

Republic of Indonesia
Ministry of Public Works and Housing

**THE PROJECT FOR
PROMOTING COUNTERMEASURES AGAINST
LAND SUBSIDENCE IN JAKARTA**

**Study on Acceleration of Flood Control MP in
JABODETABEK
Final Report**

October 2022

JAPAN INTERNATIONAL COOPERATION AGENCY

**YACHIYO ENGINEERING CO., LTD.
CTI ENGINEERING INTERNATIONAL CO., LTD.
KOKUSAI KOGYO CO., LTD.
PASCO CORPORATION**

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Abbreviations

Abbreviations	Formal Name	In Japanese
ALOS	Advanced Land Observing Satellite	陸域観測技術衛星
AMT	Audio-Magnetotelluric	地磁気地電流法
APINDO	Asosiasi Pengusaha Indonesia	インドネシア経営者協会
BAPPEDA	Badan Perencanaan Pembangunan Daerah	開発計画局
BAPPENAS	Badan Perencanaan Pembangunan Nasional	国家開発計画庁
BBWS-CC	Balai Besar Wilayah Sungai Ciliwung-Cisadane	チリウン・チサダネ流域管理事務所
BKAT	Balai Konservasi Air Tanah	地質調査所・地下水保全センター
BIG	Badan Informasi Geospasial	地理空間情報機構
BM	Benchmark	水準点
BPBD	Badan Penanggulangan Bencana Daerah	地域災害管理局
BPIW	Badan Pengembangan Infrastruktur Wilayah	地域社会基盤開発局
BPPT	Badan Pengkajian dan Penerapan Teknologi	技術評価応用センター
BPS	Badan Pusat Statistik	インドネシア中央統計庁
DKI Jakarta	Daerah Khusus Ibukota Jakarta	ジャカルタ特別州
DPE	Dinas Perindustrian dan Energi	ジャカルタ特別州工業・エネルギー局
DPMPSTP	Dinas Penanaman Modal dan Pelayanan Terpadu Satu Pintu	ワンストップ統合サービス・資本投資局
DSDA	Dinas Suumbar Daya Air	ジャカルタ特別州水資源局
ESDM	Energi dan Sumber Daya Mineral	エネルギー鉱山資源省
GIS	Geographic Information System	地理情報システム
GNSS	Global Navigation Satellite System	全球測位衛星システム
GPS	Global Positioning System	全地球測位システム
GW	Groundwater	地下水
InSAR	Interferometric Synthetic Aperture Radar	干渉合成開口レーダー
ITB	Institut Teknologi Bandung	バンドン工科大学
JCC	Joint Coordinating Committee	合同調整委員会
JICA	Japan International Cooperation Agency	国際協力機構
KKP	Kementerian Kelautan dan Perikanan	ジャカルタ漁業省
KLHK	Kementerian Lingkungan Hidup dan Kehutanan	環境林業省
KPK	Komisi Pemberantasan Korupsi	不正撲滅委員会
LAPAN	Lembaga Penerbangan dan Antariksa Nasional	国家航空宇宙研究所
M/M	Minutes of Meeting	協議議事録
M/P	Master Plan	マスタープラン
MRTJ	Mass Rapid Transit Jakarta	ジャカルタ都市高速鉄道
BNPB	Badan Nasional Penanggulangan Bencana	国家防災庁
NCICD	National Capital Integrated Coastal Development	国家首都統合沿岸開発

Abbreviations	Formal Name	In Japanese
NRW	Non-Revenue Water	無収水
PAM JAYA	Perusahaan Daerah Air Minum Jakarta Raya	ジャカルタ水道公社
PDAM	Perusahaan Daerah Air Minum	地方水道公社
PIC	Planning and Implementation Committee	地盤沈下対策委員会
PTPSW	Pusat Teknologi Pengembangan Sumber Daya Wilayah	地域資源開発技術センター
PUSAIR	Puslitbang Sumber Daya Air	水資源研究所
PUPR	Pekerjaan Umum dan Perumahan Rakyat	公共事業・国民住宅省
PCLSJ	Project for Promoting Countermeasures against Land Subsidence in Jakarta	ジャカルタ地盤沈下対策プロジェクト
RI	Republic of Indonesia	インドネシア共和国
R&D	Research and Development	研究・開発
R/D	Record of Discussions	討議議事録
RPJMN	Rencana Pembangunan Jangka Menengah Nasional	国家中期開発計画
SDGs	Sustainable Development Goals	持続可能な開発目標
WG	Working Group	ワーキンググループ

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Chapter 9

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Chapter1 Introduction

1.1. Background

GOI has developed the flood control facilities according to the master plan of WS Ciliwung-Cisadane in 1997 supported by JICA's cooperation, the comprehensive master plan of Ciliwung in 2013 supported by JICA cooperation (hereinafter collectively referred to as "the previous master plans"). From December 31, 2019, to the following January 1, 2020, the Jakarta metropolitan area experienced major flooding, including inland flooding. According to various press materials, 80-150 cm of flooding occurred in various parts of Jakarta. In addition, many landslides occurred mainly in mountainous areas in Bogor City and Bogor Regency in the southern part of the metropolitan area.

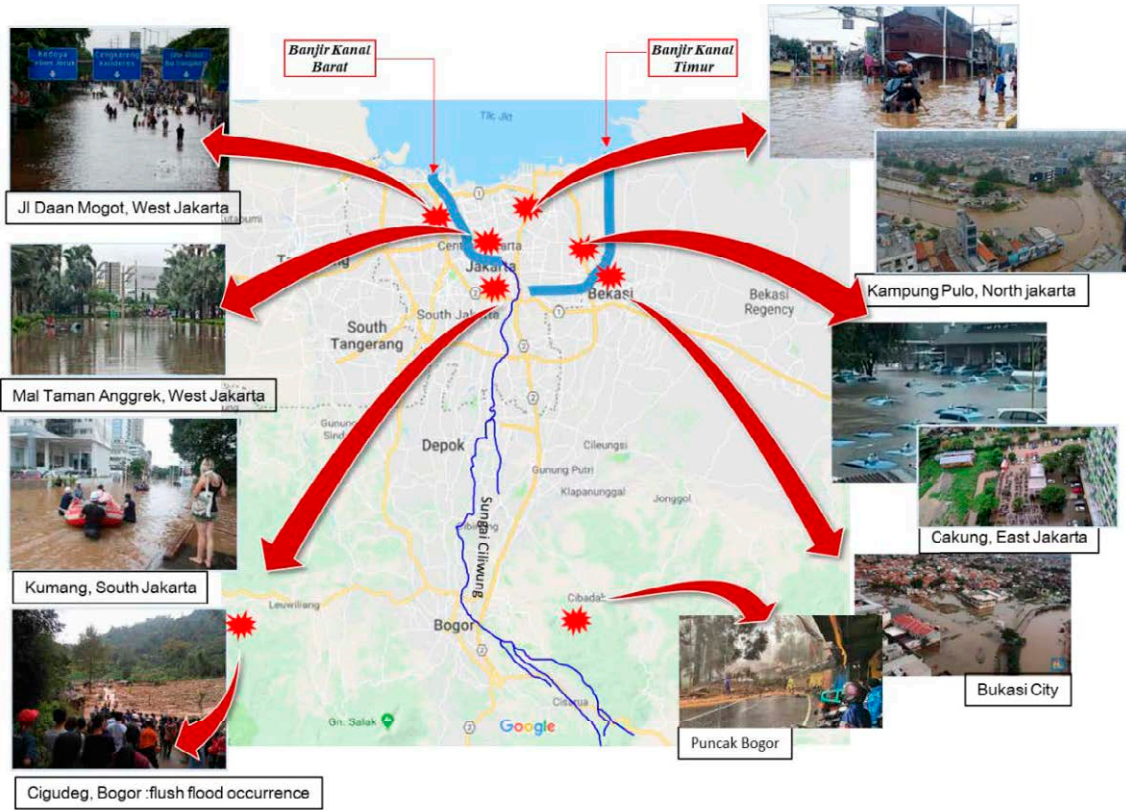
In regards to the January 2020 flood, a Joint Commitment for Flood and Landslide Control in Jabodetabekpunjur (Jakarta-Bogor-Depok-Tangerang-Bekasi-Puncak-Cianjur) area 2020 - 2024 is under preparation by relevant ministries (e.g. BAPPENAS, PUPR, and National Disaster Management Authority) and local governments (e.g. DKI Jakarta, West Java Province, Banten Province). Under this commitment, the responsible authorities will allocate a budget and implement related activities, which are stipulated in the Action Plan for Flood and Landslide Control. Based on the situation above, BAPPENAS requested JICA to accelerate the implementation of the master plan and to give added value to the joint commitment. In response to this request, JICA agreed to prepare the Survey as one of the scopes under the ongoing project, namely the Project for Promoting Countermeasures against Land Subsidence in Jakarta (hereinafter referred to as "the Project").

1.2. Damage situation

According to preliminary reports released by the National Disaster Management Agency (Badan Nasional Penanggulangan Bencana, BNPB) immediately after the disaster, the total number of deaths in the metropolitan area was 61 and the maximum number of evacuees was 446,286. The most notable characteristics of the disaster are that the number of evacuees in Bekasi City is more than 366,000, accounting for more than 80% of the total and that in Bogor and Lebak (note: not usually included in the metropolitan area) Regency, there are many deaths due to landslides.

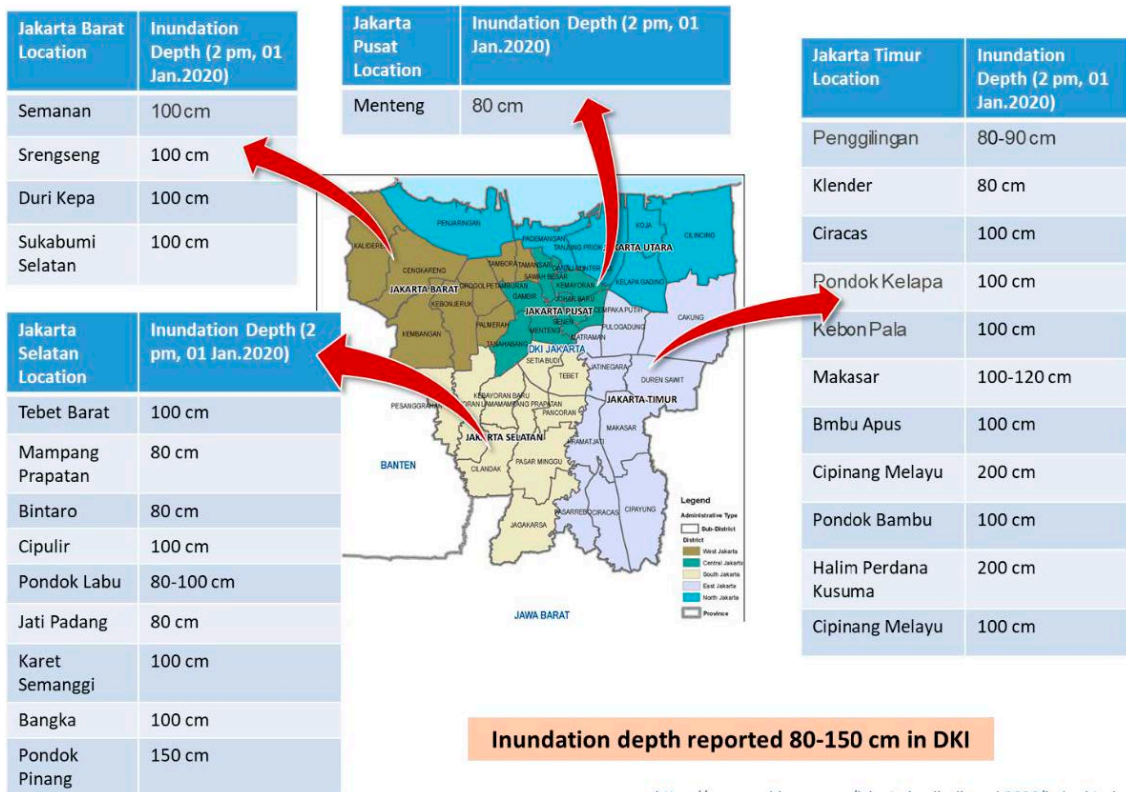
Ministry of National Development Planning of Indonesia (Badan Perencanaan Pembangunan Nasional, BAPPENAS) estimated the amount of damage at 5.2 trillion rupiah (approximately 41 billion yen) immediately after the disaster occurred, but no official announcement has been made by BNPB or other related organizations since then.

The characteristics of the rainfall and inundation conditions that caused this disaster will be described later, but one of the characteristics of this disaster as a phenomenon is the combined inundation of inland and river waters that occurred in many areas, probably due to the coincidence of the peak river discharge and the peak rainfall.



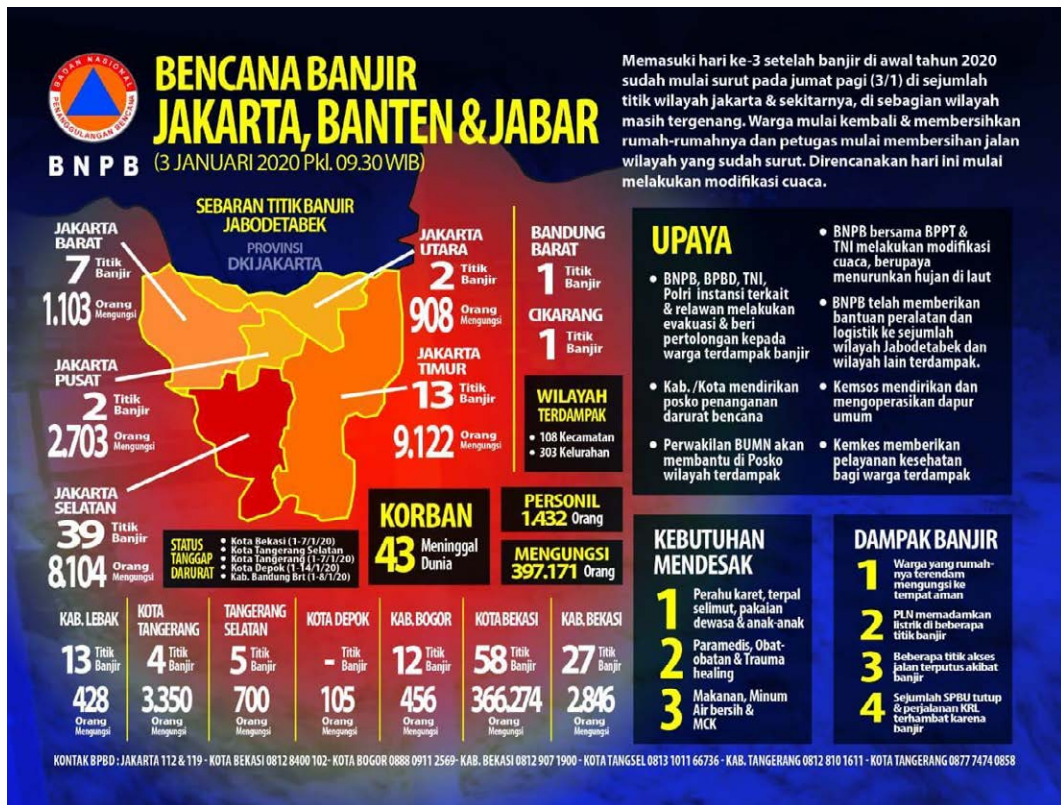
(Source: Various press materials)

Figure 1-1 Damage situation in Jakarta Metropolitan Area



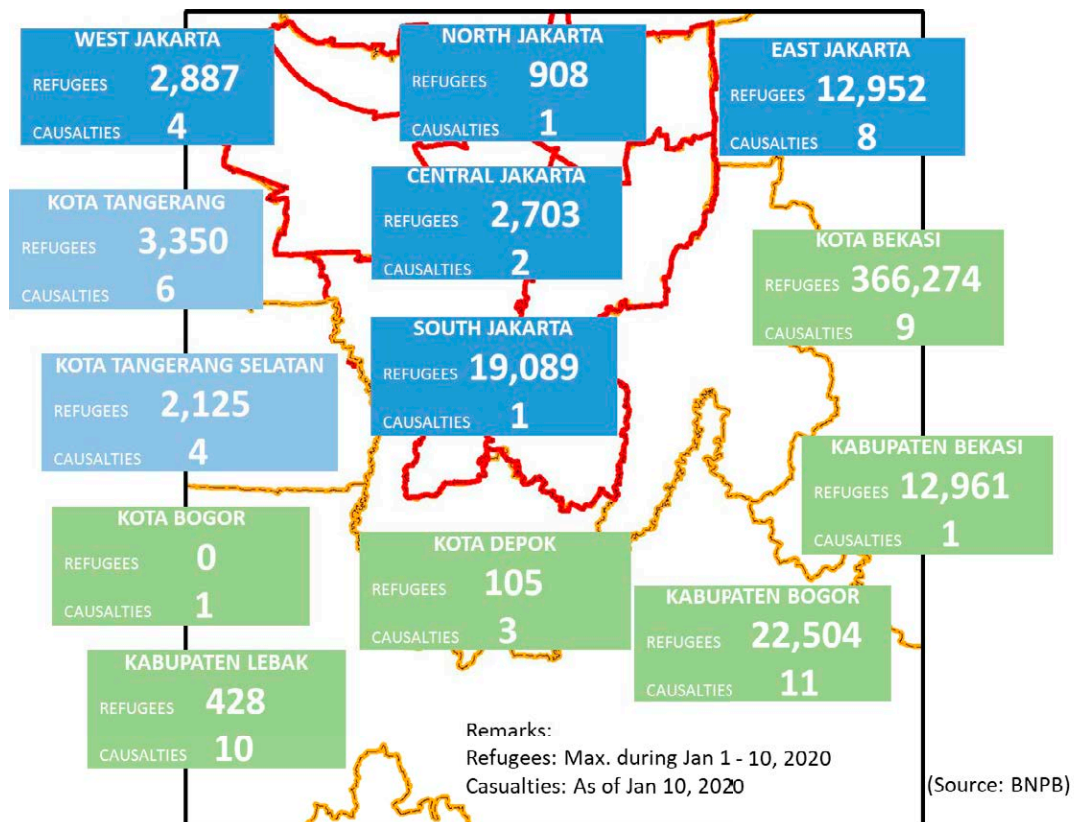
(Source: <https://www.acehimage.com/jakarta-banjir-di-awal-2020/index.html>)

Figure 1-2 Inundation depths at key locations in DKI Jakarta



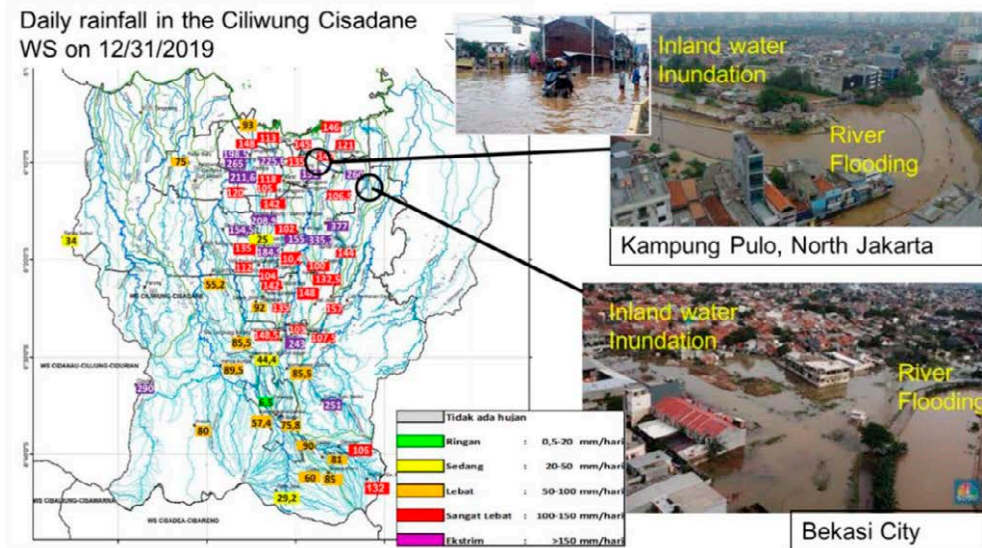
(Source : BNPB)

Figure 1-3 Preliminary document issued by the BNPB (January 3, 2020 edition)



(Source: BNPB)

Figure 1-4 Number of deaths and evacuees by city and regency



(Source: Survey team based on BMKG data)

Figure 1-5 Example of combined inland and river water inundation

1.3. Measures taken by the Government of Indonesia

1.3.1. Emergency Response by PUPR

On January 2, immediately after the disaster, Directorate of Water Resources formed a survey team consisting mainly of young staff members to survey 178 damaged sites to determine the extent of damage (area, depth, and duration of inundation), causes, and emergency measures.

Based on this, emergency measures such as sandbagging, dust and sand removal, and drainage using snake baskets and mobile pumps were implemented. The results of the investigation are detailed in Section 2.1.

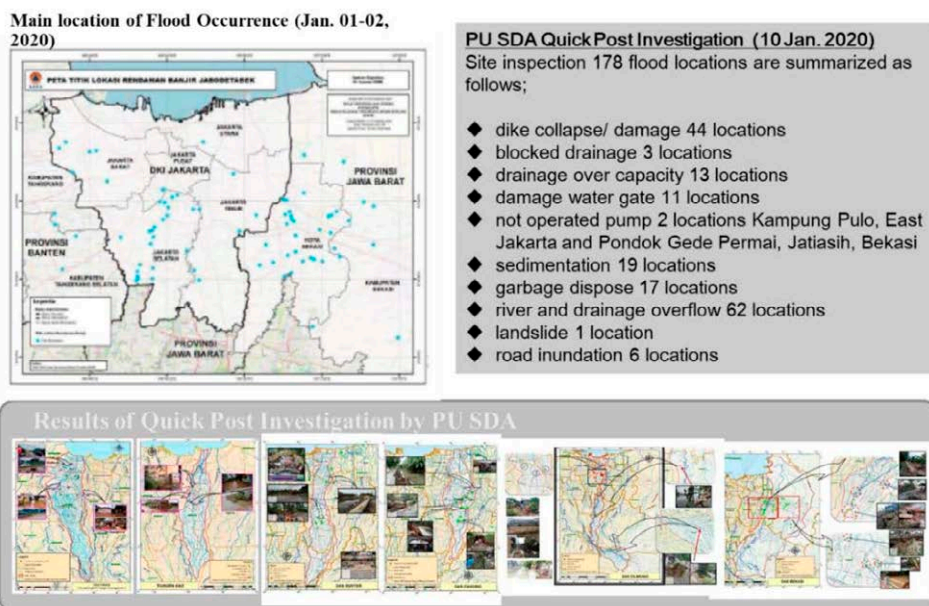


Figure 1-6 Summary of emergency survey results by PUPR

1.3.2. Action Plans from 2020 to 2024

In April 2020, Presidential Decree No. 60 of 2020 pertaining to the spatial planning of the Jakarta, Bogor, Depok, Tangerang, Bekasi, Puncak, and Cianjur metropolitan areas was issued. Within this decree, the following five policies were established in relation to flood control.

1. integrated development of upstream and downstream areas, including coastal areas
2. stricter regulation of development in riverine areas
3. strengthening the functions of situs, lakes (Danau), reservoirs (Embung), and weirs (Weir)
4. implementation of flood control measures on rivers
5. increase river flow control and runoff capacity

Based on this policy, the Ministry of the Interior Affairs of the Indonesia and BAPPENAS took the lead in formulating the strategy shown below and created a five-year action plan for the period 2020-2024, consisting of a total of 394 projects with a total budget of 42.5 trillion rupiah (approximately 340 billion yen) with all related administrative agencies. A summary is shown in Table 1-1.

1. **Coordination and Synchronization** : Strengthen management through legislation
2. **Risk Prevention and Reduction** : Pre-emptively deal with water risks.
3. **Control and Protection** : Build facilities to deal with flood risks.
4. **Increase Preparedness** : Provide fast, accurate and integrated flood risk responses.

Table 1-1 The number and budget of action plan from 2020 to 2024

Main Implementer	Number of project	Budget(billion IDR)
PUPR	80	17,132
BAPPENAS	5	0.6
LHK	2	35
DKI Jakarta	46	20,888
West Jawa Province	60	429
Cianjur Regency	1	0.5
Bogor Regency	1	110
Bogor City	8	16
Depok City	37	628
Bekasi Regency	71	43
Bekasi City	43	1,046
Banten Regency	3	5
South Tangerang City	4	44
Tangerang City	20	1,974
Tangerang Regency	12	164
Total	394	42,515

Chapter2 Basic study

2.1 Rainfall analyses

The rainfall analysis and rainfall characteristics of the flood in January 2020 are summarized below.

2.1.1 Characteristics of Past Floods in Jakarta

In recent years, large-scale flood disasters occurred in Jakarta in 1996, 2002, 2007, 2013, and 2020, causing severe damage.

Table 2-1 Characteristics of Past Floods in Jakarta

Date	Highest water level at Manggarai (EL.m)	Damage	Inundation area (km ²)	Number of fatalities *2	Direction of rainy area *3
1996/1/2-1/6 *1	9.70	Overflow,	-	-	-
2002/1/26-2/2 *1	10.50	Inland flood	87	25	from West to East
2007/1/30-2/6 *1	10.61	Overflow, Inland flood	300	80	from West to East
2013/1/8-1/20 *1	10.00	Overflow, levee damage, Inland flood	140	20	from West to East
2019/12/31-2020/1/1	9.45	Overflow, levee damage, Inland flood	142	61	from South to North

*1 : Integrated Flood Control Project for Greater Jakarta Metropolitan Area, Indonesia (draft), 2013, JICA

*2 : web information

*3 : GSMaP (Global Satellite Mapping of Precipitation)

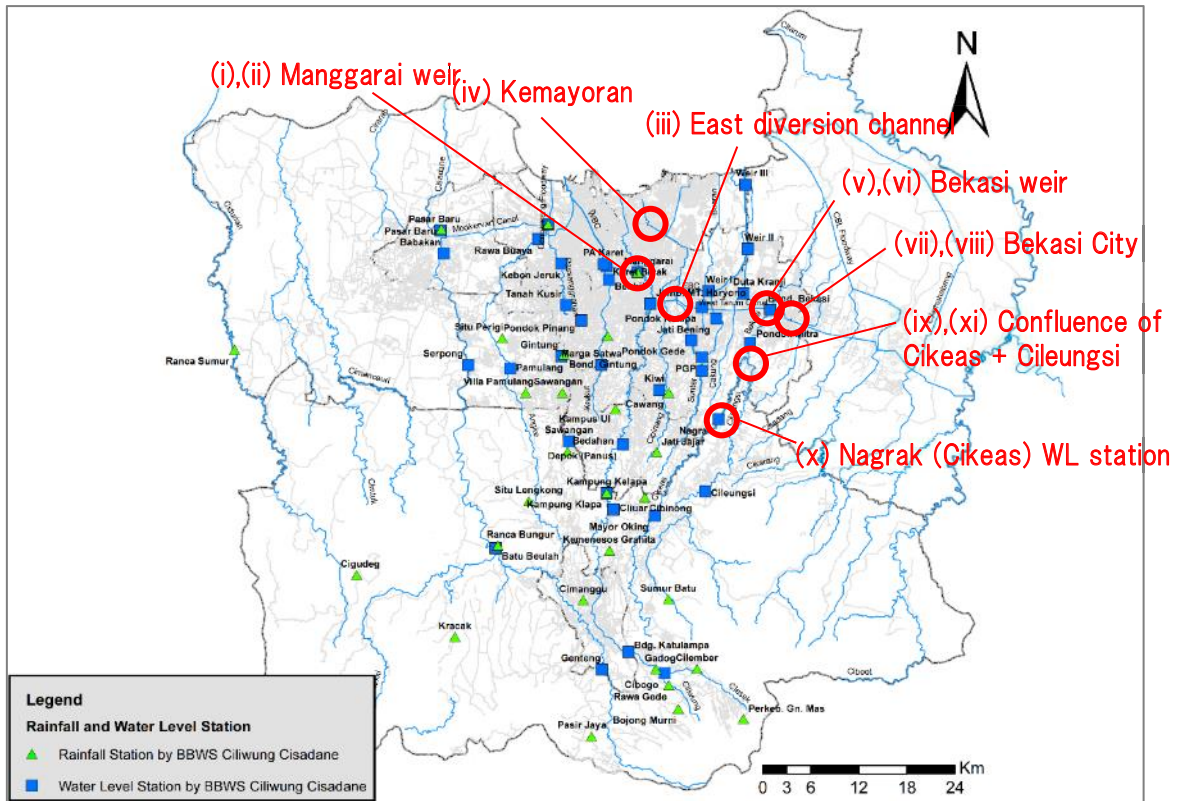
URL : https://sharaku.eorc.jaxa.jp/GSMaP/index_j.htm

2.1.2 Characteristics of the flood in January 2020

The results of field survey and characteristics of the collected hydrological data are summarized below.

(1) Field survey

Figure 2-1 shows the locations where damage conditions were confirmed, and hearings were conducted through the field survey. The results of the survey are shown on the following pages.



※(number) : corresponds to the following pages
 Source : JICA study team

Figure 2-1 Location of the field survey

(i) Upstream of Manggarai weir along the Ciliwung River / unimproved area

- The width of the Ciliwung River is narrow, and houses are concentrated along the banks of the river for about 1 km.
- The maximum water level during the flood in January 2020 beside the river was below the knee.
- In recent years, flooding occurred in 2002, 2007, and 2020.



Source : JICA study team

Figure 2-2 field survey (upstream of Manggarai weir)

(ii) Upstream of Manggarai weir along the Ciliwung River / improved area

- In the improved area of the Ciliwung River which is upstream of the unimproved area, the river width is wide and revetments have been provided.
- Since the river improvement is being made from the upstream area where land acquisition is easier, a section with insufficient flow capacity is left in the downstream area.
- According to interviews with residents, the maximum inundation depth was approx. 50 cm, and the inundation time was approx. 5 hours during the flood in January 2020. A large amount of wood, bamboo, garbage, etc. flowed from the upstream to the downstream of the river. In addition, the damage of the flood in 2007 was especially severe among the recent floods.



Source : JICA study team

Figure 2-3 field survey (upstream of Manggarai weir)

(iii) East diversion channel

- The East diversion channel have a wide river width and a revetment.
- Construction have already been completed for the development of a channel to divert 60 m³/s from the Ciliwung River to the East diversion Channel. However, since the land acquisition between the Ciliwung River and the East diversion channel has not yet been completed, the connection of these diversion channels has been delayed.



Source : JICA study team

Figure 2-4 field survey (East diversion channel)

(iv) Underpass in Kemayoran district

- An underpass in Kemayoran district is one of the worst affected areas during the flood in January 2020.
- The site has been frequently flooded even before the January 2020 flood.



Source : JICA study team

Figure 2-5 field survey (underpass in Kemayoran)

(v) Bekasi weir

- PJT2 manages and operates the Bekasi weir according to the gate operation rules.
- The installation of a siphon on the right bank worsened the flood damage, and the gate operation rules of the Bekasi weir were revised around 2014.
- Because the water quality of Citarum Barat is better than that of the Bekasi River, the water flowing down Citarum Barat is conveyed to the city as raw drinking water without merging with the Bekasi River.
- Raw drinking water for DKI Jakarta and Bekasi city is taken at the upstream of Bekasi weir.



Source : JICA study team

Figure 2-6 field survey (Bekasi weir)

(vi) Downstream of the Bekasi weir, Kalimati pumping station

- The downstream of the Bekasi weir has not been improved, and the river width is narrower than the upstream of the Bekasi weir.
- Flood in January 2020 caused inundation damage on the right bank of a tributary that joins the Bekasi River on the right bank about 100 m downstream from the Bekasi weir. According to the field survey conducted by PUPR staff, the inundation depth was 1.5 m ~ 2.0 m, and the inundation lasted for 48 hours.
- Since the ground height of the right bank of the branch river was lower than that of the left bank, flooding damage occurred only on the right bank.



Source : JICA study team

Figure 2-7 field survey (downstream of Bekasi weir, Kalimati pumping station)

(vii) Along the highway in Bekasi city -1

- According to a result of the field survey by PUPR staff, the flooded area was 256 ha by the flood in January 2020.
- The culvert under the road is narrow and there is a lot of illegally dumped garbage in the culvert. Therefore, it is guessed that there was not enough drainage capacity during the flood in January 2020.
- Since the ground height of the road was higher than the residential area on the south side, flooding damage occurred in the residential area in January 2020.
- According to a result of the hearing to the residents, the inundation depth during the flood in January 2020 was about 1.5 m.



Source : JICA study team

Figure 2-8 field survey (along the highway)

(viii) Along the highway in Bekasi city -2

- This area is one of the worst affected areas by the flood in January 2020, along the same highway of (vii).
- Inundation occurred for long periods in this residential area due to lower ground heights in the residential areas than roads and riverbanks surrounding the area.
- Inundation in January 2020 continued for 3 days.
- The front of the culvert was filled with illegally dumped garbage.



Source : JICA study team

Figure 2-9 field survey (along the highway)

(ix) Confluence of the Cikeas and Cileungsi rivers

- At downstream of the confluence of the Cikeas and Cileungsi rivers, flooding in January 2020 caused severe damage. Floods occur in this area almost every year, but the damage in January 2020 was especially severe.
- According to a result of interview to the residents, the inundation by the flood in January 2020 continued from 11:00 am on 1st January to 2:00 am on 2nd January, and the maximum inundation depth was 3 m. Sediment and garbage were found in the factory site and on the walls.



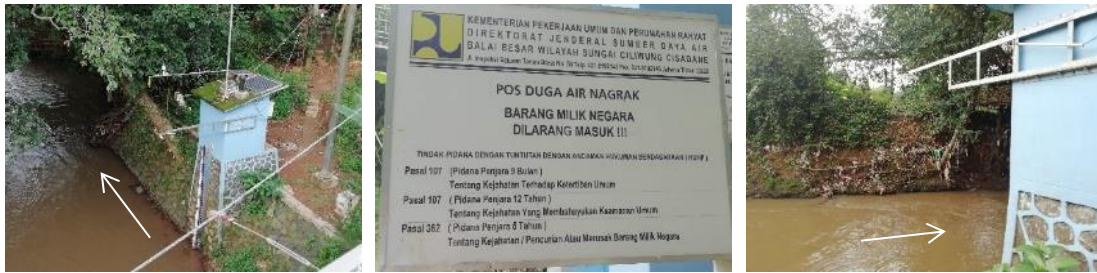
Source : JICA study team

Figure 2-10 field survey (confluence of Cikeas and Cileungsi rivers)

(x) Nagrak (Cikeas) water level station

- A CCTV has been installed at Nagrak (Cikeas) station. According to the results of interview, peak water level read from the CCTV images and collected water level data were generally consistent.

- According to a result of hearing about the flood in January 2020, the water level rose to the front of a restaurant near the Nagrak (Cikeas) station.



Source : JICA study team

Figure 2-11 field survey (Nagrak (Cikeas) station)

(xi) Embankment and overtopping in Pondok Gede Permai

- The height of the parapet embankment at Pondok Gede Permai along the Bekasi River is about 3 m, which is higher than in other areas.
- Overflow occurred due to the flood in January 2020 and the land inside the embankment was inundated.



Source : JICA study team

Figure 2-12 field survey (embankment in Pondok Gede Permai)

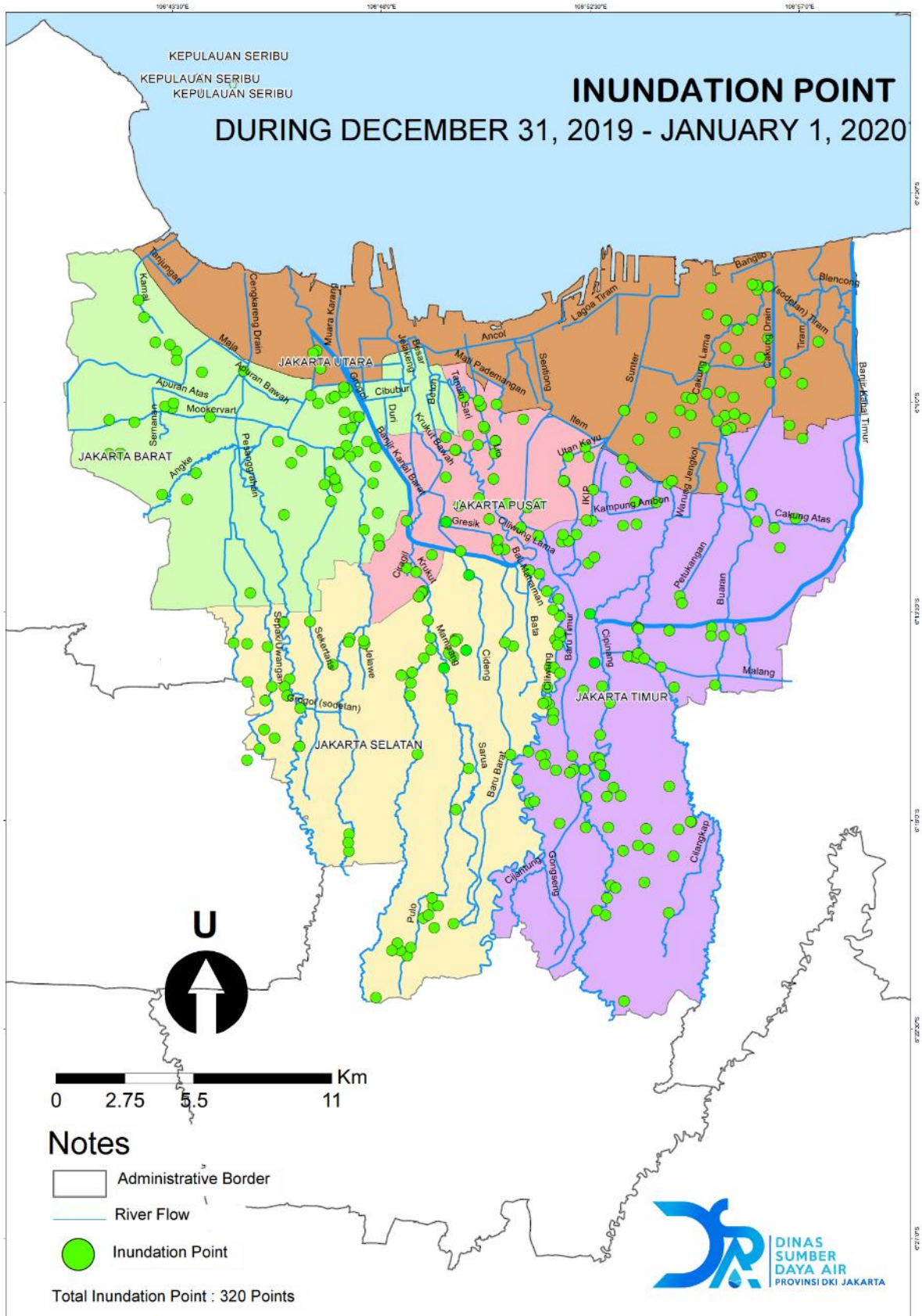
(2) Damage caused by floods

(i) Inundation area

Flooding in January 2020 inundated many districts of Jakarta. The inundation area is shown in Figure 2-13 to Figure 2-16.

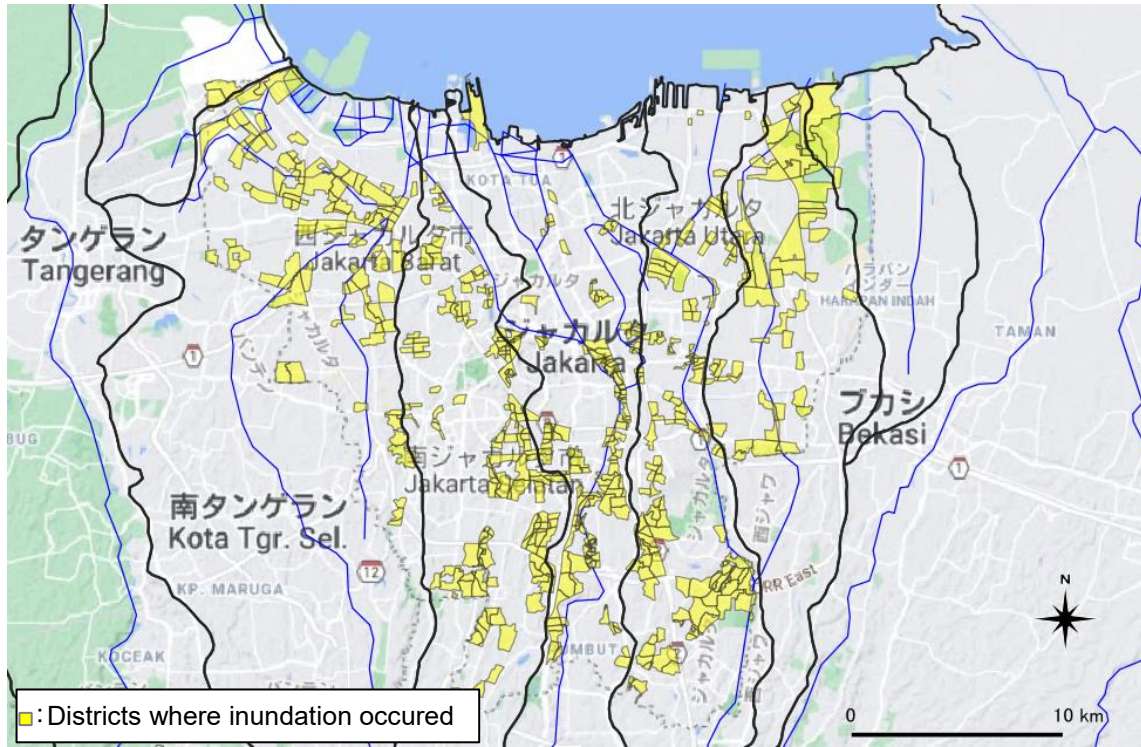
Regarding inundation area in DKI Jakarta, Figure 2-13 shows the exact location of inundation, and Figure 2-14 shows districts where inundation damage has been confirmed. Each yellow polygons in Figure 2-14 denote the entire area of an affected district not inundation area.

Flooding occurred not only along the river but also at places far from the river channel. It is considered that inundation was caused not only by overflow from river but also inland water because of drainage problems.



