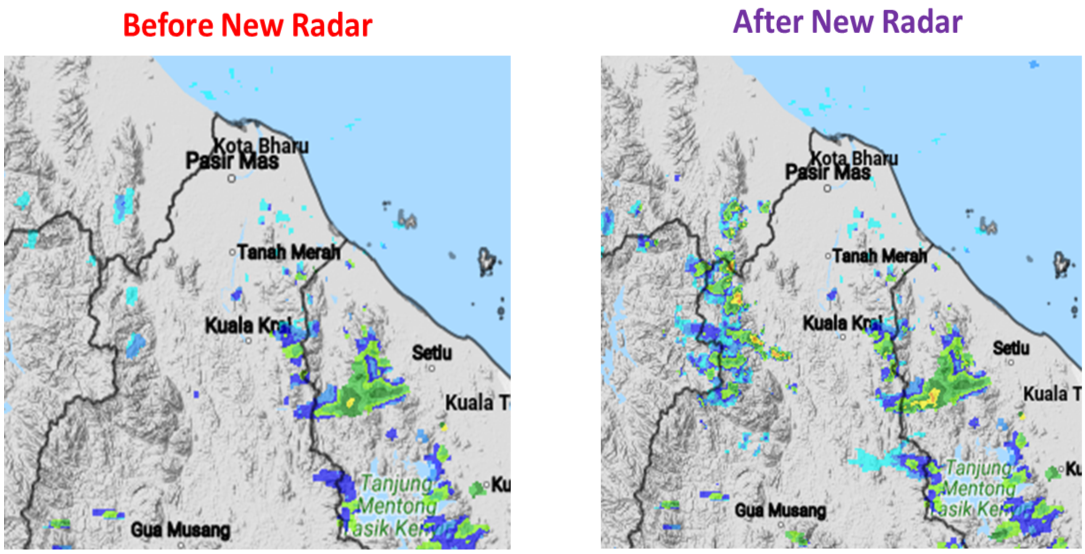


Figure 13: The figure on the left denotes radar observation before inclusion of new radar, and figure on the right denotes radar observation after inclusion of new radar. Note improved radar observation in the mountainous region (see the figure on the right).

Identified opportunities/challenges, if any, for further development or collaboration:

1. Dual polarization quantitative precipitation estimation (QPE) should be developed for improved rainfall estimation.
2. Nowcasting using Doppler Wind should be used to identify areas of potential convection.

Priority Areas Addressed:

Integrated

- Strengthen the cooperation between TRCG, WGM, WGH, and WGDRR to develop impact-based forecasts, decision-support and risk-based warning.
- Enhance collaborative activities with other regional/international frameworks/organizations, including technical cooperation between TC/AP-TCRC and TC/PTC cooperation mechanism.

Meteorology

- Enhance and provide typhoon forecast guidance based on NWP including ensembles, weather radar and satellite related products, such as QPE/QPF.
- Promote communication among typhoon operational forecast and research communities in Typhoon Committee region.
- Enhance training activities with TRCG, WGH, and WGDRR in accordance with Typhoon Committee forecast competency, knowledge sharing, and exchange of latest development and new techniques.

Hydrology

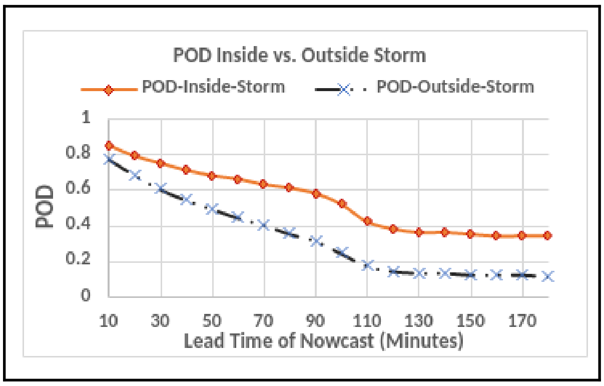
- Improve typhoon-related flood (including riverine flood, flash flood, urban flood, and coastal flood) monitoring, data collection and archiving, quality control, transmission, processing, and sharing framework.
- Enhance capacity in typhoon-related flood risk management (including land-use management, dam operation, etc.) and integrated water resources management and flood-water utilization.
- Strengthen capacity in effective flood forecasting and impact-based early warning, including hazard mapping and anticipated risk based on methodological and hydrological modelling, and operation system development.

DRR

- Enhance Members’ disaster risk reduction techniques and management strategies.

2. Verification of the Radar Integrated Nowcasting System (RaINS) during Two (2) Cyclonic Vortex Events in Malaysia.

MET Malaysia has developed the Radar Integrated Nowcasting System (RaINS) based on the Short-Range Warning of Intense Rainstorm in Localized Systems (SWIRLS) and the Rainstorm Analysis and Prediction Integrated Data-processing System (RAPIDS) that was developed by the Hong Kong Observatory (HKO). To evaluate the accuracy of the RaINS, nowcast accuracy was validated with respect to radar observation. RaINS was validated during a Tropical Depression event on 5th November 2017 which caused severe flooding in Peninsular Malaysia, and the Tropical Storm Kai-Tak on 22nd December 2017 when it was located near Peninsular Malaysia. Based on the Probability of Detection (POD) and False Alarm Ratio (FAR) skill scores, RaINS have useful lead time up to 90 minutes in areas within the storm but reduced lead time of 60 minutes in areas outside the storm.



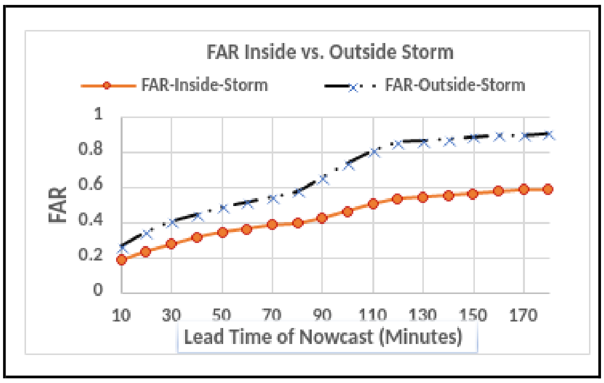


Figure 14: (Right) denotes POD skill score while (left) denotes FAR skill score Useful lead time is defined as POD exceeding FAR. Rainfall event is denoted by radar

Identified opportunities/challenges, if any, for further development or collaboration:

1. Nowcast capabilities could be further enhanced using Artificial Intelligence and the performance compared with the existing nowcasting system.
2. Radar nowcasting should include radar observation with enhanced quantitative precipitation estimation (QPE).

Priority Areas Addressed:

Integrated

- Strengthen the cooperation between TRCG, WGM, WGH, and WGDRR to develop impact-based forecasts, decision-support and risk-based warning.
- Enhance collaborative activities with other regional/international frameworks/organizations, including technical cooperation between TC/AP-TCRC and TC/PTC cooperation mechanism.

Meteorology

- Develop and enhance typhoon analysis and forecast techniques from nowcast to medium-range, and seasonal to long-range prediction.
- Enhance and provide typhoon forecast guidance based on NWP including ensembles, weather radar and satellite related products, such as QPE/QPF.
- Enhance training activities with TRCG, WGH, and WGDRR in accordance with Typhoon Committee forecast competency, knowledge sharing, and exchange of latest development and new techniques.

DRR

- Enhance Members' disaster risk reduction techniques and management strategies.

3. Annual Operating Plan for Working Group of Hydrology (AOP6: Flood Risk Watch Project for Live – Saving)

Introduction

The implementation of Annual Operation Plan 6 for Typhoon Committee Programme (AOP6) which is Flood Risk Watch for Life Saving in Malaysia has started at the end of 2018 after Ministry of Land, Infrastructure, Transport and Tourism (MLIT), submitted a proposal at the Working Group of Hydrology (WGH) meeting. In early January of 2019, the Department of Irrigation and Drainage (DID) managed a technical visit by the MLIT with the delegates from the International Centre for Water Hazard and Risk Management (ICHARM) and the Infrastructure Development Institute (IDI), Japan to Malaysia. The objective of the technical visit was to obtain information related to the construction of hydrological telemetry stations in Malaysia. In October 2019 they have make a second visit, in conjunction with the higher-level meeting about dam safety which was held in Malaysia. Recently, in December 2019, 2 delegates from IDI, Japan attended the technical field inspection in Malaysia for further clarification and understanding of hydrological data collection in Malaysia.

During the field survey, IDI experts have been taken to several hydrological station in the Klang River, Langat River and Pinang River. This is to verify and to identified the most suitable location for the establishment of a 3L Water Level Gauge (WLG) station. At the end of the visit, IDI experts have agreed to consider to install 3L WLG at 2 locations, namely Sulaiman Bridge Station in Klang River and Batu Lanchang station in Pinang River (Refer **Figure 15-A** & **Figure 15-B**).

Following from IDI's visit to Malaysia, MLIT was pleased to invite the DID delegation to Japan to understand the real condition of the operational of the 3L WLG station in Japan. A technical visit was held at the end of January 2020.

Figure 15-A: Sulaiman Bridge Station

Figure 15-B: Batu Lanchang Station

Both departments will have a further technical discussion to finalize all station construction requirements in Malaysia such as technical requirements, construction methods, notes of understanding, responsibility and security, data transmission methods and so on. However, due to the Covid-19 endemic, all such activities have been postponed since March 2020 and it is hoped that it will recover in 2021. Thus, during this period, DID and MLIT in process to finalizing all documentation requirements that do not require physical activity. It is planned that the installation of 3L WLG stations will be implemented in early of 2021 and is expected to start recording and transmitting data in March 2021.

The Covid-19 endemic has prolonged until early of year 2022. However, Japan and Malaysia still continue discussing the detail conditions for the test installation plans in preparation for resuming overseas travel after the endemic had subsided. At the same time, MLIT Japan has recruited four (4) WLG manufacturers to participate in the test installation programmed. On the 25th of January 2022, the MLIT has submitted a letter to DID informing an intention to carry out testing of 3L WLG equipment in Malaysia, through the involvement of four (4) manufacturing companies, namely as eTRUST Co.,Ltd., Midori Engineering Laboratory, YACHIYO Engineering Co.,Ltd. / OSASI Technos Inc., and MEISEI ELECTRIC Co.,Ltd.. DID has expressed their consent for the implementation of this test through a letter to MLIT dated on 17th of February 2022.

Then, on the 2nd of March 2022, DID and MLIT has held an online meeting to discuss about the installation plan of 3L WLG, the process of delivery items to Malaysia, and custom clearance procedure including import tax exemption application method. At that meeting, the participating companies was invited to present their proposal on installation plan. The installation location of the WLG also was decided to be changed to the Sentul Hydrology Station, Kuala Lumpur. Only one location was selected in order to make fairly comparison on data analysis and equipment performance between all the WLG installed. Besides that, it can facilitate the monitoring work by the DID personnel. The proposed installation location is as shown in the **Figure 15-C** below.

Figure 15-C: Propose Location for 3L WLG Installation

3L Water Level Gauge

MLIT Japan has been promoting an innovative initiative using 3L Water Level Gauge (WLG) to decrease flood damages. The meaning of 3L (Low Cost, Long Life and Localized) can be described as:

a) Low Cost : The initial cost of development is less than 10,000 USD;
b) Long Life : The WLG station can operate more than 5 years without power supply; and

c) Localised : The WLG station installation method can be modified to fit local situation.

MLIT Japan has commissioned the development of 3L WLGs to support flood management of small and medium-sized rivers from 2016 to 2017. As of the end of 2020, a number of 11,000 3L WLGs have been installed and operated in Japan. MLIT Japan has published the observation status of 3L WLGs on following English website (https://www.river.go.jp/e/).

Under the AOP6, MLIT has recruited four (4) WLG manufacturers to participate in the testing programme. In order to facilitate the delivery and installation process in Malaysia, the participating companies has appointed their representative in Malaysia. The list of the participating company and their representatives are as listed in the **Table 7** below.