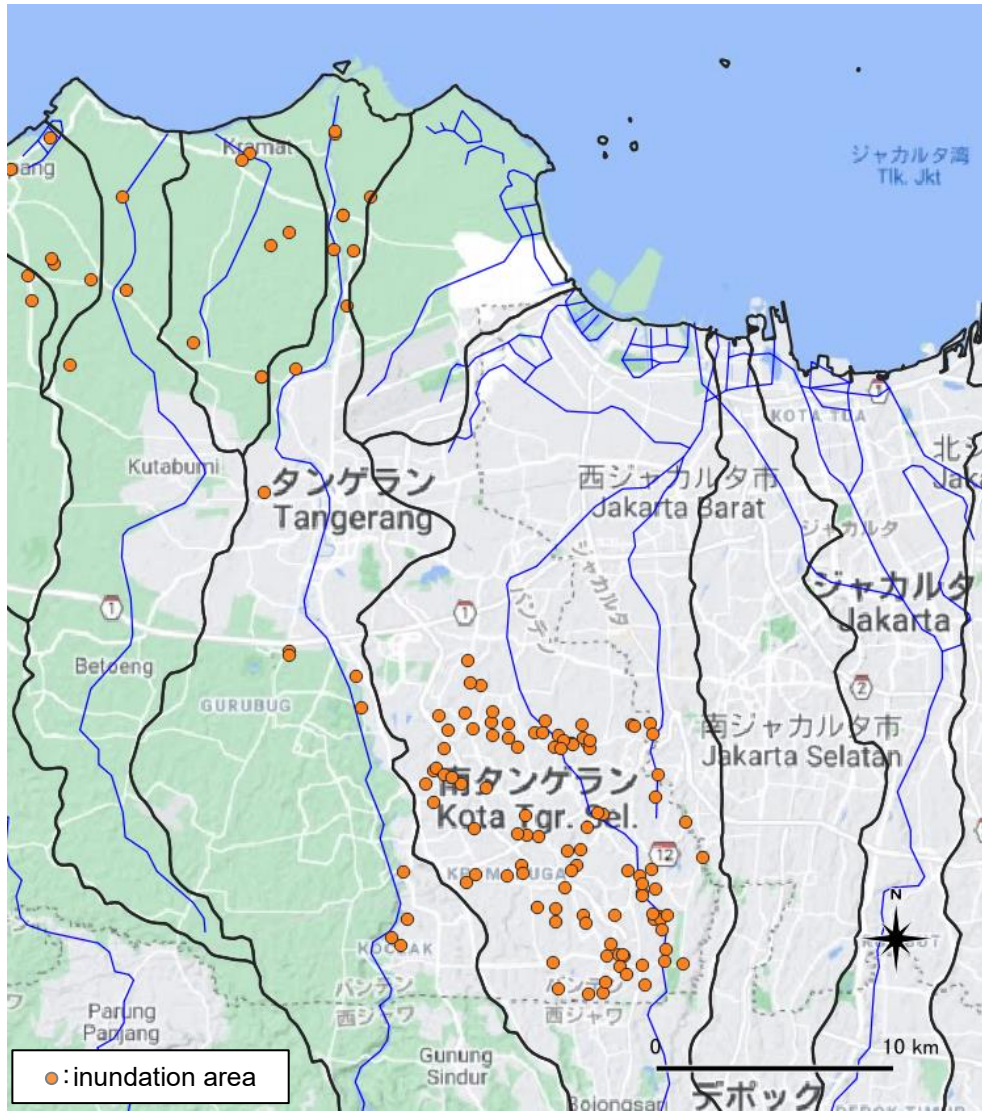
Source: Dinas SDA

Figure 2-13 Inundation area (DKI Jakarta)



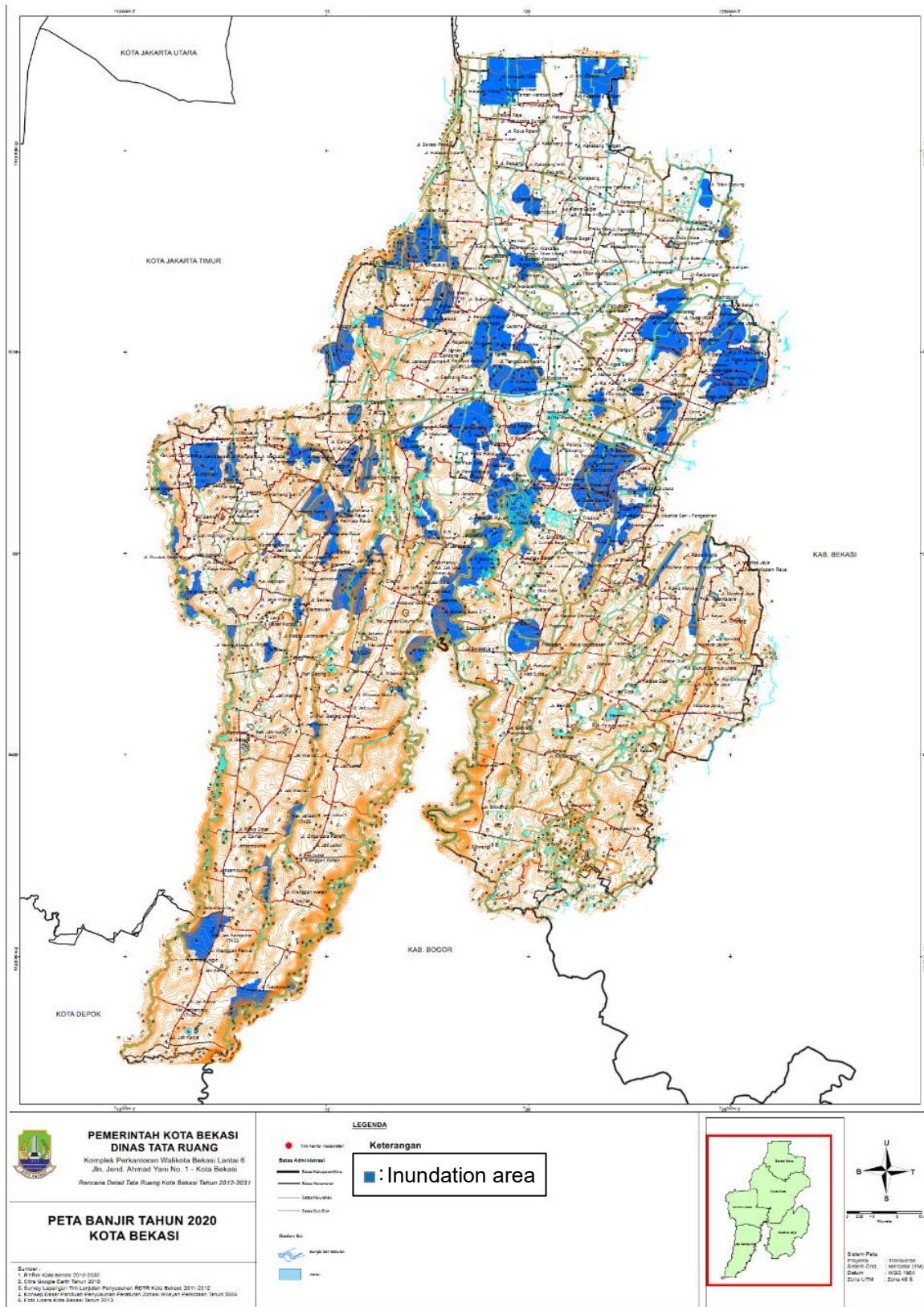
Source: Dinas SDA

Figure 2-14 Inundation area (DKI Jakarta)



Source: JICA project team and Kab Tangenrang

Figure 2-15 Inundation area (Tangerang City)



Source: Kota Bekasi

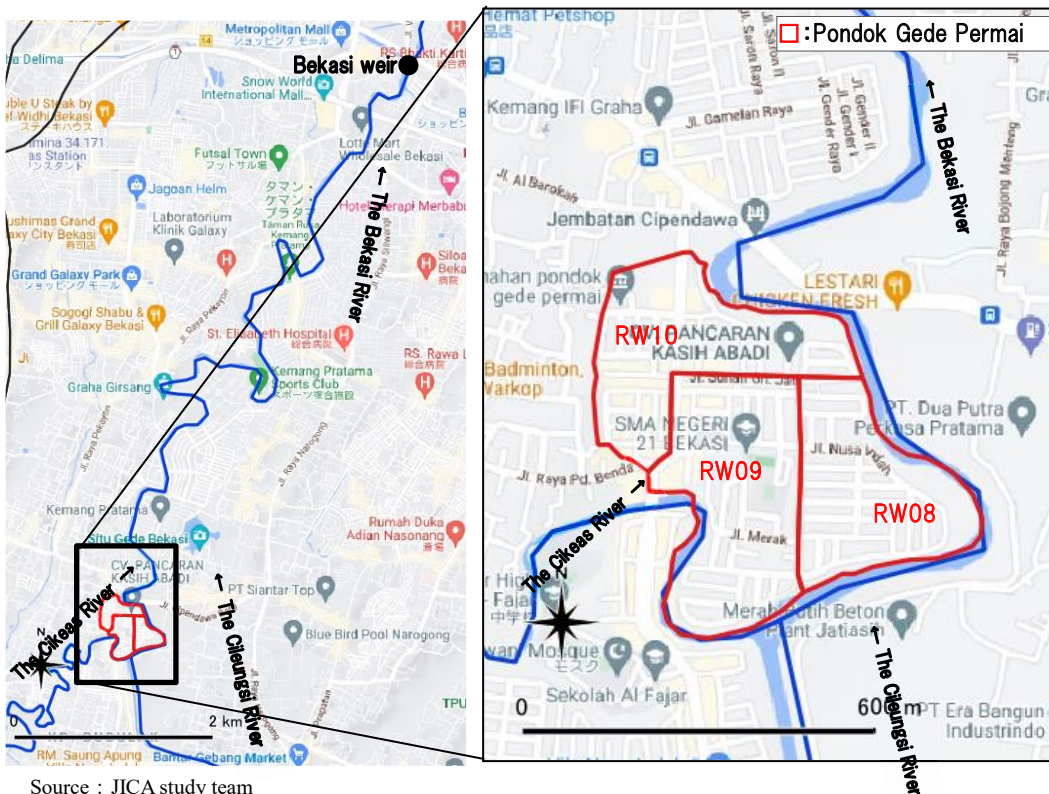
Figure 2-16 Inundation area (Bekasi City)

In the Pondok Gede Permai area, the flood water overtopped the dike and caused severe damage in January 2020 (see Figure 2-17 and Figure 2-18). The height of parapet dike in the area is approx. 3 m and Pondok Gede Permai is residential area, and thus the damage risk when the dike is collapsed is very high.



Source : resident in Pondok Gede Permai

Figure 2-17 Overflowing at Pondok Gede Permai



Source : JICA study team

Figure 2-18 Location of Pondok Gede Permai

A CCTV is working at the Nagrak (Cikeas) water level station. The CCTV images and collected water level data generally agree with the inundation conditions explained by residents. The peak water level during the flood in January 2020 exceeded the highest observable water level at the station. Therefore, the peak water level and time were not observed (see Figure 2-19 and Chapter 6.1.3(7)).



Source: BBWS-CC, river community KP2C

Figure 2-19 CCTV at Nagrak (Cikeas) water level station

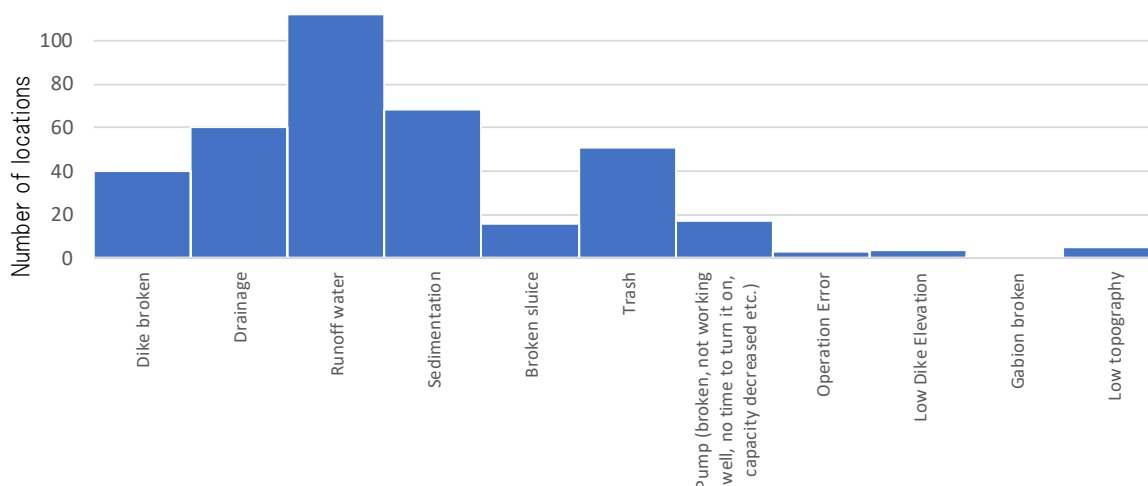
(ii) Results of field survey by PUPR

Field survey was conducted by PUPR staff after the flood in January 2020. On the day just after the flood, 2nd January, PUPR dispatched 295 junior staff to conduct a field survey, which took about one week. The purpose of the survey by PUPR staff is to investigate causes of flood damage and damage situation of structures managed by PUPR, and to examine necessary measures in future.

According to the survey results, the main causes of flood damage were founded to be increased runoff water, sediments, drainage, trash, and broken dike. The total area of the inundated area was about 2,900 ha.

In the Bekasi River basin, where flood damage was particularly severe, several locations downstream of the confluence of the Cikeas and Cileungsi Rivers were observed to have suffered from dike breach, bank erosion, and structural damage. In the Cisadane River basin, the main disasters were landslides in the upstream area and inundation along the Sabi River, while no damage was reported along the main river. In the Ciliwung River basin, which flows through the urban area of Jakarta, the main disaster was inundation in the downstream area because of sedimentation and drainage accounting for half of the inundation factors.

The survey results in each region are shown in the following tables and figure.



Source : JICA study team based on field survey by PUPR

Figure 2-20 Causes of flooding

Table 2-4 Result of field survey by PUPR :Cakung

DAS	No.	Name	Area (ha)	Depth (m)	Duration (hr)	Volume (MCM)	Reason of Inundation													
							Dike broken	Drainage	Runoff water	Sedimentation	Broken sluice	Trash	Pump broken, not working well, no time to turn it on, caused by decreased etc.2	Operational Error	Low Dike Elevation	Gabion broken	Low topography			
Cakung	43	Jati Kranat River	8.50	1.30	48.0	0.11	○		○	○										
	46	Cakung River	3.50	0.60	48.0	0.02		○	○	○	○									
	48	Cakung River	3.50	0.80	48.0	0.03	○		○	○	○									
	52	Cakung River	24.50	3.00	48.0	0.74		○	○	○	○									
	53	Cakung River	15.00	1.20	48.0	0.18	○		○	○	○									
	111	Penjol River	2.00	0.60	72.0	0.01			○											
	154	Kalinalang River Tributary with East Banjir Canal Estuary	28.00	1.50	36.0	0.42			○	○										
	155	-	-	-	-	-	N/A			○										
	156	Cakung River	8.40	1.00	12.0	0.09			○											
	157	Cakung River	9.40	1.60	48.0	0.15	○		○		○									○
	158	Kali Lingkar Luar MuliKesari	16.00	1.00	18.0	0.16			○		○									○
	170	Baru River	32.60	1.50	42.0	0.49			○	○	○									
	171	No River	8.00	1.50	12.0	0.12			○		○									
	173	Jatikramat, Baru River, Melang River	18.10	2.50	49.0	0.45			○	○	○									
	174	Cakung	10.00	2.00	36.0	0.20	○		○		○									
		Total		188.60			3.17	6	10	10	8	2	7	2	0	0	0	0	0	2

Source : JICA study team based on field survey by PUPR

Table 2-5 Result of field survey by PUPR :Ciliwung

DAS	No.	Name	Area (ha)	Depth (m)	Duration (hr)	Volume (MCM)	Reason of Inundation														
							Dike broken	Drainage	Runoff water	Sedimentation	Broken sluice	Trash	Pump broken, not working well, no time to turn it on, caused by decreased etc.2	Operational Error	Low Dike Elevation	Gabion broken	Low topography				
Ciliwung	42	Ciliwung River	0.70	1.50	15.0	0.01			○	○											
	44	Ciliwung River	16.66	4.00	12.0	0.66		○	○	○	○										
	45	Item River (empty into Sentiana River)	8.50	0.50	6.0	0.09	○		○	○	○										
	63	Drainage	1.50	0.80	7.0	0.01			○	○	○										
	68	Cidene River	0.78	1.00	6.0	0.01	○		○	○	○										
	69	Cidene River	0.42	0.50	6.0	0.00	○		○	○	○										
	71	-	1.00	0.80	10.0	0.01			○											○	
	72	West Banjir Canal Channel	-	1.70	-	N/A															
	74	-	0.00	0.00	0.0	0.00															
	76	Drainage Channel to Ciliwung River	10.00	1.50	28.0	0.15			○		○										
	77	Jani River (Flows to Ciliwung)	1.00	0.30	3.0	0.00			○		○										
	79	Kalibata Tebet Timur Drainase Channel	25.00	1.20	24.0	0.30															
	80	Ciliwung	68.00	1.00	36.0	0.68															
	81	Ciliwung	0.01	3.00	48.0	0.00			○												
	82	Sodelan Kalibata	0.70	1.00	8.0	0.01			○		○										
	83	NK (small river which is used as Saluran Drainase)	2.74	1.00	6.0	0.03			○		○										
	84.1	Ciliwung	6.50	3.00	56.0	0.20					○										
	85.1	Ciliwung	1.00	1.00	56.0	0.01			○		○										
	84.2	Ciliwung	3.50	3.00	36.0	0.11					○										
	85.2	Ciliwung	1.50	4.00	58.0	0.06	○				○										
	86	Manang River	1.80	1.60	27.0	0.03			○		○										
	89	Ciliwung River	2.00	6.00	48.0	0.12					○										
	94	Ciliwung River	-	5.00	48.0	0.00					○										
	100	Jl. Perum LIPI	-	-	-	N/A					○										
	101	Situ Cibaurum Irrigation Channel (Perum Puri Citayam Per	-	-	-	N/A			○												
	102	Situ Cibaurum Irrigation Channel	-	-	-	N/A															
	103	Situ Cibaurum	20.00	1.50	23.0	0.30					○										
	104	Gidurian	-	-	-	N/A															
	105	Ciliwung	-	-	-	N/A															
		Total		173.21			2.74	5	11	17	14	1	8	1	0	1	0	0	0	0	

Source : JICA study team based on field survey by PUPR

Table 2-6 Result of field survey by PUPR :Cipinang

DAS	No.	Name	Area (ha)	Depth (m)	Duration (hr)	Volume (MCM)	Reason of Inundation														
							Dike broken	Drainage	Runoff water	Sedimentation	Broken sluice	Trash	Pump broken, not working well, no time to turn it on, caused by decreased etc.2	Operational Error	Low Dike Elevation	Gabion broken	Low topography				
Cipinang	34	Cipinang	4.80	1.50	24.0	0.07			○												
	35	Sungai Induk Keelil	24.00	1.20	24.0	0.29			○												
	36	Cipinang	10.00	1.50	72.0	0.15	○														
	37	Cipinang	2.25	0.40	10.0	0.01			○												
	38	Cipinang River	-	-	-	N/A			○		○										
	Total		41.05			0.52	1	2	3	0	0	0	0	0	0	0	0	0	0	0	

Source : JICA study team based on field survey by PUPR

Table 2-7 Result of field survey by PUPR :Cisadane

DAS	No.	Name	Area (ha)	Depth (m)	Duration (hr)	Volume (MCM)	Reason of Inundation														
							Dike broken	Drainage	Runoff water	Sedimentation	Broken sluice	Trash	Pump broken, not working well, no time to turn it on, caused by decreased etc.2	Operational Error	Low Dike Elevation	Gabion broken	Low topography				
Cisadane	16	Kalisabi	48.41	2.00	19.0	0.97			○												
	106	Anak Sungai Cisadane	-	-	-	N/A															
	107	Anak Sungai Cisadane	-	-	-	N/A															
		Total		48.41			0.97	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Source : JICA study team based on field survey by PUPR

Table 2-8 Result of field survey by PUPR :Cidurian

DAS	No.	Name	Area (ha)	Depth (m)	Duration (hr)	Volume (MCM)	Reason of Inundation													
							Dike broken	Drainage	Runoff water	Sedimentation	Broken sluice	Trash	Pump broken, not working well, no time to turn it on, capacity decreased etc.)	Operation Error	Low Dike Elevation	Gabion broken	Low topography			
Cidurian	30	Sunzai Cidurian (Kewenangan Pusat)	-	-	-	#N/A														
	31	Cimengentebung River	-	2.00	2.0	#N/A			○											
		Total	0.00			0.00	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Source : JICA study team based on field survey by PUPR

Table 2-9 Result of field survey by PUPR :Ciujung

DAS	No.	Name	Area (ha)	Depth (m)	Duration (hr)	Volume (MCM)	Reason of Inundation													
							Dike broken	Drainage	Runoff water	Sedimentation	Broken sluice	Trash	Pump broken, not working well, no time to turn it on, capacity decreased etc.)	Operation Error	Low Dike Elevation	Gabion broken	Low topography			
Ciujung	23	Ciberang River (DAS Ciujung/Kewenangan Pusat)	0.00	0.00	0.0	0.00			○											
	24	Ciberang	9.00	2.00	1.0	0.18			○											
	25	Ciberang River	-	2.00	12.5	#N/A	○		○											
	26	Ciberang River (Berduns Cibunul)	10.00	6.50	2.5	0.65			○											
	27	Ciberang River (DAS Ciujung/Kewenangan Pusat)	-	6.00	2.0	#N/A		○												
	28	Ciberang River (DAS Ciujung/Kewenangan Pusat)	-	6.00	2.0	#N/A														
	32	Ciberang River (DAS Ciujung/Kewenangan Pusat)	0.00	0.00	0.0	0.00														
	33	Ciberang River (DAS Ciujung/Kewenangan Pusat)	0.22	3.00	3.0	0.01			○											
		Total	19.22			0.84	1	1	4	1	0	0	0	0	0	0	0	0	0	0

Source : JICA study team based on field survey by PUPR

Table 2-10 Result of field survey by PUPR :Krukut

DAS	No.	Name	Area (ha)	Depth (m)	Duration (hr)	Volume (MCM)	Reason of Inundation													
							Dike broken	Drainage	Runoff water	Sedimentation	Broken sluice	Trash	Pump broken, not working well, no time to turn it on, capacity decreased etc.)	Operation Error	Low Dike Elevation	Gabion broken	Low topography			
Krukut	95	Krukut River	0.03	1.50	48.0	0.00				○										
	60	Krukut River	0.72	2.00	48.0	0.01	○		○	○										
	65	Krukut River	40.00	1.20	48.0	0.48	○		○	○			○							
	66	Krukut River	0.43	2.00	24.0	0.01			○											
	69	Krukut River	0.60	1.20	30.0	0.01		○	○	○	○	○								
	73	Krukut River	6.00	1.00	12.0	0.08			○											
	76	Krukut River	15.00	3.00	30.0	0.45		○												
	86	Mampang River	1.80	1.60	27.0	0.03		○	○	○										
	87	Mampang River	2.40	1.50	8.0	0.04			○	○			○							
	88	Krukut River	2.90	6.00	22.0	0.12			○	○			○							
	90	Mampang	2.00	1.60	33.0	0.03		○		○				○						
	91	Mampang	9.70	1.10	27.0	0.11			○											
	92	Mampang River	0.91	0.40	18.0	0.06			○											
	93	Krukut River dan Mampang River	1.00	2.00	24.0	0.02			○	○				○						
		Total	83.69			1.38	2	4	11	9	1	6	2	0	0	0	0	0	0	

Source : JICA study team based on field survey by PUPR

Table 2-11 Result of field survey by PUPR :Pesanggrahan

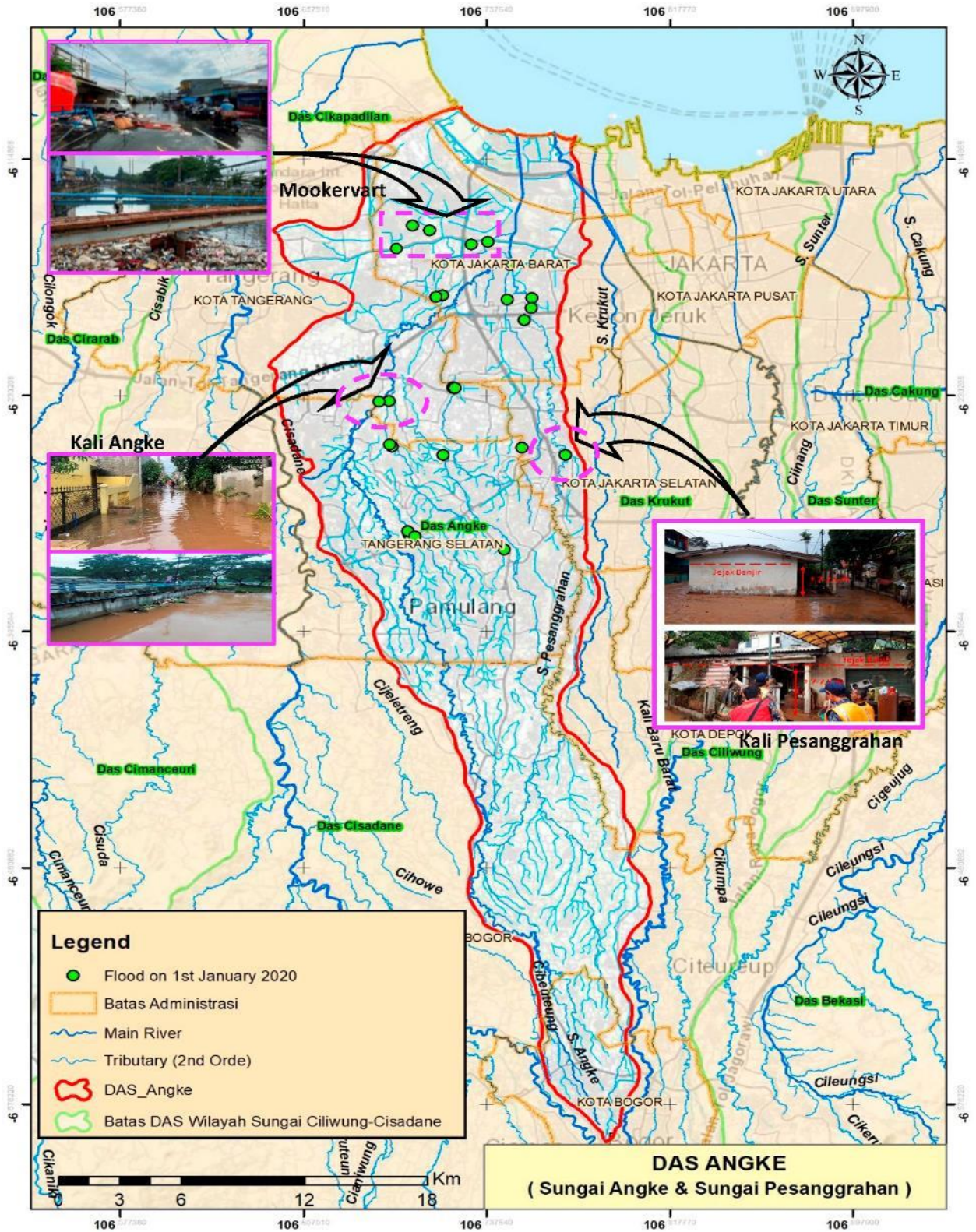
DAS	No.	Name	Area (ha)	Depth (m)	Duration (hr)	Volume (MCM)	Reason of Inundation													
							Dike broken	Drainage	Runoff water	Sedimentation	Broken sluice	Trash	Pump broken, not working well, no time to turn it on, capacity decreased etc.)	Operation Error	Low Dike Elevation	Gabion broken	Low topography			
Pesanggrahan	9	Bembangan, Angka, Pesanggrahan River	0.80	0.60	60.0	0.00		○	○											
	10	Pesanggrahan	0.24	0.80	-	0.00		○												
	11	Pesanggrahan	3.12	1.65	32.0	0.05								○						
		Total	4.16			0.05	0	2	1	0	0	0	0	1	0	0	0	0	0	

Source : JICA study team based on field survey by PUPR

Table 2-12 Result of field survey by PUPR :Sunter

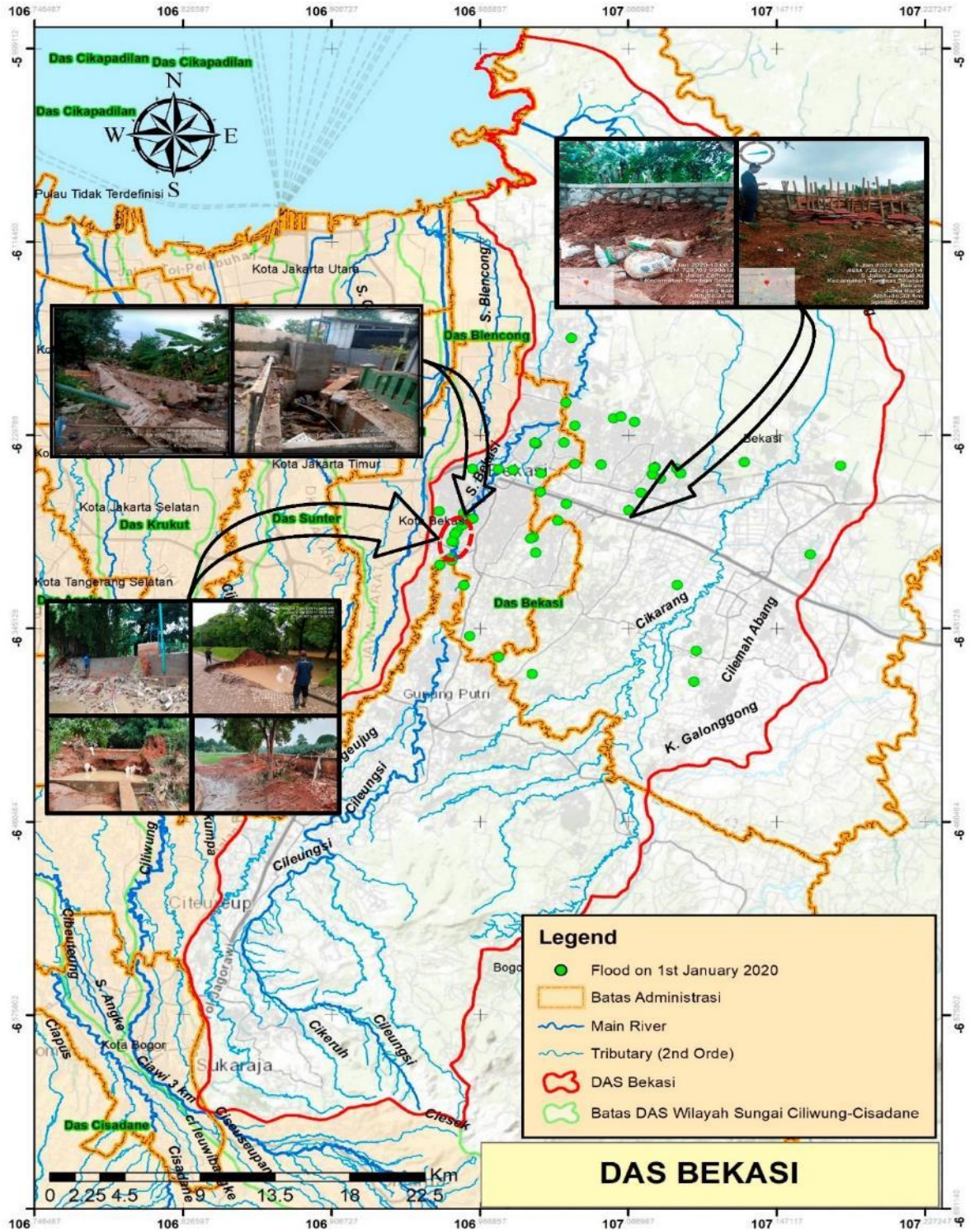
DAS	No.	Name	Area (ha)	Depth (m)	Duration (hr)	Volume (MCM)	Reason of Inundation													
							Dike broken	Drainage	Runoff water	Sedimentation	Broken sluice	Trash	Pump broken, not working well, no time to turn it on, capacity decreased etc.)	Operation Error	Low Dike Elevation	Gabion broken	Low topography			
Sunter	40	Cipinang River	10.00	0.50	20.0	0.05			○											
	41	Sunter River	-	3.00	20.0	#N/A	○													
	46	Utan Kayu River (ends in Sunter River)	6.00	0.70	12.0	0.04	○	○												
	39	Sunter River	61.60	1.00	12.0	0.62	○													
	47	Ek Koja Irrigation Canal (Koja Weir - East Banjir Canal)	10.00	1.50	48.0	0.15		○	○	○										
	98	Cikeas River dan Cileungsi River meeting (DAS Cileungsi R	19.00	2.50	20.0	0.48			○											
	108	Patukangan River	13.00	0.70	48.0	0.09														
	109	Patukangan River	22.90	1.20	48.0	0.27			○											
		Total	142.40			1.70	3	2	4	1	1	3	0	0	0	0	0	0	0	

Source : JICA study team based on field survey by PUPR



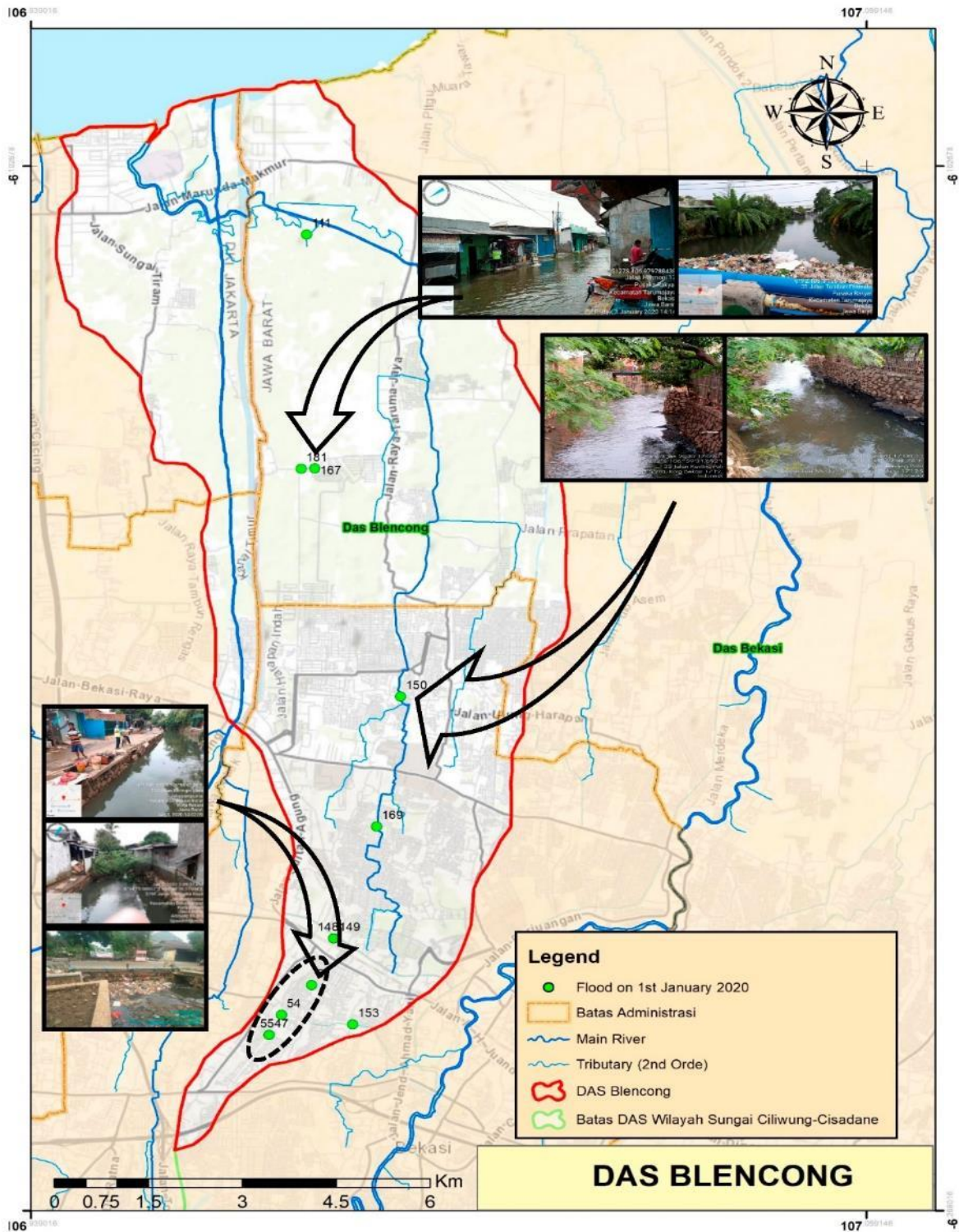
Source: "Investigation Result 2020" by PUPR

Figure 2-21 Result of field survey by PUPR: Angke, Pasanggrahan



Source: "Investigation Result 2020" by PUPR

Figure 2-22 Result of field survey by PUPR: Bekasi



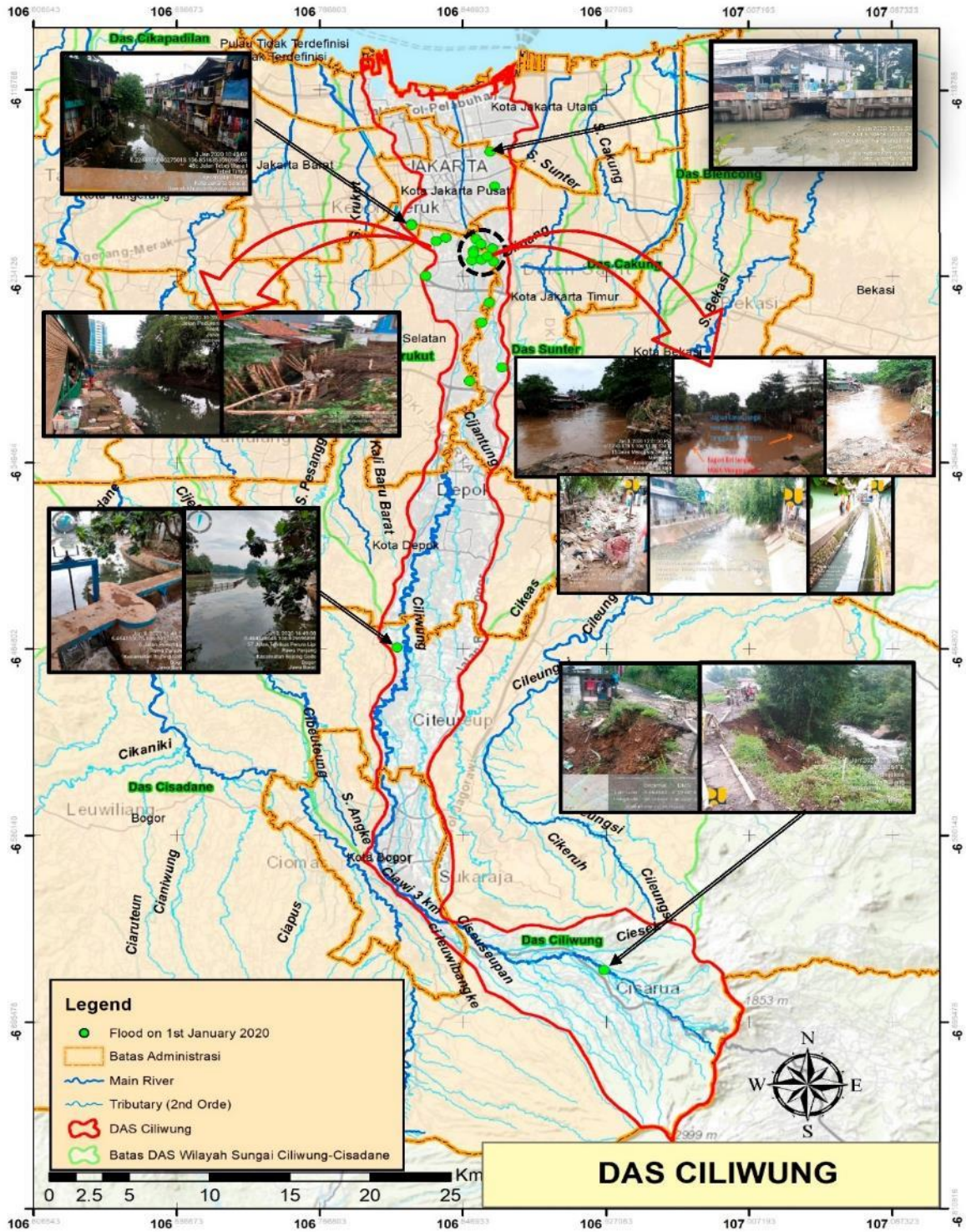
Source: "Investigation Result 2020" by PUPR

Figure 2-23 Results of field study by PUPR staff: Blencong Basin



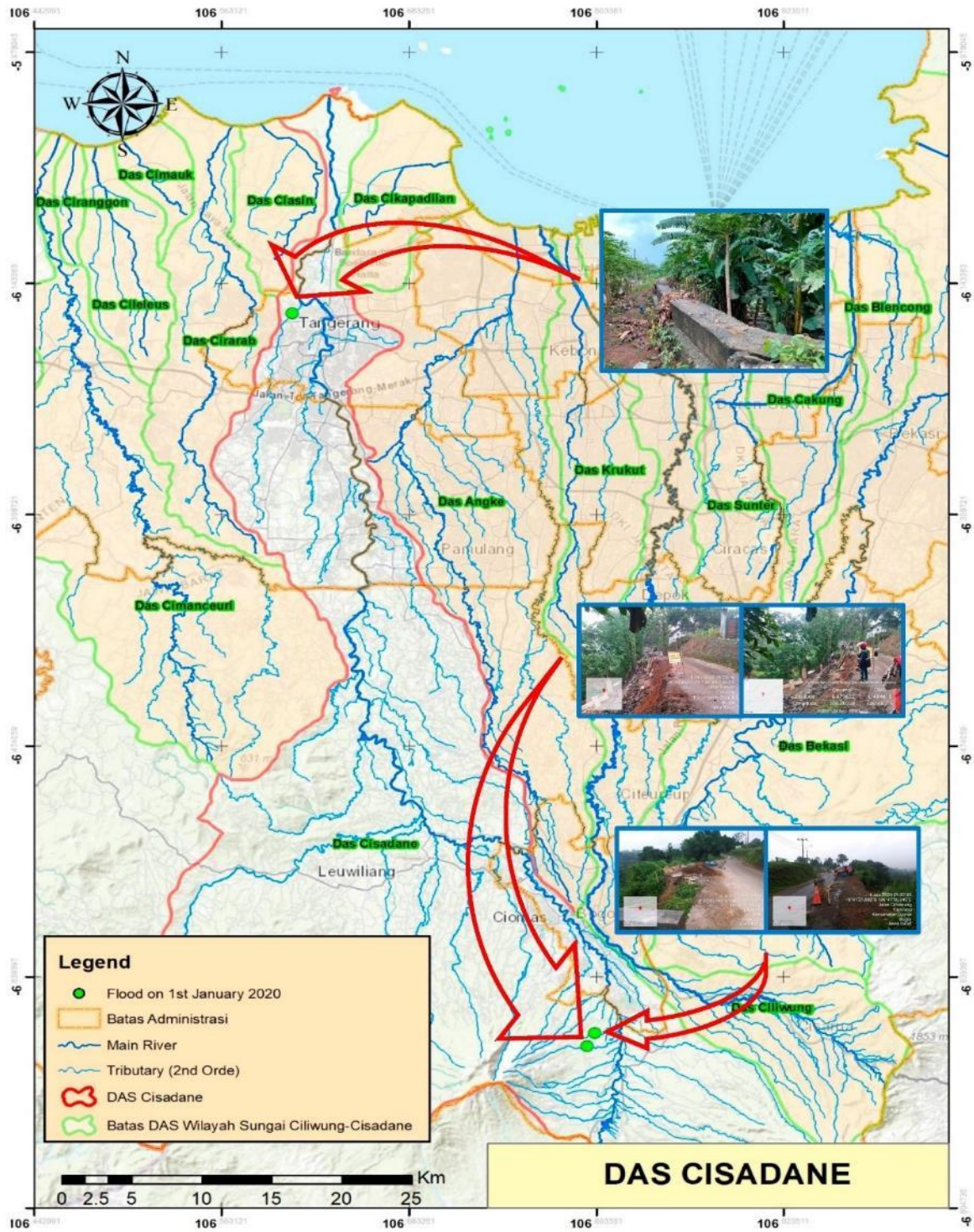
Source: "Investigation Result 2020" by PUPR

Figure 2-24 Result of field survey by PUPR: Cakung



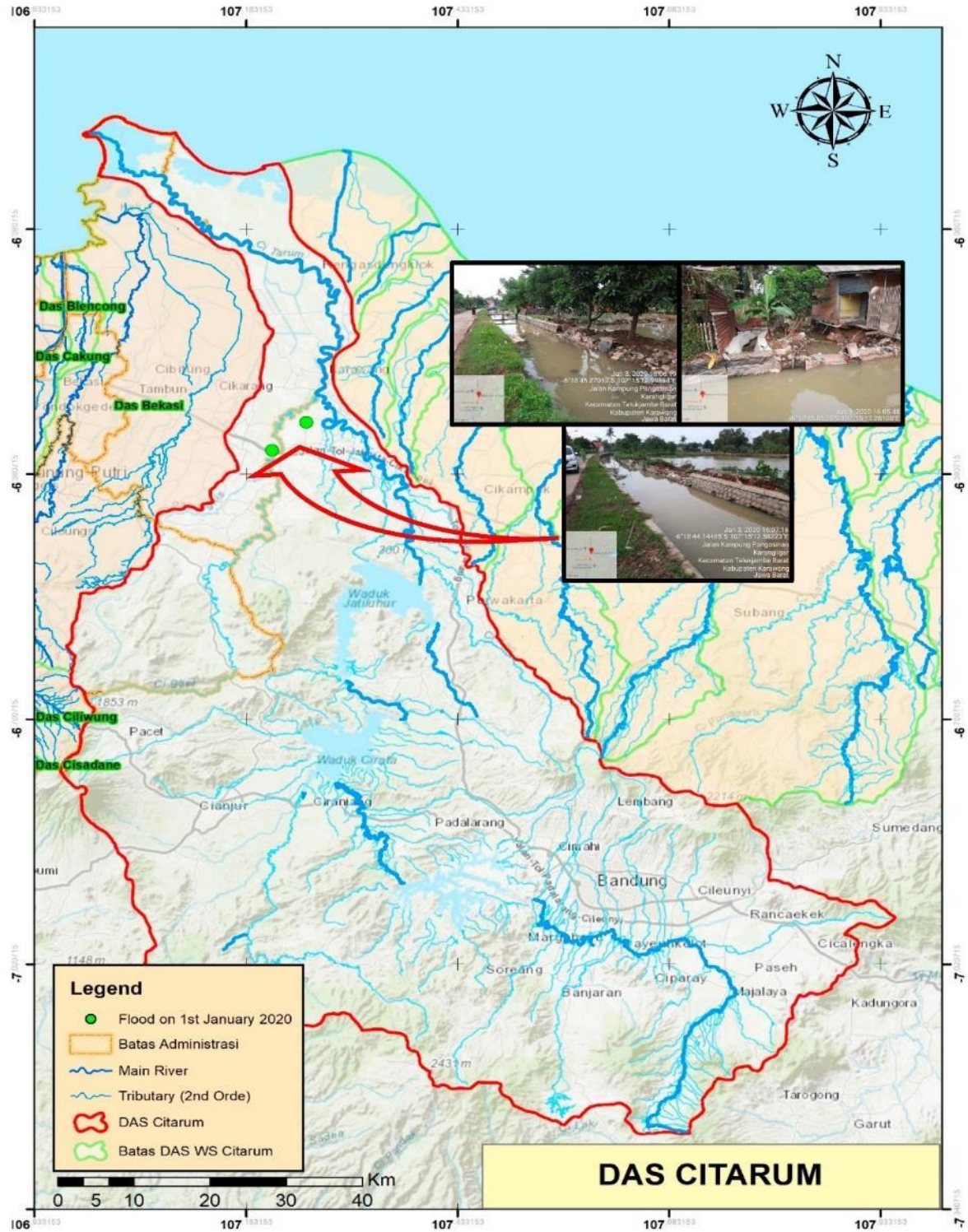
Source: "Investigation Result 2020" by PUPR

Figure 2-26 Result of field survey by PUPR: Ciliwung



Source: "Investigation Result 2020" by PUPR

Figure 2-27 Result of field survey by PUPR: Cisadane



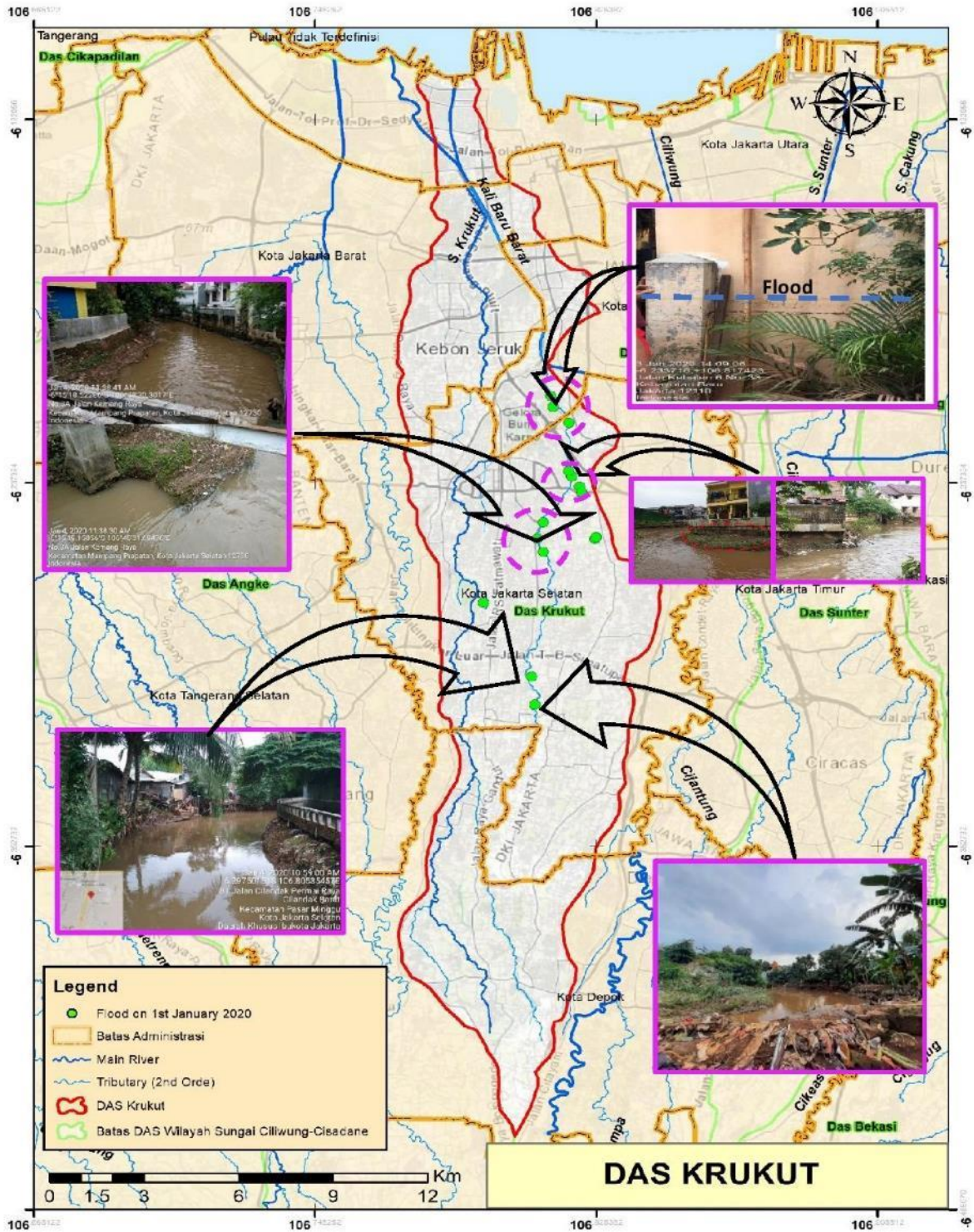
Source: "Investigation Result 2020" by PUPR

Figure 2-28 Result of field survey by PUPR: Citarum



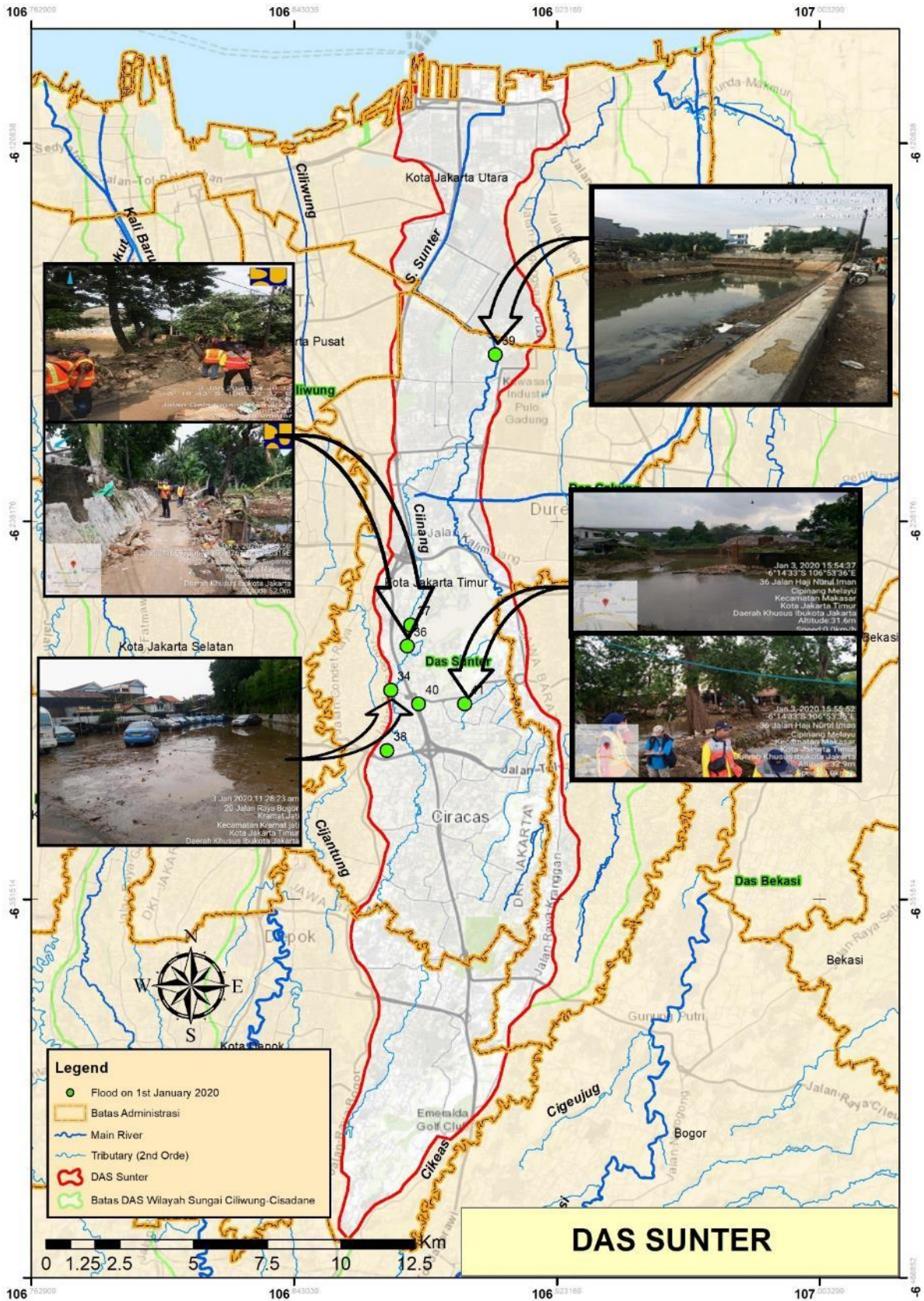
Source: "Investigation Result 2020" by PUPR

Figure 2-29 Result of field survey by PUPR: Ciujung



Source: "Investigation Result 2020" by PUPR

Figure 2-30 Result of field survey by PUPR:Krukut



Source: "Investigation Result 2020" by PUPR

Figure 2-31 Result of field survey by PUPR : Sunter

(iii) Victims by the flood in January 2020

The National Disaster Management Agency (BNPB) reported that 511 thousand people were affected by flood and landslides in and around Jabodetabek as of 18th January 2020. The area with the highest number of victims was Bekasi city, with 366,274 people.

Table 2-13 Victims by the flood in January 2020

No	Area	affected number		maximum water level (m)	number of evacuee		dead	lost	number of evacuation site	affected number	
		kecamatan	kelurahan / desa		house	people				house	people
1	Kab Bekasi	18	34	3.0	800	2,800	1		3	1,355	3,123
2	Kota Bekasi	12	51	6.0	34,683	149,537	9		97	104,114	366,274
3	Kab Bogor	13	47	2.0	3,856	15,115	11		40	1,123	3,384
4	Kota Tangerang	13	60	3.0	484	3,350	6		0	24,745	53,931
5	Kota Tangerang Selatan	7	50	2.0	607	2,125	4		3	18,045	65,001
6	Jakarta Timur	10	22	2.0	2,318	9,122	8		26	1,588	5,126
7	Jakarta Barat	6	18	1.0	725	2,942	4		5	0	0
8	Jakarta Selatan	8	19	2.0	562	8,104	1		29	0	0
9	Jakarta Utara	2	6	0.7	36	908	1		10	0	0
10	Jakarta Pusat	3	3	0.0	535	2,703	2		0	0	0
11	Kab Lebak	6	30	1.0	4,618	16,163	10	1	13	2,914	11,656
12	Kota Bogor	6	16	0.8	0	0	1		0	0	0
13	Kota Depok	11	18	2.0	30	105	3		7	1,306	2,976
	Sum	115	374	25.5	49,254	212,974	61	1	233	155,190	511,471

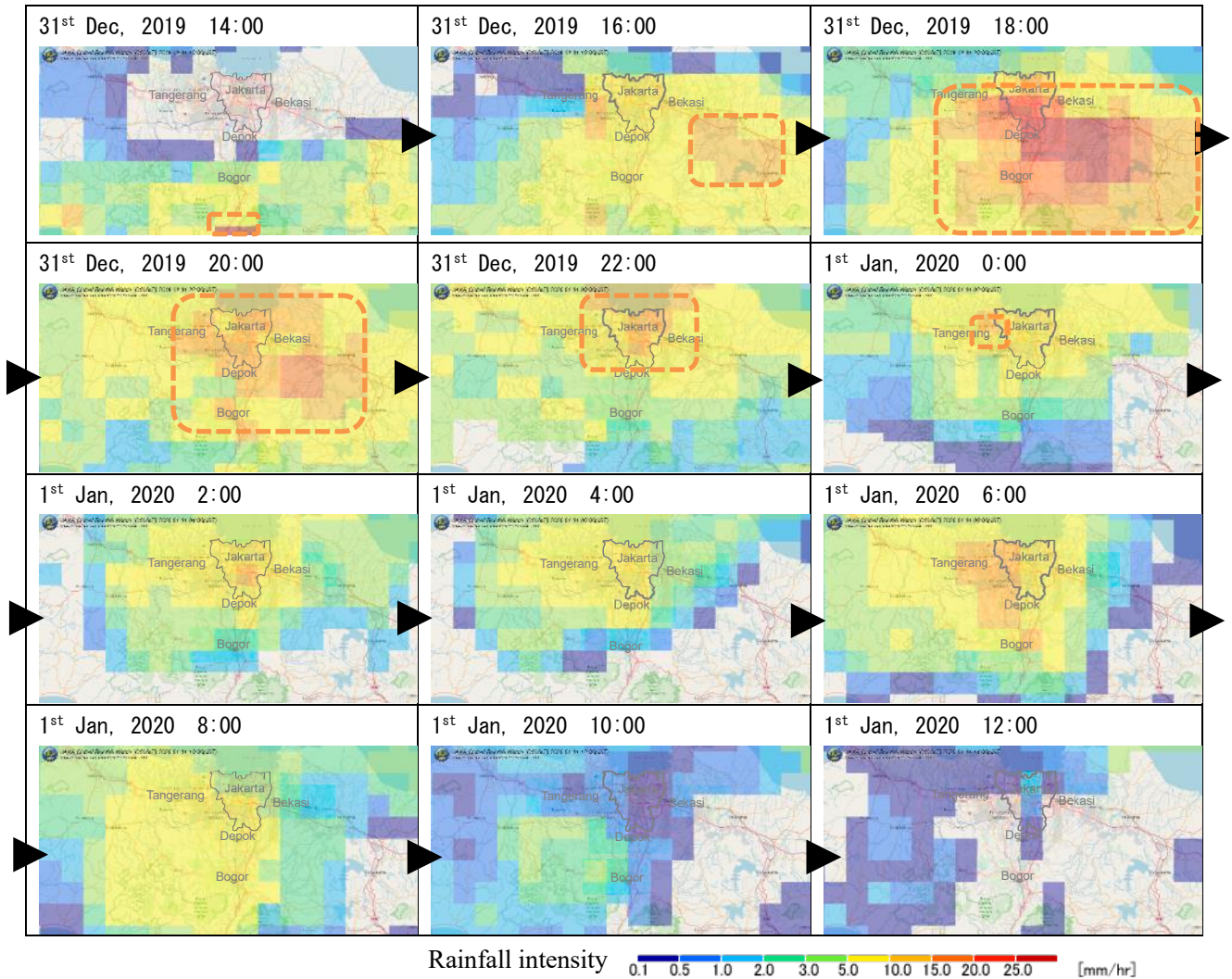
※ as of 2020/1/18

Source: BNPB Twitter (@BNPB_Indonesia)

(3) Direction of rainy area

The direction of movement of the rainy area during the flood in January 2020 was different from that of typical floods in Jakarta. During the flood in January 2020, the rainy area moved from south to north (from upstream to downstream in the basin). On the other hand, in the cases of other past floods, rainy area moved from west to east.

Firstly, rainfall in the upstream areas of the river basins (south) generated flood water, which flowed down, raising river water level. Then the rainy area also moved to downstream (north), adding more flood water in the downstream areas. Due to these characteristics of the rainy area movement, flood in the downstream area of the basin, which is the center of the urban area, became more serious.



Source: JICA study team based on GSMaP

Figure 2-32 2020.1 Direction of rainy area

(4) Hydrological data

Hydrological data of rainfall, water level and discharge during the flood in January 2020 were collected.

(i) Rainfall data

Hourly rainfall data at 15 stations during the flood in January 2020 were collected from BMKG, BBWS-CC and PJT 2. A collection list of hourly rainfall data is shown in Table 2-14, and a location map of observation stations is shown in Figure 2-33. A hyetograph of each station is shown in Figure 2-35, and contour maps of daily rainfall are shown in Figure 2-36.

Regarding the collected hourly rainfall data, 24-hour rainfall of 7am to 7am, which was calculated as a sum of the hourly rainfalls, has to coincide with the daily rainfall data which were separately collected. However, there are considerable differences between the estimated 24-hour rainfall and the daily rainfall data in many cases. In these cases, the hourly rainfalls were adjusted, so that the 24-hour rainfall would coincide with the daily rainfall data by prioritizing the daily rainfall data, which are publicly used in official flood information materials and seems more reliable.

The hyetograph has two peaks in the afternoon of 31st December 2019 and in the early morning of 1st January 2020. The first peak was about 30 mm/hour and the second peak was about 70 mm/hour, namely the rainfall intensity was larger in the second peak on 1st January, as seen in Figure 2-34.

Table 2-14 Collection list of hourly rainfall data

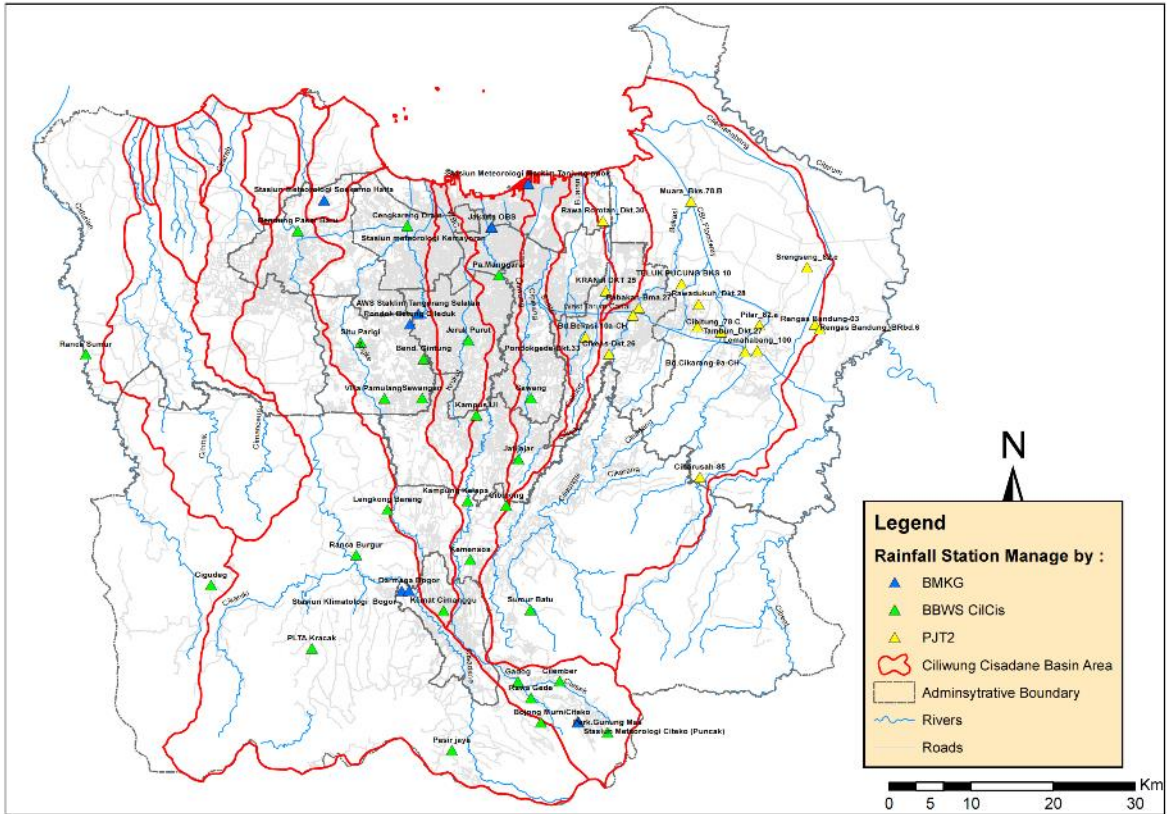
No.	Stations	Collection Status		Daily rainfall (mm)			Latitude (° S)	Longitude (° E)	Administrator
		Hourly Data	Daily Data	31 st Dec 2019	1 st Jan 2020	2 nd Jan 2020			
1	Gadog	○	○	95.5	34.0	0.0	-6.65	106.87	BBWS-CC
2	KpKelapa	○	○	148.5	6.1	0.0	-6.46	106.81	BBWS-CC
3	SumurBatu	○	○	251.0	25.1	40.9	-6.57	106.88	BBWS-CC
4	Cigudeg	○	○	290.0	11.2	0.0	-6.55	106.53	BBWS-CC
5	KampusUI	○	○	107.5	155.2	8.5	-6.36	106.82	BBWS-CC
6	LengkongBarang	○	○	85.5	27.0	1.5	-6.46	106.73	BBWS-CC
7	JerukPurut	○	○	102.0	13.0	0.0	-6.28	106.81	BBWS-CC
8	VillaPamulang	○	○	112.0	52.5	18.5	-6.34	106.72	BBWS-CC
9	Cawang_ARR	○	○	109.0	51.0	0.0	-6.34	106.88	BBWS-CC
10	RancaSumur_ARR	○	○	34.0	23.5	0.0	-6.29	106.40	BBWS-CC
11	(WL 17) Sungai Cileungsi	○		0.0	164.5	84.0	-6.45	106.92	PJT2
12	(WL 22) Sungai Cikeas	○		0.0	316	53.0	-6.37	106.94	PJT2
13	Stasiun Meteorologi Citeko (Puncak)	○	○	57.5	60.0	73.7	-6.70	106.94	BMKG
14	AWS Puspipstek Serpong	○	○	0.0	55.2	0.0	-6.36	106.67	BMKG
15	AWS Digi Stamet Cengkareng	○	○	0.0	148.0	40.0	-6.13	106.66	BMKG
16	Stasiun meteorologi Kemayoran		○	0.0	145.0	0.0	-6.16	106.84	BMKG
17	Stasiun meteorologi Soekarno Hatta		○	0.0	148.0	40.0	-6.13	106.66	BMKG
18	Stasiun Meteorologi Maritim Tanjung priok		○	0.0	146.0	0.0	-6.11	106.88	BMKG

No.	Stations	Collection Status		Daily rainfall (mm)			Latitude (° S)	longitude (° E)	Administrator
		Hourly Data	Daily Data	31 st Dec 2019	1 st Jan 2020	2 nd Jan 2020			
19	Stasiun Klimatologi Pondok Betung		○	0.0	208.9	0.0	-6.26	106.75	BMKG
20	Stasiun Klimatologi Bogor		○	0.0	86.8	50.2	-6.55	106.74	BMKG
21	ARG Pulomas		○	0.0	110.2	0.0	-6.17	106.88	BMKG
22	ARG Kelapa Gading		○	0.8	107.9	0.0	-6.17	106.91	BMKG
23	ARG Manggarai		○	0.0	189.0	0.0	-6.21	106.85	BMKG
24	ARG Sukapura (Bekasi)		○	0.0	107.9	0.0	-6.13	106.96	BMKG
25	AWS Halim Perdana Kusumah		○	0.0	377.0	0.0	-6.26	106.90	BMKG
26	ARG Tomang		○	0.0	225.6	0.0	-6.17	106.78	BMKG
27	ARG Lebak Bulus		○	0.0	107.4	0.0	-6.30	106.78	BMKG
28	ARG Ciganjur		○	0.0	110.4	42.4	-6.34	106.80	BMKG
29	AWS BSD		○	0.0	105.3	0.0	-6.28	106.65	BMKG
30	AWS Parung Bogor		○	0.0	98.3	45.7	-6.42	106.73	BMKG

○ : Collected

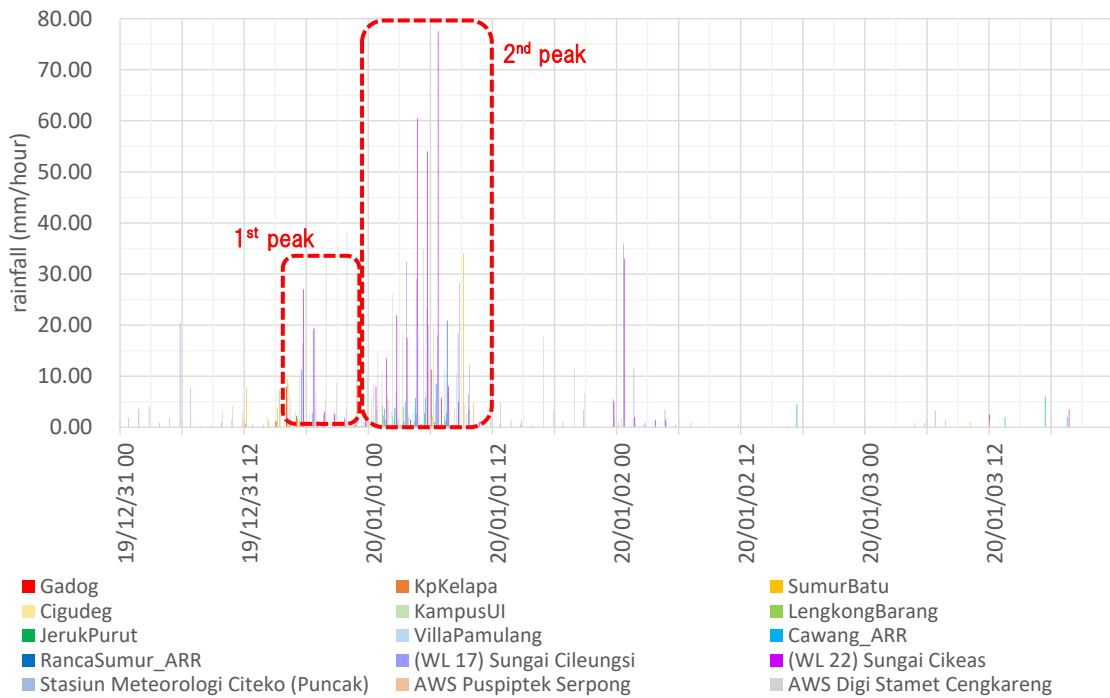
※Daily data : from 7am to 7am

Source: JICA study team



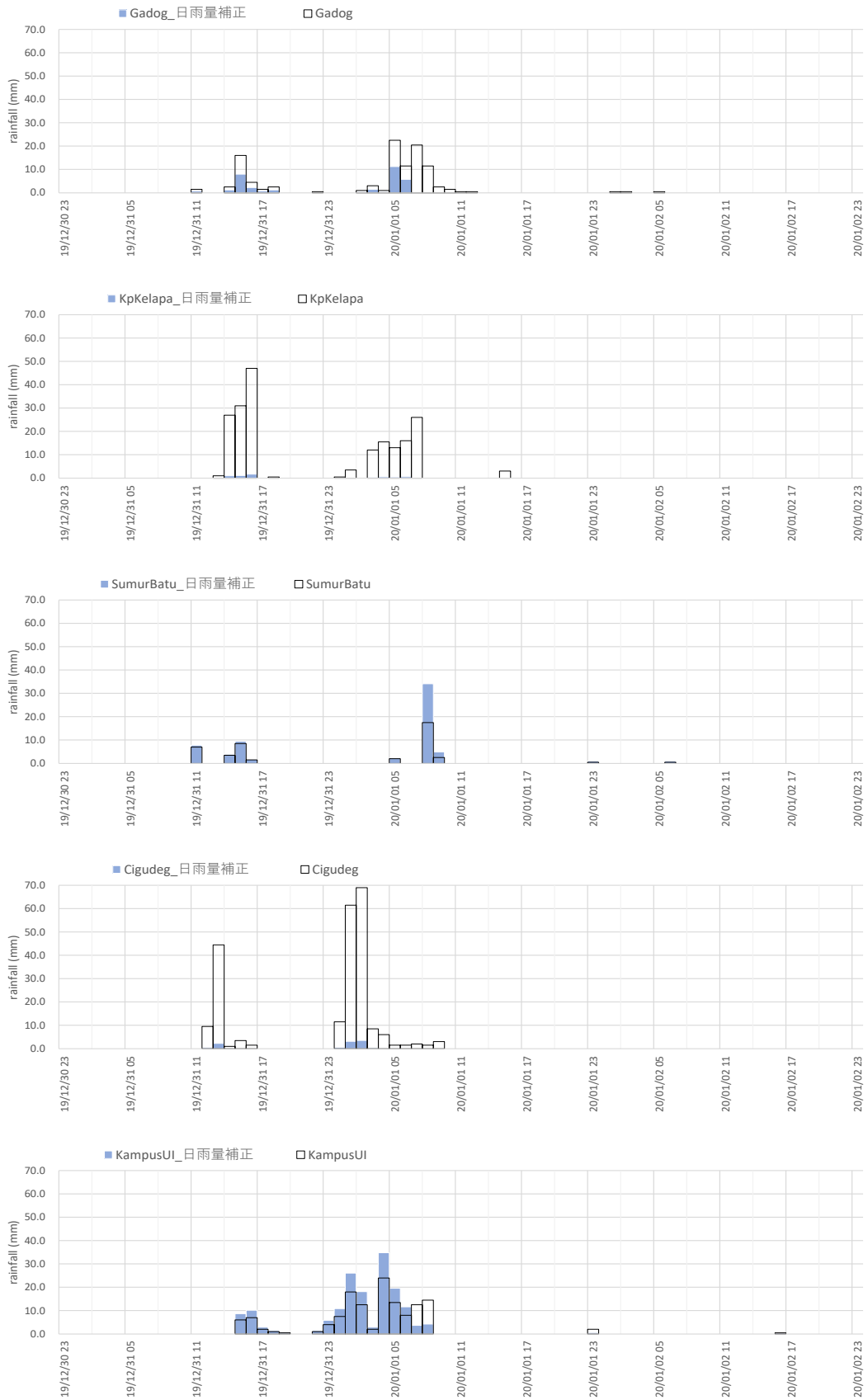
Source: JICA study team

Figure 2-33 Map of rainfall stations



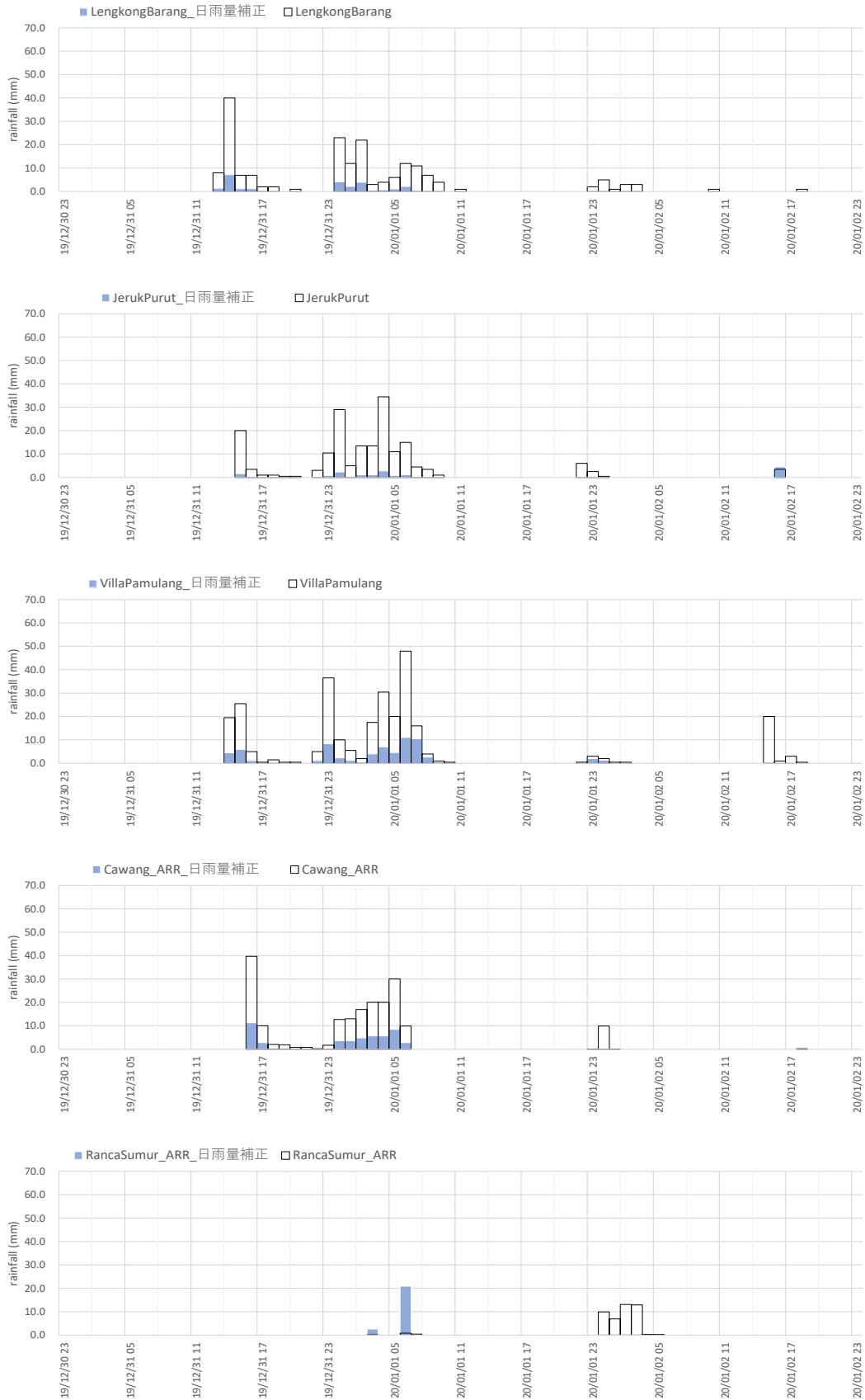
Source: JICA study team

Figure 2-34 Hyetograph (Flood in January 2020)



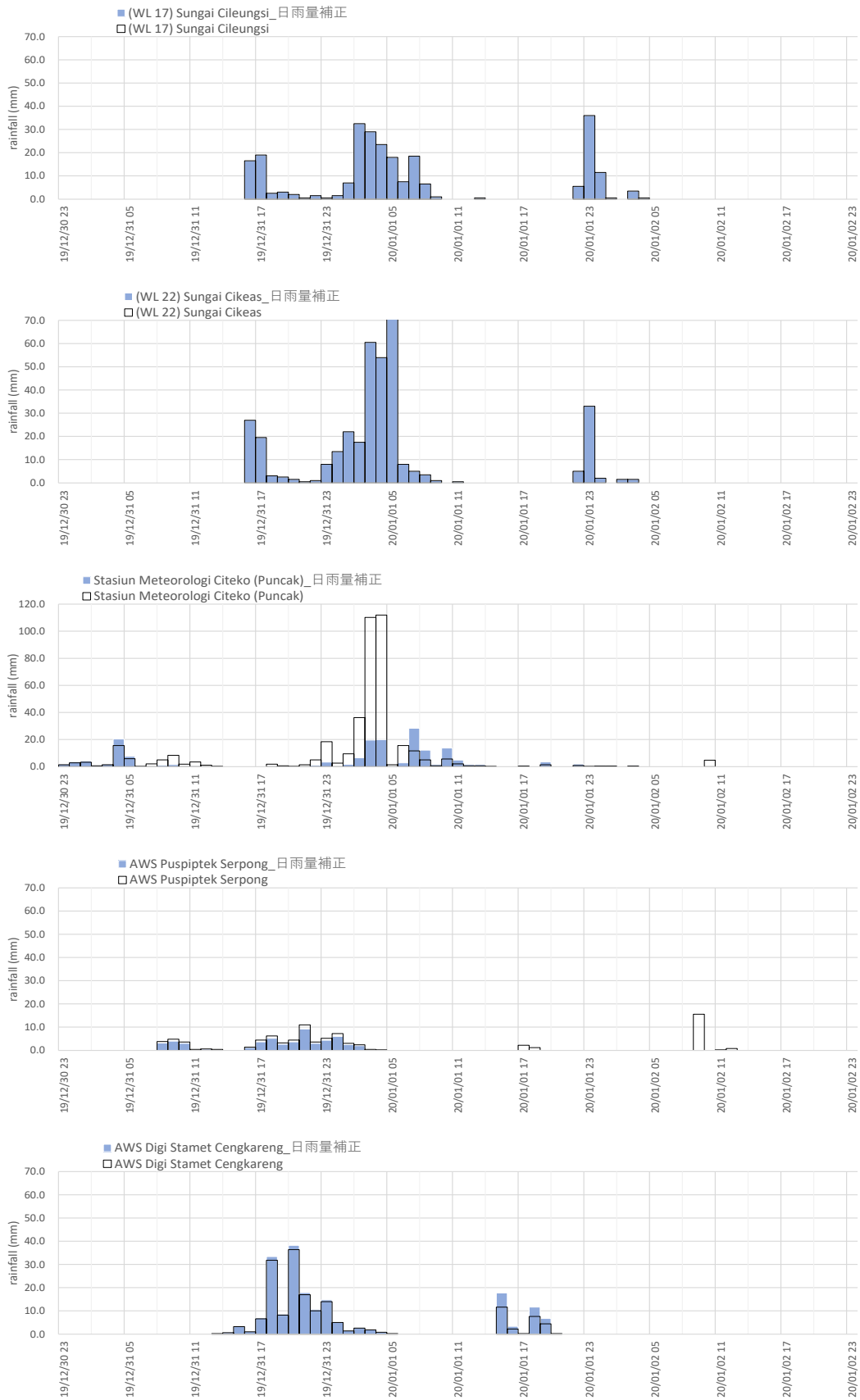
Source: JICA study team

Figure 2-35 (1/3) Hyetograph (Flood in January 2020)



Source: JICA study team

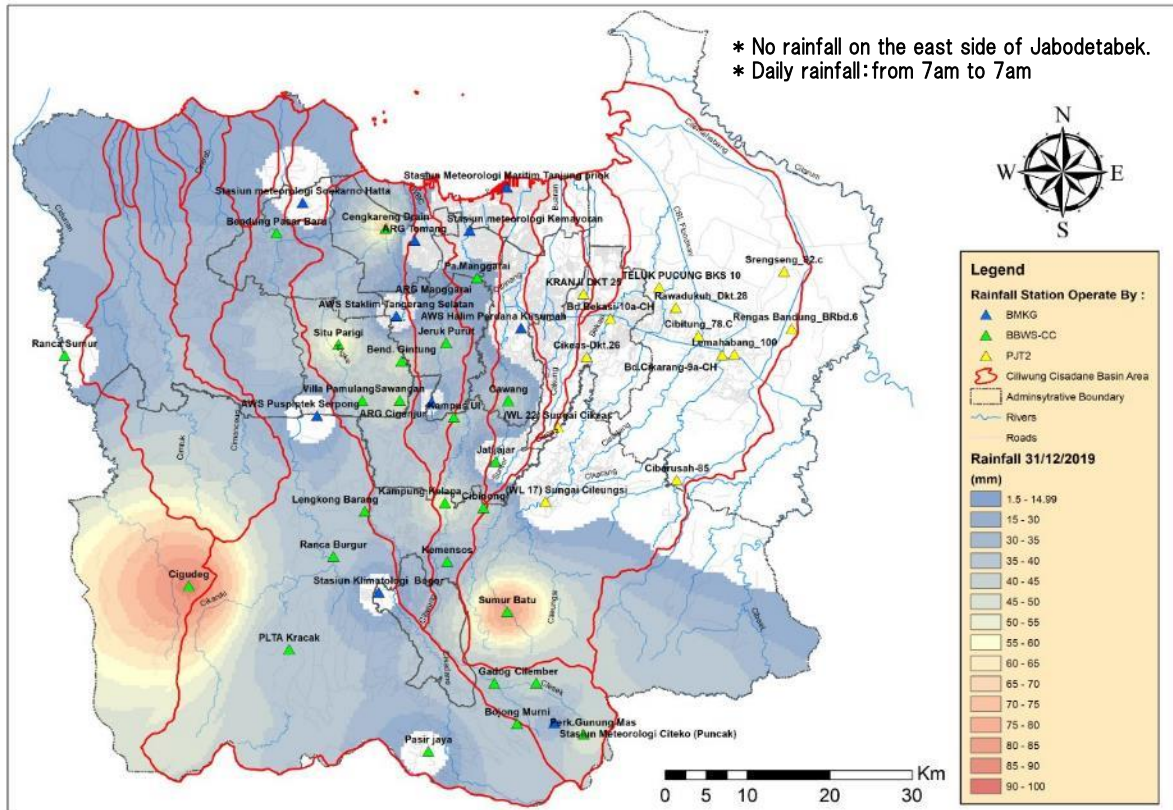
Figure 2-35 (2/3) Hyetograph (Flood in January 2020)



Source: JICA study team

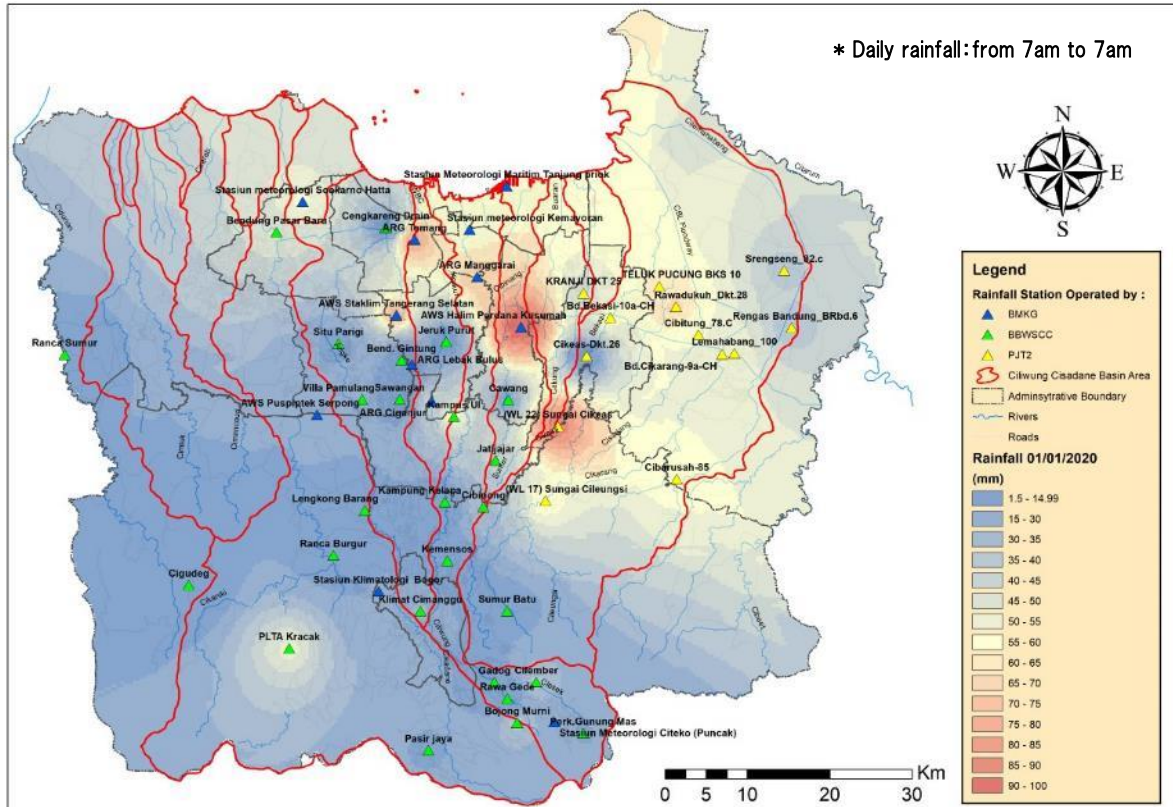
Figure 2-35 (3/3) Hyetograph (Flood in January 2020)