Table 7: List of the Participating Company

No.	Participating Company Name	Web Page (English Site)	Representative Company Name in Malaysia
1	eTRUST Co., Ltd.	https://etrust.ne.jp/corporate/	Vanguard Electronic Sdn. Bhd.
2	Midori Engineering Laboratory	https://midori-eng.com/en/	Maintek Technologies Sdn. Bhd.
3	YACHIYO Engineering Co.,Ltd. / OSASI Technos Inc.	https://www.yachiyo-eng.co.jp/e/ https://www.osasi.co.jp/en/	Spatialworks Sdn. Bhd.
4	MEISEI ELECTRIC Co.,Ltd.	https://www.meisei.co.jp/english/	IHI Corporation, KL Branch (as Representative), and NEXTGMATRIX ENGINEERING (as installer)

Installation Progress

Before the delivery of WLG to Malaysia that was carried out by the participating companies, several matters has been informed and decided as follows:

bridge as shown in **Figure 16** have been sent to all the participating companies through MLIT, for their reference;

b. The WLG installation point on the bridge has been set as shown in **Figure 17**;

c. The participating companies were informed about the existence of one (1) WLG unit owned by DID at the steel bridge which it will be used for data comparison with WLG from Japan. In addition, the installation of WLG must be done at a distance of at least 6m from the river bank due to the existence of exposed sedimentation during low water level at a distance of 4m from the river bank. Please refer to **Figure 18**; and

d. The participating companies is allowed to install the WLG on the existing safety railing on that steel bridge, but they must responsible for the damage and failure that will occur. In addition, the participating companies also need to make repairs to the original condition of the safety railing after the testing programme is completed. The picture of the safety railing is as shown in **Figure 19**.

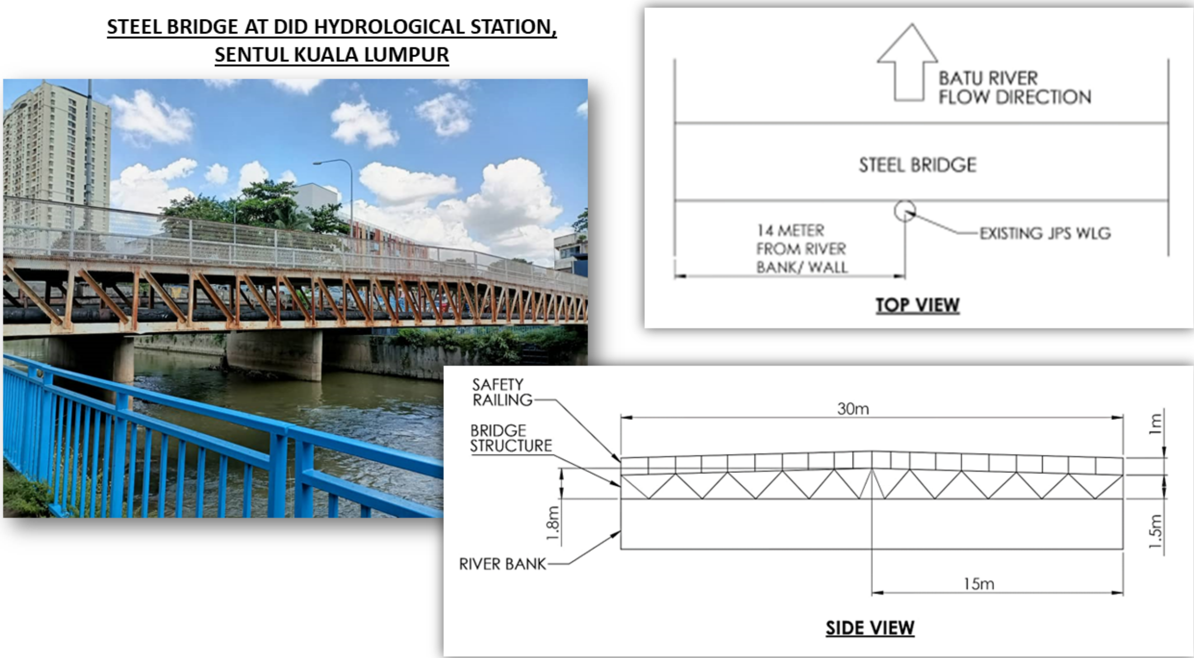
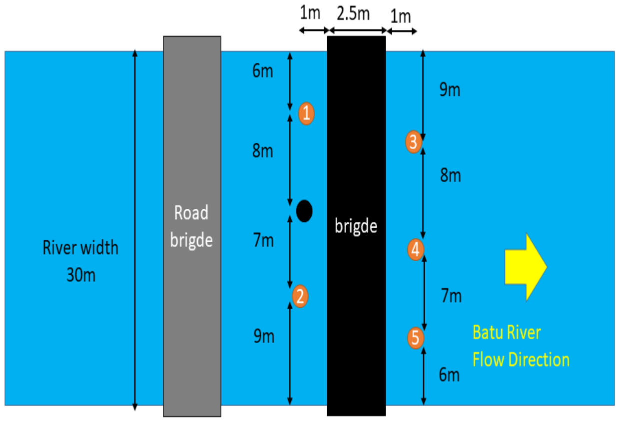


Figure 16: Steel Bridge at Sentul Hydrological Station, Kuala Lumpur



Symbol	Participant Company Name
1	eTRUST Co.,Ltd.
2	eTRUST Co.,Ltd.
3	Midori Engineering Laboratory
4	YACHIYO Engineering Co.,Ltd. / OSASI Technos Inc.
5	MEISEI ELECTRIC Co.,Ltd.