■ 31st December 2019



Source: JICA study team

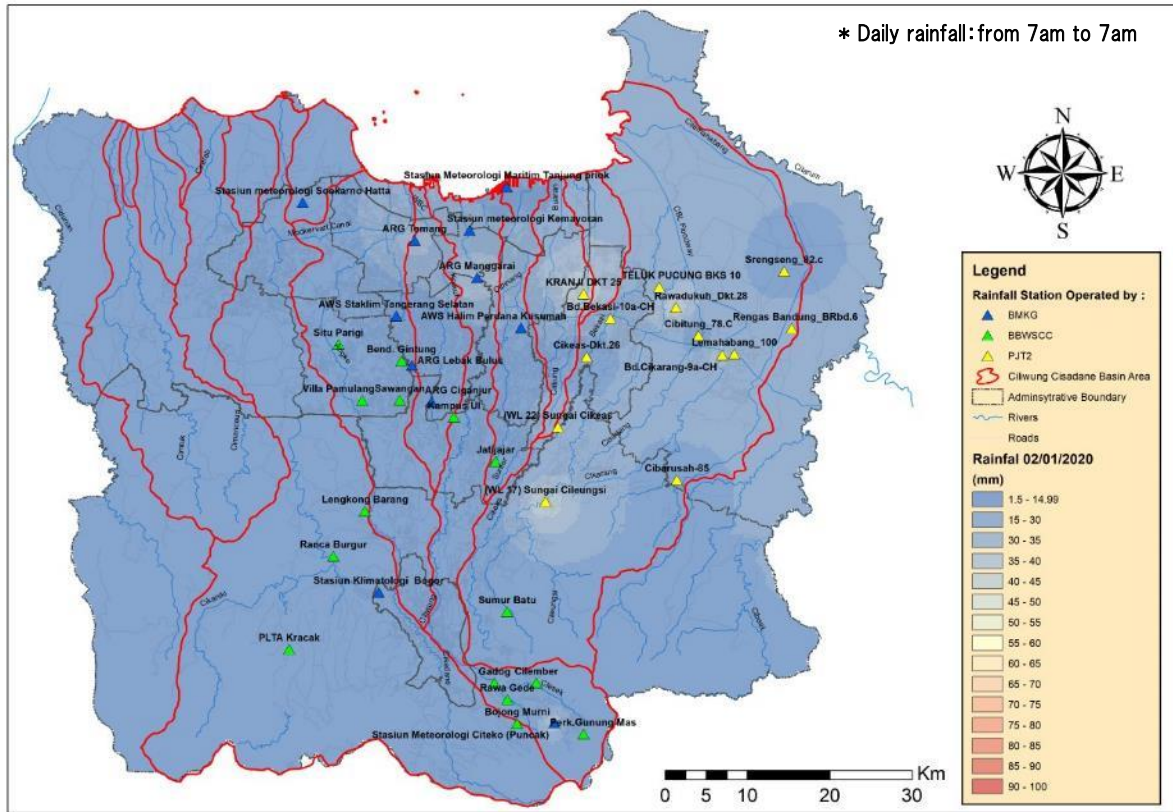
■ 1st January 2020



Source: JICA study team

Figure 2-36 (1/2) Contour map of daily rainfall (flood in January 2020)

■ 2nd January 2020



Source: JICA study team

Figure 2-36 (2/2) Contour map of daily rainfall (flood in January 2020)

(ii) Water level

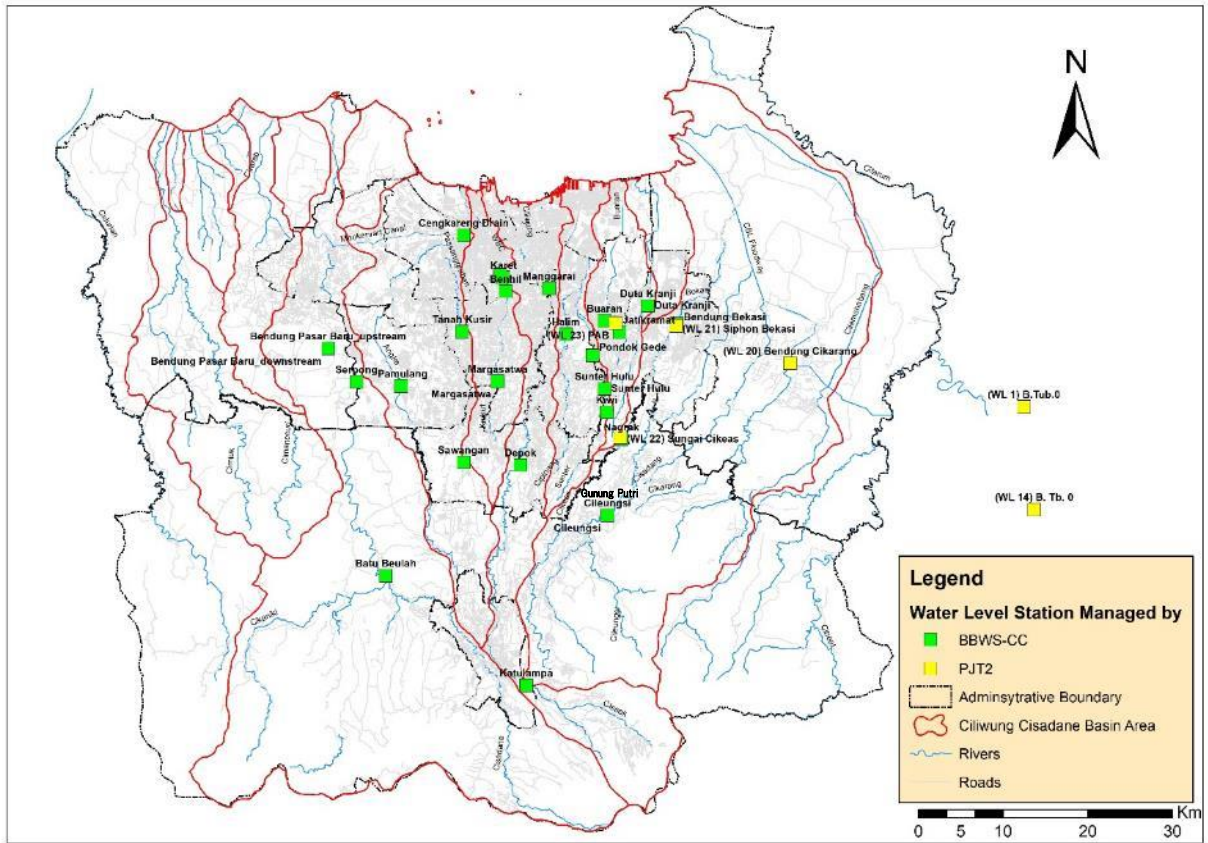
Water level data at 36 stations during the flood in January 2020 were collected from BBWS-CC and PJT2. A collection list of water level data is shown in Table 2-15, and a map of stations is shown in Figure 2-37. Hydrographs of water level at each station are shown in Figure 2-38 to Figure 2-41.

It seems that just after the increase of soil moisture caused by the rainfall on 31st December 2019 (Figure 2-38 : 1st peak), the rainfall on 1st January 2020 (Figure 2-38 : 2nd peak) generated flash runoff, resulting in a rapid rise of river water level.

Table 2-15 Collection list of water level data

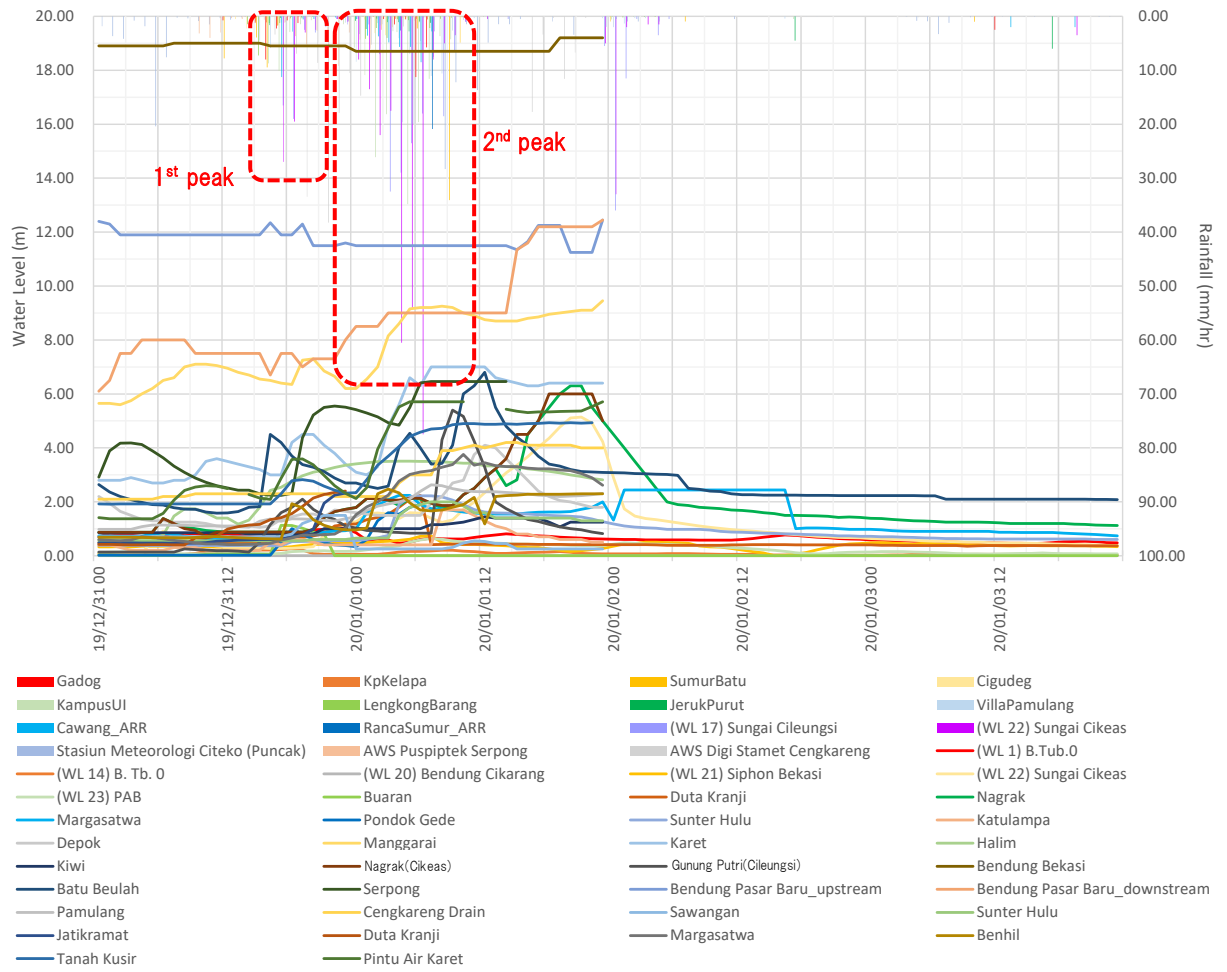
No.	Station	highest water level		Latitude (°S)	Longitude (°E)	Administrator
1	Buaran	1.13	m	-6.247	106.921	BBWS-CC
2	Duta Kranji	2.24	m	-6.231	106.967	BBWS-CC
3	Nagrak	6.3	m	-6.373	106.939	BBWS-CC
4	Cileungsi	5.4	m	-6.453	106.924	BBWS-CC
5	Margasatwa	2.44	m	-6.311	106.808	BBWS-CC
6	Pondok Gede	1.9	m	-6.283	106.909	BBWS-CC
7	Sunter Hulu	2.22	m	-6.319	106.921	BBWS-CC
8	Katulampa	354.7	EL.m	-6.634	106.838	BBWS-CC
9	Depok	4.1	EL.m	-6.400	106.832	BBWS-CC
10	Manggarai	52.42	EL.m	-6.212	106.862	BBWS-CC
11	Karet	16.0	EL.m	-6.201	106.814	BBWS-CC
12	Halim	23.51	EL.m	-6.261	106.880	BBWS-CC
13	Kiwi	77.45	EL.m	-6.344	106.924	BBWS-CC
14	Nagrak(Cikeas)	6.0	EL.m	-6.373	106.939	BBWS-CC
15	Gunung Putri(Cileungsi)	77.4	EL.m	-6.453	106.924	BBWS-CC
16	Bendung Bekasi	39.32	EL.m	-6.250	106.998	BBWS-CC
17	Batu Beulah	124.8	EL.m	-6.517	106.689	BBWS-CC
18	Serpong	31.46	EL.m	-6.312	106.658	BBWS-CC
19	Bendung Pasar Baru upstream	45.45	EL.m	-6.276	106.628	BBWS-CC
20	Bendung Pasar Baru downstream	45.45	EL.m	-6.276	106.628	BBWS-CC
21	Pamulang	42.63	EL.m	-6.316	106.705	BBWS-CC
22	Cengkareng Drain	26.2	EL.m	-6.156	106.772	BBWS-CC
23	Sawangan	78.5	EL.m	-6.397	106.772	BBWS-CC
24	Sunter Hulu	2.0	EL.m	-6.319	106.921	BBWS-CC
25	Jatikramat	2.32	EL.m	-6.259	106.937	BBWS-CC
26	Duta Kranji	15.4	EL.m	-6.231	106.967	BBWS-CC
27	Margasatwa	38.76	EL.m	-6.311	106.808	BBWS-CC
28	Benhil	13.47	EL.m	-6.215	106.816	BBWS-CC
29	Tanah Kusir	57.93	EL.m	-6.258	106.770	BBWS-CC
30	Pintu Air Karet	5.71	EL.m	-6.198	106.810	BBWS-CC
31	(WL 1) B.Tub.0	17.45	EL.m	-6.338	107.366	PJT2
32	(WL 14) B. Tb. 0	27.5	EL.m	-6.447	107.377	PJT2
33	(WL 20) Bendung Cikarang	22.64	EL.m	-6.292	107.118	PJT2
34	(WL 21) Siphon Bekasi	48.59	EL.m	-6.252	106.997	PJT2
35	(WL 22) Sungai Cikeas	110.81	EL.m	-6.371	106.938	PJT2
36	(WL 23) PAB	18.12	EL.m	-6.249	106.933	PJT2

Source: JICA study team



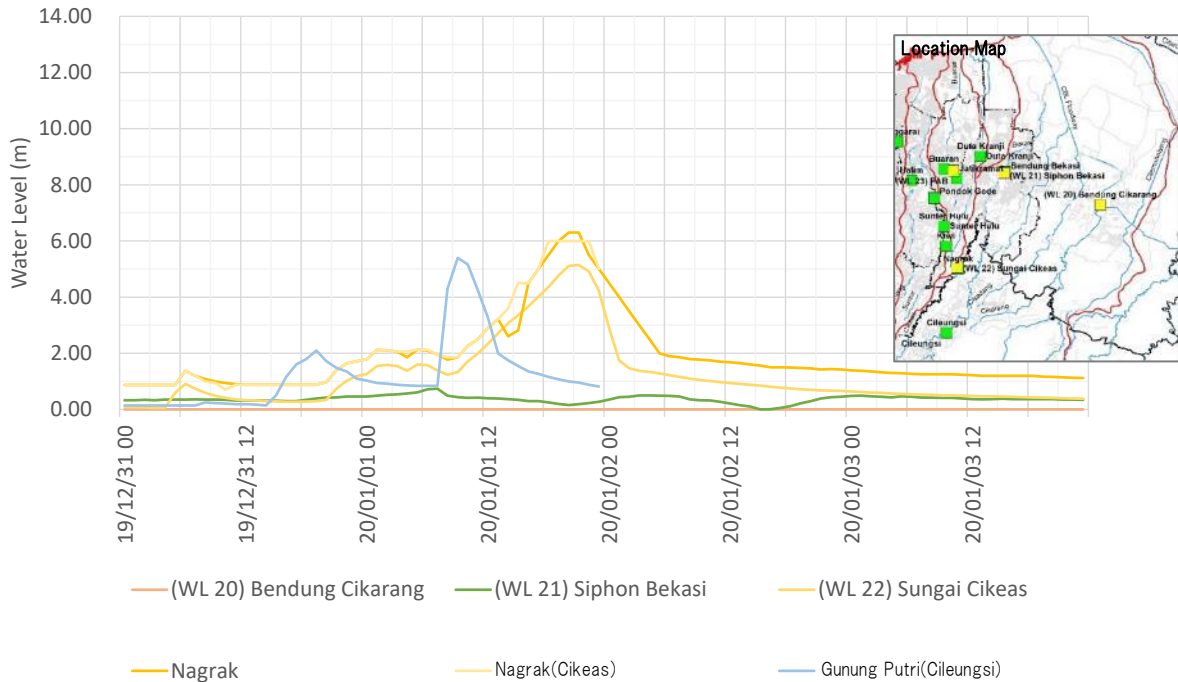
Source: JICA study team

Figure 2-37 Map of water level stations



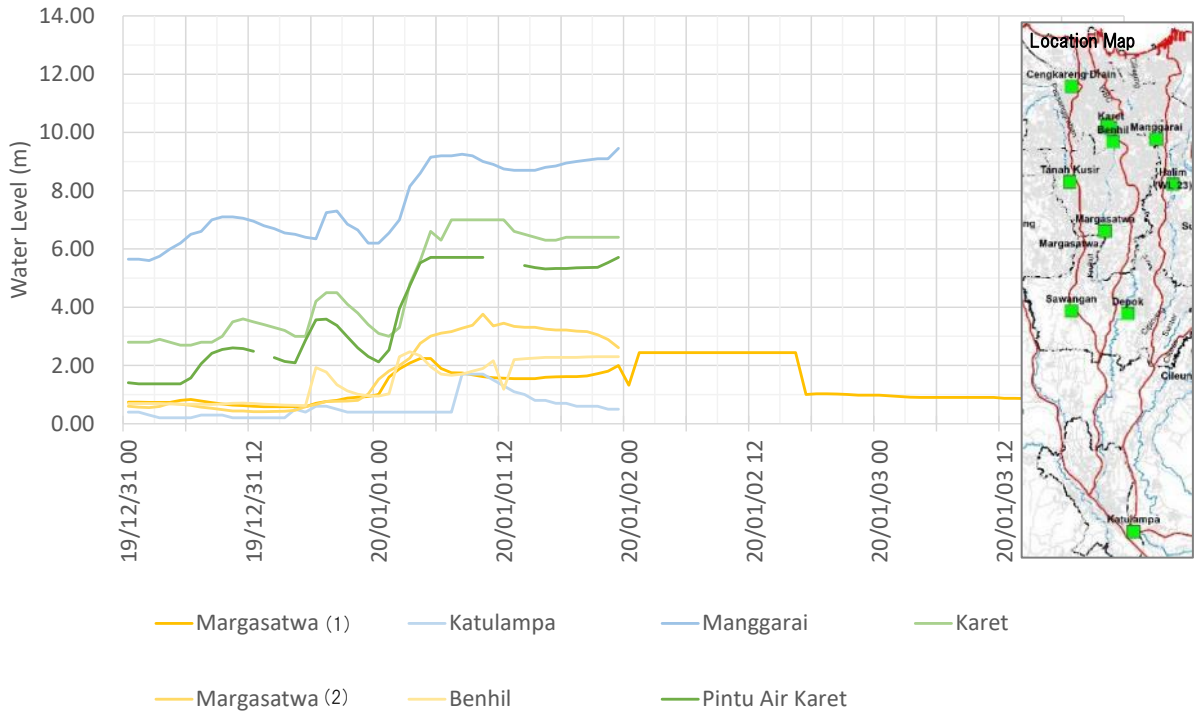
Source: JICA study team

Figure 2-38 WL Hydrograph (Flood in January 2020)



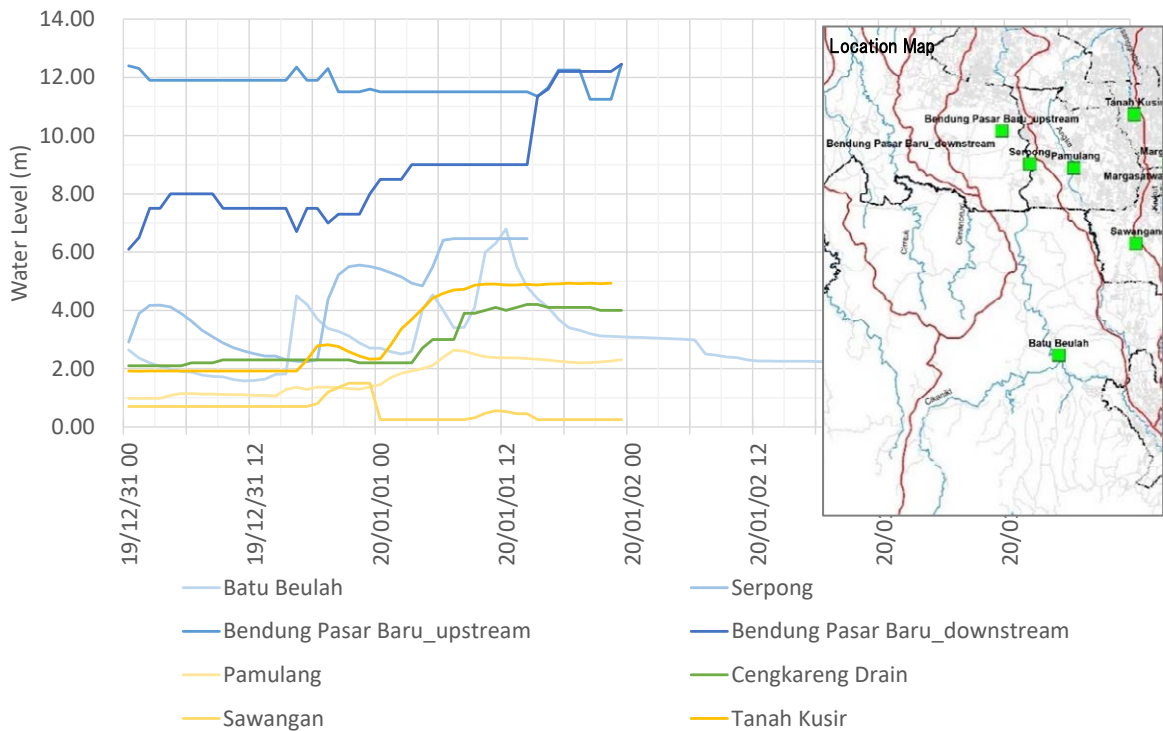
Source: JICA study team

Figure 2-39 WL Hydrograph (Flood in January 2020, the Bekasi River basin)



Source: JICA study team

Figure 2-40 WL Hydrograph (Flood in January 2020, the Ciliwung River basin)



Source: JICA study team

Figure 2-41 WL Hydrograph (Flood in January 2020, the Cisadane River basin)

(iii) Discharge, H-Q equation

Discharge data at 13 stations during the flood in January 2020 were collected from BBWS-CC. The collection list of the discharge data is shown in Table 2-16, and the location map of stations is shown in Figure 2-42.

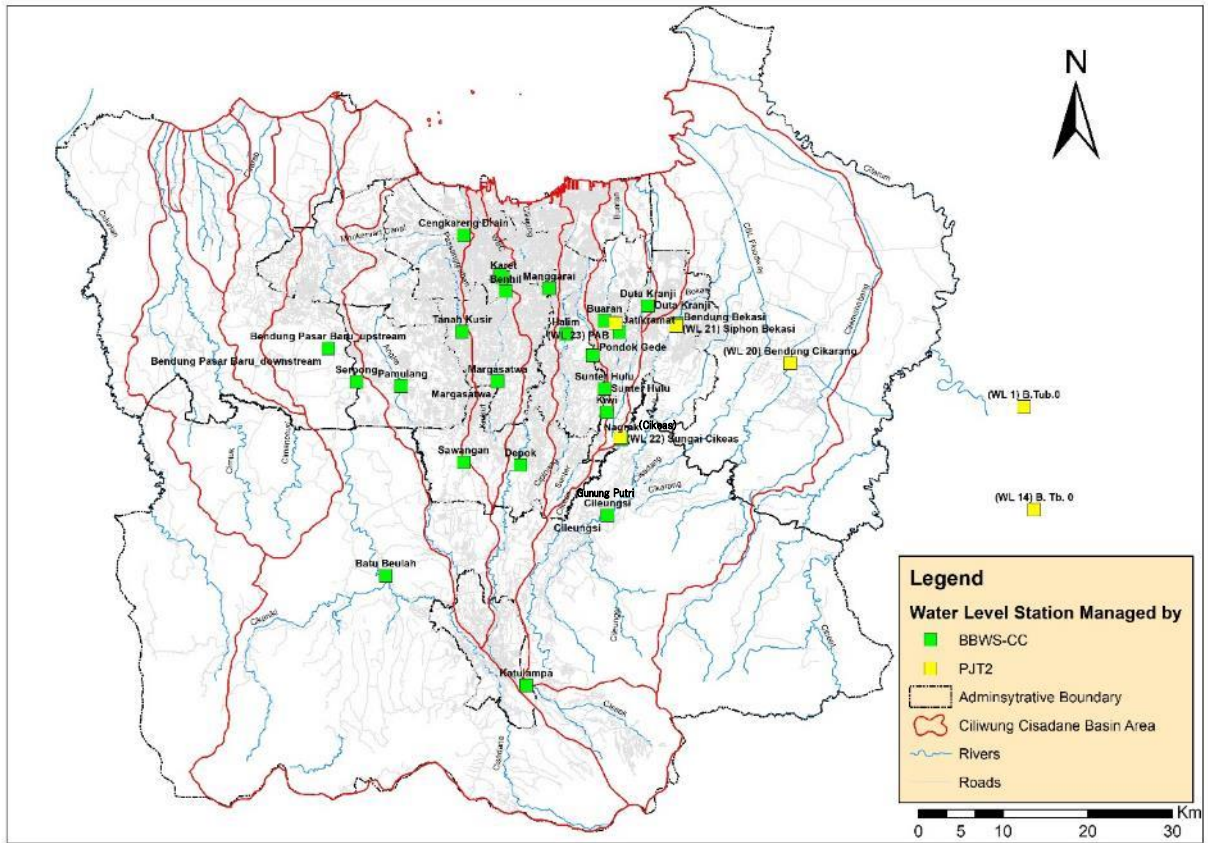
A hydrograph of discharge data at each station is shown in Figure 2-43 and the collected H-Q equations (discharge rating curves) are shown in Table 2-17.

The H-Q equation shown in Table 2-17 was collected from BBWS-CC. The person in charge of BBWS-CC does not know how and when the H-Q equation was set. It is necessary to update the H-Q equation as appropriate according to the changes of river channel characteristics at the observatory site. Creating a rule to update the H-Q equation regularly is needed.

Table 2-16 Collection list of discharge data

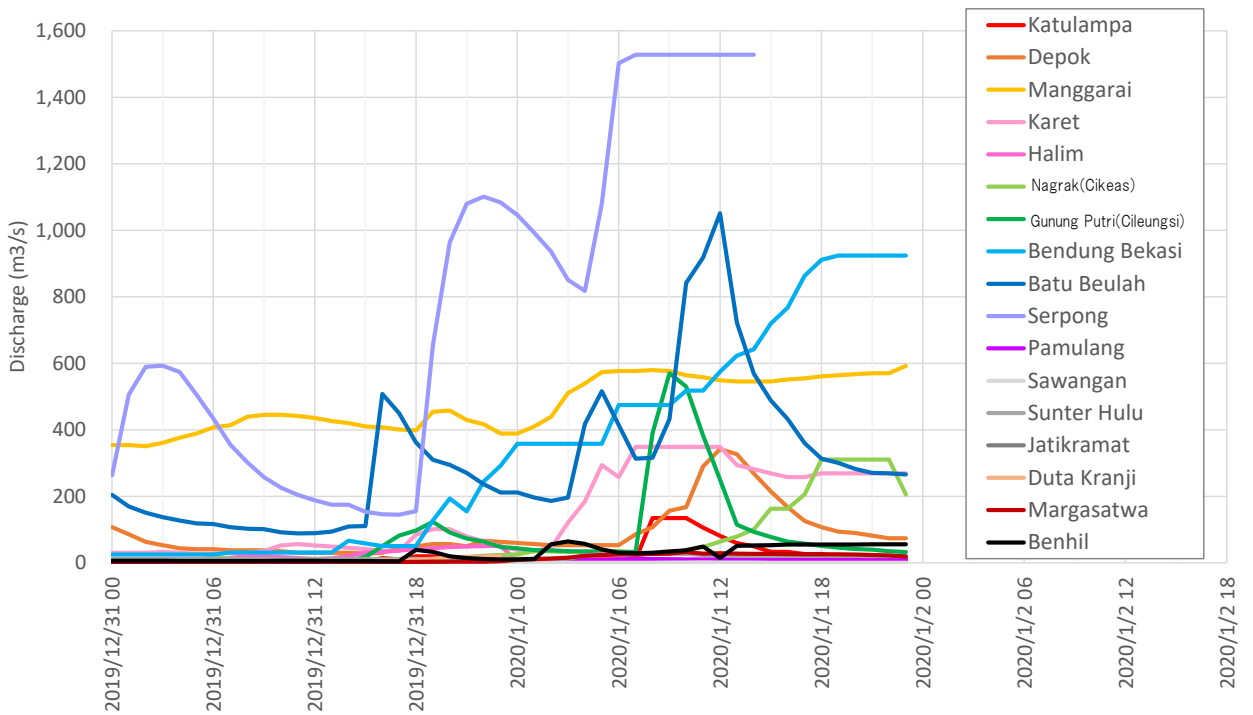
No.	Station	Max discharge (m ³ /s)	Latitude (°S)	Longitude (°E)	Administrator
1	Katulampa	134.5	-6.634	106.838	BBWS-CC
2	Depok	342.2	-6.400	106.832	BBWS-CC
3	Manggarai	592.3	-6.212	106.862	BBWS-CC
4	Karet	348.4	-6.201	106.814	BBWS-CC
5	Halim	51.2	-6.261	106.880	BBWS-CC
6	Nagrak(Cikeas)	310.3	-6.373	106.939	BBWS-CC
7	Gunung Putri(Cileungsi)	569.9	-6.453	106.924	BBWS-CC
8	Bendung Bekasi	924.3	-6.250	106.998	BBWS-CC
9	Batu Beulah	1051.4	-6.517	106.689	BBWS-CC
10	Serpong	1528.1	-6.312	106.658	BBWS-CC
11	Pamulang	11.6	-6.316	106.705	BBWS-CC
12	Sawangan	6.0	-6.397	106.772	BBWS-CC
13	Sunter Hulu	28.4	-6.319	106.921	BBWS-CC
14	Jatikramat	20.9	-6.259	106.937	BBWS-CC
15	Duta Kranji	20.0	-6.231	106.967	BBWS-CC
16	Margasatwa	32.5	-6.311	106.808	BBWS-CC
17	Benhil	64.3	-6.215	106.816	BBWS-CC

Source: JICA study team



Source: JICA study team

Figure 2-42 Map of discharge station



Source: JICA study team

Figure 2-43 Discharge hydrograph (Flood in January 2020)

Table 2-17 H-Q equation at stations

$$Q = c * (H + a)^b$$

DATA RATING CURVE				
No	Nama Pos	Rating Curve		
		a	b	c
S.Cisadane				
1	Genteng	-0,544	1,934	6,087
2	Batu Beulah	-0,281	1,852	28,015
3	Serpong	0,270	2,061	35,686
4	Babakan	-0,507	1,967	21,498
5	Bendung Pasar Baru			
S.Ciliwung				
6	Cibogo			
7	Katulampa	-0,094	2,020	41,307
8	Kampung Kelapa	0,140	2,298	23,055
9	Cipayung Girang			
10	Jemb.Panus	-0,056	1,703	22,748
11	MT.Haryono	-0,200	1,898	3,868
12	Manggarai			
13	Ciluer			
S.Angke				
14	Pamulang	0,371	-1,496	2,236
15	Rawa Buaya	0,256	1,799	7,494
S.Pesanggrahan				
16	Sawangan	0,140	1,940	2,312
17	Tanah Kusir			
18	Kebon Jeruk	0,529	1,812	3,813
S.Grogol				
19	Pondong Pinang	0,080	1,894	10,677
S.Krukut				
20	Margasatwa	0,090	1,518	4,197
21	Benhill	0,250	2,250	6,768
S.Cipinang				
22	Kiwi			
23	Halim	0,000	1,474	7,904
S.Sunter				
24	Jatiwarna			
25	Pondok Gede	0,168	1,186	8,825
S.Jati Kramat				
26	Jatibening	0,100	1,950	3,728
S.Buaran				
27	Pondok Kelapa	-0,110	1,625	1,460
S.Cakung				
28	Duta Kranji	0,010	1,861	3,892
S.Cikeas				
29	Mayor Oking			
30	Nagrak			
S.Cileungsi				
31	Cileungsi	0,300	1,769	26,219
S.Bekasi				
32	Pondok Gede Permai			
33	Pondok Mitra Lestari			
34	Bendung Bekasi			
S.Cengkareng				
35	Cengkareng Drain			
BKB				
36	Karet Bivak	1,944	3,341	0,322
37	PA,Karet			
BKT				
38	Weir I	80,670	0,212	25,330
39	Weir II	38,400	0,098	19,864
40	Weir III	743,440	0,838	59,830
Situ Gintung				
41	Bend.Gintung			

Source: BBWS-CC

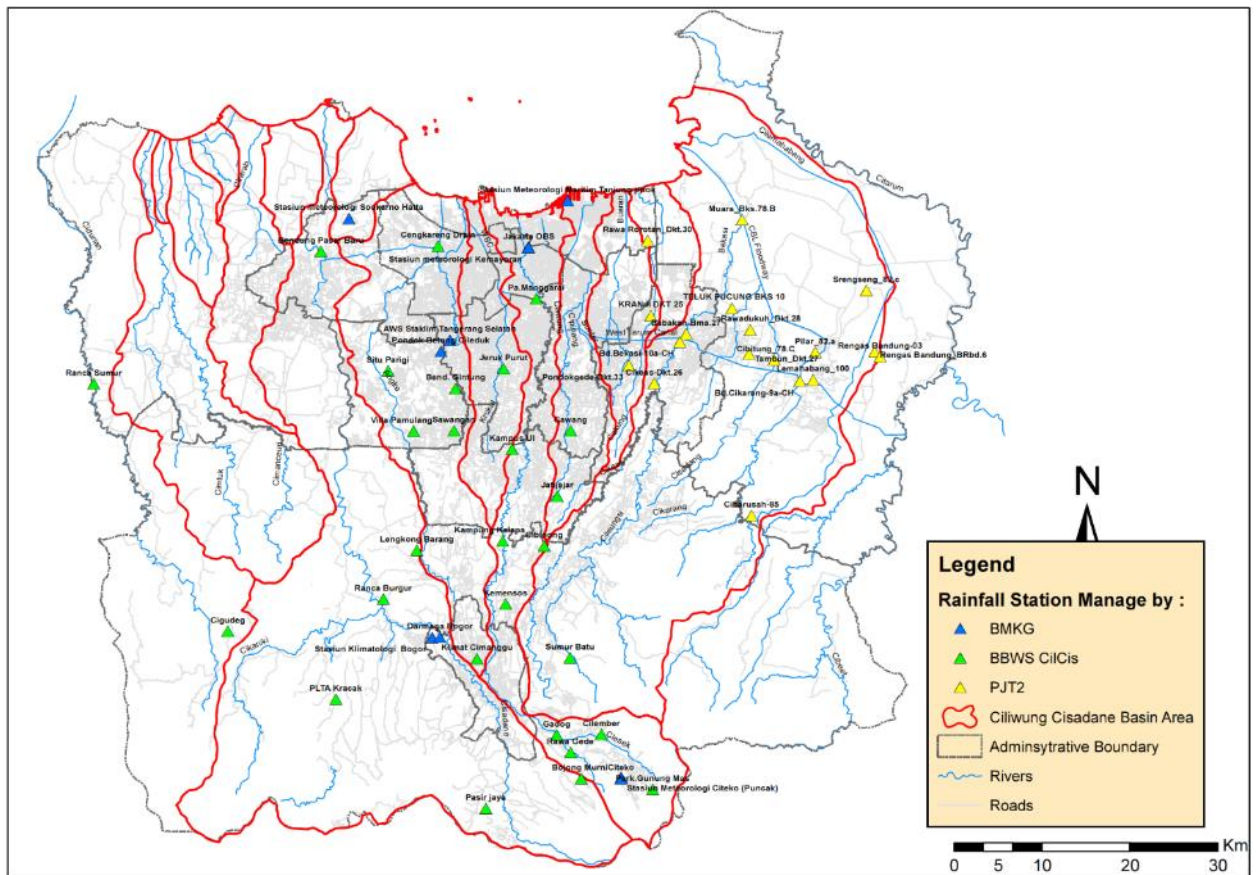
2.1.3 Collection of historical rainfall data

Historical daily rainfall data of 51 stations were collected from BMKG, BBWS-CC and PJT2.

(1) Status of data collection

Daily rainfall data at a total of 51 stations were collected: 8 stations from BMKG, 25 stations from BBWS-CC, and 18 stations from PJT2. Status of data collection is shown in Table 2-18 and the map of stations is shown in Figure 2-44.

Rainfall data of which station location is not clear were excluded.



Source: JICA study team

Figure 2-44 Map of rainfall stations

Table 2-18 (1/3) Status of data collection

managed by	BMKG								BBWS-CC						
Station Name	AWS Staklim Tangerang Selatan	Stasiun Klimatologi Bogor	Stasiun Meteorologi Citeko (Puncak)	Stasiun meteorologi Kemayoran	Stasiun Meteorologi Maritim Tanjung Priok	Stasiun meteorologi Soekarno Hatta	Pondok Betung Cileduk	Darmaga Bogor	Bojong Murni	Cigudeg	Pasir Jaya	Ranca Burgur	PLTA Krakak	Bendung Pasar Baru	
Latitude (° S)	-6.25	-6.55	-6.70	-6.16	-6.11	-6.13	-6.26	-6.55	-6.70	-6.55	-6.73	-6.51	-6.62	-6.16	
Longitude (° E)	106.76	106.74	106.94	106.84	106.88	106.66	106.75	106.75	106.89	106.53	106.80	106.69	106.64	106.63	
1973	-	-	-	-	○	-	-	-	-	-	-	-	-	-	
1974	-	-	-	-	○	-	-	-	-	-	-	-	-	-	
1975	-	-	-	-	○	-	-	-	-	-	-	-	-	-	
1976	○	-	-	-	○	-	-	-	-	-	-	-	-	-	
1977	○	-	-	-	○	-	-	-	-	-	-	-	-	-	
1978	○	-	-	-	○	-	-	-	-	-	-	-	-	-	
1979	○	-	-	-	○	-	-	-	-	-	-	-	-	-	
1980	○	-	-	○	○	-	-	-	-	-	-	-	-	-	
1981	○	-	-	○	○	-	-	-	-	-	-	-	-	-	
1982	○	-	-	○	○	-	○	-	-	-	-	-	-	-	
1983	○	-	-	○	○	-	○	-	-	-	-	-	-	-	
1984	○	○	-	○	○	-	○	-	-	-	-	-	-	-	
1985	○	○	○	○	○	○	○	○	-	-	-	-	-	-	
1986	○	○	○	○	○	○	○	○	-	-	-	-	-	-	
1987	○	○	○	○	○	○	○	○	-	-	-	-	-	-	
1988	○	○	○	○	○	○	○	○	-	-	-	-	-	-	
1989	○	○	○	○	○	○	○	○	-	-	-	-	-	-	
1990	○	○	○	○	○	○	○	○	-	-	-	-	-	-	
1991	○	○	○	○	○	○	○	○	-	-	-	-	-	-	
1992	○	○	○	○	○	○	○	○	-	-	-	-	-	-	
1993	○	○	○	○	○	○	○	○	-	-	-	-	-	-	
1994	○	○	○	○	○	○	○	○	-	-	-	-	-	-	
1995	○	○	○	○	○	○	○	○	-	-	-	-	-	-	
1996	○	○	○	○	○	○	○	○	-	-	-	-	-	-	
1997	○	○	○	○	○	○	○	○	-	-	-	○	-	-	
1998	○	○	○	○	○	○	○	○	-	-	○	○	-	-	
1999	○	○	○	○	○	○	○	○	-	-	○	○	-	-	
2000	○	○	○	○	○	○	○	○	-	-	○	○	-	-	
2001	○	○	○	○	○	○	○	○	-	-	○	○	-	-	
2002	○	○	○	○	○	○	○	○	-	-	○	○	-	-	
2003	○	○	○	○	○	○	○	○	-	-	○	○	-	○	
2004	○	○	○	○	○	○	○	○	-	-	○	○	○	○	
2005	○	○	○	○	○	○	○	○	-	-	○	○	-	○	
2006	○	○	○	○	○	○	○	○	-	-	-	-	-	○	
2007	○	○	○	○	○	○	○	○	-	-	-	-	-	-	
2008	○	○	○	○	○	○	○	○	-	-	○	○	○	○	
2009	○	○	○	○	○	○	-	-	-	-	○	○	○	○	
2010	○	○	○	○	○	○	-	-	-	○	○	○	○	○	
2011	○	○	○	○	○	○	-	-	-	○	○	○	○	○	
2012	○	○	○	○	○	○	-	-	-	○	○	○	○	○	
2013	○	○	○	○	○	○	-	-	-	○	○	○	○	○	
2014	○	○	○	○	○	○	-	-	-	○	○	○	○	○	
2015	○	○	○	○	○	○	-	-	-	○	○	○	○	○	
2016	○	○	○	○	○	○	-	-	-	○	○	○	○	○	
2017	○	○	○	○	○	○	-	-	-	○	○	○	○	○	
2018	○	○	○	○	○	○	-	-	-	○	○	○	○	○	
2019	○	○	○	○	○	○	-	-	○	○	○	○	○	○	
2020	○	○	○	○	○	○	-	-	○	○	○	○	○	○	
number of data years	45	37	36	41	48	36	27	19	2	11	21	22	14	17	

○ : Collected

— : No data

Source: JICA study team

Table 2-18 (2/3) Status of data collection

managed by	BBWS-CC																		
Station Name	Perk.Gu nung Mas	Cilember	Gadog	Kampung Kelapa	Kampus UI	Cibinong	Kemosos	Pa.Man ggarai	Villa Pamulang	Lengko ng Barang	Ranca Sumur	Situ Parigi	Sawang an	Bend. Gintung	Jeruk Purut	Jatijajar	Cawang	Sumur Batu	Cengk reng Drain
Latitude (° S)	-6.71	-6.65	-6.65	-6.46	-6.36	-6.46	-6.52	-6.21	-6.34	-6.46	-6.29	-6.28	-6.34	-6.30	-6.28	-6.41	-6.34	-6.57	-6.15
Longitude(° E)	106.97	106.91	106.87	106.81	106.82	106.86	106.82	106.85	106.72	106.73	106.40	106.70	106.76	106.77	106.81	106.87	106.88	106.88	106.75
1973	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	-	-	○	-	-	-	-	-	-	-	-	-	○	-	-	-	○	-	-
1999	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-	○	-	-
2000	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-	○	-	-
2001	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002	-	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2003	○	○	○	-	○	○	-	○	-	-	-	-	-	-	-	-	-	-	○
2004	○	○	○	-	○	○	-	○	-	-	-	-	-	-	-	-	○	-	○
2005	○	○	-	-	○	○	-	○	-	-	-	-	○	-	-	-	○	-	○
2006	○	-	-	-	○	○	-	○	-	-	-	-	○	-	-	-	○	-	○
2007	○	-	-	-	○	○	-	○	-	-	-	-	○	-	-	-	○	-	○
2008	○	-	○	-	○	○	-	○	-	-	-	-	○	-	-	-	○	-	○
2009	○	-	○	-	○	○	-	-	-	-	-	-	○	-	-	-	○	-	○
2010	○	-	○	-	○	○	-	-	-	-	○	-	○	-	-	-	○	-	○
2011	○	○	○	-	○	○	-	-	-	-	○	-	○	-	-	-	○	-	○
2012	○	○	○	-	○	○	-	-	-	-	○	-	○	-	-	-	○	-	○
2013	○	○	○	-	○	○	-	-	-	-	○	-	○	-	-	-	○	-	○
2014	○	○	○	-	○	○	-	-	-	-	○	-	○	-	-	-	○	○	○
2015	○	○	○	-	○	○	-	-	-	-	○	-	○	-	-	-	○	○	○
2016	○	○	○	-	○	○	-	-	-	-	○	-	○	-	-	-	○	○	○
2017	○	○	○	-	○	○	-	-	-	-	○	-	○	-	-	○	○	○	○
2018	○	○	○	-	○	○	-	-	-	-	○	-	○	-	-	○	○	○	○
2019	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
2020	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
number of data years	18	13	20	2	18	31	2	8	2	2	11	2	17	6	2	4	20	7	18

○ : Collected

— : No data

Source: JICA study team

Table 2-18 (3/3) Status of data collection

managed by	PJT2																		
Station Name	TELUK PUCUNG BKS 10	KRANJI DKT 25	Rawa Rorotan_Dkt.30	Muara_Bks.78	Babakan-Bma.27	Tambun_Dkt.27	Rawadukuh_Dkt.28	Cibitung_78.C	Pilar_82.a	Srengeng 82.c	Lemahabang_100	Rengas Bandung_g_BRbd .6	Rengas Bandung-g-03	Cibarusah-85	Bd.Cikarang-9a-CH	Bd.Bekasi-10a-CH	Cikeas-Dkt.26	Pondokgede-Dkt.33	
Latitude (° S)	-6.22	-6.22	-6.15	-6.13	-6.24	-6.26	-6.24	-6.27	-6.26	-6.20	-6.29	-6.26	-6.27	-6.43	-6.29	-6.25	-6.29	-6.28	
Longitude(° E)	107.05	106.97	106.96	107.06	107.00	107.07	107.07	107.09	107.13	107.19	107.13	107.19	107.20	107.07	107.12	107.00	106.97	106.94	
1973	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1974	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1975	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1976	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1977	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1978	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1979	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1982	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1983	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1984	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1986	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1987	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1988	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1990	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1991	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1992	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1994	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1995	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1996	○	-	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
1997	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	-	
1998	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	-	
1999	○	○	○	○	○	○	○	○	○	○	○	○	○	-	○	○	○	-	
2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2002	○	-	○	-	○	-	-	○	○	-	○	-	○	○	○	○	○	-	
2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2004	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2005	-	-	-	-	-	-	-	○	-	-	○	-	○	○	○	○	-	-	
2006	○	○	○	○	○	○	-	○	-	-	○	-	○	○	○	○	-	-	
2007	○	○	○	○	○	-	○	○	○	○	○	-	○	○	○	○	○	-	
2008	○	○	○	○	○	-	○	○	○	○	○	-	○	○	○	○	-	-	
2009	○	○	○	○	○	-	○	○	○	○	○	-	○	○	○	○	○	-	
2010	○	○	○	○	○	-	○	○	○	○	○	-	○	○	○	○	○	-	
2011	○	○	○	○	○	-	○	○	○	○	○	-	○	○	○	○	○	-	
2012	○	○	○	○	○	-	○	○	○	○	○	-	○	○	○	○	○	-	
2013	○	○	○	-	-	○	○	○	○	○	○	-	○	○	○	○	○	-	
2014	○	-	-	-	-	○	○	○	○	○	○	-	○	○	○	○	○	-	
2015	○	○	○	○	○	-	○	○	○	○	○	-	○	○	○	○	○	-	
2016	○	○	○	○	○	○	○	○	○	○	○	-	○	○	○	○	○	-	
2017	○	○	-	○	○	-	-	○	○	○	○	-	○	○	○	○	○	-	
2018	○	○	-	○	○	-	-	○	○	○	○	-	○	○	○	○	○	-	
2019	○	○	-	○	○	-	-	○	○	-	○	-	○	○	○	○	○	-	
2020	○	○	-	-	-	-	-	○	○	-	○	-	○	○	○	○	○	-	
number of data years	20	17	15	16	15	8	17	21	17	18	21	12	16	20	21	21	18	1	

○ : Collected

— : No data

Source: JICA study team

(2) Annual maximum daily rainfall

The annual maximum daily rainfall at each station is shown in Table 2-19 and Figure 2-45.

Table 2-19 (1/6) Annual maximum daily rainfall

Station Name	BMKG															
	AWS Staklim Tangerang Selatan		Stasiun Klimatologi Bogor		Stasiun Meteorologi Citeko (Puncak)		Stasiun meteorologi Kemayoran		Stasiun Meteorologi Maritim Tanjung priok		Stasiun meteorologi Soekarno Hatta		Pondok Betung Cileduk		Darmaga Bogor	
1973	-	-	-	-	-	-	-	-	109.0	2/6	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	127.0	1/9	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	67.5	4/27	-	-	-	-	-	-
1976	57.0	1/29	-	-	-	-	-	-	102.0	3/7	-	-	-	-	-	-
1977	71.0	12/9	-	-	-	-	-	-	246.5	1/19	-	-	-	-	-	-
1978	94.0	4/20	-	-	-	-	-	-	106.9	12/28	-	-	-	-	-	-
1979	87.0	3/19	-	-	-	-	-	-	130.9	12/14	-	-	-	-	-	-
1980	88.0	4/12	-	-	-	-	92.2	1/12	82.0	1/18	-	-	-	-	-	-
1981	171.0	12/26	-	-	-	-	125.2	12/25	166.5	12/25	-	-	-	-	-	-
1982	71.0	3/28	-	-	-	-	65.3	12/2	76.3	2/13	-	-	69.4	3/27	-	-
1983	75.0	10/26	-	-	-	-	97.7	2/3	105.2	1/21	-	-	74.7	10/26	-	-
1984	122.0	5/14	114.0	8/31	-	-	79.9	5/15	88.8	12/31	-	-	114.6	5/16	-	-
1985	107.0	5/19	105.0	2/6	87.0	9/27	148.3	1/14	106.7	1/14	64.0	12/26	105.5	5/20	123.8	2/4
1986	173.0	12/13	110.0	6/16	94.1	8/6	94.0	2/10	114.9	2/11	175.0	1/28	173.9	12/14	-	-
1987	170.0	1/2	88.0	5/6	79.7	5/11	99.8	2/8	106.0	1/26	189.0	1/2	81.8	6/5	93.4	5/5
1988	101.0	12/19	89.0	1/18	79.1	1/23	70.4	1/10	100.0	1/21	101.0	1/10	106.2	12/19	93.4	1/18
1989	86.4	5/8	240.0	2/13	100.8	11/8	80.5	12/12	100.0	5/5	86.0	12/12	129.2	2/6	244.5	2/13
1990	134.0	5/13	188.3	8/7	140.9	1/7	58.6	1/22	215.6	12/3	83.0	1/27	130.7	5/13	-	-
1991	122.8	3/24	105.0	3/6	151.2	2/24	139.5	3/15	180.4	1/8	98.0	2/28	125.2	3/16	-	-
1992	129.0	4/24	112.2	10/4	135.8	1/30	98.3	8/22	170.8	1/22	116.0	1/23	128.9	4/23	117.5	5/5
1993	103.0	4/22	176.3	8/20	84.9	3/1	101.0	1/9	178.0	2/8	136.0	2/7	130.2	2/8	-	-
1994	93.8	1/22	100.0	4/4	109.7	1/21	92.6	5/10	98.2	2/25	85.0	2/25	89.5	1/21	126.3	5/10
1995	128.9	6/18	87.6	11/11	118.7	12/31	75.7	6/17	103.2	12/13	80.0	12/12	125.3	6/18	132.8	11/6
1996	129.5	2/10	157.0	5/19	123.0	1/3	216.2	2/9	102.1	1/17	107.0	2/9	213.3	2/11	156.5	5/19
1997	94.0	1/14	113.5	5/20	69.0	1/8	125.6	1/13	118.3	4/4	103.0	1/14	110.9	1/14	113.5	5/20
1998	123.5	3/28	127.1	4/13	87.5	3/5	162.2	2/27	110.9	1/30	108.0	2/27	123.8	3/28	129.2	4/12
1999	111.0	1/14	149.6	4/29	80.3	5/6	147.2	7/19	106.0	1/26	97.0	7/19	113.2	1/14	172.4	4/29
2000	103.4	11/17	93.8	8/28	94.5	7/3	94.8	1/25	65.2	1/27	94.5	4/26	107.3	11/16	133.6	2/2
2001	104.0	10/2	107.5	5/24	111.3	3/1	82.2	1/22	210.0	12/30	84.3	1/22	112.9	10/2	111.5	4/28
2002	109.2	1/23	127.0	1/30	145.9	1/30	168.5	2/1	147.1	1/29	88.0	1/28	128.7	1/22	148.3	1/30
2003	119.2	5/13	123.3	5/13	128.8	2/5	199.7	12/29	126.7	2/4	115.0	12/30	130.4	2/13	124.7	5/13
2004	94.0	1/31	141.6	8/15	79.3	4/22	129.3	4/21	121.4	4/21	114.5	2/17	95.9	3/13	-	-
2005	104.5	7/16	126.5	2/21	161.0	1/19	124.1	1/18	109.9	2/10	158.1	5/15	109.6	3/24	123.5	2/21
2006	79.3	4/21	136.4	1/13	134.4	1/24	72.0	4/13	90.3	2/18	61.5	6/6	70.3	1/17	136.1	1/12
2007	339.8	2/2	155.5	4/28	245.3	2/4	234.7	2/1	182.2	2/1	153.2	12/4	346.3	2/2	131.2	2/4
2008	209.0	2/2	104.5	3/13	107.2	12/20	192.7	2/1	87.9	2/1	316.3	2/2	209.4	2/2	114.2	3/17
2009	114.0	2/2	115.1	5/6	89.0	1/14	122.5	1/18	148.9	1/13	106.7	1/11	-	-	-	-
2010	108.9	9/15	144.5	9/4	118.8	6/9	93.0	10/25	88.3	2/17	106.2	6/1	-	-	-	-
2011	61.9	4/27	97.6	5/21	117.6	11/18	119.2	2/14	78.5	11/23	75.5	12/28	-	-	-	-
2012	79.8	12/3	116.0	4/17	63.2	12/9	105.2	11/14	75.1	11/19	101.1	4/4	-	-	-	-
2013	96.0	12/1	136.8	9/8	130.2	3/5	193.4	1/17	117.8	1/17	397.4	12/31	-	-	-	-
2014	119.5	2/23	169.1	4/6	192.8	1/30	147.9	1/18	284.0	2/1	104.1	1/17	-	-	-	-
2015	117.0	2/10	155.8	11/9	86.8	11/17	277.5	2/10	247.0	2/10	127.7	2/10	-	-	-	-
2016	112.7	4/20	108.6	4/21	88.0	1/2	124.5	4/21	112.7	4/21	147.6	2/26	-	-	-	-
2017	80.2	11/13	117.6	6/30	90.0	11/18	179.7	2/21	148.6	2/17	125.5	6/14	-	-	-	-
2018	86.3	4/23	134.5	5/17	164.1	2/6	104.6	2/16	129.6	3/28	85.4	4/4	-	-	-	-
2019	77.4	2/17	141.0	12/15	120.5	4/24	90.5	3/6	130.3	3/5	57.0	3/5	-	-	-	-
2020	208.9	1/1	122.9	10/5	118.7	2/8	277.5	2/25	155.5	2/8	147.9	1/1	-	-	-	-
average	114.8	-	128.06	-	114.7	-	129.3	-	128.7	-	122.1	-	128.0	-	133.0	-

— : No data

Source: JICA study team

Table 2-19 (2/6) Annual maximum daily rainfall

Station Name	BBWSSC															
	Bojong Murni		Cigudeg		Pasir jaya		Ranca Burgur		PLTA Kracak		Bendung Pasar Baru		Perk.Gunung Mas		Cilember	
1973	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	300.0	1/10	-	-	-	-	-	-	-	-
1998	-	-	-	-	86.0	1/27	510.0	2/18	-	-	-	-	-	-	-	-
1999	-	-	-	-	69.0	2/8	300.0	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	70.5	12/18	475.0	2/20	-	-	-	-	-	-	-	-
2001	-	-	-	-	105.0	7/18	18.0	6/16	-	-	-	-	-	-	-	-
2002	-	-	-	-	141.0	4/1	150.0	5/8	-	-	-	-	-	-	-	-
2003	-	-	-	-	112.0	8/28	88.0	3/23	-	-	66.0	2/27	118.0	12/10	110.0	4/30
2004	-	-	-	-	99.0	12/19	20.5	11/20	114.0	5/24	97.0	2/17	78.0	2/16	84.0	1/17
2005	-	-	-	-	114.0	9/24	105.0	6/18	-	-	92.0	4/4	157.0	1/18	173.5	1/18
2006	-	-	-	-	-	-	-	-	-	-	45.0	1/24	127.0	1/23	-	-
2007	-	-	-	-	-	-	-	-	-	-	-	-	156.0	2/3	347.5	2/3
2008	-	-	-	-	138.0	4/7	30.0	1/3	126.0	11/3	88.0	4/12	105.0	3/12	134.0	1/1
2009	-	-	-	-	154.0	6/2	20.5	9/10	104.0	11/6	125.0	11/7	152.0	1/13	-	-
2010	-	-	32.5	2/9	145.0	3/26	20.2	7/19	351.0	5/25	107.0	1/19	106.0	2/19	-	-
2011	-	-	39.0	11/5	122.0	1/6	60.3	6/27	64.5	7/20	114.0	4/30	115.0	1/13	52.0	4/25
2012	-	-	4.0	12/13	140.0	11/17	64.8	4/16	175.0	8/12	78.0	3/28	80.0	3/29	78.0	6/7
2013	-	-	3.9	2/16	99.0	2/16	63.5	2/4	158.0	3/24	94.0	1/18	120.0	1/15	20.0	12/6
2014	-	-	3.7	10/29	102.0	5/30	8.1	1/12	160.0	2/22	66.0	3/12	120.0	1/23	75.0	1/13
2015	-	-	290.0	1/22	72.0	4/26	290.0	1/23	103.0	8/12	38.0	12/17	58.0	11/16	99.0	12/15
2016	-	-	380.0	8/9	116.0	11/15	30.5	12/12	266.5	10/18	65.0	2/26	90.0	7/22	78.0	3/27
2017	-	-	129.5	3/26	107.0	1/2	32.0	11/3	130.0	8/12	55.0	12/1	112.0	7/28	78.0	3/27
2018	-	-	31.8	6/26	127.0	6/24	24.0	10/23	98.6	11/25	93.0	4/4	150.0	2/5	150.0	2/5
2019	85.0	12/31	290.0	12/31	108.0	2/15	114.0	4/26	114.0	1/8	75.0	12/31	132.0	12/31	128.0	10/8
2020	123.0	9/21	95.0	2/10	124.5	3/24	129.0	2/29	140.0	3/24	139.0	1/31	127.5	2/19	124.0	4/29
average	104.0		118.1		112.0		129.7		150.3		84.5		116.9		115.4	

— : No data

Source: JICA study team

Table 2-19 (3/6) Annual maximum daily rainfall

Station Name	BBWSCC																	
	Gadog		Kampung Kelapa		Kampus UI		Cibinong		Kemensos		PA.Manggarai		Villa Pamulang		Lengkong Barang		Ranca Sumur	
1973	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	115.0	8/16	-	-	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	-	180.0	6/14	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	110.0	4/15	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	78.0	5/4	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	122.0	12/6	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	103.0	6/11	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	162.0	4/30	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	80.0	4/14	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	111.0	12/17	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	107.0	8/25	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	95.0	11/24	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	123.0	6/7	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	125.0	12/5	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	979.0	6/1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	118.0	1/3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	490.0	12/31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2001	125.0	6/7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002	127.0	1/18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2003	161.0	4/29	-	-	102.0	2/13	146.0	10/7	-	-	264.5	12/30	-	-	-	-	-	-
2004	97.0	5/16	-	-	117.0	4/9	114.0	12/13	-	-	133.5	4/20	-	-	-	-	-	-
2005	-	-	-	-	95.0	6/16	150.0	9/24	-	-	191.0	7/14	-	-	-	-	-	-
2006	-	-	-	-	93.5	4/12	122.5	12/23	-	-	129.0	2/8	-	-	-	-	-	-
2007	-	-	-	-	156.5	2/2	97.0	4/3	-	-	153.0	2/1	-	-	-	-	-	-
2008	156.0	2/6	-	-	152.0	12/8	132.0	11/3	-	-	227.5	1/31	-	-	-	-	-	-
2009	85.0	1/13	-	-	137.0	3/23	77.0	1/26	-	-	-	-	-	-	-	-	-	-
2010	96.0	8/25	-	-	109.0	2/19	75.0	6/19	-	-	-	-	-	-	-	-	160.4	1/31
2011	73.5	12/28	-	-	117.4	12/2	90.0	5/22	-	-	-	-	-	-	-	-	136.0	4/2
2012	113.0	11/19	-	-	128.2	4/3	89.0	12/11	-	-	-	-	-	-	-	-	129.0	12/7
2013	145.0	7/21	-	-	101.7	4/7	82.0	8/10	-	-	-	-	-	-	-	-	185.2	7/29
2014	149.5	12/21	-	-	151.5	11/25	81.0	12/10	-	-	-	-	-	-	-	-	171.2	2/3
2015	130.5	3/1	-	-	97.2	2/10	70.0	2/12	-	-	-	-	-	-	-	-	126.8	2/2
2016	106.5	11/6	-	-	141.5	4/21	135.0	7/4	-	-	-	-	-	-	-	-	168.4	2/25
2017	143.0	4/13	-	-	105.7	5/5	85.0	3/26	-	-	-	-	-	-	-	-	82.0	3/7
2018	125.0	2/5	-	-	95.2	9/3	100.0	10/28	-	-	-	-	-	-	-	-	87.0	4/23
2019	105.5	4/23	148.5	12/31	122.6	4/29	107.5	12/31	63.0	12/31	106.5	12/31	112.0	12/31	104.5	12/18	108.5	1/1
2020	113.0	2/7	152.5	10/4	155.2	1/1	104.0	10/4	68.0	4/29	228.0	2/22	94.5	1/26	121.0	10/4	125.0	5/18
average	181.9		150.5		121.0		108.6		65.5		179.1		103.3		112.8		134.5	

— : No data

Source: JICA study team

Table 2-19 (4/6) Annual maximum daily rainfall

Station Name	BBWSCC															
	Situ Parigi		Sawangan		Bend. Gintung		Jeruk Purut		Jatijajar		Cawang		Sumur Batu		Cengkareng Drain	
1973	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	-	-	51.0	2/18	-	-	-	-	-	-	985.0	7/4	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	468.0	2/22	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	425.0	7/28	-	-	-	-
2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	126.0	12/30
2004	-	-	-	-	-	-	-	-	-	-	145.0	11/29	-	-	87.0	4/23
2005	-	-	134.5	11/18	-	-	-	-	-	-	314.0	6/30	-	-	114.0	7/15
2006	-	-	115.5	4/20	-	-	-	-	-	-	67.5	4/22	-	-	60.0	1/13
2007	-	-	270.0	2/1	-	-	-	-	-	-	195.0	2/3	-	-	131.0	12/3
2008	-	-	128.5	3/13	-	-	-	-	-	-	143.0	2/2	-	-	54.0	4/21
2009	-	-	85.0	11/13	-	-	-	-	-	-	99.0	5/6	-	-	139.0	5/5
2010	-	-	108.0	10/23	-	-	-	-	-	-	121.0	10/26	-	-	75.0	7/4
2011	-	-	76.0	5/19	-	-	-	-	-	-	55.0	1/6	-	-	83.0	12/27
2012	-	-	83.4	11/21	-	-	-	-	-	-	103.0	3/5	-	-	54.0	12/22
2013	-	-	100.0	11/14	-	-	-	-	-	-	149.0	1/17	-	-	91.0	2/17
2014	-	-	100.0	7/11	-	-	-	-	-	-	138.0	1/29	175.0	11/20	105.0	12/27
2015	-	-	43.6	2/6	50.0	12/20	-	-	-	-	130.0	3/10	181.0	2/10	124.0	2/9
2016	-	-	105.0	1/30	95.0	5/21	-	-	-	-	146.0	8/15	153.0	7/4	120.0	2/25
2017	-	-	39.8	7/23	105.5	6/6	-	-	41.6	6/11	330.0	12/12	205.0	10/8	110.0	2/21
2018	-	-	60.0	10/27	108.0	9/2	-	-	83.0	10/28	195.0	1/15	450.5	11/29	83.0	10/22
2019	158.0	12/31	135.0	12/31	135.0	12/31	102.0	12/31	102.8	4/8	109.0	12/31	251.0	12/31	423.0	1/10
2020	175.0	10/26	50.7	3/16	92.0	10/10	102.0	2/25	105.5	10/24	108.0	2/22	130.5	2/8	156.0	2/24
average	166.5		99.2		97.6		102.0		83.2		221.3		220.9		118.6	

— : No data

Source: JICA study team

Table 2-19 (5/6) Annual maximum daily rainfall

Station Name	PJT2																	
	TELUK PUCUNG BKS 10		KRANJI DKT 25		Rawa Rorotan_Dkt.30		Muara_Bks.78.B		Babakan-Bma.27		Tambun_Dkt.27		Rawadukuh_Dkt. 28		Cibitung_78.C		Pilar_82.a	
1973	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	110.0	1/3	-	-	188.0	2/10	143.0	2/10	94.0	1/4	142.0	1/3	120.0	2/10	100.0	2/10	171.0	1/3
1997	110.0	2/5	110.0	2/5	77.0	11/25	92.0	1/14	101.0	4/14	127.0	1/8	110.0	1/8	97.0	1/26	113.0	1/27
1998	84.0	3/9	82.0	2/8	83.0	2/8	100.0	3/18	58.0	3/18	78.0	2/8	75.0	3/9	78.0	3/18	86.0	4/27
1999	105.0	12/30	58.0	1/26	102.0	1/26	50.0	1/26	53.0	7/1	48.0	2/14	50.0	2/9	87.0	1/26	156.0	12/6
2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002	117.0	1/30	-	-	279.0	1/30	-	-	74.0	2/9	-	-	-	-	138.0	1/30	710.0	3/5
2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2004	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-	-	1/1	-	-	-	-	123.0	1/19	-	-
2006	78.0	2/20	75.0	2/20	55.0	3/29	49.0	1/31	87.0	2/26	94.0	2/26	-	-	70.0	11/30	-	-
2007	85.0	12/1	235.0	4/22	67.0	12/1	82.0	12/16	80.0	12/16	-	-	80.0	12/4	78.0	12/20	93.0	5/11
2008	119.0	3/20	67.0	4/1	56.0	12/23	76.0	1/1	70.0	1/1	-	-	90.0	2/19	120.0	2/19	100.0	2/19
2009	168.0	1/19	116.0	1/19	105.0	1/19	75.0	1/14	72.0	12/7	-	-	158.0	1/15	80.0	1/15	116.0	1/15
2010	82.0	12/24	84.0	12/24	83.0	12/24	75.0	12/7	72.0	12/7	-	-	114.0	10/5	105.0	1/19	95.0	10/5
2011	90.0	12/3	80.0	12/3	55.0	5/6	75.0	12/27	75.0	2/6	-	-	120.0	5/25	80.0	12/2	54.0	12/11
2012	45.0	1/8	65.0	1/10	45.0	3/10	65.0	4/2	68.0	4/2	-	-	80.0	12/1	55.0	3/10	59.0	12/6
2013	154.0	1/18	32.0	1/18	53.0	1/18	-	-	-	-	107.0	5/1	105.0	1/17	97.0	1/19	128.0	1/18
2014	154.0	2/26	-	-	-	-	-	-	-	-	107.0	5/1	100.0	11/25	95.0	2/3	141.0	1/13
2015	147.0	2/9	188.0	12/28	95.0	11/17	25.0	5/8	25.0	5/3	-	-	105.0	2/10	45.0	2/9	74.0	2/19
2016	116.0	2/26	105.0	2/26	80.0	2/28	102.0	2/18	105.0	2/2	73.0	11/16	110.0	2/26	127.0	9/25	107.0	2/26
2017	98.0	2/20	125.0	2/20	-	-	90.0	2/18	87.0	2/19	-	-	-	-	80.0	2/20	112.0	2/20
2018	120.0	12/14	120.0	2/16	-	-	54.0	2/5	-	-	-	-	102.0	2/16	70.0	11/27	16.0	1/3
2019	74.0	3/4	76.0	12/23	-	-	23.0	1/25	-	-	-	-	85.0	4/25	42.0	4/25	-	-
2020	162.0	1/1	120.0	1/1	-	-	-	-	-	-	-	-	180.0	1/1	147.0	1/1	-	-
average	110.9		102.2		94.9		73.5		74.7		97.0		104.9		91.1		137.1	

— : No data

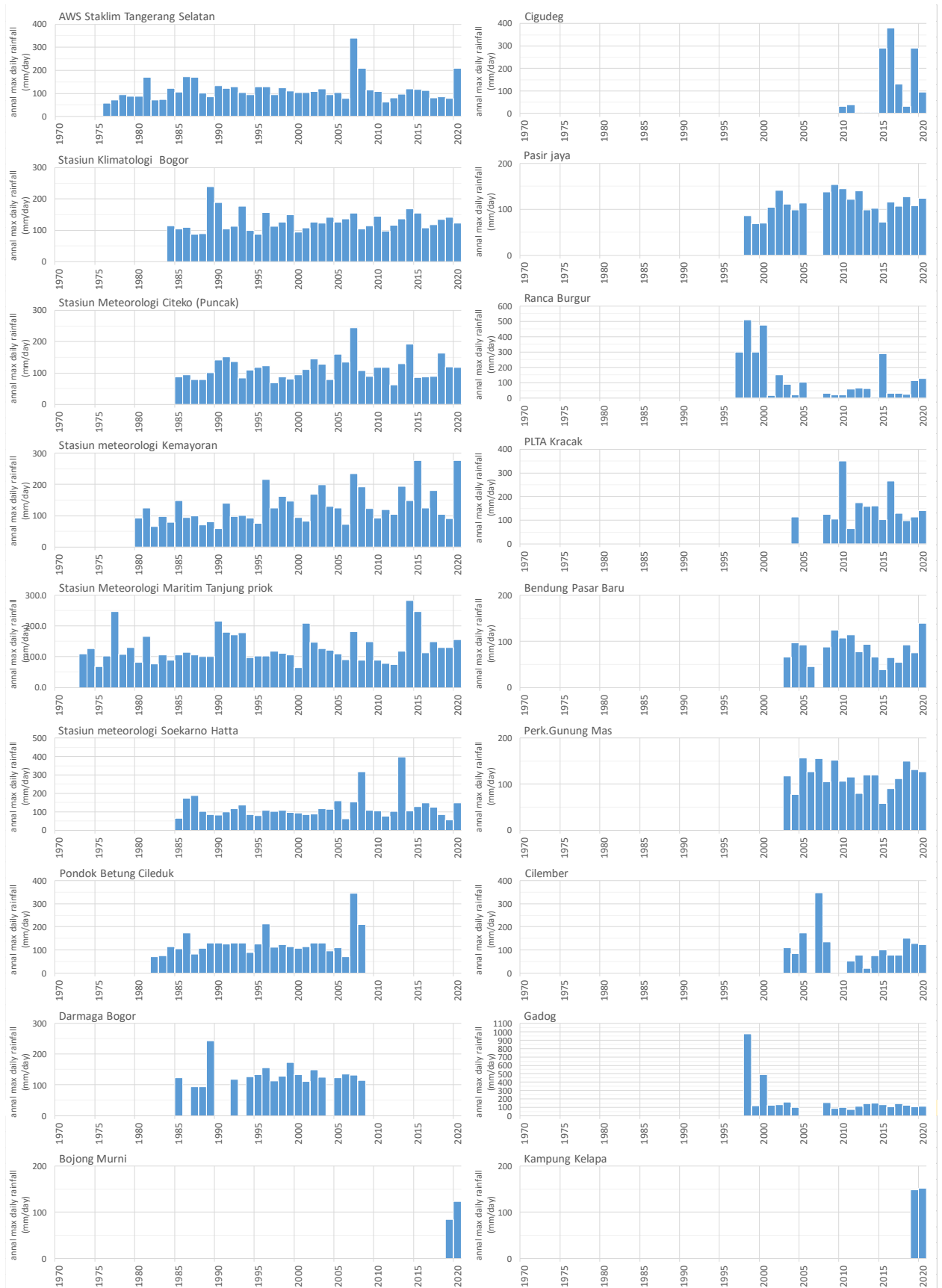
Source: JICA study team

Table 2-19 (6/6) Annual maximum daily rainfall

Station Name	PJT2																	
	Srengseng_82.c		Lemahabang_100		Rengas Bandung_BRbd.6		Rengas Bandung-03		Cibarusah-85		Bd.Cikarang-9a-CH		Bd.Bekasi-10a-CH		Cikeas-Dkt.26		Pondokgede-Dkt.33	
1973	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	125.0	2/11	121.0	1/3	72.0	1/3	68.0	1/3	75.0	2/28	92.0	1/4	125.0	2/29	125.0	8/11	84.0	2/11
1997	118.0	1/26	100.0	12/16	80.0	1/4	73.0	1/4	65.0	4/9	92.0	4/4	78.0	3/6	95.0	1/8	-	-
1998	93.0	9/24	163.0	2/14	19.0	1/13	85.0	10/8	32.0	1/9	96.0	2/13	89.0	4/16	100.0	9/24	-	-
1999	76.0	10/23	92.0	2/8	57.0	2/8	79.0	2/8	-	1/1	75.0	11/1	80.0	2/8	100.0	4/10	-	-
2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002	-	-	84.0	4/1	-	-	90.0	1/30	58.0	12/27	132.0	1/30	100.0	1/30	120.0	7/8	-	-
2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2004	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2005	-	-	87.0	1/18	-	-	62.0	3/4	77.0	6/14	92.0	3/5	115.0	5/7	-	-	-	-
2006	-	-	16.0	12/20	-	-	60.0	2/9	66.0	1/28	28.0	12/5	56.0	12/23	-	-	-	-
2007	82.0	12/21	241.0	2/2	-	-	231.0	2/2	106.0	5/10	124.0	2/2	124.0	12/4	75.0	12/4	-	-
2008	80.0	2/5	195.0	3/11	-	-	110.0	2/19	90.0	3/19	81.0	11/15	97.0	3/6	-	-	-	-
2009	130.0	1/14	181.0	1/15	-	-	115.0	1/15	99.0	1/15	178.0	1/15	117.0	1/15	90.0	3/24	-	-
2010	87.0	1/15	185.0	1/18	-	-	90.0	4/9	111.0	2/19	116.0	9/10	104.0	12/7	94.0	2/20	-	-
2011	60.0	5/6	65.0	6/6	42.0	12/28	45.0	11/29	75.0	4/24	67.0	4/14	65.0	5/25	75.0	11/3	-	-
2012	101.0	1/8	74.0	4/3	43.0	1/26	44.0	4/3	74.0	4/7	145.0	2/27	114.0	2/27	135.5	12/22	-	-
2013	141.0	1/18	171.0	1/18	-	-	67.0	1/18	132.0	5/19	164.0	2/10	120.0	1/17	133.0	5/2	-	-
2014	167.0	2/23	213.0	1/18	-	-	16.0	10/23	131.0	1/13	184.0	1/18	190.0	1/18	128.0	1/13	-	-
2015	95.0	2/2	61.0	11/9	28.0	12/14	-	-	71.0	3/2	83.0	12/7	112.0	2/10	140.0	2/10	-	-
2016	87.0	2/2	129.0	9/25	42.0	11/14	-	-	135.0	11/23	117.0	8/20	70.0	2/26	91.5	4/21	-	-
2017	125.0	2/20	89.0	2/20	91.0	12/12	26.0	2/19	114.0	2/12	64.0	3/27	135.0	3/18	186.5	2/21	-	-
2018	94.0	12/15	72.0	3/8	75.5	2/3	-	-	90.0	12/13	122.0	12/15	78.0	3/8	152.5	11/12	-	-
2019	114.0	1/27	80.0	4/9	69.0	1/27	-	-	97.0	2/7	156.0	3/5	101.0	3/16	117.0	4/9	-	-
2020	91.0	1/1	141.0	1/1	83.0	1/1	-	-	150.0	1/1	135.0	1/1	150.0	1/1	66.0	1/3	-	-
average	103.7		121.9		58.5		78.8		92.4		111.6		105.7		112.4		84.0	

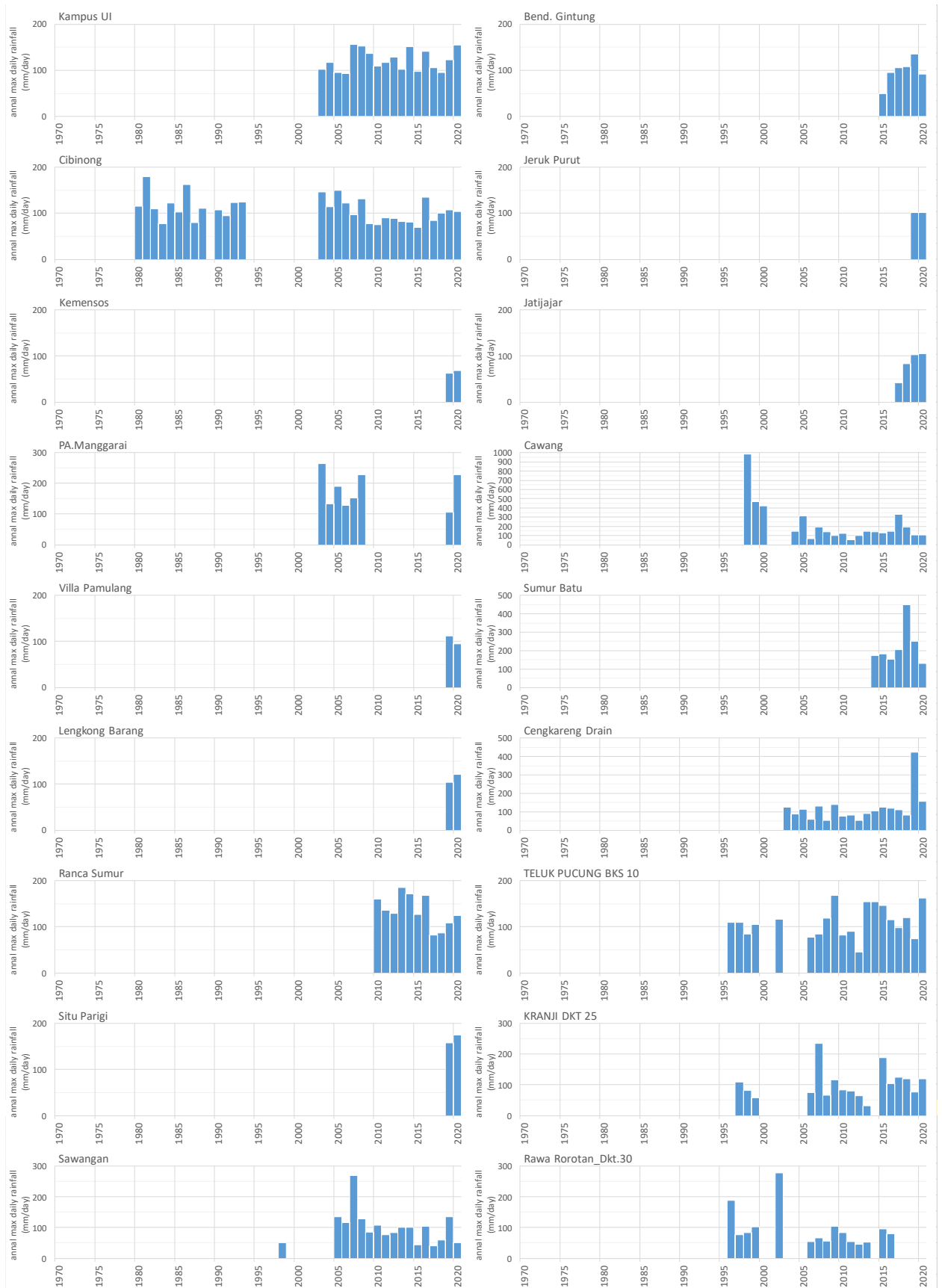
— : No data

Source: JICA study team



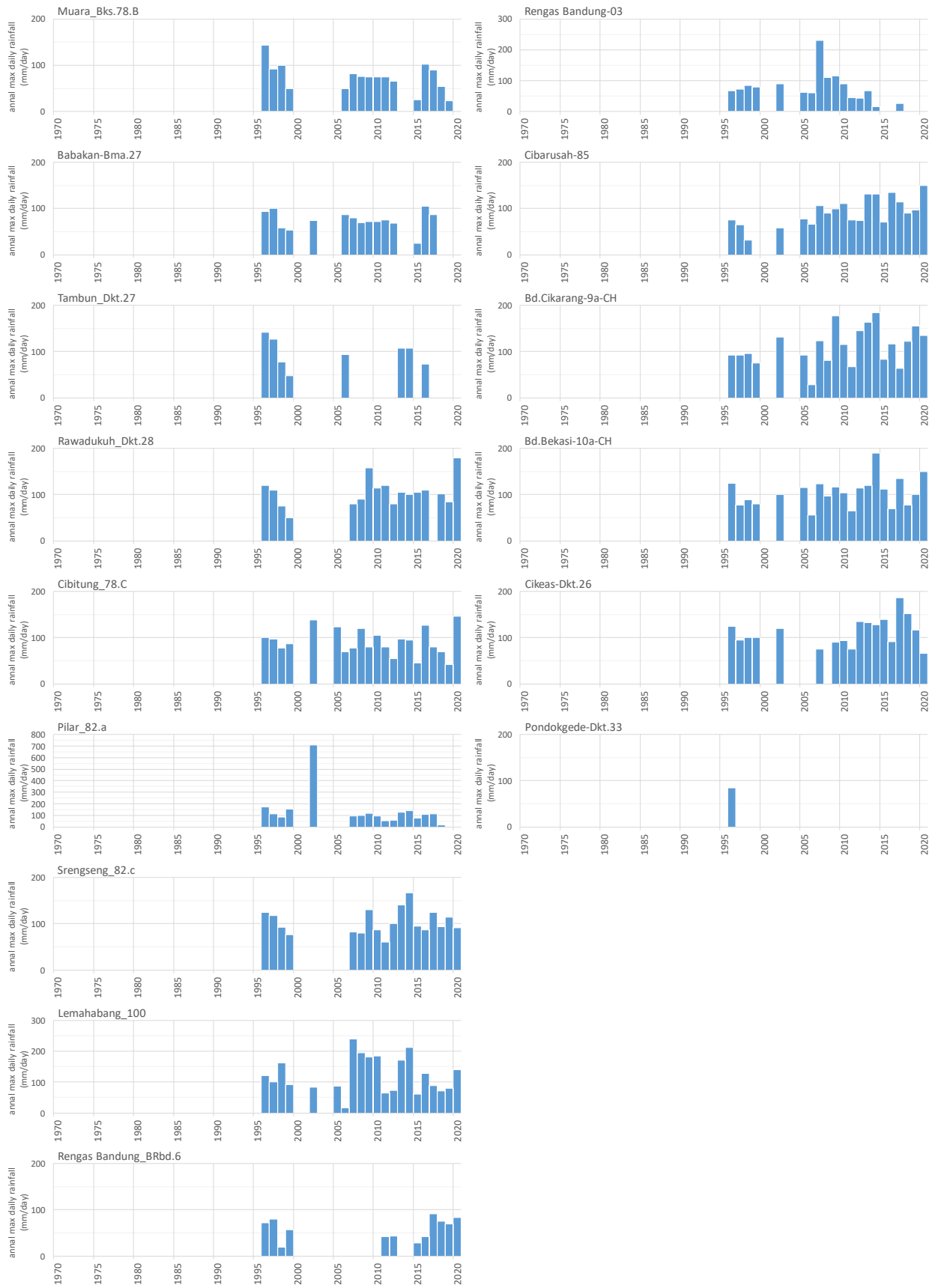
Source: JICA study team

Figure 2-45 (1/3) Annual maximum daily rainfall



Source: JICA study team

Figure 2-45 (2/3) Annual maximum daily rainfall



Source: JICA study team

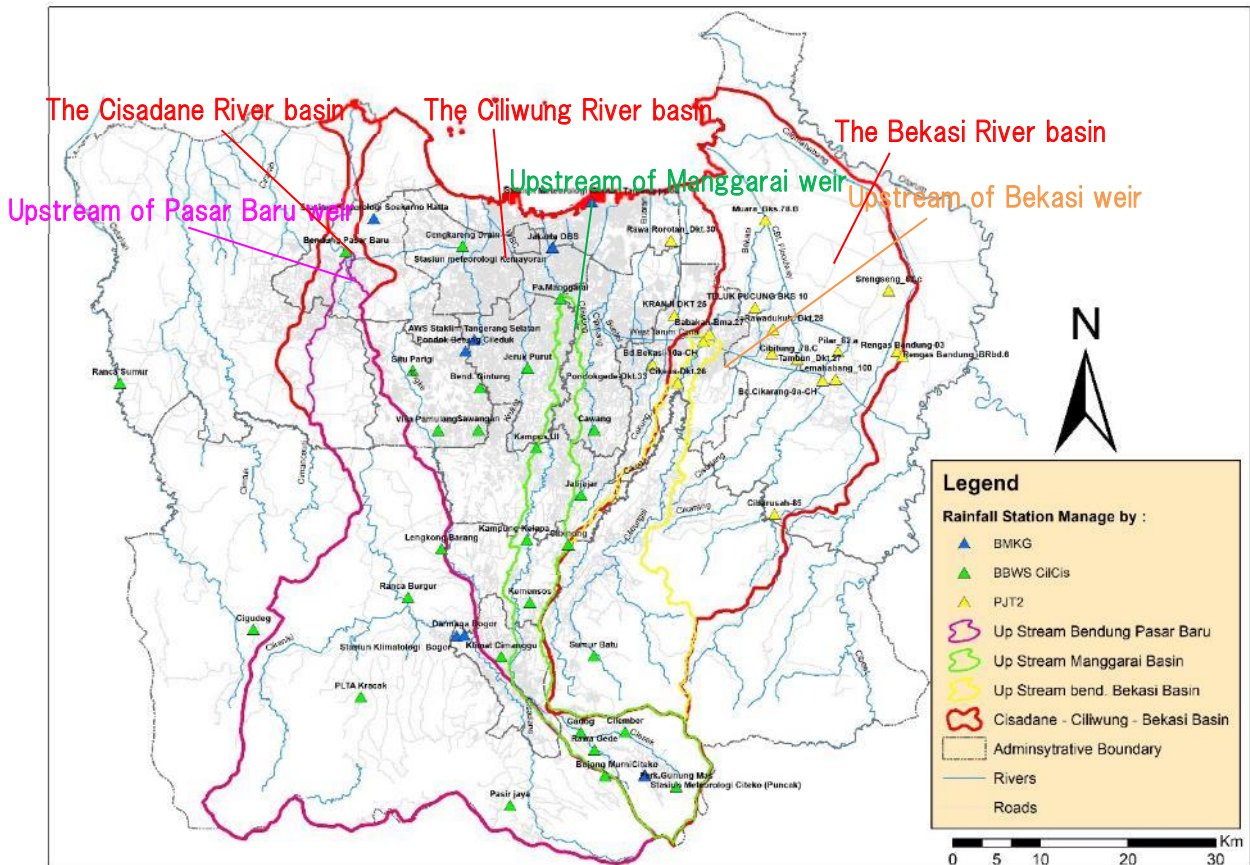
Figure 2-45 (3/3) Annual maximum daily rainfall

2.1.4 Hydrological analyses

To evaluate the return period of the flood in January 2020 and estimate design rainfall of the target safety level, evaluation of daily rainfall probability at each basin and each station was carried out by using the collected rainfall data. The hydrological analysis is based on daily rainfall because the existing river improvement plans use daily rainfall as design rainfall, and the duration of rainfall in January 2020 is also about 24 hours.