Figure 17: Arrangement of Sensor Placement on the Bridge

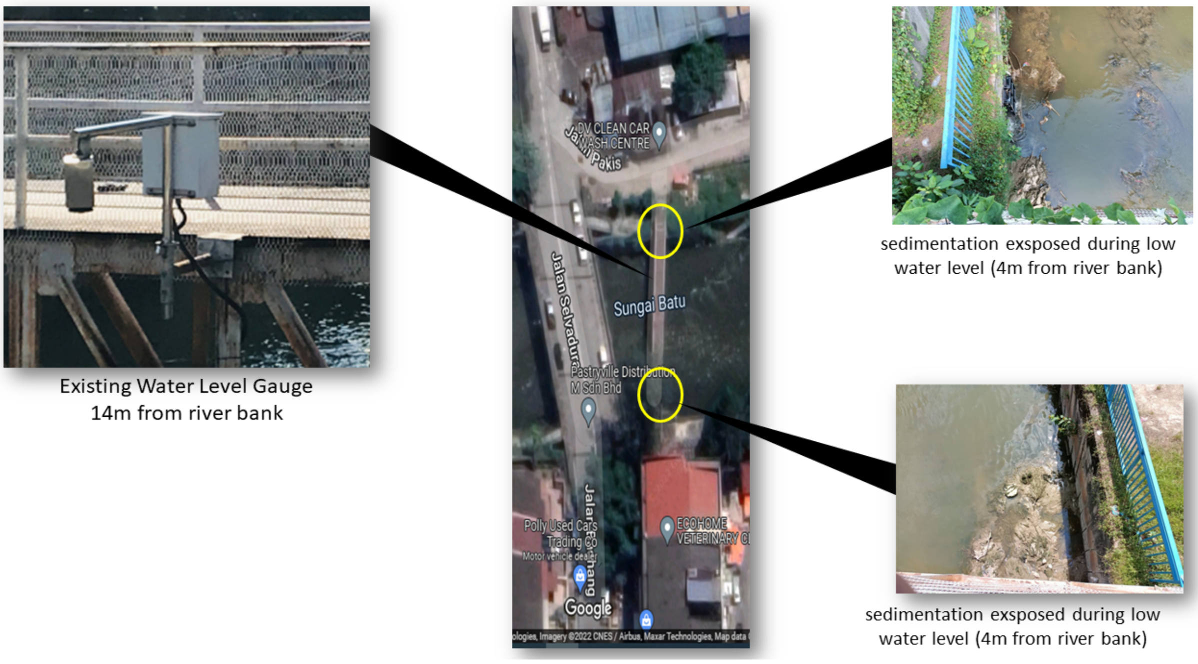


Figure 18: Installation Location

STEEL BRIDGE SAFETY RAILING

Figure 19: Steel Bridge Safety Railing

The installation work has been carried out in stages by each of the participating companies. The first installation works was carried out by the Midori Engineering Laboratory on the 11th of May 2022, followed by MEISEI ELECTRIC Co.,Ltd. on the 23rd of May 2022. Then, the YACHIYO Engineering Co., Ltd. / OSASI Technos Inc. completed their WLG installation works on the 27th of June 2022. And finally, on the 26th of June 2022, eTRUST Co.,Ltd. have installed their WLG on site. The picture of all WLG installed on the steel bridge at the Sentul Hydrology Station is as shown in the **Figure 20**. The summary of installation date of WLG is shown in the **Table 8** below.

Table 8: Installation Date

No.	Participating Company	Installation Date
1	Midori Engineering Laboratory	11/5/2022
2	MEISEI ELECTRIC Co.,Ltd.	23/5/2022
3	YACHIYO Engineering Co.,Ltd. / OSASI Technos Inc.	27/6/2022
4	eTRUST Co.,Ltd.	26/7/2022

Figure 20: Picture of all WLG installed at site

WLG Installation by Midori Engineering Laboratory

The installation works of WLG from Midori Engineering Laboratory was carried out from 11th to 13th of May 2022 with the assistant of Maintek Technologies Sdn. Bhd. from Malaysia. The picture of the installed WLG is shown in **Figure 21** below.

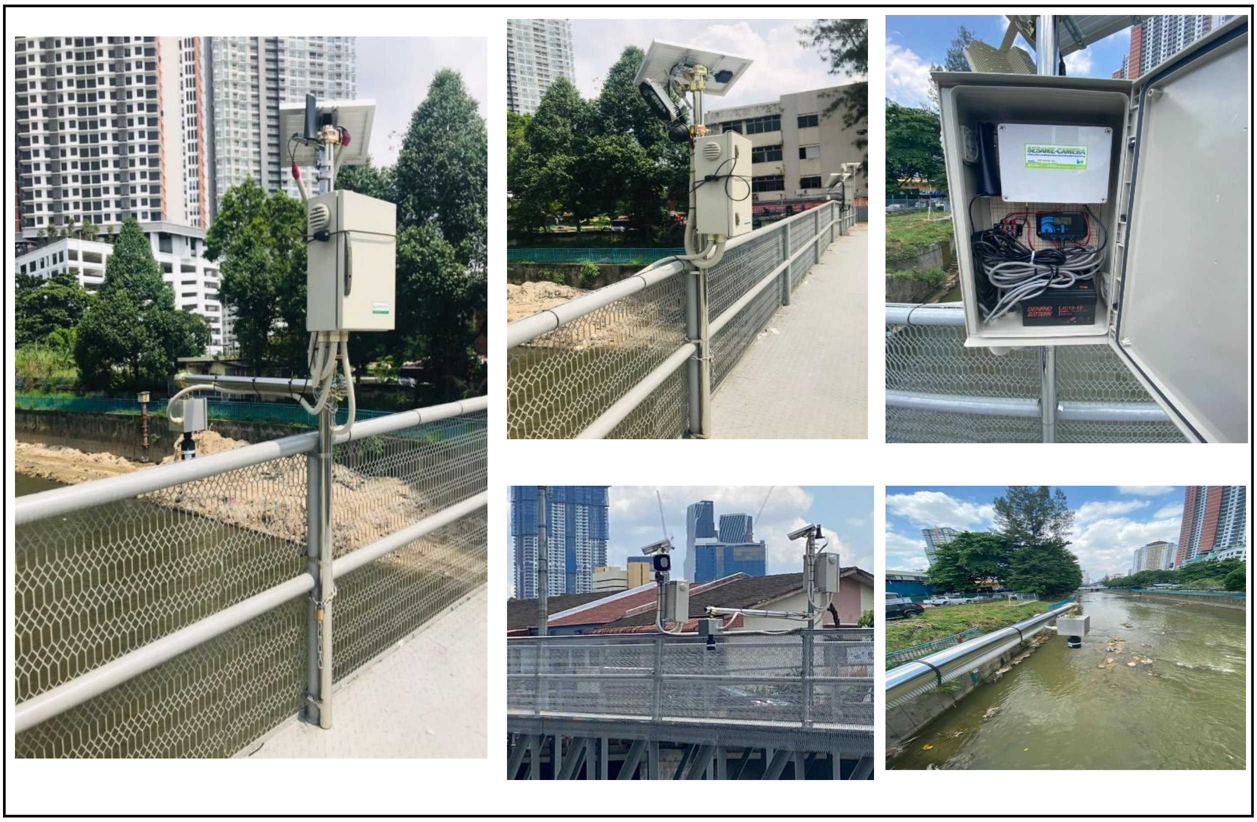


Figure 21: Picture of WLG Installation Progress of Midori Engineering Laboratory

WLG Installation by MEISEI ELECTRIC Co.,Ltd.

Installation works of WLG by MEISEI ELECTRIC Co.,Ltd. was completed on 23rd of May 2022 by IHI Corporation and NEXTGMATRIX ENGINEERING who are respectively appointed representatives and installers in Malaysia. The picture of installation works is shown in the **Figure22** below.

Figure 22: Picture of WLG Installation Progress of MEISEI ELECTRIC CO., Ltd.

WLG Installation by YACHIYO Engineering Co. Ltd. / OSASI Technos Inc.

Installation works of WLG from YACHIYO Engineering Co. Ltd. / OSASI Technos Inc. was implemented from 27 June 2022 by their appointed representative in Malaysia, namely Spatialworks Sdn. Bhd. The picture of installation work is shown **Figure 23**.

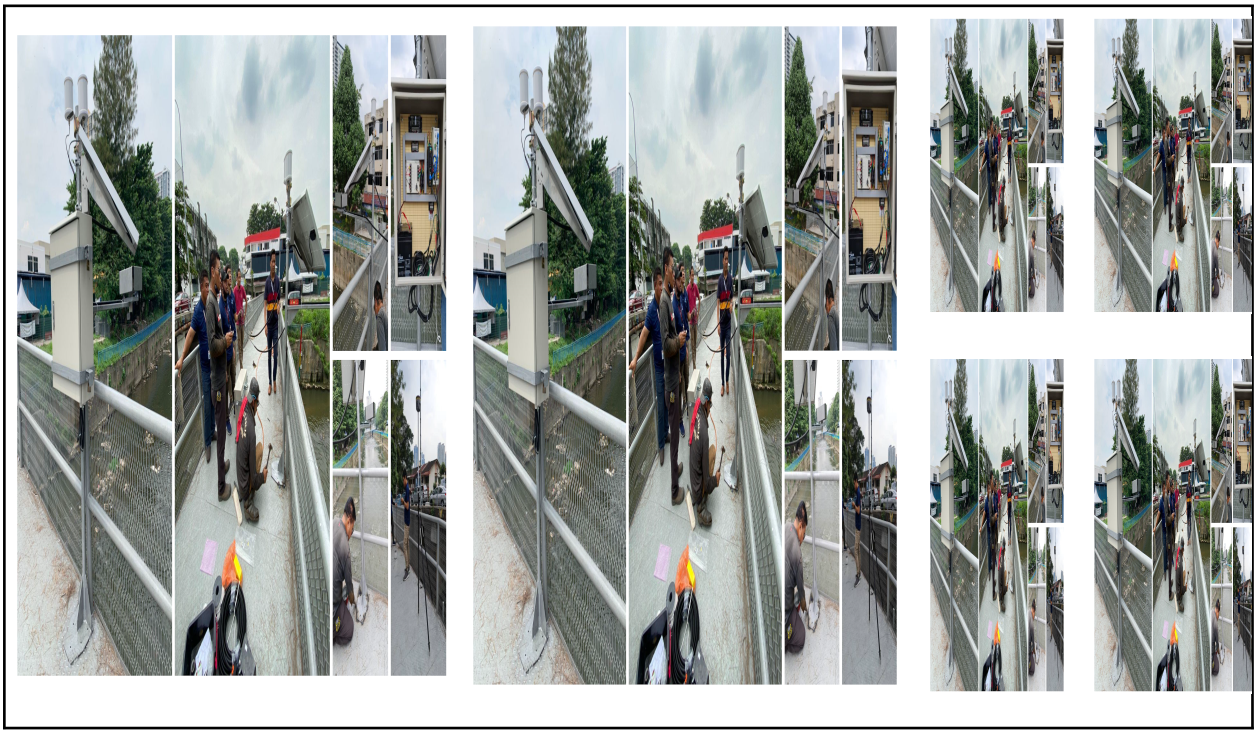


Figure 23 : Picture of WLG Installation Progress of YACHIO Engineering Co. Ltd. / OSASI Technos Inc.

WLG Installation by eTRUST Co. Ltd.

The installation works of two (2) numbers of WLG by eTRUST Co.,Ltd. was completed by their own staff, namely Mr. Masaru Suzuki and the engineer Mr. Watanabe from 26th to 29th of July 2022. This works was assisted by personnel from Vanguard Electronic Sdn. Bhd., which is the appointed representative in Malaysia. The picture of installation works is shown in **Figure 24**.