(1) Calculation of basin average rainfall

Using the historical rainfall data, the basin average daily rainfall in the following basins were calculated for (1) All catchment area of the Bekasi River basin, (2) Upstream basin of Bekasi weir, (3) All catchment area of the Ciliwung River basin, (4) Upstream basin of Manggarai weir, (5) All catchment area of the Cisadane River basin, and (6) Upstream basin of Pasar Baru weir. A map of these areas is shown in Figure 2-46.



Source: JICA study team

Figure 2-46 Map of basins

(i) The Bekasi River basin

For the entire Bekasi River basin (area : 1,447 km²), the basin average daily rainfalls were calculated by the Thiessen method. 14 cases of Thiessen polygons were set, considering the data availability. The cases of the Thiessen polygons are presented in Table 2-20, the area of each polygon in Table 2-21, the Thiessen coefficient in Table 2-22, and the map of Thiessen polygons in Figure 2-47.

○ : Collected
— : No Data

Table 2-20 Cases of Tiessen polygons (the Bekasi River basin)

Station Name	AWS Halim Perdana Kusumah	Cibinong	Sumur Batu	TELUK PUCUNG BKS 10	Muara_Bk s.78.B	Rawaduku h_Dkt.28	Cibitung_ 78.C	Pilar_82.a	Srengsen g_82.c	Lemahaba ng_100	Rengas Bandung- 03	Cibarusah -85	Bd.Cikara ng-9a-CH	Bd.Bekasi -10a-CH	Cikeas- Dkt.26	(WL 17) Sungai Cileungsi	(WL 22) Sungai Cikeas	year
Latitude	-6.26248	-6.460483	-6.57469	-6.217227	-6.126952	-6.239588	-6.270512	-6.262396	-6.199135	-6.290694	-6.266858	-6.429159	-6.291785	-6.251666	-6.294211	-6.4534	-6.37138	
Longitude	106.8971	106.85636	106.8829	107.04831	107.05876	107.06692	107.09167	107.1335	107.18552	107.13113	107.19983	107.06844	107.11776	106.99507	106.96906	106.9244	106.9377	
Case1	-	-	-	○	○	○	○	○	○	○	○	○	○	○	○	-	-	1996-1998
Case2	-	-	-	○	○	○	○	○	○	○	○	-	○	○	○	-	-	1999
Case3	-	-	-	○	-	-	○	○	-	○	○	○	○	○	○	-	-	2002
Case4	-	○	-	-	-	-	○	-	-	○	○	○	○	○	-	-	-	2005
Case5	-	○	-	○	○	-	○	-	-	○	○	○	○	○	-	-	-	2006
Case6	-	○	-	○	○	○	○	○	○	○	○	○	○	○	○	-	-	2007,2009-2012
Case7	-	○	-	○	○	○	○	○	○	○	○	○	○	○	-	-	-	2008
Case8	-	○	-	○	-	○	○	○	○	○	○	○	○	○	○	-	-	2013
Case9	-	○	○	○	-	○	○	○	○	○	○	○	○	○	○	-	-	2014
Case10	-	○	○	○	○	○	○	○	○	-	-	○	○	○	○	-	-	2015-2016,2018
Case11	-	○	○	○	○	-	○	○	○	○	○	○	○	○	○	-	-	2017
Case12	-	○	○	○	○	○	○	-	○	-	-	○	○	○	○	-	-	2019
Case13	-	○	○	○	-	○	-	-	○	-	-	○	○	○	-	-	-	2020
Case14	○	○	○	○	-	○	-	-	○	○	-	○	○	○	-	○	○	2020.1

Source: JICA study team

Table 2-21 Area of each polygon (the Bekasi River basin) unit: km²

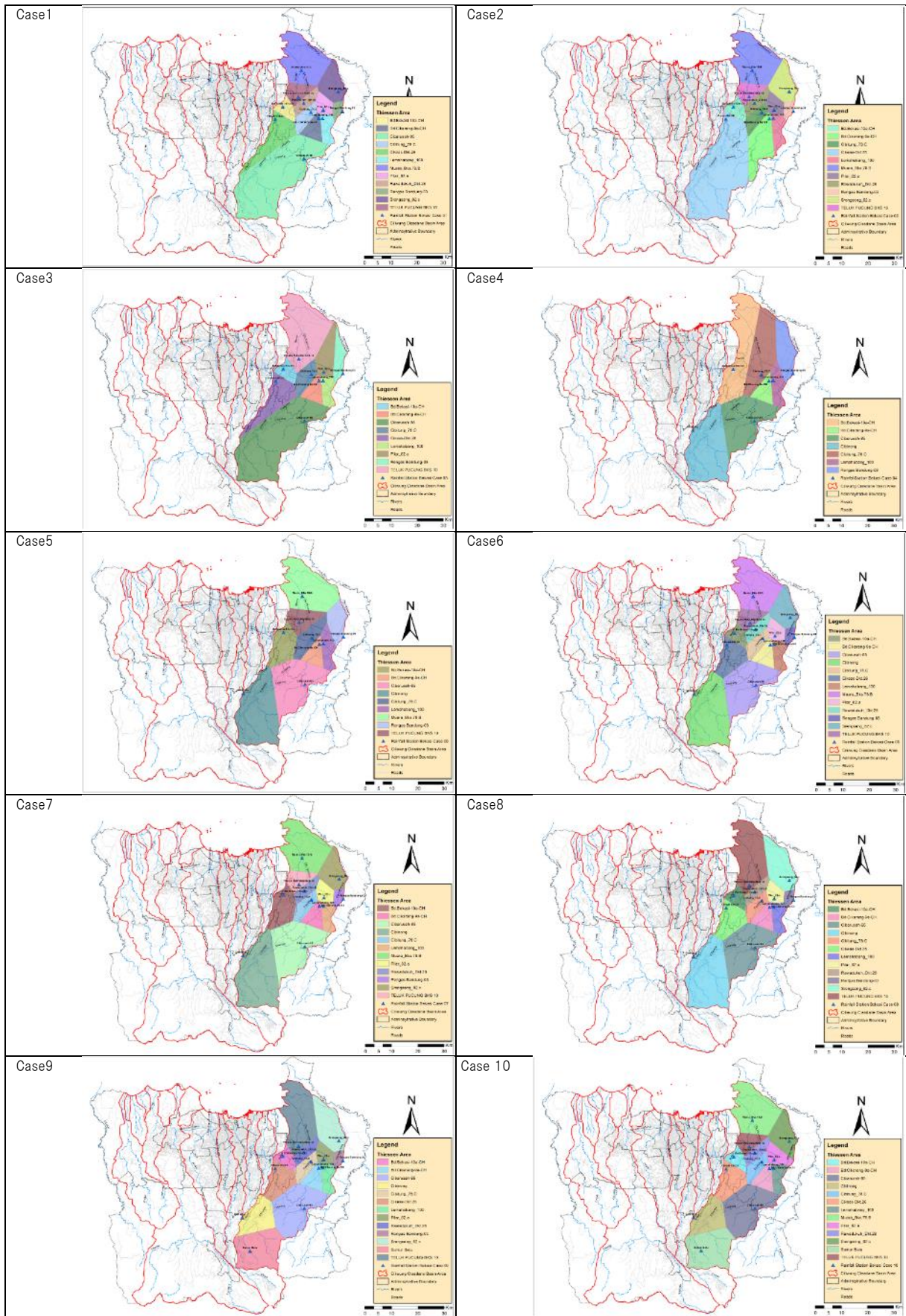
Station Name	AWS Halim Perdana Kusumah	Cibinong	Sumur Batu	TELUK PUCUNG BKS 10	Muara_Bk s.78.B	Rawaduku h_Dkt.28	Cibitung_ 78.C	Pilar_82.a	Srengsen g_82.c	Lemahaba ng_100	Rengas Bandung- 03	Cibarusah -85	Bd.Cikara ng-9a-CH	Bd.Bekasi -10a-CH	Cikeas- Dkt.26	(WL 17) Sungai Cileungsi	(WL 22) Sungai Cikeas	year
Latitude	-6.26248	-6.460483	-6.57469	-6.217227	-6.126952	-6.239588	-6.270512	-6.262396	-6.199135	-6.290694	-6.266858	-6.429159	-6.291785	-6.251666	-6.294211	-6.4534	-6.37138	
Longitude	106.8971	106.85636	106.8829	107.04831	107.05876	107.06692	107.09167	107.1335	107.18552	107.13113	107.19983	107.06844	107.11776	106.99507	106.96906	106.9244	106.9377	
Case1	0.0	0.0	0.0	58.6	255.8	43.1	50.8	42.6	106.4	49.6	21.3	572.9	52.8	41.8	151.7	0.0	0.0	1996-1998
Case2	0.0	0.0	0.0	58.6	255.8	43.1	51.4	42.6	106.4	56.2	21.3	0.0	152.6	41.8	617.5	0.0	0.0	1999
Case3	0.0	0.0	0.0	348.2	0.0	0.0	65.5	101.3	0.0	49.6	61.8	572.9	52.8	43.7	151.7	0.0	0.0	2002
Case4	0.0	356.1	0.0	0.0	0.0	0.0	246.3	0.0	0.0	67.8	124.0	288.8	53.7	310.7	0.0	0.0	0.0	2005
Case5	0.0	356.1	0.0	88.5	297.3	0.0	91.4	0.0	0.0	67.8	83.9	288.8	53.7	119.9	0.0	0.0	0.0	2006
Case6	0.0	347.7	0.0	58.6	255.8	43.1	50.8	42.6	106.4	49.6	21.3	265.3	52.8	41.8	111.6	0.0	0.0	2007,2009-2012
Case7	0.0	356.1	0.0	58.6	255.8	43.1	54.3	42.6	106.4	49.6	21.3	288.8	52.8	118.1	0.0	0.0	0.0	2008
Case8	0.0	347.7	0.0	261.1	0.0	43.1	50.8	42.6	159.7	49.6	21.3	265.3	52.8	41.8	111.6	0.0	0.0	2013
Case9	0.0	132.5	225.1	261.1	0.0	43.1	50.8	42.6	159.7	49.6	21.3	255.4	52.8	41.8	111.6	0.0	0.0	2014
Case10	0.0	132.5	225.1	58.6	255.8	43.1	50.8	54.0	113.3	52.5	0.0	255.4	52.8	41.8	111.6	0.0	0.0	2015-2016,2018
Case11	0.0	132.5	225.1	82.2	255.8	0.0	65.5	45.3	106.7	49.6	21.3	255.4	52.8	43.7	111.6	0.0	0.0	2017
Case12	0.0	132.5	225.1	58.6	255.8	46.2	60.9	0.0	126.3	79.4	0.0	255.4	53.7	41.8	111.6	0.0	0.0	2019
Case13	0.0	132.5	225.1	261.1	0.0	46.2	60.9	0.0	179.6	79.4	0.0	255.4	53.7	41.8	111.6	0.0	0.0	2020
Case14	0.0	40.1	196.8	261.1	0.0	46.2	64.4	0.0	179.6	79.4	0.0	195.6	53.7	80.9	0.0	151.5	98.2	2020.1

Source: JICA study team

Table 2-22 Thiessen coefficient (the Bekasi River basin)

Station Name	AWS Halim Perdana Kusumah	Cibinong	Sumur Batu	TELUK PUCUNG BKS 10	Muara_Bk s.78.B	Rawaduku h_Dkt.28	Cibitung_ 78.C	Pilar_82.a	Srengsen g_82.c	Lemahaba ng_100	Rengas Bandung- 03	Cibarusah -85	Bd.Cikara ng-9a-CH	Bd.Bekasi -10a-CH	Cikeas- Dkt.26	(WL 17) Sungai Cileungsi	(WL 22) Sungai Cikeas	year
Latitude	-6.26248	-6.460483	-6.57469	-6.217227	-6.126952	-6.239588	-6.270512	-6.262396	-6.199135	-6.290694	-6.266858	-6.429159	-6.291785	-6.251666	-6.294211	-6.4534	-6.37138	
Longitude	106.8971	106.85636	106.8829	107.04831	107.05876	107.06692	107.09167	107.1335	107.18552	107.13113	107.19983	107.06844	107.11776	106.99507	106.96906	106.9244	106.9377	
Case1	0.000	0.000	0.000	0.040	0.177	0.030	0.035	0.029	0.074	0.034	0.015	0.396	0.036	0.029	0.105	0.000	0.000	1996-1998
Case2	0.000	0.000	0.000	0.040	0.177	0.030	0.036	0.029	0.074	0.039	0.015	0.000	0.105	0.029	0.427	0.000	0.000	1999
Case3	0.000	0.000	0.000	0.241	0.000	0.000	0.045	0.070	0.000	0.034	0.043	0.396	0.036	0.030	0.105	0.000	0.000	2002
Case4	0.000	0.246	0.000	0.000	0.000	0.000	0.170	0.000	0.000	0.047	0.086	0.200	0.037	0.215	0.000	0.000	0.000	2005
Case5	0.000	0.246	0.000	0.061	0.205	0.000	0.063	0.000	0.000	0.047	0.058	0.200	0.037	0.083	0.000	0.000	0.000	2006
Case6	0.000	0.240	0.000	0.040	0.177	0.030	0.035	0.029	0.074	0.034	0.015	0.183	0.036	0.029	0.077	0.000	0.000	2007,2009-2012
Case7	0.000	0.246	0.000	0.040	0.177	0.030	0.037	0.029	0.074	0.034	0.015	0.200	0.036	0.082	0.000	0.000	0.000	2008
Case8	0.000	0.240	0.000	0.180	0.000	0.030	0.035	0.029	0.110	0.034	0.015	0.183	0.036	0.029	0.077	0.000	0.000	2013
Case9	0.000	0.092	0.155	0.180	0.000	0.030	0.035	0.029	0.110	0.034	0.015	0.176	0.036	0.029	0.077	0.000	0.000	2014
Case10	0.000	0.092	0.155	0.040	0.177	0.030	0.035	0.037	0.078	0.036	0.000	0.176	0.036	0.029	0.077	0.000	0.000	2015-2016,2018
Case11	0.000	0.092	0.155	0.057	0.177	0.000	0.045	0.031	0.074	0.034	0.015	0.176	0.036	0.030	0.077	0.000	0.000	2017
Case12	0.000	0.092	0.155	0.040	0.177	0.032	0.042	0.000	0.087	0.055	0.000	0.176	0.037	0.029	0.077	0.000	0.000	2019
Case13	0.000	0.092	0.155	0.180	0.000	0.032	0.042	0.000	0.124	0.055	0.000	0.176	0.037	0.029	0.077	0.000	0.000	2020
Case14	0.000	0.028	0.136	0.180	0.000	0.032	0.044	0.000	0.124	0.055	0.000	0.135	0.037	0.056	0.000	0.105	0.068	2020.1

Source: JICA study team



Source: JICA study team

Figure 2-47 (1/2) Map of Thiessen polygons (the Bekasi River basin)

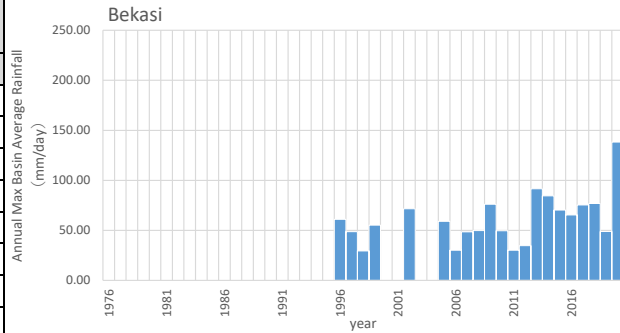
The basin average daily rainfalls were calculated by the Thiessen method, and the obtained annual maximum basin average daily rainfalls are presented in Table 2-23.

It was confirmed that the flood in January 2020 was the largest rainfall since 1996 (138.24 mm on 1st January 2020). This supports the answer of the residents during the filed survey that the flood in 2020 was the largest flood in the Bekasi River basin in the last 50 years.

Table 2-23 Annual maximum basin average daily rainfall (the Bekasi River basin)

Bekasi		
	basin average rainfall	date
1996	61.03	1996/2/10
1997	48.73	1997/1/14
1998	29.51	1998/9/24
1999	55.28	1999/6/15
2000		#N/A
2001		#N/A
2002	71.62	2002/1/30
2003		#N/A
2004		#N/A
2005	59.11	2005/1/19
2006	30.21	2006/2/19
2007	48.51	2007/12/4
2008	49.89	2008/1/2
2009	76.17	2009/1/15
2010	49.70	2010/2/19
2011	30.24	2011/1/18
2012	34.68	2012/12/11
2013	91.52	2013/1/18
2014	84.57	2014/1/18
2015	70.42	2015/2/10
2016	65.39	2016/2/26
2017	75.44	2017/2/20
2018	76.91	2018/11/30
2019	48.87	2019/12/31
2020	138.24	2020/1/1
average	61.72	-

Source: JICA study team



(ii) Upstream basin of Bekasi weir

For the upstream basin of Bekasi weir (area : 393 km²), the basin average daily rainfalls were calculated by the Thiessen method. 11 cases of Thiessen polygons were set considering the availability of data. The cases of the Thiessen polygons are shown in Table 2-24, the area of each polygon in Table 2-25, the Thiessen coefficient in Table 2-26, and the map of Thiessen polygons in Figure 2-48.

Table 2-24 Cases of Thiessen polygons (upstream of Bekasi weir)

○ : Collected
— : No Data

Station Name	Cilember	Gadog	Cibinong	Sumur Batu	Bd.Bekasi -10a-CH	Cikeas-Dkt.26	(WL 17) Sungai Cileungsi	(WL 22) Sungai Cikeas	year
Latitude	-6.652867	-6.65343	-6.460483	-6.57469	-6.251666	-6.294211	-6.4534	-6.37138	
Longitude	106.91492	106.8692	106.85636	106.8829	106.99507	106.96906	106.9244	106.9377	
Case1	-	-	-	-	○	○	-	-	1996, 1997
Case2	-	○	-	-	○	○	-	-	1998, 1999, 2002
Case3	○	○	○	-	-	-	-	-	2003, 2004
Case4	○	-	○	-	○	-	-	-	2005
Case5	-	-	○	-	○	-	-	-	2006
Case6	-	-	○	-	○	○	-	-	2007
Case7	-	○	○	-	○	-	-	-	2008
Case8	-	○	○	-	○	○	-	-	2009, 2010
Case9	○	○	○	-	○	○	-	-	2011-2013
Case10	○	○	○	○	○	○	-	-	2014-2020
Case12	○	○	○	○	○	-	○	○	2020.1

Source: JICA study team

Table 2-25 Area of each polygon (upstream of Bekasi weir) unit: km²

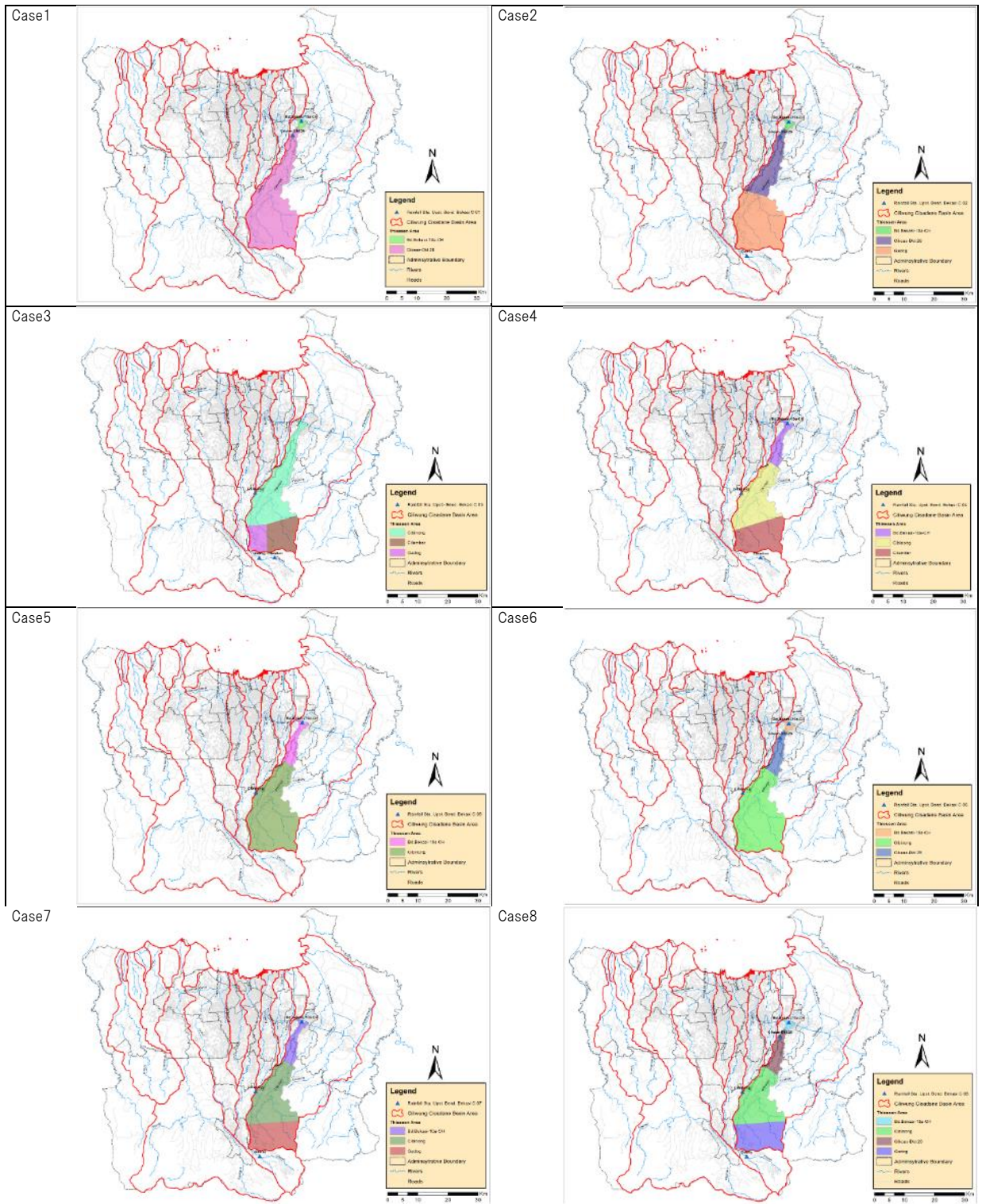
Station Name	Cilember	Gadog	Cibinong	Sumur Batu	Bd.Bekasi -10a-CH	Cikeas-Dkt.26	(WL 17) Sungai Cileungsi	(WL 22) Sungai Cikeas	year
Latitude	-6.652867	-6.65343	-6.460483	-6.57469	-6.251666	-6.294211	-6.4534	-6.37138	
Longitude	106.91492	106.8692	106.85636	106.8829	106.99507	106.96906	106.9244	106.9377	
Case1	0.0	0.0	0.0	0.0	8.3	385.1	0.0	0.0	1996, 1997
Case2	0.0	271.8	0.0	0.0	8.3	113.3	0.0	0.0	1998, 1999, 2002
Case3	99.8	52.8	240.8	0.0	0.0	0.0	0.0	0.0	2003, 2004
Case4	147.0	0.0	201.0	0.0	45.4	0.0	0.0	0.0	2005
Case5	0.0	0.0	348.0	0.0	45.4	0.0	0.0	0.0	2006
Case6	0.0	0.0	334.3	0.0	8.3	50.9	0.0	0.0	2007
Case7	0.0	139.7	208.3	0.0	45.4	0.0	0.0	0.0	2008
Case8	0.0	139.7	194.5	0.0	8.3	50.9	0.0	0.0	2009, 2010
Case9	99.8	52.8	181.7	0.0	8.3	50.9	0.0	0.0	2011-2013
Case10	35.2	14.9	117.3	166.9	8.3	50.9	0.0	0.0	2014-2020
Case12	35.2	14.9	41.5	148.1	18.5	0.0	81.8	53.3	2020.1

Source: JICA study team

Table 2-26 Thiessen coefficient (upstream of Bekasi weir)

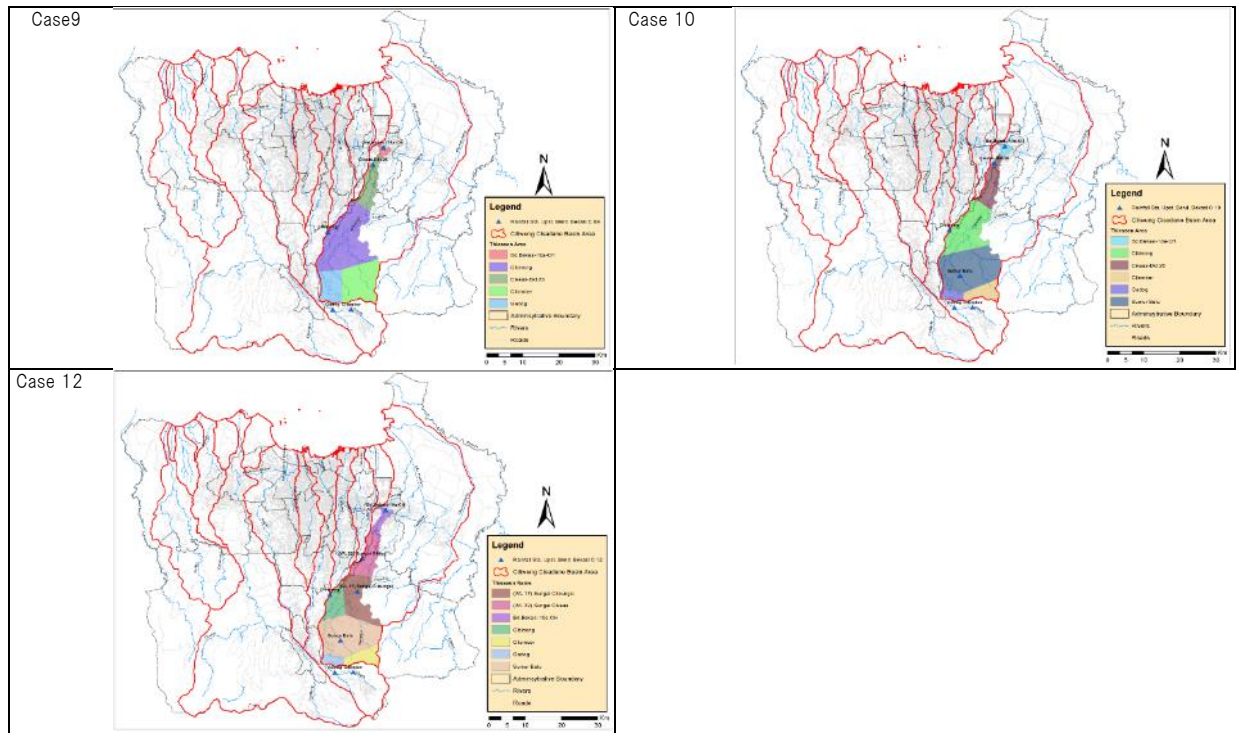
Station Name	Cilember	Gadog	Cibinong	Sumur Batu	Bd.Bekasi -10a-CH	Cikeas-Dkt.26	(WL 17) Sungai Cileungsi	(WL 22) Sungai Cikeas	year
Latitude	-6.652867	-6.65343	-6.460483	-6.57469	-6.251666	-6.294211	-6.4534	-6.37138	
Longitude	106.91492	106.8692	106.85636	106.8829	106.99507	106.96906	106.9244	106.9377	
Case1	0.000	0.000	0.000	0.000	0.021	0.979	0.000	0.000	1996, 1997
Case2	0.000	0.691	0.000	0.000	0.021	0.288	0.000	0.000	1998, 1999, 2002
Case3	0.254	0.134	0.612	0.000	0.000	0.000	0.000	0.000	2003, 2004
Case4	0.374	0.000	0.511	0.000	0.115	0.000	0.000	0.000	2005
Case5	0.000	0.000	0.885	0.000	0.115	0.000	0.000	0.000	2006
Case6	0.000	0.000	0.850	0.000	0.021	0.129	0.000	0.000	2007
Case7	0.000	0.355	0.529	0.000	0.115	0.000	0.000	0.000	2008
Case8	0.000	0.355	0.494	0.000	0.021	0.129	0.000	0.000	2009, 2010
Case9	0.254	0.134	0.462	0.000	0.021	0.129	0.000	0.000	2011-2013
Case10	0.090	0.038	0.298	0.424	0.021	0.129	0.000	0.000	2014-2020
Case12	0.090	0.038	0.106	0.377	0.047	0.000	0.208	0.136	2020.1

Source: JICA study team



Source: JICA study team

Figure 2-48 (1/2) Map of Thiessen polygons (upstream of Bekasi weir)



Source: JICA study team

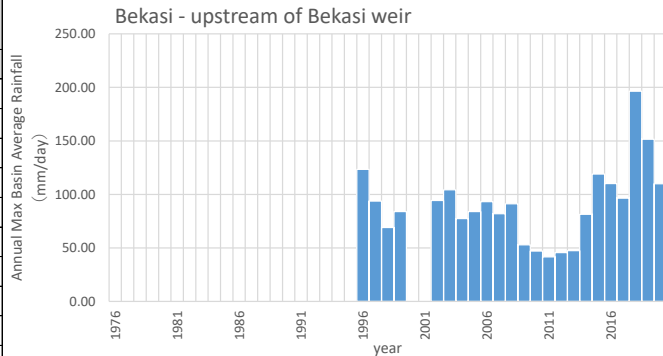
Figure 2-48(2/2) Map of Thiessen polygons (upstream of Bekasi weir)

The basin average daily rainfalls were calculated by the Thiessen method, and the obtained annual maximum basin average daily rainfalls are presented shown in Table 2-27.

It was confirmed that the flood in January 2020 has the second largest rainfall (151.54 mm on 12/31/2019) following the one in 2018 since 1996. However, since there is no information on significant damage in 2018 in the Bekasi River basin, the basin average rainfall for the entire Bekasi River basin (Chapter 2.1.4(1)(i)) is more consistent with the actual damage in the Bekasi River basin than in the upstream basin of Bekasi weir.

Table 2-27 Annual maximum basin average daily rainfall (upstream of Bekasi weir)

Bekasi - upstream of Bekasi weir		
	basin average rainfall	date
1996	123.34	1996/8/11
1997	93.76	1997/1/14
1998	69.05	1998/6/1
1999	83.95	1999/1/3
2000	#N/A	#N/A
2001	#N/A	#N/A
2002	94.29	2002/1/29
2003	104.25	2003/10/7
2004	77.39	2004/12/13
2005	84.03	2005/1/18
2006	93.33	2006/12/24
2007	81.98	2007/12/4
2008	91.20	2008/11/3
2009	52.86	2009/1/13
2010	47.10	2010/2/17
2011	41.56	2011/5/22
2012	45.56	2012/2/18
2013	47.54	2013/1/17
2014	81.50	2014/11/20
2015	119.08	2015/2/10
2016	110.06	2016/7/4
2017	96.56	2017/10/12
2018	196.44	2018/11/29
2019	151.54	2019/12/31
2020	109.91	2020/1/1
average	91.14	-



Source: JICA study team

(iii) The Ciliwung River basin

For the entire Ciliwung River basin (area : 1,596 km²), the basin average daily rainfalls were calculated by the Thiessen method. 21 cases of Thiessen polygons were set considering the availability of data. The cases of the Thiessen polygons are shown in Table 2-28, the area of each polygon in Table 2-29, the Thiessen coefficient in Table 2-30, and the map of Thiessen polygons in Figure 2-49.

Table 2-28 Cases of Thiessen polygons (the Ciliwung River basin)

○ : Collected
- : No Data

Station Name	Stasiun Klimatologi Bogor	Stasiun Meteorologi Citeko (Puncak)	Stasiun meteorologi Kemayoran	Stasiun Meteorologi Maritim Tanjung Priok	Stasiun meteorologi Soekarno Hatta	Pondok Betung Cileduk	ARG Manggarai	AWS Halim Perdana Kusumah	ARG Tomang	ARG Lebak Bulus	ARG Ciganjur	Perk.Gunung Mas	Cilember	Gadag	Kampung Kelapa	year
Latitude	-6.553858	-6.6968	-6.15559	-6.10781	-6.125537	-6.26156	-6.20748	-6.26248	-6.166699	-6.304318	-6.3443	-6.709083	-6.652867	-6.65343	-6.45527	
Longitude	106.74185	106.93501	106.84	106.88053	106.65691	106.7508	106.8487	106.8971	106.78	106.7774	106.799	106.96738	106.91492	106.8692	106.814	
Case1	○	○	○	○	○	○	-	-	-	-	-	-	-	-	-	1985-1988, 1990-1993
Case2	○	○	○	○	○	○	-	-	-	-	-	-	-	-	-	1996
Case3	○	○	○	○	○	○	-	-	-	-	-	-	-	-	-	1997
Case4	○	○	○	○	○	○	-	-	-	-	-	-	-	○	-	1998
Case5	○	○	○	○	○	○	-	-	-	-	-	-	-	○	-	1999
Case6	○	○	○	○	○	○	-	-	-	-	-	-	-	○	-	2000
Case7	○	○	○	○	○	○	-	-	-	-	-	-	-	○	-	2001
Case8	○	○	○	○	○	○	-	-	-	-	-	-	-	○	-	2002
Case9	○	○	○	○	○	○	-	-	-	-	-	○	○	○	-	2003
Case10	○	○	○	○	○	○	-	-	-	-	-	○	○	○	-	2004
Case11	○	○	○	○	○	○	-	-	-	-	-	○	○	-	-	2005
Case12	○	○	○	○	○	○	-	-	-	-	-	○	-	-	-	2006-2007
Case13	○	○	○	○	○	○	-	-	-	-	-	○	-	○	-	2008
Case14	○	○	○	○	○	○	-	-	-	-	-	○	-	○	-	2009, 2010
Case15	○	○	○	○	○	○	-	-	-	-	-	○	○	○	-	2011-2013
Case16	○	○	○	○	○	○	-	-	-	-	-	○	○	○	-	2014
Case17	○	○	○	○	○	○	-	-	-	-	-	○	○	○	-	2015-2016
Case18	○	○	○	○	○	○	-	-	-	-	-	○	○	○	-	2017, 2018
Case19	○	○	○	○	○	○	-	-	-	-	-	○	○	○	○	2019
Case20	○	○	○	○	○	○	-	-	-	-	-	○	○	○	○	2020
Case21	○	○	○	○	○	○	-	○	○	○	○	○	○	○	○	2020.1

Station Name	Kampus UI	Cibinong	Kemenso	Pa.Manggarai	Villa Pamulang	Lengkong Barang	Situ Parigi	Sawangan	Bend. Gintung	Jeruk Purut	Jatijajar	Cawang	Rawa Gede	Cengkareng Drain	KRANJI DKT 25	Rawa Rorotan_Dkt.30	year
Latitude	-6.36121	-6.460483	-6.519911	-6.207633	-6.34299	-6.46463	-6.281569	-6.342672	-6.299414	-6.27926	-6.409486	-6.34267	-6.671369	-6.15365	-6.224979	-6.148191	
Longitude	106.8238	106.85636	106.8169	106.84849	106.723	106.7263	106.69675	106.76422	106.76597	106.8149	106.86977	106.8834	106.88341	106.74793	106.96546	106.96193	
Case1	-	○	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1985-1988, 1990-1993
Case2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	○	1996
Case3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	○	○	1997
Case4	-	-	-	-	-	-	-	○	-	-	-	○	-	-	○	○	1998
Case5	-	-	-	-	-	-	-	-	-	-	-	○	-	-	○	○	1999
Case6	-	-	-	-	-	-	-	-	-	-	-	○	-	-	-	-	2000
Case7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2001
Case8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	○	2002
Case9	○	○	-	○	-	-	-	-	-	-	-	-	-	○	-	-	2003
Case10	○	○	-	○	-	-	-	-	-	-	-	○	-	○	-	-	2004
Case11	○	○	-	○	-	-	-	○	-	-	-	○	-	○	-	-	2005
Case12	○	○	-	○	-	-	-	○	-	-	-	○	-	○	○	○	2006-2007
Case13	○	○	-	○	-	-	-	○	-	-	-	○	-	○	○	○	2008
Case14	○	○	-	-	-	-	-	○	-	-	-	○	-	○	○	○	2009, 2010
Case15	○	○	-	-	-	-	-	○	-	-	-	○	-	○	○	○	2011-2013
Case16	○	○	-	-	-	-	-	○	-	-	-	○	-	○	-	-	2014
Case17	○	○	-	-	-	-	-	○	○	-	-	○	-	○	○	○	2015-2016
Case18	○	○	-	-	-	-	-	○	○	-	○	○	-	○	○	○	2017, 2018
Case19	○	○	○	○	○	○	○	○	○	○	○	○	-	○	○	○	2019
Case20	○	○	○	○	○	○	○	○	○	○	○	○	-	○	○	○	2020
Case21	○	○	○	○	○	○	○	○	○	○	-	○	-	○	○	-	2020.1

Source: JICA study team

Table 2-29 Area of each polygon (the Ciliwung River basin) unit: km²

Station Name	Stasiun Klimatologi Bogor	Stasiun Meteorologi Citeko (Puncak)	Stasiun meteorologi Kemayoran	Stasiun Meteorologi Maritim Tanjung Priok	Stasiun meteorologi Soekarno Hatta	Pondok Betung Ciledug	ARG Manggarai	AWS Halim Perdana Kusumah	ARG Tomang	ARG Lebak Bulus	ARG Ciganjur	Perk.Gunung Mas	Cilember	Gadag	Kampung Kelapa	year	
Latitude	-6.553858	-6.9686	-6.15559	-6.10781	-6.125537	-6.26156	-6.20748	-6.26248	-6.166699	-6.304318	-6.3443	-6.709083	-6.652867	-6.65343	-6.45527		
Longitude	106.74185	106.93501	106.84	106.88053	106.65691	106.7508	106.8487	106.8971	106.78	106.7774	106.799	106.96738	106.91492	106.8692	106.814		
Case1	107.2	152.3	293.3	168.8	180.1	402.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1985-1988, 1990-1993
Case2	241.5	152.3	214.5	38.2	180.1	545.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1996
Case3	240.9	152.3	181.8	38.2	180.1	477.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1997
Case4	140.9	112.2	179.6	38.2	180.1	225.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.6	0.0	1998
Case5	168.8	112.2	179.6	38.2	180.1	335.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.6	0.0	1999
Case6	168.8	112.2	218.3	165.2	180.1	335.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.6	0.0	2000
Case7	224.0	112.2	302.0	168.8	180.1	552.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.6	0.0	2001
Case8	224.0	112.2	214.5	38.2	180.1	545.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.6	0.0	2002
Case9	88.9	35.6	67.1	141.0	128.8	226.6	0.0	0.0	0.0	0.0	0.0	51.2	38.3	44.8	0.0	0.0	2003
Case10	88.9	35.6	67.1	141.0	128.8	226.6	0.0	0.0	0.0	0.0	0.0	51.2	38.3	44.8	0.0	0.0	2004
Case11	97.9	35.6	67.1	141.0	128.8	175.6	0.0	0.0	0.0	0.0	0.0	51.2	72.7	0.0	0.0	0.0	2005
Case12	105.2	100.7	67.0	38.2	128.8	175.6	0.0	0.0	0.0	0.0	0.0	51.6	0.0	0.0	0.0	0.0	2006-2007
Case13	87.6	60.6	67.0	38.2	128.8	175.6	0.0	0.0	0.0	0.0	0.0	51.6	0.0	57.6	0.0	0.0	2008
Case14	87.6	60.6	149.9	38.2	138.7	0.0	0.0	0.0	0.0	0.0	0.0	51.6	0.0	57.6	0.0	0.0	2009, 2010
Case15	87.6	35.6	149.9	38.2	138.7	0.0	0.0	0.0	0.0	0.0	0.0	51.2	38.3	44.8	0.0	0.0	2011-2013
Case16	87.6	35.6	188.6	165.2	138.7	0.0	0.0	0.0	0.0	0.0	0.0	51.2	38.3	44.8	0.0	0.0	2014
Case17	87.6	35.6	188.6	165.2	138.7	0.0	0.0	0.0	0.0	0.0	0.0	51.2	38.3	44.8	0.0	0.0	2015-2016
Case18	87.6	35.6	139.6	81.3	135.9	0.0	0.0	0.0	0.0	0.0	0.0	51.2	38.3	44.8	0.0	0.0	2017, 2018
Case19	22.1	35.6	67.1	81.3	122.2	0.0	0.0	0.0	0.0	0.0	0.0	51.2	38.3	39.9	64.9	67.0	2019
Case20	22.1	35.6	67.1	81.3	122.2	0.0	0.0	0.0	0.0	0.0	0.0	51.2	38.3	39.9	67.0	67.0	2020
Case21	22.1	35.6	53.6	81.2	122.2	0.0	37.2	84.9	67.3	15.3	26.4	51.2	38.3	39.9	67.0	67.0	2020.1

Station Name	Kampus UI	Cibinong	Kemenso	Pa.Mangarai	Villa Pamulang	Lengkong Barang	Situ Parigi	Sawangan	Bend. Gintung	Jeruk Purut	Jatijajar	Cawang	Rawa Gede	Cengkareng Drain	KRANJI DKT 25	Rawa Rorotan_Dkt.30	year	
Latitude	-6.36121	-6.460483	-6.519911	-6.207633	-6.34299	-6.46463	-6.281569	-6.342672	-6.299414	-6.27926	-6.409486	-6.34267	-6.671369	-6.15365	-6.224979	-6.148191		
Longitude	106.8238	106.85636	106.8169	106.84849	106.723	106.7263	106.69675	106.76422	106.76597	106.8149	106.86977	106.8834	106.88341	106.74793	106.96546	106.96193		
Case1	0	293.56584	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1985-1988, 1990-1993
Case2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	225.28646	0	1996
Case3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	224.47946	102.76853	0	1997
Case4	0	0	0	0	0	0	0	209.50161	0	0	0	234.01893	0	0	116.67718	102.76853	0	1998
Case5	0	0	0	0	0	0	0	0	0	0	0	305.93844	0	0	116.67718	102.76853	0	1999
Case6	0	0	0	0	0	0	0	0	0	0	0	359.59254	0	0	0	0	0	2000
Case7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2001
Case8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	225.28691	0	2002
Case9	289.82475	118.96816	0	241.33866	0	0	0	0	0	0	0	0	0	125.16856	0	0	0	2003
Case10	178.99668	113.95072	0	199.25423	0	0	0	0	0	0	0	157.93006	0	125.16856	0	0	0	2004
Case11	95.091765	112.8547	0	199.25423	0	0	0	137.32871	0	0	0	157.93006	0	125.16856	0	0	0	2005
Case12	95.091765	112.85545	0	122.51187	0	0	0	137.32871	0	0	0	136.37872	0	125.16856	99.304506	101.94534	0	2006-2007
Case13	95.091765	112.85541	0	122.51187	0	0	0	137.32871	0	0	0	136.37872	0	125.16856	99.304506	101.94534	0	2008
Case14	98.489938	112.85541	0	0	0	0	0	239.7949	0	0	0	155.45942	0	187.24018	116.67683	102.76853	0	2009, 2010
Case15	98.489938	112.85541	0	0	0	0	0	239.7949	0	0	0	155.45942	0	187.24018	116.67683	102.76853	0	2011-2013
Case16	98.489938	112.85541	0	0	0	0	0	239.7949	0	0	0	209.1099	0	187.24075	0	0	0	2014
Case17	98.489938	112.85541	0	0	0	0	0	239.7949	0	0	0	209.10986	0	187.24018	0	0	0	2015-2016
Case18	77.780433	90.774822	0	0	0	0	0	112.53812	187.60488	0	48.252284	134.87955	0	156.29185	175.08091	0	0	2017, 2018
Case19	61.011798	16.779544	70.130651	100.61691	48.478322	41.979613	103.21331	48.509925	54.082218	81.570948	45.437797	109.39326	0	136.90851	156.85633	0	0	2019
Case20	70.962037	35.519052	70.130651	100.61691	48.478322	41.979613	103.21331	48.509925	54.082218	81.570948	0	124.06664	0	136.90851	156.8564	0	0	2020
Case21	56.425226	35.519052	70.130651	35.194527	48.478322	41.979613	103.04603	37.953485	40.99989	65.98543	0	98.110434	0	94.035079	127.38623	0	0	2020.1