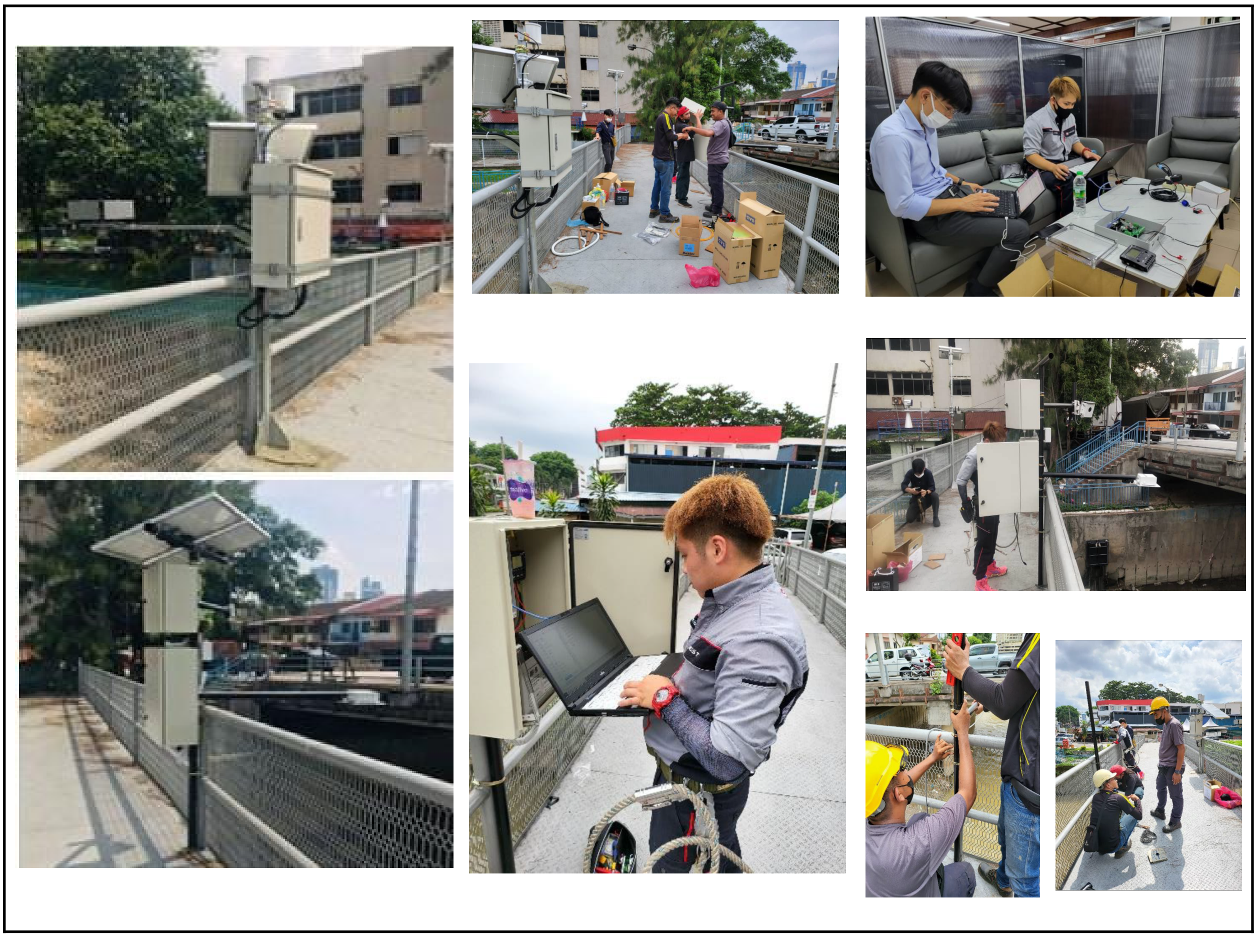


Figure 24 : Picture of WLG Installation Progress of eTRUST Co., Ltd.

Data Monitoring and Analysis

The main objectives of the 3L WLG testing programme is to check the accuracy of observation data and operability of the Japan WLG equipment. **Figure 25** shows the observation and analysis processes which are consist of data acquisition, data analysis, result and as well as findings. All the WLG elevation values including DID WLG but except AOP6-5 were deployed based on the stick gauge level installed at site. Besides that, the elevation value (Reduced Level) for AOP6-5 was set using GPS Surveying method. At the data acquisition stage, all WLG data was downloaded from the DID server for period of time for analysis purposes. The 3L WLG data also displayed at DID Web Portal as shown in the **Figure 26**, and it can be monitored in real-time. In order to verified the WLG data captured by the sensor, DID had obtain the water level stick gauge reading at site, from 15^{th} August to 8^{th}

and stick gauge. The performance analysis is based on data received performance, compliance to data format, and data quality or accuracy.