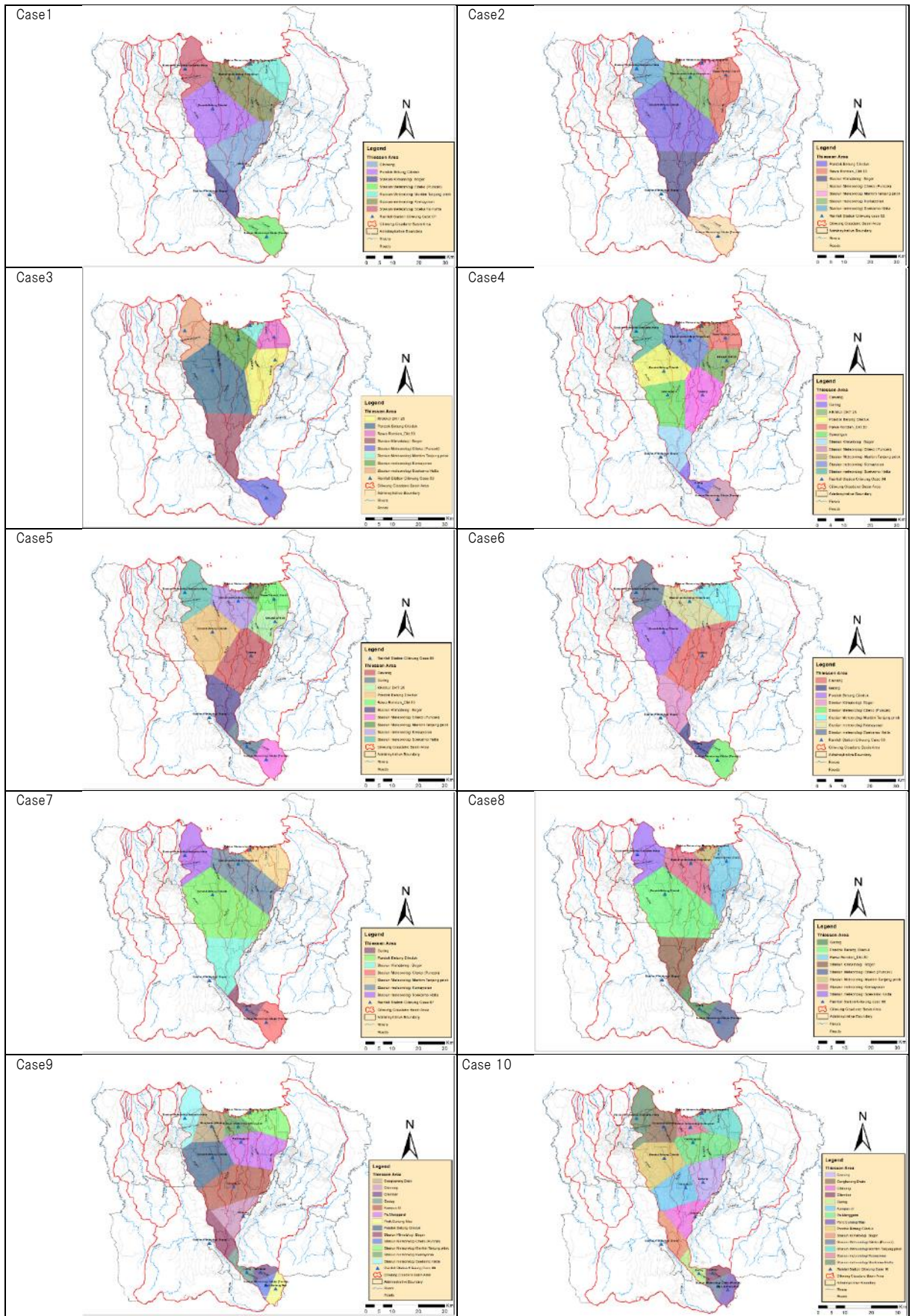
Source: JICA study team

Table 2-30 Thiessen coefficient (the Ciliwung River basin)

Station Name	Stasiun Klimatologi Bogor	Stasiun Meteorologi Citeko (Puncak)	Stasiun meteorologi Kemayoran	Stasiun Meteorologi Maritim Tanjung Priok	Stasiun meteorologi Soekarno Hatta	Pondok Betung Cileduk	ARG Manggarai	AWS Halim Perdana Kusumah	ARG Tomang	ARG Lebak Bulus	ARG Ciganjur	Perk.Gunung Mas	Cilemer	Gadag	Kampung Kelapa	year
Latitude	-6.553858	-6.6968	-6.15559	-6.10781	-6.125537	-6.26156	-6.20748	-6.26248	-6.166699	-6.304318	-6.3443	-6.709083	-6.652867	-6.65343	-6.45527	
Longitude	106.74185	106.93501	106.84	106.88053	106.65691	106.7508	106.8487	106.8971	106.78	106.7774	106.799	106.96738	106.91492	106.8692	106.814	
Case1	0.07	0.10	0.18	0.11	0.11	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1985-1988, 1990-1993
Case2	0.15	0.10	0.13	0.02	0.11	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1996
Case3	0.15	0.10	0.11	0.02	0.11	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1997
Case4	0.09	0.07	0.11	0.02	0.11	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	1998
Case5	0.11	0.07	0.11	0.02	0.11	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	1999
Case6	0.11	0.07	0.14	0.10	0.11	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	2000
Case7	0.14	0.07	0.19	0.11	0.11	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	2001
Case8	0.14	0.07	0.13	0.02	0.11	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	2002
Case9	0.06	0.02	0.04	0.09	0.08	0.14	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.03	0.00	2003
Case10	0.06	0.02	0.04	0.09	0.08	0.14	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.03	0.00	2004
Case11	0.06	0.02	0.04	0.09	0.08	0.11	0.00	0.00	0.00	0.00	0.00	0.03	0.05	0.00	0.00	2005
Case12	0.07	0.06	0.04	0.02	0.08	0.11	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	2006-2007
Case13	0.05	0.04	0.04	0.02	0.08	0.11	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.04	0.00	2008
Case14	0.05	0.04	0.09	0.02	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.04	0.00	2009, 2010
Case15	0.05	0.02	0.09	0.02	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.03	0.00	2011-2013
Case16	0.05	0.02	0.12	0.10	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.03	0.00	2014
Case17	0.05	0.02	0.12	0.10	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.03	0.00	2015-2016
Case18	0.05	0.02	0.09	0.05	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.03	0.00	2017, 2018
Case19	0.01	0.02	0.04	0.05	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.02	0.04	2019
Case20	0.01	0.02	0.04	0.05	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.02	0.04	2020
Case21	0.01	0.02	0.03	0.05	0.08	0.00	0.02	0.05	0.04	0.01	0.02	0.03	0.02	0.02	0.04	2020.1

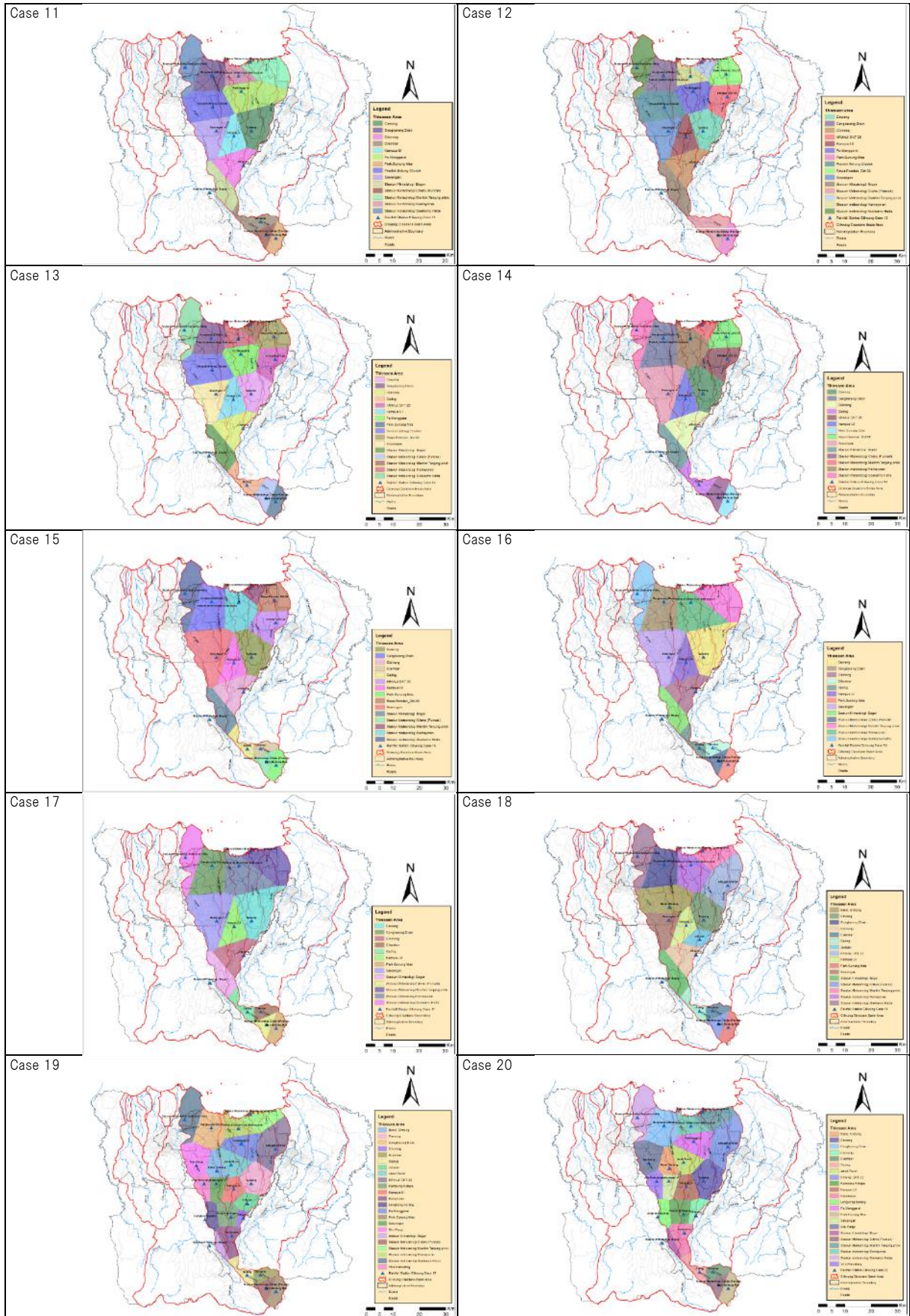
Station Name	Kampus UI	Cibinong	Kemenso	Pa.Mangarai	Villa Pamulang	Lengkong Barang	Situ Parigi	Sawangan	Bend. Gintung	Jeruk Purut	Jatijajar	Cawang	Rawa Gede	Cengkareng Drain	KRANJI DKT 25	Rawa Rorotan_Dkt.30	year
Latitude	-6.36121	-6.460483	-6.519911	-6.207633	-6.34299	-6.46463	-6.281569	-6.342672	-6.299414	-6.27926	-6.409486	-6.34267	-6.671369	-6.15365	-6.224979	-6.148191	
Longitude	106.8238	106.85636	106.8169	106.84849	106.723	106.7263	106.69675	106.76422	106.76597	106.8149	106.86977	106.8834	106.88341	106.74793	106.96546	106.96193	
Case1	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1985-1988, 1990-1993
Case2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	1996
Case3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.06	1997
Case4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.15	0.00	0.00	0.07	0.06	1998
Case5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.07	0.06	1999
Case6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	2000
Case7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2001
Case8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	2002
Case9	0.18	0.07	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	2003
Case10	0.11	0.07	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.08	0.00	0.00	2004
Case11	0.06	0.07	0.00	0.12	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.10	0.00	0.08	0.00	0.00	2005
Case12	0.06	0.07	0.00	0.08	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.09	0.00	0.08	0.06	0.00	2006-2007
Case13	0.06	0.07	0.00	0.08	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.09	0.00	0.08	0.06	0.06	2008
Case14	0.06	0.07	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.10	0.00	0.12	0.07	0.06	2009, 2010
Case15	0.06	0.07	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.10	0.00	0.12	0.07	0.06	2011-2013
Case16	0.06	0.07	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.13	0.00	0.12	0.00	0.00	2014
Case17	0.06	0.07	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.13	0.00	0.12	0.00	0.00	2015-2016
Case18	0.05	0.06	0.00	0.00	0.00	0.00	0.00	0.07	0.12	0.00	0.03	0.08	0.00	0.10	0.11	0.00	2017, 2018
Case19	0.04	0.01	0.04	0.06	0.03	0.03	0.06	0.03	0.03	0.05	0.03	0.07	0.00	0.09	0.10	0.00	2019
Case20	0.04	0.02	0.04	0.06	0.03	0.03	0.06	0.03	0.03	0.05	0.00	0.08	0.00	0.09	0.10	0.00	2020
Case21	0.04	0.02	0.04	0.02	0.03	0.03	0.06	0.02	0.03	0.04	0.00	0.06	0.00	0.06	0.08	0.00	2020.1

Source: JICA study team



Source: JICA study team

Figure 2-49 (1/3) Map of Thiessen polygons (the Ciliwung River basin)



Source: JICA study team

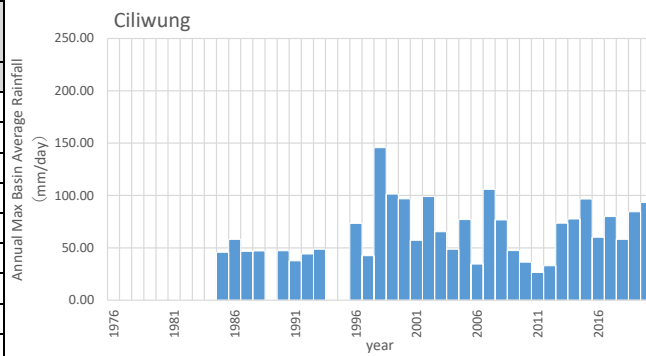
Figure 2-49 (2/3) Map of Thiessen polygons (the Ciliwung River basin)

The basin average daily rainfalls were calculated by the Thiessen method, and the obtained annual maximum basin average daily rainfalls are shown in Table 2-31.

The basin average daily rainfall of the flood in January 2020 is about 90 mm, and it was confirmed that the flood had the largest rainfall in the last 5 years. The Ciliwung River basin experienced severe flood damage in February 2007. The basin average rainfall in 2007 was 106 mm, and it is the second largest rainfall in the statistical period.

Table 2-31 Annual maximum basin average daily rainfall (the Ciliwung River basin)

Ciliwung		
	basin average rainfall	date
1985	45.80	1985/1/14
1986	58.12	1986/12/15
1987	46.67	1987/2/8
1988	46.94	1988/12/20
1989		#N/A
1990	47.17	1990/1/22
1991	37.65	1991/2/24
1992	44.02	1992/10/4
1993	48.59	1993/2/7
1994		#N/A
1995		#N/A
1996	73.28	1996/2/11
1997	42.55	1997/1/15
1998	145.75	1998/7/4
1999	101.41	1999/2/22
2000	96.82	2000/7/28
2001	57.09	2001/12/30
2002	99.05	2002/1/30
2003	65.30	2003/12/30
2004	48.58	2004/2/19
2005	76.93	2005/1/19
2006	34.41	2006/1/24
2007	105.81	2007/2/3
2008	76.63	2008/2/2
2009	47.38	2009/1/13
2010	36.36	2010/1/19
2011	26.44	2011/2/14
2012	32.86	2012/4/3
2013	73.51	2013/1/17
2014	77.58	2014/1/18
2015	96.60	2015/2/10
2016	60.06	2016/4/21
2017	79.95	2017/2/21
2018	58.00	2018/2/5
2019	84.49	2019/12/31
2020	93.29	2020/1/1
average	65.61	-



Source: JICA study team

(iv) Upstream basin of Manggarai weir

For the upstream basin of Manggarai weir (area: 337 km²), the basin average daily rainfall were calculated by the Thiessen method. 11 cases of Thiessen polygons were set considering the availability of data. The cases of the Thiessen polygons are shown in Table 2-32, the area of each polygon in Table 2-33, the Thiessen coefficient in Table 2-34, and the map of Thiessen polygons in Figure 2-50.

Table 2-32 Cases of Thiessen polygons (upstream of Manggarai weir)

○ : Collected
— : No Data

Station Name	Stasiun Meteorologi Citeko (Puncak)	Stasiun meteorologi Kemayoran	Perk.Gunung Mas	Cilember	Gadog	Kampung Kelapa	Kampus UI	Cibinong	Kemenso	Pa.Manggarai	year
Latitude	-6.6968	-6.15559	-6.709083	-6.652867	-6.65343	-6.45527	-6.36121	-6.460483	-6.519911	-6.207633	
Longitude	106.93501	106.84	106.96738	106.91492	106.8692	106.814	106.8238	106.85636	106.8169	106.84849	
Case1	-	○	-	-	-	-	-	○	-	-	1980-1984
Case2	○	○	-	-	-	-	-	○	-	-	1985-1988, 1990-1993
Case3	○	○	-	-	-	-	-	-	-	-	1989, 1994-1997
Case4	○	○	-	-	○	-	-	-	-	-	1998-2002
Case5	○	○	○	○	○	-	○	○	-	○	2003, 2004
Case6	○	○	○	○	-	-	○	○	-	○	2005
Case7	○	○	○	-	-	-	○	○	-	○	2006, 2007
Case8	○	○	○	-	○	-	○	○	-	○	2008
Case9	○	○	○	-	○	-	○	○	-	-	2009, 2010
Case10	○	○	○	○	○	-	○	○	-	-	2011-2018
Case11	○	○	○	○	○	○	○	○	○	○	2019, 2020, 2020.1

Source: JICA study team

Table 2-33 Area of each polygon (upstream of Manggarai weir) unit: km²

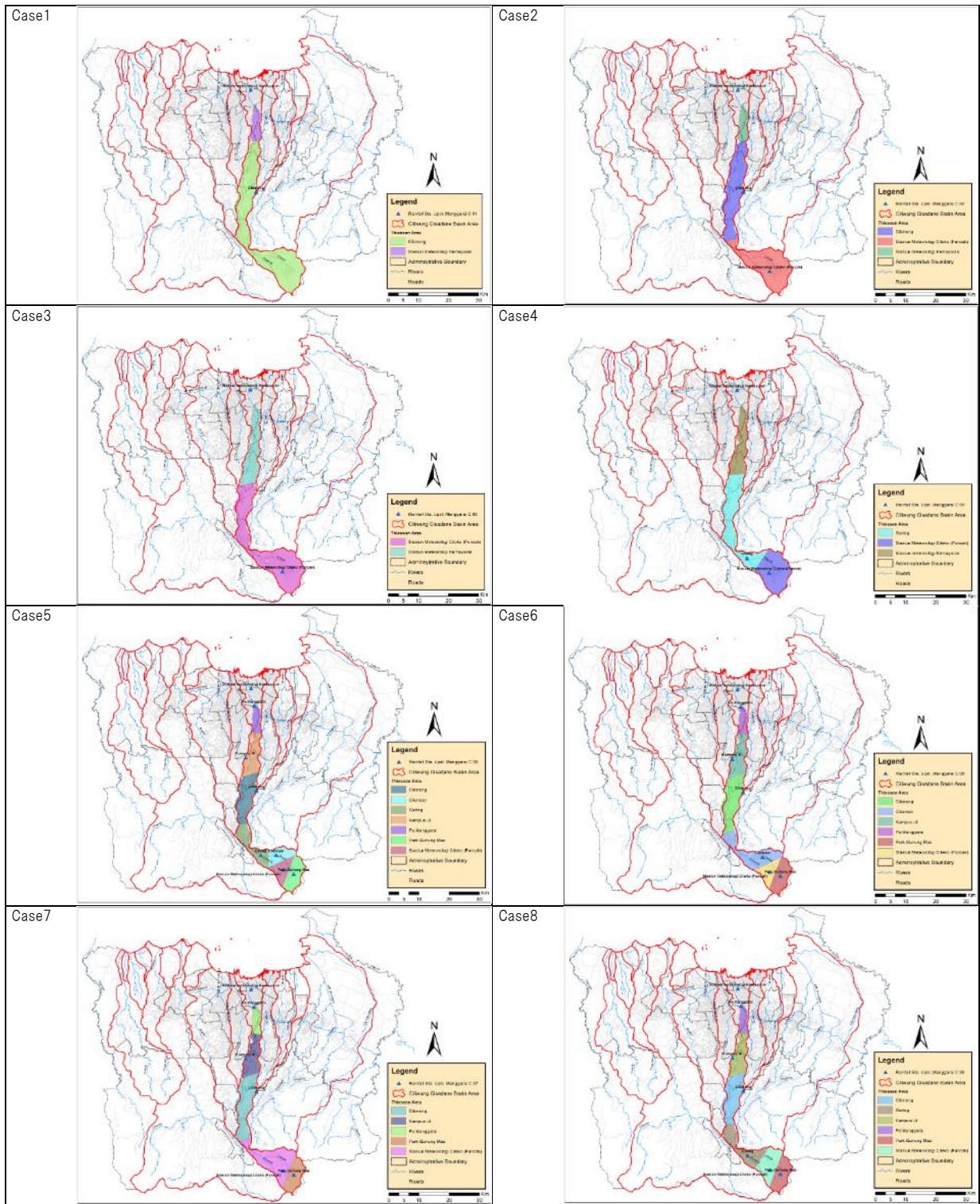
Station Name	Stasiun Meteorologi Citeko (Puncak)	Stasiun meteorologi Kemayoran	Perk.Gunung Mas	Cilember	Gadog	Kampung Kelapa	Kampus UI	Cibinong	Kemenso	Pa.Manggarai	year
Latitude	-6.6968	-6.15559	-6.709083	-6.652867	-6.65343	-6.45527	-6.36121	-6.460483	-6.519911	-6.207633	
Longitude	106.93501	106.84	106.96738	106.91492	106.8692	106.814	106.8238	106.85636	106.8169	106.84849	
Case1	0.0	29.4	0.0	0.0	0.0	0.0	0.0	307.7	0.0	0.0	1980-1984
Case2	160.3	29.4	0.0	0.0	0.0	0.0	0.0	147.4	0.0	0.0	1985-1988, 1990-1993
Case3	244.3	92.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1989, 1994-1997
Case4	111.4	75.4	0.0	0.0	150.3	0.0	0.0	0.0	0.0	0.0	1998-2002
Case5	35.7	0.0	50.2	38.4	55.0	0.0	56.8	78.7	0.0	22.3	2003, 2004
Case6	35.7	0.0	50.2	87.0	0.0	0.0	56.8	85.0	0.0	22.3	2005
Case7	109.7	0.0	50.6	0.0	0.0	0.0	56.8	97.7	0.0	22.3	2006, 2007
Case8	60.8	0.0	50.6	0.0	67.9	0.0	56.8	78.7	0.0	22.3	2008
Case9	60.8	13.6	50.6	0.0	67.9	0.0	65.6	78.7	0.0	0.0	2009, 2010
Case10	35.7	13.6	50.2	38.4	55.0	0.0	65.6	78.7	0.0	0.0	2011-2018
Case11	35.7	0.0	50.2	38.4	39.7	29.8	54.8	17.7	48.4	22.3	2019, 2020, 2020.1

Source: JICA study team

Table 2-34 Thiessen coefficient (upstream of Manggarai weir)

Station Name	Stasiun Meteorologi Citeko (Puncak)	Stasiun meteorologi Kemayoran	Perk.Gunung Mas	Cilember	Gadog	Kampung Kelapa	Kampus UI	Cibinong	Kemenso	Pa.Manggarai	year
Latitude	-6.6968	-6.15559	-6.709083	-6.652867	-6.65343	-6.45527	-6.36121	-6.460483	-6.519911	-6.207633	
Longitude	106.93501	106.84	106.96738	106.91492	106.8692	106.814	106.8238	106.85636	106.8169	106.84849	
Case1	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.91	0.00	0.00	1980-1984
Case2	0.48	0.09	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00	1985-1988, 1990-1993
Case3	0.72	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1989, 1994-1997
Case4	0.33	0.22	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00	1998-2002
Case5	0.11	0.00	0.15	0.11	0.16	0.00	0.17	0.23	0.00	0.07	2003, 2004
Case6	0.11	0.00	0.15	0.26	0.00	0.00	0.17	0.25	0.00	0.07	2005
Case7	0.33	0.00	0.15	0.00	0.00	0.00	0.17	0.29	0.00	0.07	2006, 2007
Case8	0.18	0.00	0.15	0.00	0.20	0.00	0.17	0.23	0.00	0.07	2008
Case9	0.18	0.04	0.15	0.00	0.20	0.00	0.19	0.23	0.00	0.00	2009, 2010
Case10	0.11	0.04	0.15	0.11	0.16	0.00	0.19	0.23	0.00	0.00	2011-2018
Case11	0.11	0.00	0.15	0.11	0.12	0.09	0.16	0.05	0.14	0.07	2019, 2020, 2020.1

Source: JICA study team



Source: JICA study team

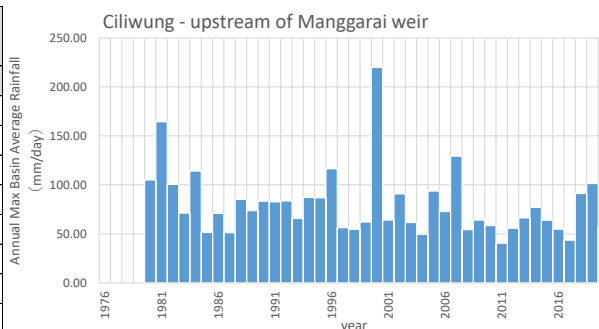
Figure 2-50 (1/2) Map of Thiessen polygons (upstream of Manggarai weir)

The basin average daily rainfalls were calculated by the Thiessen method, and the annual maximum basin average daily rainfalls are shown in Table 2-35.

The basin average daily rainfall of the flood in January 2020 is about 100 mm (31st December 2019), and it was confirmed that the flood had the largest rainfall in the last 10 years. The Ciliwung River basin experienced severe flood damage in February 2007. The basin average rainfall in 2007 was also large, about 130 mm, which seems large enough to cause such flood damage.

Table 2-35 Annual maximum basin average daily rainfall (upstream of Manggarai weir)

Ciliwung - upstream of Manggarai weir		
	basin average rainfall	date
1980	104.98	1980/8/16
1981	164.33	1981/6/14
1982	100.41	1982/4/15
1983	71.20	1983/5/4
1984	114.03	1984/12/6
1985	51.57	1985/9/11
1986	70.85	1986/4/30
1987	51.12	1987/11/7
1988	85.20	1988/12/17
1989	73.64	1989/11/8
1990	83.38	1990/1/7
1991	82.62	1991/2/24
1992	83.52	1992/1/30
1993	65.66	1993/12/5
1994	87.19	1994/1/21
1995	86.86	1995/12/31
1996	116.48	1996/1/3
1997	56.34	1997/12/11
1998	54.61	1998/6/2
1999	62.10	1999/1/3
2000	219.88	2000/12/31
2001	64.11	2001/2/8
2002	90.77	2002/1/29
2003	61.50	2003/2/13
2004	49.56	2004/4/22
2005	93.65	2005/1/18
2006	72.84	2006/1/24
2007	129.34	2007/2/4
2008	54.21	2008/1/2
2009	64.18	2009/1/13
2010	58.41	2010/2/19
2011	40.38	2011/12/28
2012	55.46	2012/4/3
2013	66.30	2013/1/17
2014	77.05	2014/1/18
2015	63.96	2015/2/10
2016	54.85	2016/7/4
2017	43.62	2017/5/3
2018	91.14	2018/2/5
2019	101.33	2019/12/31
2020	57.67	2020/1/1
average	79.91	-



Source: JICA study team

(v) The Cisadane River basin

For the entire Cisadane River basin (area : 1,377 km²), the basin average daily rainfalls were calculated by the Thiessen method. 8 cases of Thiessen polygons were set considering the availability of data. The cases of the Thiessen polygons are shown in Table 2-36, the area of each polygon in Table 2-37, the Thiessen coefficient in Table 2-38, and the map of Thiessen polygons in Figure 2-51.

Table 2-36 Cases of Tiessen polygons (the Cisadane River basin)

○ : Collected
— : No Data

Station Name	Stasiun Klimatologi Bogor	Stasiun meteorologi Soekarno Hatta	Pondok Betung Cileduk	Darmaga Bogor	AWS Puspittek Serpong	Bojong Murni	Cigudeg	Pasir jaya	Ranca Burgur	PLTA Kracak	Bendung Pasar Baru	Villa Pamulang	Lengkong Barang	Situ Parigi	year
Latitude	-6.553858	-6.125537	-6.26156	-6.55358	-6.359751	-6.697861	-6.54759	-6.728414	-6.514417	-6.616972	-6.159203	-6.34299	-6.46463	-6.281569	-
Longitude	106.74185	106.65691	106.7508	106.7498	106.67332	106.89429	106.5331	106.79674	106.69194	106.64358	106.62836	106.723	106.7263	106.6968	-
Case1	○	○	○	○	-	-	-	○	○	-	-	-	-	-	1998-2002
Case2	○	○	○	○	-	-	-	○	○	-	○	-	-	-	2003, 2005
Case3	○	○	○	-	-	-	-	○	○	○	○	-	-	-	2004
Case4	○	○	○	○	-	-	-	○	○	○	○	-	-	-	2008
Case5	○	○	-	-	-	-	-	○	○	○	○	-	-	-	2009
Case6	○	○	-	-	-	-	○	○	○	○	○	-	-	-	2010-2018
Case7	○	○	-	-	-	○	○	○	○	○	○	○	○	○	2019-2020
Case8	○	○	-	-	○	○	○	○	○	○	○	○	○	○	2020.1

Source: JICA study team

Table 2-37 Area of each polygon (the Cisadane River basin) unit: km²

Station Name	Stasiun Klimatologi Bogor	Stasiun meteorologi Soekarno Hatta	Pondok Betung Cileduk	Darmaga Bogor	AWS Puspittek Serpong	Bojong Murni	Cigudeg	Pasir jaya	Ranca Burgur	PLTA Kracak	Bendung Pasar Baru	Villa Pamulang	Lengkong Barang	Situ Parigi	year	
Latitude	-6.553858	-6.125537	-6.26156	-6.55358	-6.359751	-6.697861	-6.54759	-6.728414	-6.514417	-6.616972	-6.159203	-6.34299	-6.46463	-6.281569	-	
Longitude	106.74185	106.65691	106.7508	106.7498	106.67332	106.89429	106.5331	106.79674	106.69194	106.64358	106.62836	106.723	106.7263	106.6968	-	
Case1	147.8	139.7	130.4	56.8	0.0	0.0	0.0	391.9	509.8	0.0	0.0	0.0	0.0	0.0	0.0	1998-2002
Case2	147.8	35.3	89.7	56.8	0.0	0.0	0.0	391.9	509.8	0.0	145.1	0.0	0.0	0.0	0.0	2003, 2005
Case3	118.3	35.3	89.7	0.0	0.0	0.0	0.0	273.5	259.5	455.0	145.1	0.0	0.0	0.0	0.0	2004
Case4	63.0	35.3	89.7	56.8	0.0	0.0	0.0	272.0	259.5	455.0	145.1	0.0	0.0	0.0	0.0	2008
Case5	118.3	35.3	0.0	0.0	0.0	0.0	0.0	273.5	296.2	455.0	198.1	0.0	0.0	0.0	0.0	2009
Case6	118.3	35.3	0.0	0.0	0.0	0.0	106.1	273.5	275.5	369.7	198.1	0.0	0.0	0.0	0.0	2010-2018
Case7	116.5	35.3	0.0	0.0	0.0	96.5	106.1	177.0	127.4	369.7	94.7	68.5	81.2	103.6	0.0	2019-2020
Case8	116.5	35.3	0.0	0.0	129.8	96.5	106.1	177.0	127.0	369.7	94.7	2.5	63.9	57.5	0.0	2020.1

Source: JICA study team

Table 2-38 Thiessen coefficient (the Cisadane River basin)

Station Name	Stasiun Klimatologi Bogor	Stasiun meteorologi Soekarno Hatta	Pondok Betung Cileduk	Darmaga Bogor	AWS Puspittek Serpong	Bojong Murni	Cigudeg	Pasir jaya	Ranca Burgur	PLTA Kracak	Bendung Pasar Baru	Villa Pamulang	Lengkong Barang	Situ Parigi	year	
Latitude	-6.553858	-6.125537	-6.26156	-6.55358	-6.359751	-6.697861	-6.54759	-6.728414	-6.514417	-6.616972	-6.159203	-6.34299	-6.46463	-6.281569	-	
Longitude	106.74185	106.65691	106.7508	106.7498	106.67332	106.89429	106.5331	106.79674	106.69194	106.64358	106.62836	106.723	106.7263	106.6968	-	
Case1	0.11	0.10	0.09	0.04	0.00	0.00	0.00	0.28	0.37	0.00	0.00	0.00	0.00	0.00	0.00	1998-2002
Case2	0.11	0.03	0.07	0.04	0.00	0.00	0.00	0.28	0.37	0.00	0.11	0.00	0.00	0.00	0.00	2003, 2005
Case3	0.09	0.03	0.07	0.00	0.00	0.00	0.00	0.20	0.19	0.33	0.11	0.00	0.00	0.00	0.00	2004
Case4	0.05	0.03	0.07	0.04	0.00	0.00	0.00	0.20	0.19	0.33	0.11	0.00	0.00	0.00	0.00	2008
Case5	0.09	0.03	0.00	0.00	0.00	0.00	0.00	0.20	0.22	0.33	0.14	0.00	0.00	0.00	0.00	2009
Case6	0.09	0.03	0.00	0.00	0.00	0.00	0.08	0.20	0.20	0.27	0.14	0.00	0.00	0.00	0.00	2010-2018
Case7	0.08	0.03	0.00	0.00	0.00	0.07	0.08	0.13	0.09	0.27	0.07	0.05	0.06	0.08	0.00	2019-2020
Case8	0.08	0.03	0.00	0.00	0.09	0.07	0.08	0.13	0.09	0.27	0.07	0.00	0.05	0.04	0.00	2020.1

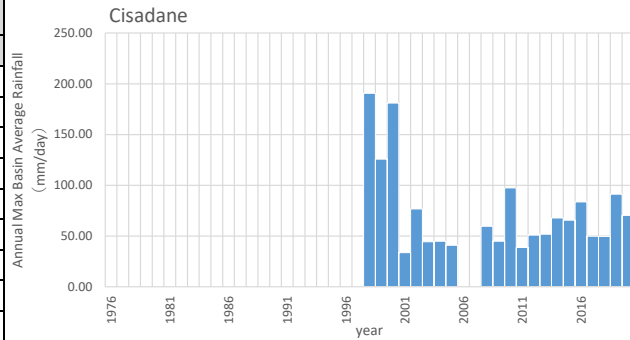
Source: JICA study team

The basin average daily rainfalls were calculated by the Thiessen method, and the annual maximum basin average daily rainfalls are shown in Table 2-39.

The basin average daily rainfall of the flood in January 2020 was about 70 mm in the Cisadane River basin, which is almost equal to an average of recent years. Damage from the flood in 2020 was limited to a few areas, and no significant damage was observed along the main river. The analysis result of annual maximum basin average daily rainfall well reflects the actual situation of flood damage.

Table 2-39 Annual maximum basin average daily rainfall (the Cisadane River basin)

	Cisadane	
	basin average rainfall	date
1998	190.56	1998/2/18
1999	125.83	1999/1/16
2000	181.05	2000/2/20
2001	33.67	2001/7/18
2002	76.76	2002/1/30
2003	44.33	2003/3/23
2004	45.01	2004/5/24
2005	41.02	2005/6/18
2006		#N/A
2007		#N/A
2008	59.72	2008/4/7
2009	44.91	2009/11/6
2010	97.46	2010/5/25
2011	38.74	2011/1/6
2012	51.00	2012/11/17
2013	51.90	2013/3/24
2014	67.86	2014/2/22
2015	65.55	2015/1/23
2016	83.69	2016/10/18
2017	49.84	2017/2/24
2018	49.61	2018/6/24
2019	91.21	2019/12/31
2020	70.35	2020/1/1
average	74.29	-



Source: JICA study team

(vi) Upstream basin of Pasar Baru weir

For the upstream basin of Pasar Baru weir (area : 1,258 km²), the basin average daily rainfalls were calculated by the Thiessen method. 5 cases of Thiessen polygons were set considering the availability of data. The cases of the Thiessen partitions are shown in Table 2-40, the area of each polygon in Table 2-41, the Thiessen coefficient in Table 2-42, and the map of Thiessen polygons in Figure 2-52.

Table 2-40 Cases of Thiessen polygons (upstream of Pasar Baru weir) [○]: Collected
_□: No Data

Station Name	Stasiun Klimatologi Bogor	Stasiun meteorologi Soekarno Hatta	Darmaga Bogor	Bojong Murni	Pasir jaya	Ranca Burgur	PLTA Kracak	Bendung Pasar Baru	Villa Pamulang	Lengkong Barang	Situ Parigi	year
Latitude	-6.553858	-6.125537	-6.55358	-6.697861	-6.728414	-6.514417	-6.616972	-6.159203	-6.34299	-6.46463	-6.281569	-
Longitude	106.74185	106.65691	106.7498	106.89429	106.79674	106.69194	106.64358	106.62836	106.723	106.7263	106.69675	-
Case1	○	○	○	-	○	○	-	○	-	-	-	2003, 2005
Case2	○	○	-	-	○	○	○	○	-	-	-	2004
Case3	○	○	○	-	○	○	○	○	-	-	-	2008
Case4	○	○	-	-	○	○	○	○	-	-	-	2009-2018
Case5	○	○	-	○	○	○	○	○	○	○	○	2019, 2020, 2020.1

Source: JICA study team

Table 2-41 Area of each polygon (upstream of Pasar Baru weir) unit: km²

Station Name	Stasiun Klimatologi Bogor	Stasiun meteorologi Soekarno Hatta	Darmaga Bogor	Bojong Murni	Pasir jaya	Ranca Burgur	PLTA Kracak	Bendung Pasar Baru	Villa Pamulang	Lengkong Barang	Situ Parigi	year
Latitude	-6.553858	-6.125537	-6.55358	-6.697861	-6.728414	-6.514417	-6.616972	-6.159203	-6.34299	-6.46463	-6.281569	
Longitude	106.74185	106.65691	106.7498	106.89429	106.79674	106.69194	106.64358	106.62836	106.723	106.7263	106.69675	
Case1	147.8	0.0	56.8	0.0	391.9	546.5	0.0	115.3	0.0	0.0	0.0	2003, 2005
Case2	118.3	0.0	0.0	0.0	273.5	296.2	455.0	115.3	0.0	0.0	0.0	2004
Case3	63.0	0.0	56.8	0.0	272.0	296.2	455.0	115.3	0.0	0.0	0.0	2008
Case4	118.3	0.0	0.0	0.0	273.5	296.2	455.0	115.3	0.0	0.0	0.0	2009-2018
Case5	116.5	0.0	0.0	96.5	177.0	148.2	455.0	28.3	68.5	81.2	87.1	2019, 2020, 2020.1

Source: JICA study team

Table 2-42 Thiessen coefficient (upstream of Pasar Baru weir)

Station Name	Stasiun Klimatologi Bogor	Stasiun meteorologi Soekarno Hatta	Darmaga Bogor	Bojong Murni	Pasir jaya	Ranca Burgur	PLTA Kracak	Bendung Pasar Baru	Villa Pamulang	Lengkong Barang	Situ Parigi	year
Latitude	-6.553858	-6.125537	-6.55358	-6.697861	-6.728414	-6.514417	-6.616972	-6.159203	-6.34299	-6.46463	-6.281569	
Longitude	106.74185	106.65691	106.7498	106.89429	106.79674	106.69194	106.64358	106.62836	106.723	106.7263	106.69675	
Case1	0.12	0.00	0.05	0.00	0.31	0.43	0.00	0.09	0.00	0.00	0.00	2003, 2005
Case2	0.09	0.00	0.00	0.00	0.22	0.24	0.36	0.09	0.00	0.00	0.00	2004
Case3	0.05	0.00	0.05	0.00	0.22	0.24	0.36	0.09	0.00	0.00	0.00	2008
Case4	0.09	0.00	0.00	0.00	0.22	0.24	0.36	0.09	0.00	0.00	0.00	2009-2018
Case5	0.09	0.00	0.00	0.08	0.14	0.12	0.36	0.02	0.05	0.06	0.07	2019, 2020, 2020.1

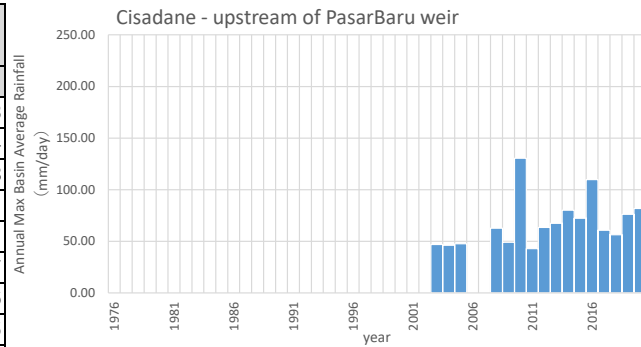
Source: JICA study team

The basin average daily rainfalls were calculated by the Thiessen method, and the annual maximum basin average daily rainfalls are shown in Table 2-43.

The basin average daily rainfall of the flood in January 2020 was about 80 mm in the upstream basin of Pasar Baru weir, which is only about 10 mm larger than an average of recent years. Damage by the flood in 2020 was limited to a few areas, and no significant damage was observed along the main river. The analysis result of annual maximum basin average daily rainfall well reflects the actual situation of flood damage.

Table 2-43 Annual maximum basin average daily rainfall (upstream of Pasar Baru weir)

Cisadane - upstream of PasarBaru weir		
	basin average rainfall	date
2003	46.87	2003/3/23
2004	46.16	2004/5/24
2005	47.69	2005/6/18
2006		#N/A
2007		#N/A
2008	62.74	2008/4/7
2009	49.12	2009/11/6
2010	130.57	2010/5/25
2011	42.98	2011/1/6
2012	63.49	2012/8/12
2013	67.54	2013/3/24
2014	80.25	2014/2/22
2015	72.36	2015/1/23
2016	109.77	2016/10/18
2017	60.71	2017/2/24
2018	56.37	2018/6/24
2019	76.19	2019/12/31
2020	81.86	2020/3/24
average	68.42	-



Source: JICA study team

(2) Probable rainfall of each basin

Probable daily rainfalls of several return periods for each basin were estimated through the statistical analysis on the annual maximum basin average daily rainfalls, using the hydrological statistics utility Ver.1.5 (Japan Institute of Country-ology and Engineering).

The hydrological statistics utility supports 13 extreme distribution models as presented in Table 2-44. For quantifying the fitness of extreme distribution models to the data, the Standard Least-Squares Criterion (SLSC) which is widely used in flood control planning in Japan was applied. The extreme distribution model that gives the minimum SLSC is adopted as the most suitable distribution model.

Table 2-44 Probability distribution model (annual maximum series data)

	Probability distribution model	Abbreviation
1	Exponential distribution	Exp
2	Gumbel distribution	Gumbel
3	Square root exponential maximum value distribution	SqrtEt
4	Generalized extreme value distribution	Gev
5	Log Pearson Type III distribution (real space method)	LP3Rs
6	Log Pearson Type III distribution (logarithmic space)	LogP3
7	Iwai method	Iwai
8	Ishihara-Takase method	IshiTaka
9	Log-normal distribution 3 quantile-parameterized distribution	LN3Q
10	Log-normal distribution 3 parameters (Slade II)	LN3PM
11	Log-normal distribution 2 parameters (Slade I, L-moments)	LN2LM
12	Log-normal distribution 2 parameters (Slade I, moments)	LN2PM
13	Log-normal distribution 4 parameters (Slade IV, moments)	LN4PM

Source: Japan Institute of Country-ology and Engineering

(i) The Bekasi River basin

For the basin average daily rainfall in the Bekasi River basin, the estimation results of the probable rainfalls are shown in Table 2-45 and Figure 2-53. SqrtEt that gave the minimum SLSC was adopted as the most suitable distribution model. The probable rainfall of 50-year return period was estimated at 142.5 mm.