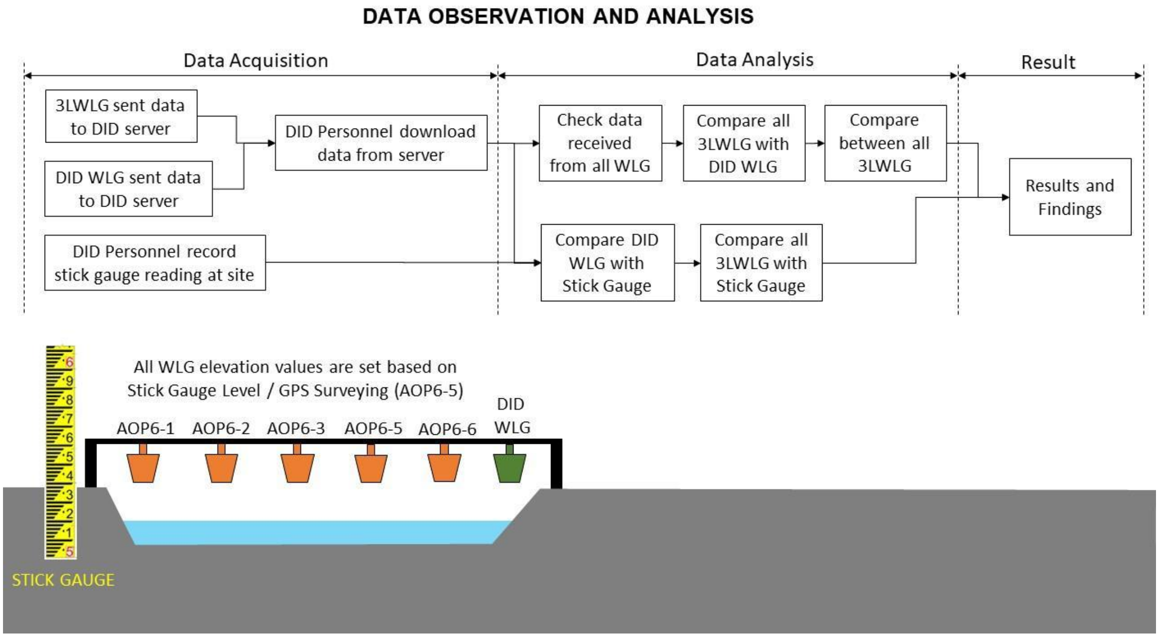


Figure 25: Data Observation and Analysis Chart

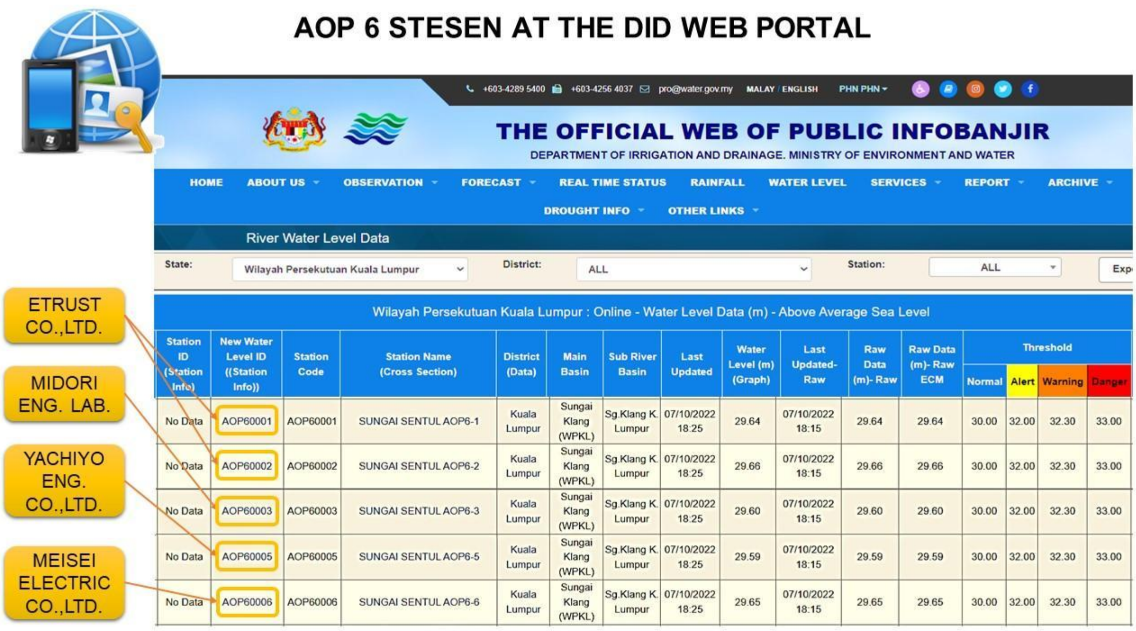


Figure 26: DID Web Portal for Flood Information and Hydrology Data

Other than that, the simple analysis of data received at server has been done by checking number of files received at DID server for period of one (1) month from 1st to 31st of August 2022. The analysis result is as shown in **Figure 27** which can be conclude that all the WLG have good and excellence performance in term of data availability. Unfortunately, one (1) of the WLG which is AOP6-1 (AOP60001) is out of observation due to power supply related problem. The participant company for AOP6-1 have been inform by MLIT/IDI regarding this issue.

DATA RECEIVED ANALYSIS AT DID SERVER FROM 1ST TO 31ST OF AUGUST 2022

3L WLG NAME	PARTICIPANT COMPANY	TOTAL DATA MISSING (Number of Files)	PERCENTAGE OF DATA RECEIVED
AOP60001	eTRUST Co., Ltd.	1688	43.28%
AOP60002	eTRUST Co., Ltd.	44	98.52%
AOP60003	Midori Engineering Laboratory	22	99.26%
AOP60005	YACHIYO Engineering Co.,Ltd. / OSASI Technos Inc.	9	99.70%
AOP60006	MEISEI ELECTRIC Co.,Ltd.	1	99.97%

- AOP60001 is out of observation due to the power supply-related problem.
- AOP60006 and AOP6005 have an excellence performance regarding sending data.

Figure 27: Data Received Analysis Result

According to the analysis for compliance to DID data format, it can be concluded that data sent by all the WLG is acceptable for this test and observation programme. However, a little improvement is required in order to fulfil the DID requirement for water level gauge. The result for this analysis is shown in the **Figure 28**.

COMPLIANCE OF DATA FORMAT

	COMPLIANCE OF DATA FORMAT																			
	$ - Start of message	Station Code	RTU I.D	Date and Time stamp	Nr – Normal, A1 – Rainfall Alarm, A2 – Water Level Alarm, A3 – RF and WL Alarm	Battery Voltage (V)	GSM/Comm – GSM/Comm signal strength (dbm or ASU : 0 to 33 integer)	Int_Bat – Internal battery voltage (V)	Solar Output (V)	WL_Alert threshold value (m)	WL_Warning threshold value (m)	WL_Danger threshold value (m)	WL1_Sensor ID	Water Level 1 in meter, +/- (m)	Hand-phone Officer 1 (PHN)	Station Name	Lat – Latitude	Long – Longitude	* - End of message
AOP60001	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No data	No data	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AOP60002	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No data	No data	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AOP60003	Yes	Yes	Yes	Yes	Send alert code 'A2', even the WL below alert threshold.	Yes	Yes	Wrong data send. Data send is battery voltage.	Wrong data send. Data send is battery voltage.	Yes	Yes	Yes	Yes	Yes	No data	No data	Yes	Yes	Yes
AOP60005	Yes	Yes	Yes	Yes	Send alert code 'A2', even the WL below alert threshold.	Yes	Yes	No data	Wrong data send. Data send is battery voltage.	Yes	Yes	Yes	Yes	Yes	No data	No data	Yes	Yes	Yes
AOP60006	Yes	Yes	Yes	Yes	Yes	Yes	Data send for 15th minute only. No data for 5th and 10th minute.	No data	No data	Yes	Yes	Yes	Yes	Yes	No data	No data	Yes	Yes	Yes

List of Non Compliance of Data Format:

1. No data for internal battery voltage, and solar output voltage.
2. The data sent for alert code 'A2', even the water level is below alert threshold (normal). The correct data is nr.
3. The data sent for internal battery voltage, and solar output voltage is battery voltage, which is wrong.
4. No data for Officer Handphone Number and Station Name.
5. Data of communication signal strength sent for 15th minute only, which is no data for 5th and 10th minute.

Figure 28: Data Format Analysis Result

Figure 29 and **Figure 30** shows the finding of the quality and accuracy of WLG data. From the graph, it shows that all the WLG and stick gauge produces same pattern of water level data during the period from 15th of August to 8th of September 2022. Although there are some data difference between all the WLG and stick gauge, however the accuracy between them is more than 99%. The comparison analysis between WLG and stick gauge data has been carried out to check the data pattern. Base on the analysis result as shown in Figure A-18, the difference between WLG versus stick gauge is larger than the difference between all WLG. There are one (1) uncertainty might occur which is the accuracy of the stick gauge reading. The reading of the stick gauge is carried out by DID personnel, and this process can contribute to the parallax error. Besides that, the difference between all the WLG might happen due to the initial setting of all the WLG, where they setting according to the stick gauge reading. Based on this finding, the initial elevation setting shall be reconfigured based on DID WLG only.

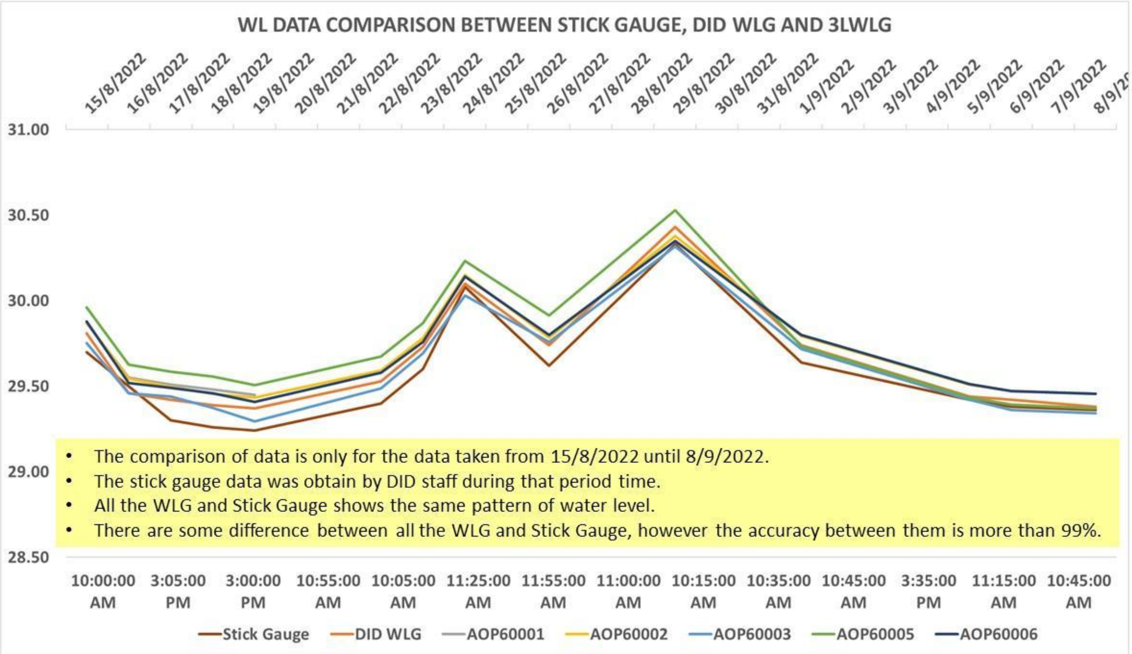


Figure 29: Data Comparison Graph

AVERAGE DATA COMPARISON BETWEEN STICK GAUGE, DID WLG AND 3LWLG

	Stick Gauge	DID WLG	AOP60001	AOP60002	AOP60003	AOP60005	AOP60006
Stick Gauge		99.68%	99.41%	99.54%	99.77%	99.40%	99.55%
DID WLG	83.33m		99.72%	99.79%	99.87%	99.66%	99.80%
AOP60001	172mm	82mm		99.94%	99.93%	99.93%	99.93%
AOP60002	135mm	54.29mm	19.13mm		99.99%	99.99%	99.99%
AOP60003	49.33mm	34mm	19.74mm	1.88mm		100%	100%
AOP60005	174.4mm	95.7mm	19.87mm	2.01mm	0.13mm		100%
AOP60006	132.4mm	49.07mm	19.83mm	1.97mm	0.08mm	0.05mm	

ACCURACY

DIFFERENCE

- BLUE CELL = Comparison of 3LWLG with DID Stick Gauge and DID WLG, shows that the average difference is from 34mm to 174.4mm.
- GREEN CELL = Comparison between all 3LWLG, shows that the average difference is from 0.05mm to 19.87mm.
- There are big average difference between All the WLG compared to Stick Gauge.
- The Stick Gauge reading is done by DID Staff. There will be a parallax error might occur.
- The initial setting value in WLG during installation is based on the Stick Gauge on site.
- The initial elevation setting shall be reconfigure in all WLG and should referring to DID WLG to make better and fair comparison.

Figure 30: Data Comparison Result

Conclusion

After going through the long planning and the implementation delayed due to the Covid-19 endemic, the 3L WLG testing programme has started after all five set of (5) WLG have been successfully installed by the four (4) participating companies at the Sentul Hydrology Station, Kuala Lumpur. First stage of data analysis has been completed for all WLG, and can be summarize as below;

a) All WLG show consistent and excellence performance in term of data availability except AOP6-1 (AOP60001) which is out of observation due to power supply related problem;

b) Data format and data quality for all WLG is acceptable, however a little improvement is required in order to fulfil the DID requirement for water level gauge;

c) The initial elevation setting shall be reconfigured at all WLG and should referring DID WLG only for fair data quality comparison and processing method;

d) Power supply performance for 3L WLG system will be included in the future analysis.

Identified opportunities/challenges, if any, for further development or collaboration:

The challenges in implementing this project can be categorized into 3 forms namely:

i. Determination of technical specifications of hydrological and communication equipment to meet the operational requirements in Malaysia
ii. Method of installation and data sharing
iii. The current scenario related to Covit'19 which makes it difficult to implement physical projects

Priority Areas Addressed:

Hydrology

Ensure complete and consistent hydrological data in a various weather condition. Hydrological data is a key input in flood modeling that has a significant impact on the accuracy of the flood forecast result. Hydrological data especially rainfall and water level can measure the flood condition and also flood warning. The robust and reliable instrumentation for collecting hydrological data is crucial for flood forecasting and monitoring.

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