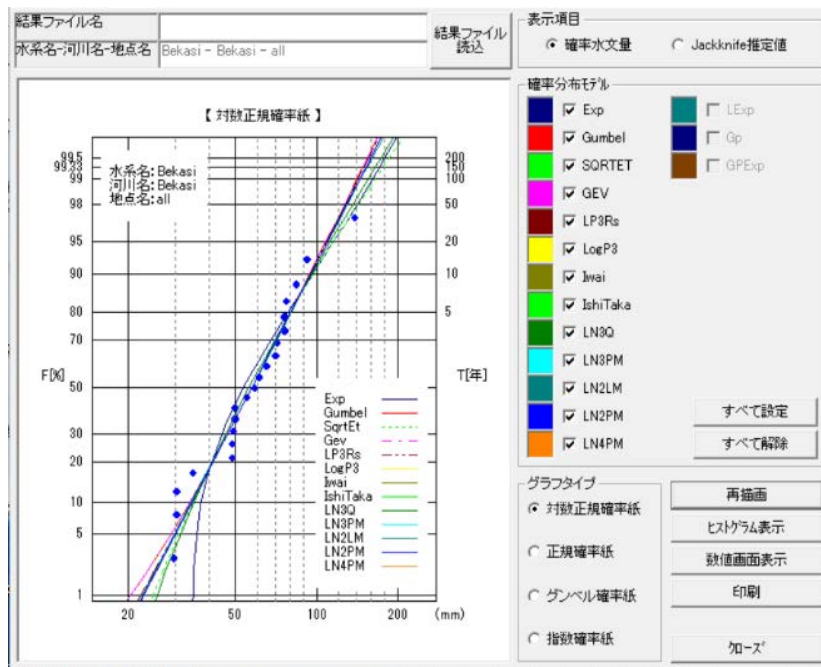
Table 2-45 Probable rainfall (the Bekasi River basin)

	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
X-COR(99%)	0.968	0.975	0.979	0.975	0.975	-	-	-	0.978	-	0.976	0.976	-	-	-	-
P-COR(99%)	0.939	0.987	0.981	0.987	0.987	-	-	-	0.982	-	0.986	0.986	-	-	-	-
SLSC(99%)	0.05	0.046	0.04	0.046	0.044	-	-	-	0.05	-	0.044	0.044	-	-	-	-
対数尤度	-90.4	-95	-95.1	-95	-	-	-	-	-94.9	-	-94.9	-94.9	-	-	-	-
pAIC	184.8	193.9	194.2	195.9	0	-	-	-	195.9	-	193.7	193.7	-	-	-	-
X-COR(50%)	0.956	0.948	0.961	0.948	0.947	-	-	-	0.956	-	0.949	0.949	-	-	-	-
P-COR(50%)	0.972	0.978	0.975	0.978	0.978	-	-	-	0.976	-	0.977	0.977	-	-	-	-
SLSC(50%)	0.065	0.082	0.061	0.082	0.073	-	-	-	0.068	-	0.07	0.071	-	-	-	-

確率水文学	確率年	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
確率水文学	2	53.4	57.6	56.1	57.5	57.5	-	-	-	56.1	-	57.3	57.3	-	-	-	-
	3	64.4	68.1	66.9	68.1	68.2	-	-	-	66.8	-	68.1	67.9	-	-	-	-
	5	78.3	79.8	79.9	79.8	80.1	-	-	-	79.4	-	80.2	80	-	-	-	-
	10	97.2	94.6	97.8	94.6	95	-	-	-	96.1	-	95.6	95.2	-	-	-	-
	20	116.1	108.7	116.3	108.8	109.2	-	-	-	112.9	-	110.5	109.9	-	-	-	-
	30	127.1	116.8	127.7	117	117.4	-	-	-	123	-	119.2	118.4	-	-	-	-
	50	141	127	142.5	127.2	127.6	-	-	-	136	-	130.1	129.2	-	-	-	-
	80	153.8	136.3	156.8	136.6	137	-	-	-	148.3	-	140.3	139.2	-	-	-	-
	100	159.9	140.7	163.7	141	141.5	-	-	-	154.2	-	145.1	143.9	-	-	-	-
	150	170.9	148.7	176.7	149.1	149.6	-	-	-	165.3	-	154	152.6	-	-	-	-
	200	178.7	154.4	186.2	154.9	155.4	-	-	-	173.3	-	160.3	158.9	-	-	-	-
	400	197.6	168	209.9	168.7	169.4	-	-	-	193.1	-	175.8	174.1	-	-	-	-

■: Probability distribution model to be adopted, rainfall equivalent to flood in January 2020

Source: JICA study team



Source: JICA study team

Figure 2-53 Probable rainfall (the Bekasi River basin)

(ii) Upstream basin of Bekasi weir

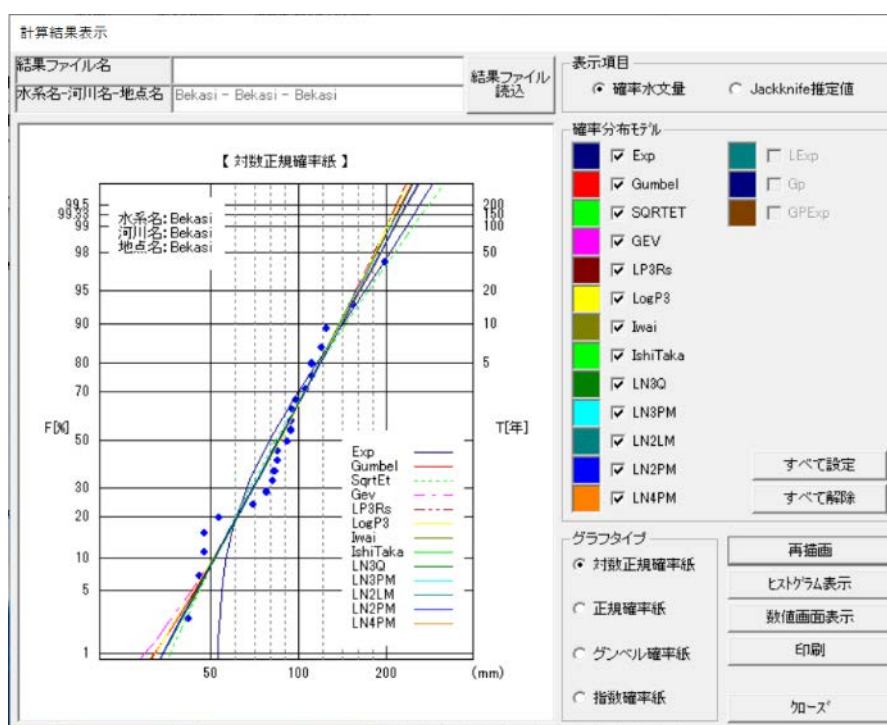
For the basin average daily rainfall in the upstream of Bekasi weir, the estimation results of the probable rainfalls are shown in Table 2-46 and Figure 2-54. SqrtEt that gave the smallest estimation error of the JackKnife method among the models of the minimum SLSC was adopted as the most suitable distribution model. The probable rainfall of 50-year return period was estimated at 212.4 mm.

Table 2-46 Probable rainfall (upstream of Bekasi weir)

	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
X-COR(99%)	0.968	0.98	0.981	0.978	0.977	0.978	0.98	-	0.98	-	0.98	0.98	-	-	-	-
P-COR(99%)	0.922	0.979	0.97	0.981	0.98	0.98	0.976	-	0.978	-	0.977	0.977	-	-	-	-
SLSC(99%)	0.05	0.041	0.041	0.045	0.046	0.046	0.046	-	0.047	-	0.046	0.046	-	-	-	-
対数尤度	-107.2	-112.8	-113.2	-112.8	-112.7	-112.7	-112.7	-	-112.7	-	-112.7	-112.7	-	-	-	-
pAIC	218.5	229.5	230.3	231.5	231.4	231.4	231.5	-	231.4	-	229.5	229.5	-	-	-	-
X-COR(50%)	0.98	0.971	0.982	0.966	0.965	0.978	0.973	-	0.971	-	0.972	0.972	-	-	-	-
P-COR(50%)	0.966	0.971	0.967	0.97	0.969	0.98	0.969	-	0.97	-	0.969	0.969	-	-	-	-
SLSC(50%)	0.047	0.063	0.053	0.076	0.071	0.07	0.06	-	0.062	-	0.06	0.06	-	-	-	-

確率水文量	確率年	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
確率水文量	2	79.2	85.2	83.2	86	86	85.9	84.7	-	85	-	84.8	84.8	-	-	-	-
	3	95	100.3	99.3	101.2	101.5	101.4	100.3	-	100.2	-	100.4	100.4	-	-	-	-
	5	114.9	117.1	118.8	117.8	118.3	118.3	118	-	117.1	-	118	118	-	-	-	-
	10	141.9	138.2	145.4	138.1	138.7	139	140.4	-	138.3	-	140.2	140.2	-	-	-	-
	20	168.9	158.4	173.2	157.1	157.7	158.1	162.2	-	158.6	-	161.6	161.6	-	-	-	-
	30	184.7	170	190.2	167.7	168.3	168.9	174.8	-	170.3	-	174	174.1	-	-	-	-
	50	204.6	184.6	212.4	180.8	181.3	182.2	190.8	-	185	-	189.7	189.7	-	-	-	-
	80	222.9	197.9	233.7	192.6	193.1	194.2	205.6	-	198.5	-	204.2	204.2	-	-	-	-
	100	231.6	204.2	244.1	198.1	198.6	199.8	212.7	-	205	-	211.1	211.1	-	-	-	-
	150	247.4	215.6	263.6	208	208.5	210	225.6	-	216.7	-	223.7	223.8	-	-	-	-
	200	258.6	223.7	277.8	214.9	215.5	217.1	234.9	-	225.1	-	232.8	232.8	-	-	-	-
	400	285.6	243.2	313.3	231.1	232.1	234.2	257.6	-	245.4	-	254.9	254.9	-	-	-	-

■ : Probability distribution model to be adopted, rainfall equivalent to flood in January 2020
Source: JICA study team



Source: JICA study team

Figure 2-54 Probable rainfall (upstream of Bekasi weir)

(iii) The Ciliwung River basin

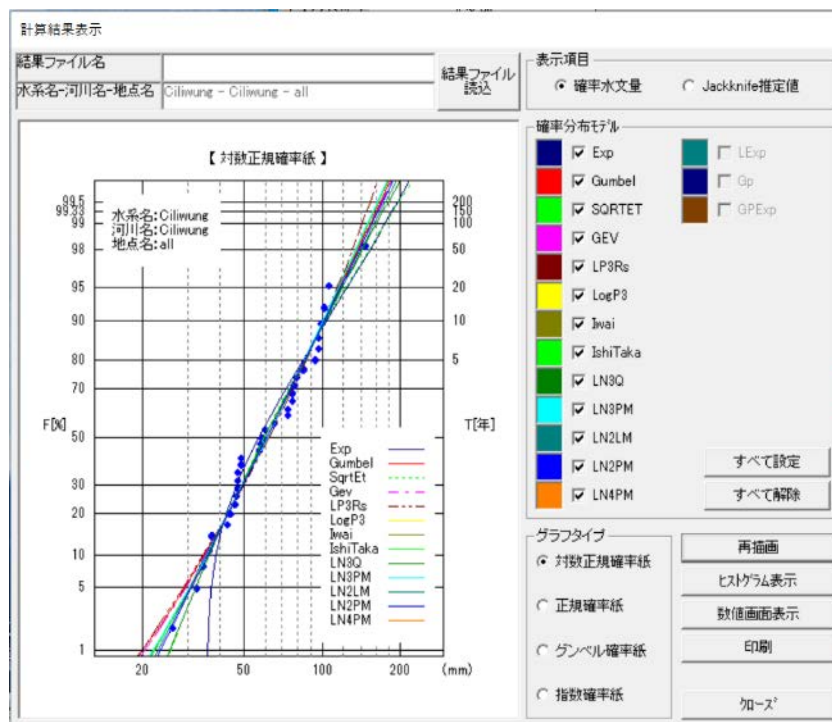
For the basin average daily rainfall in the Ciliwung River basin, the estimation results of the probable rainfalls are shown in Table 2-47 and Figure 2-55. LN2PM that gave the smallest estimation error of the JackKnife method among the models of the minimum SLSC was adopted as the most suitable distribution model. The probable rainfall of 50-year return period was estimated at 138.7 mm.

Table 2-47 Probable rainfall (the Ciliwung River basin)

	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
X-COR(99%)	0.972	0.987	0.981	0.987	0.986	-	0.987	0.987	0.985	0.987	0.987	0.987	-	-	-	-
P-COR(99%)	0.97	0.989	0.99	0.989	0.989	-	0.989	0.989	0.99	0.989	0.99	0.99	-	-	-	-
SLSC(99%)	0.048	0.032	0.035	0.032	0.035	-	0.032	0.032	0.031	0.032	0.03	0.03	-	-	-	-
対数尤度	-145.2	-152.2	-151.9	-152.1	-152.1	-	-151.9	-151.9	-151.7	-151.9	-151.8	-151.8	-	-	-	-
pAIC	294.3	308.3	307.9	310.2	310.2	-	309.8	309.8	309.4	309.9	307.6	307.6	-	-	-	-
X-COR(50%)	0.968	0.971	0.969	0.971	0.969	-	0.971	0.971	0.97	0.971	0.971	0.971	-	-	-	-
P-COR(50%)	0.965	0.968	0.962	0.967	0.973	-	0.967	0.967	0.964	0.967	0.968	0.966	-	-	-	-
SLSC(50%)	0.072	0.057	0.065	0.057	0.065	-	0.063	0.064	0.067	0.064	0.062	0.063	-	-	-	-

確率水文学	確率年	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
	2	56.4	61.1	59.2	60.9	62.2	-	61.2	61.2	59.8	61.2	60.7	60.7	-	-	-	-
	3	68.6	72.6	70.7	72.4	74	-	72.6	72.5	71.3	72.6	72.5	72.2	-	-	-	-
	5	83.8	85.5	84.6	85.4	86.6	-	85.3	85.1	84.6	85.2	85.8	85.1	-	-	-	-
	10	104.6	101.7	103.5	101.7	101.4	-	101.1	100.7	102	100.7	102.9	101.6	-	-	-	-
	20	125.3	117.3	123.3	117.5	114.6	-	116.1	115.6	119.3	115.5	119.5	117.6	-	-	-	-
	30	137.5	126.2	135.3	126.7	121.8	-	124.8	124.1	129.5	124	129.2	127	-	-	-	-
	50	152.7	137.4	151.1	138.2	130.5	-	135.6	134.8	142.6	134.6	141.4	138.7	-	-	-	-
	80	166.8	147.6	166.3	148.7	138.1	-	145.5	144.6	154.9	144.3	152.8	149.6	-	-	-	-
	100	173.5	152.4	173.7	153.7	141.6	-	150.3	149.2	160.8	148.9	158.2	154.8	-	-	-	-
	150	185.6	161.2	187.5	162.9	147.9	-	158.9	157.7	171.8	157.3	168.2	164.3	-	-	-	-
	200	194.2	167.5	197.6	169.4	152.2	-	165	163.7	179.7	163.2	175.4	171.1	-	-	-	-
	400	215	182.4	222.9	185.1	162.3	-	179.9	178.3	199.2	177.7	192.9	187.8	-	-	-	-

■: Probability distribution model to be adopted, rainfall equivalent to flood in January 2020
Source: JICA study team



Source: JICA study team

Figure 2-55 Probable rainfall (the Ciliwung River basin)

(iv) Upstream basin of Manggarai weir

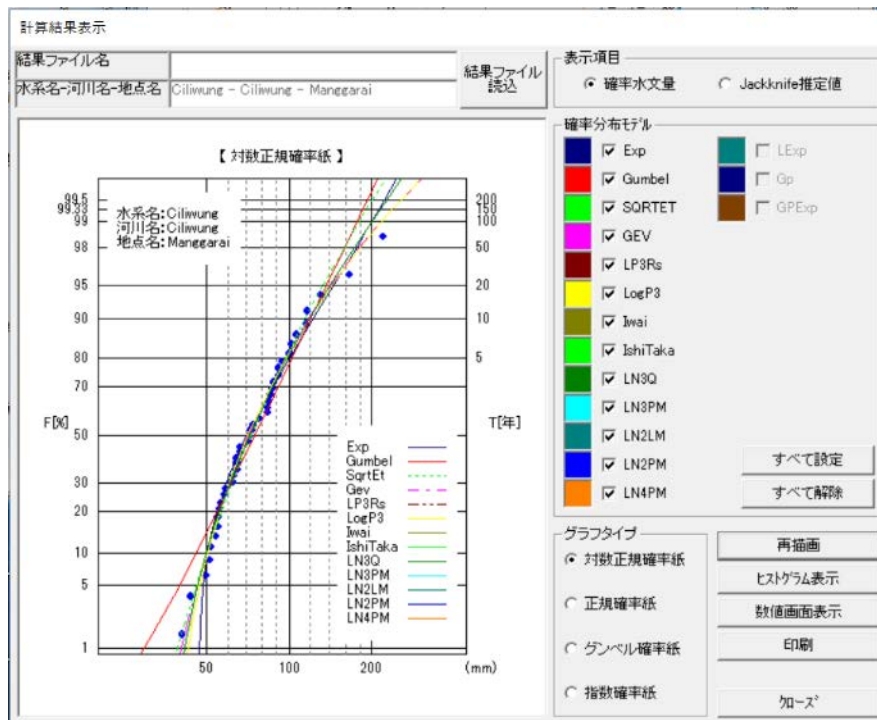
For the basin average daily rainfall in the upstream of Manggarai weir, the estimation results of the probable rainfalls are shown in Table 2-48 and Figure 2-56. Gev that gave the minimum SLSC was adopted as the most suitable distribution model. The probable rainfall of 50-year return period was estimated at 180.3 mm.

Table 2-48 Probable rainfall (upstream of Manggarai weir)

	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
X-COR(99%)	0.982	0.959	0.978	0.993	-	0.992	-	-	0.986	-	-	-	-	-	-	-
P-COR(99%)	0.984	0.992	0.996	0.997	-	0.997	-	-	0.997	-	-	-	-	-	-	-
SLSC(99%)	0.043	0.067	0.05	0.021	-	0.022	-	-	0.026	-	-	-	-	-	-	-
対数尤度	-184.5	-191.9	-189.5	-189.1	-	-189.6	-	-	-189.1	-	-	-	-	-	-	-
pAIC	373	387.9	382.9	384.1	-	385.2	-	-	384.2	-	-	-	-	-	-	-
X-COR(50%)	0.971	0.961	0.975	0.988	-	0.992	-	-	0.979	-	-	-	-	-	-	-
P-COR(50%)	0.987	0.99	0.991	0.989	-	0.997	-	-	0.99	-	-	-	-	-	-	-
SLSC(50%)	0.068	0.13	0.098	0.038	-	0.038	-	-	0.047	-	-	-	-	-	-	-

確率水文量	確率年	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
	2	69.8	74.9	72.6	70.9	-	70.7	-	-	71.5	-	-	-	-	-	-	-
	3	83.2	87.7	83.7	82.3	-	82.3	-	-	83.5	-	-	-	-	-	-	-
	5	100.1	101.9	96.9	96.8	-	97.3	-	-	98.4	-	-	-	-	-	-	-
	10	123	119.9	114.7	118	-	119.3	-	-	119.3	-	-	-	-	-	-	-
	20	146	137.1	133.1	142.2	-	144	-	-	141.3	-	-	-	-	-	-	-
	30	159.4	146.9	144.2	158.1	-	160	-	-	154.9	-	-	-	-	-	-	-
	50	176.3	159.3	158.7	180.3	-	182.2	-	-	172.9	-	-	-	-	-	-	-
	80	191.9	170.6	172.5	203	-	204.7	-	-	190.3	-	-	-	-	-	-	-
	100	199.2	176	179.3	214.7	-	216.2	-	-	198.9	-	-	-	-	-	-	-
	150	212.7	185.7	191.8	237.5	-	238.5	-	-	215	-	-	-	-	-	-	-
	200	222.2	192.6	200.9	255	-	255.6	-	-	226.9	-	-	-	-	-	-	-
	400	245.1	209.2	223.7	302.4	-	301.2	-	-	257	-	-	-	-	-	-	-

■ : Probability distribution model to be adopted, rainfall equivalent to flood in January 2020
Source: JICA study team



Source: JICA study team
Figure 2-56 Probable rainfall (upstream of Manggarai weir)

(v) The Cisadane River basin

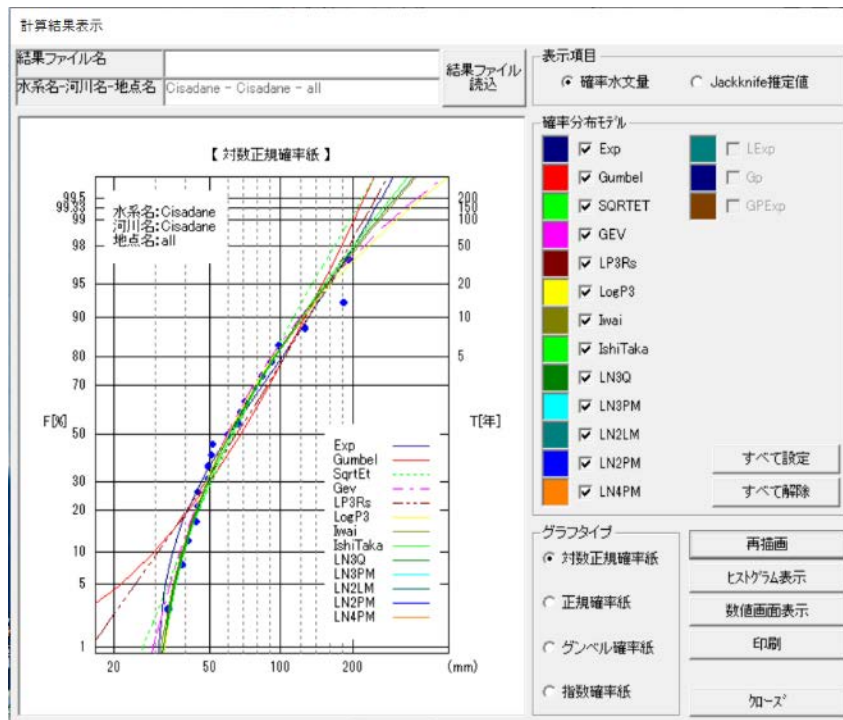
For the basin average daily rainfall in the Cisadane River basin, the estimation results of the probable rainfalls are shown in Table 2-49 and Figure 2-57. Iwai that gave the minimum SLSC was adopted as the most suitable distribution model. The probable rainfall of 50-year return period was estimated at 210.8 mm.

Table 2-49 Probable rainfall (the Cisadane River basin)

	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
X-COR(99%)	0.978	0.947	0.967	0.973	0.963	0.974	0.978	0.978	0.978	-	-	-	-	-	-	-
P-COR(99%)	0.989	0.968	0.987	0.994	0.976	0.995	0.993	0.992	0.994	-	-	-	-	-	-	-
SLSC(99%)	0.046	0.072	0.08	0.035	0.064	0.032	0.029	0.034	0.03	-	-	-	-	-	-	-
対数尤度	-100.3	-103.7	-100.9	-99.8	-102.7	-99.2	-99.4	-99.4	-99.3	-	-	-	-	-	-	-
pAIC	204.7	211.3	205.8	205.5	211.4	204.4	204.7	204.4	204.6	-	-	-	-	-	-	-
X-COR(50%)	0.969	0.967	0.967	0.954	0.968	0.974	0.963	0.964	0.963	-	-	-	-	-	-	-
P-COR(50%)	0.988	0.987	0.995	0.995	0.987	0.995	0.994	0.995	0.995	-	-	-	-	-	-	-
SLSC(50%)	0.072	0.129	0.153	0.064	0.095	0.054	0.057	0.067	0.061	-	-	-	-	-	-	-

確率水文量	確率年	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
	2	60.9	67.6	63.4	59.7	65.2	59.8	61	61.9	60.8	-	-	-	-	-	-	-
	3	78.6	84.6	76.2	72.9	82.8	73.6	75.5	75.9	74.9	-	-	-	-	-	-	-
	5	100.9	103.4	91.7	91.1	103.4	93	95	94.4	93.9	-	-	-	-	-	-	-
	10	131.2	127	112.9	120.3	130.4	124.4	124.6	122.1	122.6	-	-	-	-	-	-	-
	20	161.5	149.7	135	157.1	157.2	163.9	158.5	153.2	155.4	-	-	-	-	-	-	-
	30	179.2	162.8	148.6	183.1	173	191.6	180.5	173.2	176.8	-	-	-	-	-	-	-
	50	201.6	179.1	166.3	221.7	193	232.4	210.8	200.6	206.1	-	-	-	-	-	-	-
	80	222.1	194	183.4	264	211.7	277	241.4	227.9	235.6	-	-	-	-	-	-	-
	100	231.8	201.1	191.7	286.8	220.6	300.8	256.8	241.6	250.5	-	-	-	-	-	-	-
	150	249.6	213.9	207.3	333.3	237.1	349.1	286.5	267.9	279.2	-	-	-	-	-	-	-
	200	262.1	223	218.7	370.7	248.9	387.8	308.8	287.6	300.8	-	-	-	-	-	-	-
	400	292.4	244.9	247.2	478.9	277.7	498.7	367.5	338.9	357.5	-	-	-	-	-	-	-

■ : Probability distribution model to be adopted, rainfall equivalent to flood in January 2020
Source: JICA study team



Source: JICA study team

Figure 2-57 Probable rainfall (the Cisadane River basin)

(vi) Upstream basin of Pasar Baru weir

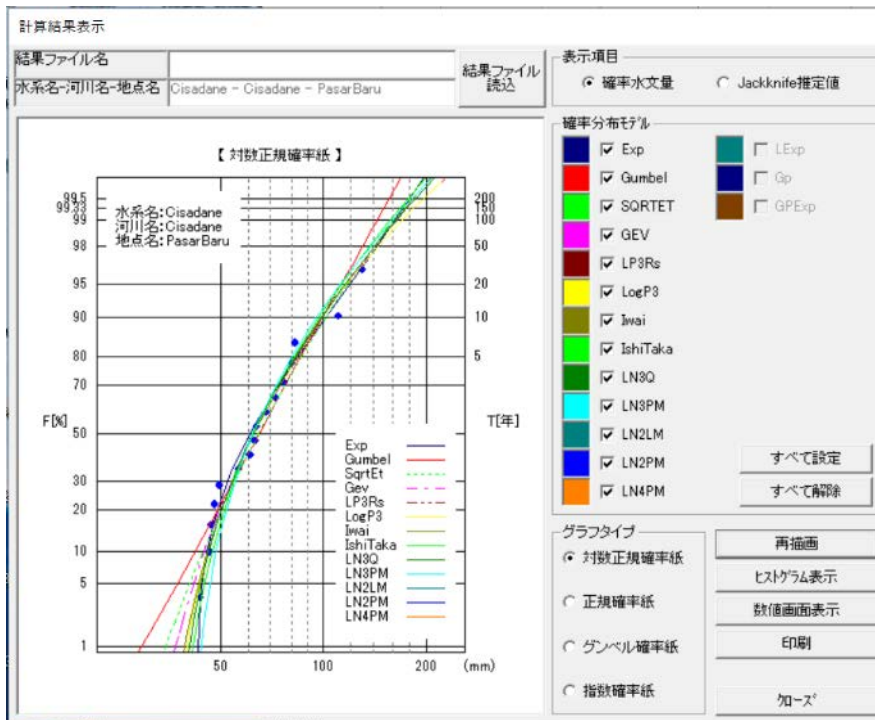
For the basin average daily rainfall in the upstream of Pasar Baru weir, the estimation results of the probable rainfalls are shown in Table 2-50 and Figure 2-58. Gev that gave the minimum SLSC was adopted as the most suitable distribution model. The probable rainfall of 50-year return period was estimated at 144.9 mm.

Table 2-50 Probable rainfall (upstream of Pasar Baru weir)

	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
X-COR(99%)	0.99	0.976	0.987	0.99	-	0.991	0.99	0.991	0.991	0.991	-	-	-	-	-	-
P-COR(99%)	0.989	0.989	0.99	0.99	-	0.99	0.99	0.989	0.989	0.986	-	-	-	-	-	-
SLSC(99%)	0.029	0.045	0.032	0.03	-	0.031	0.033	0.044	0.035	0.074	-	-	-	-	-	-
対数尤度	-68.1	-70.7	-70	-69.7	-	-69.3	-69.3	-69.2	-69.2	-69.7	-	-	-	-	-	-
pAIC	140.1	145.3	144.1	145.4	-	144.5	144.6	144.4	144.3	145.5	-	-	-	-	-	-
X-COR(50%)	0.983	0.979	0.982	0.984	-	0.991	0.983	0.984	0.984	0.984	-	-	-	-	-	-
P-COR(50%)	0.982	0.983	0.984	0.987	-	0.99	0.986	0.987	0.986	0.987	-	-	-	-	-	-
SLSC(50%)	0.041	0.081	0.053	0.047	-	0.046	0.048	0.058	0.05	0.063	-	-	-	-	-	-

確率水文学	確率年	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
	2	60.5	64.5	64.2	61.8	-	61.8	62.3	62.1	61.7	61.8	-	-	-	-	-	-
	3	71	74.5	74.2	70.8	-	70.9	71.7	70.8	70.8	69.9	-	-	-	-	-	-
	5	84.2	85.7	86.1	82.2	-	82.5	83.3	81.6	82.4	80.4	-	-	-	-	-	-
	10	102.2	99.7	102.1	98.6	-	99.2	99.7	97	98.7	95.8	-	-	-	-	-	-
	20	120.1	113.1	118.7	116.9	-	117.6	117	113.4	116.4	112.7	-	-	-	-	-	-
	30	130.6	120.9	128.7	128.7	-	129.5	127.7	123.6	127.5	123.4	-	-	-	-	-	-
	50	143.9	130.6	141.8	144.9	-	145.6	141.8	137.1	142.2	137.9	-	-	-	-	-	-
	80	156	139.4	154.2	161.4	-	161.8	155.6	150.3	156.6	152.2	-	-	-	-	-	-
	100	161.8	143.6	160.3	169.7	-	170	162.3	156.9	163.7	159.3	-	-	-	-	-	-
	150	172.3	151.2	171.6	185.9	-	185.9	175	169.2	177.2	172.9	-	-	-	-	-	-
	200	179.8	156.6	179.8	198.3	-	197.9	184.4	178.2	187.2	183	-	-	-	-	-	-
	400	197.8	169.6	200.4	231.1	-	229.6	208.2	201.4	212.7	209.1	-	-	-	-	-	-

■ : Probability distribution model to be adopted, rainfall equivalent to flood in January 2020
Source: JICA study team



Source: JICA study team

Figure 2-58 Probable rainfall (upstream of Pasar Baru weir)

(vii) Summary of probable rainfall in each basin

The estimated probable rainfalls and the design rainfalls of the existing river improvement plans are summarized in Table 2-51. The estimated probable rainfalls are bigger than the

design rainfalls for the upstream basin of Manggarai weir and the Cisadane River basin, but smaller for the Bekasi River basin and the upstream basin of Pasar Baru weir.

The main reason of the differences between the existing plan and this study is the differences of the estimation methods, especially the number of stations, the number of data years, the calculation method of basin average rainfall, and the adopted distribution models. In particular, the calculation methods of basin average rainfalls applied in the existing plans for the Bekasi and Cisadane River basins seem to be too rough, compared with the Thiessen method applied in this study. Since this study used data of more stations as well as more years, it is deemed that the estimated probable rainfalls reflect the recent rainfall trend more appropriately.

Table 2-51 Probable rainfall (summary of each basin)

Basin		The Bekasi River basin	Upstream of Bekasi weir
1/50		142.5 mm/day	212.4 mm/day
1/100		163.7 mm/day	244.1 mm/day
probability distribution model, SLSC		SqrtEt, 0.04	SqrtEt, 0.041
Number of stations		7~13 stations	2~6 stations
Statistical years		21 years (1996~2020)	23 years (1996~2020)
Flood in Jan 2020*	basin average daily rainfall	138.2 mm/day	151.5 mm/day
	Return period	43-year	11-year
Existing plan	1/50	162.1 mm/day	—
	1/100	175.2 mm/day	—
	Notes	DD in 2015, Gumbel, 6 stations, 1989~2014, arithmetic average rainfall	—

Basin		The Ciliwung River basin	Upstream of Manggarai weir
1/50		138.7 mm/day	180.3 mm/day
1/100		154.8 mm/day	214.7 mm/day
probability distribution model, SLSC		LN 2 PM, 0.03	Gev, 0.021
Number of stations		7~23 stations	2~10 stations
Statistical years		33 years (1985~2020)	41 years (1980~2020)
Flood in Jan 2020*	basin average daily rainfall	93.3 mm/day	101.3 mm/day
	Return period	7-year	6-year
Existing plan	1/50	—	176.5 mm/day
	1/100	—	192.9 mm/day
	Notes	—	JICA study in 2013, Gumbel, 8 stations, 1992~2008, Thiessen method

Basin		The Cisadane River basin	Upstream of Pasar Baru weir
1/50		210.8 mm/day	144.9 mm/day
1/100		256.8 mm/day	169.7 mm/day
probability distribution model, SLSC		Iwai, 0.029	Gev, 0.03
Number of stations		6~11 stations	6~10 stations
Statistical years		21 years (1998~2020)	16 years (2003~2020)
Flood in Jan 2020*	basin average daily rainfall	91.2 mm/day	78.9 mm/day
	Return period	5-year	4-year
Existing plan	1/50	105.0 mm/day	185.7 mm/day
	1/100	116.0 mm/day	206.8 mm/day
	Notes	MP in 1997, Gumbel, basin average rainfall was calculated by probable rainfall at an observatory station.	DD in 2015, Gumbel and L-moments, 5 stations, 2005~2014, basin average rainfall by Thiessen method based on probable rainfall at observatory site

*See 0 for the return period of the flood in Jan 2020

Source: JICA study team

(3) Rainfall probability of the flood in January 2020

The return period of the flood in January 2020 in terms of daily rainfall was also estimated for each station and for each basin.

(i) Probability of each station

The return period of daily rainfall at each observatory station during the flood in January 2020 was estimated as shown in Table 2-52. The maximum return period is 30 to 50 years at Rawadukuh_Dkt.28 station (180 mm/day).

Table 2-52 (1/2) Rainfall probability of the flood in Jan 2020

Station	AWS Staklim Tangerang Selatan	Stasiun Klimatologi Bogor	Stasiun Meteorologi Siteko (Puncak)	Stasiun meteorologi Kemayoran	Stasiun Meteorologi Maritim Tanjung priok	Stasiun 2-93etrology Soekarno Hatta
Daily rainfall (mm/day)	208.9	44.4	60.0	145.3	146.1	147.9
Date	2020/1/1	2020/1/1	2020/1/1	2020/1/1	2020/1/1	2020/1/1
Return period	1/20 ~ 1/30	~ 1/2	~ 1/2	1/3 ~ 1/5	1/3 ~ 1/5	1/5 ~ 1/10

Station	Pondok Betung Cileduk	Darmaga Bogor	Bojong Murni	Cigudeg	Pasir jaya	Ranca Burgur
Daily rainfall (mm/day)	—	—	87.0	290.0	42.0	89.0
Date	—	—	2020/1/1	2019/12/31	2020/1/1	2019/12/31
Return period	—	—	Error	Error	~ 1/2	1/2 ~ 1/3

Station	PLTA Kracak	Bendung Pasar Baru	Perk.Gunung Mas	Cilember	Gadog	Kampung Kelapa
Daily rainfall (mm/day)	137.0	125.0	132.0	105.0	95.5	148.5
Date	2020/1/1	2020/1/1	2019/12/31	2019/12/31	2019/12/31	2019/12/31
Return period	1/2 ~ 1/3	1/10 ~ 1/20	1/3 ~ 1/5	1/2 ~ 1/3	~ 1/2	Error

Station	Depok	Kampus UI	Cibinong	Kemensos	Pa. Manggarai	Villa Pamulang
Daily rainfall (mm/day)	103.0	155.2	107.5	63.0	106.5	112.0
Date	2020/1/1	2020/1/1	2019/12/31	2019/12/31	2019/12/31	2019/12/31
Return period	Error	1/10 ~ 1/20	1/2 ~ 1/3	Error	~ 1/2	Error

Station	Lengkong Barang	Ranca Sumur	Situ Parigi	Sawangan	Bend. Gintung	Jeruk Purut
Daily rainfall (mm/day)	85.5	34.0	158.0	135.0	135.0	102.0
Date	2019/12/31	2019/12/31	2019/12/31	2019/12/31	2019/12/31	2019/12/31
Return period	Error	~ 1/2	Error	1/5 ~ 1/10	1/10 ~ 1/20	Error

*Error : The hydrological statistics utility fails to calculate the probable rainfall. The cause is the number of samples is too small.

*— : No Data

Source: JICA study team

Table 2-52(2/2) Rainfall probability of the flood in Jan 2020

Station	Jatijajar	Cawang	Sumur Batu	Cengkareng Drain	TELUK PUCUNG BKS 10	KRANJI DKT 25
Daily rainfall (mm/day)	100.8	109.0	251.0	185.0	162.0	120.0
Date	2020/1/1	2019/12/31	2019/12/31	2019/12/31	2020/1/1	2020/1/1
Return period	1/2 ~ 1/3	~ 1/2	1/3 ~ 1/5	1/5 ~ 1/10	1/10 ~ 1/20	1/3 ~ 1/5

Station	Rawa Rolotan _ Dkt. 30	Muara Bks. 78 .B	Babakan-Bma. 27	Tambun _ Dkt. 27	Rawadukuh _ Dkt. 28	Civitung _ 78 C
Daily rainfall (mm/day)	—	—	—	—	180.0	147.0
Date	—	—	—	—	2020/1/1	2020/1/1
Return period	—	—	—	—	1/30 ~ 1/50	1/20 ~ 1/30

Station	Pilar _ 82 .a	Srengseng 82 .c	Lemahabang 100	Rengas Bandung BRbd.6	Rengas Bandung-03	Cibarusah -85
Daily rainfall (mm/day)	—	91.0	141.0	83.0	—	150.0
Date	—	2020/1/1	2020/1/1	2020/1/1	—	2020/1/1
Return period	—	~ 1/2	1/2 ~ 1/5	1/5 ~ 1/10	—	1/20 ~ 1/30

Station	Bd. Cikarang -9 a-CH	Bd. Bekasi -10 a-CH	Cikeas-Dkt. 26	Pondoggede – Dkt. 33
Daily rainfall (mm/day)	135.0	150.0	16.5	—
Date	2020/1/1	2020/1/1	2020/1/2	—
Return period	1/3 ~ 1/5	1/10 ~ 1/20	~ 1/2	—

*Error : The hydrological statistics utility fails to calculate the probable rainfall. The cause is the number of samples is too small.

*— : No Data

Source: JICA study team

(ii) Probability of basin average rainfall

The return period of basin average daily rainfall for each basin during the flood in January 2020 was estimated as shown in Table 2-53. In the Bekasi River basin, where the flood damage was particularly severe, the return period is 43 years.

Table 2-53 Rainfall probability of the flood in Jan 2020

Basin	the Bekasi River basin	the Ciliwung River basin	the Cisadane River basin
Basin average rainfall (mm/day)	138.2	93.3	91.2
Date	2020/1/1	2020/1/1	2019/12/31
Return period	1/43	1/7	1/5
Probability distribution model	SqrtEt	LN2PM	Iwai

Basin	Upstream of Bekasi weir	Upstream of Manggarai	Upstream of Pasar Baru
Basin average rainfall (mm/day)	151.5	101.3	78.9
Date	2019/12/31	2019/12/31	2020/1/1
Return period	1/11	1/6	1/4
Probability distribution model	SqrtEt	Gev	Gev

Source: JICA study team

(4) [Reference] Probable rainfall of each basin using POT data

Based on basin average daily rainfalls calculated in 2.1.4(1), probable rainfalls were estimated by using POT data (Peaks Over Threshold data) for reference. POT data are not annual maximum series (AMS) data. The AMS data are generally used to estimate the probable rainfalls in accordance with the Technical Standards for River and Sabo, MLIT Japan, as conducted in the previous sections.

The number of the POT data used for the estimation of the probable rainfalls is the same as the AMS data. The hydrological statistics utility Ver.1.5 (Japan Institute of Country-ology and Engineering) supports three probability distribution models for POT data as presented in Table 2-54. The probability distribution model that gives the minimum SLSC is adopted.

For the design rainfall, the rainfall within the design rainfall duration shall be used for hydrological statistical analysis. The data for this hydrological statistical analysis are the annual maximum series data (AMS data), or peaks over threshold data (POT data) which are selected, in descending order, as many as the AMS data. In addition, the design rainfall will be determined in consideration of the fitness and stability of the probability distribution model.

Source : Guideline of flood control plan, 2000, Japan Institute of Country-ology and Engineering

Figure 2-59 Number of data for statistical analysis

Table 2-54 Probability distribution model (POT data)

	Probability distribution model	Abbreviation
1	Exponential distribution (L-moments)	Lexp
2	Generalized Pareto distribution	Gp
3	Generalized Pareto distribution (Exponential distribution)	GpExp

Source : Japan Institute of Country-ology and Engineering

(i) The Bekasi River basin

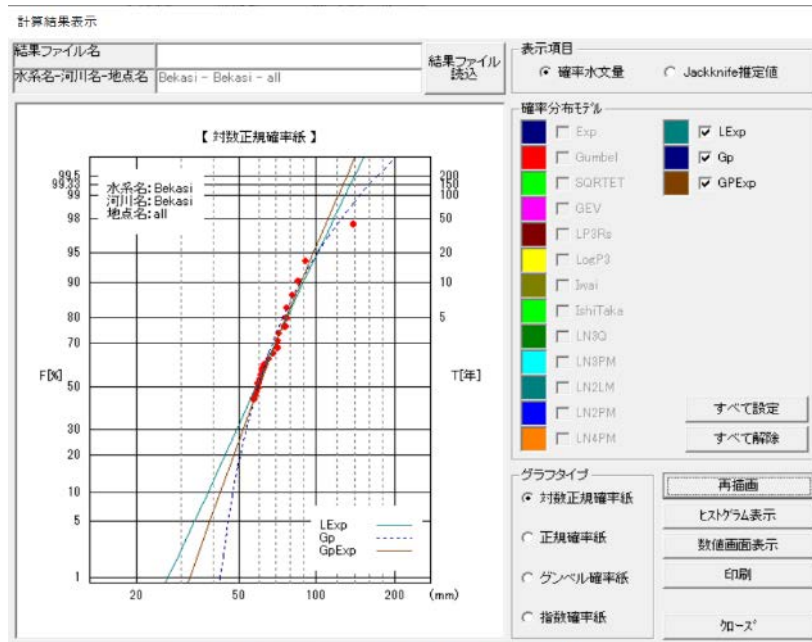
For the basin average daily rainfall in the Bekasi River basin, the estimation results of the probable rainfalls based on the POT data are shown in Table 2-55 and Figure 2-60. Gp that gave the minimum SLSC was adopted as the most suitable distribution model. The probable rainfall of 50-year return period was estimated at 125.0 mm.

Table 2-55 Probable rainfall (the Bekasi River basin)

	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp	
X-COR(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.951	0.978	0.951
P-COR(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.991	0.991	0.992
SLSC(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.074	0.039	0.098
対数尤度	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-80.1	-76.9	-77.2
pAIC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	164.3	159.7	158.4
X-COR(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.933	0.965	0.933
P-COR(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.978	0.985	0.986
SLSC(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.119	0.051	0.158

確率水文量	確率年	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp	
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	58.3	59.4	60.1
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	67.3	65.9	67.9
	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	77.3	74.3	76.6
	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	89.8	86.9	87.5
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101.8	101.5	97.9
	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	108.8	111.2	103.9
	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	117.4	125	111.5
	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	125.3	139.3	118.3
	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	129.1	146.8	121.6
	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	135.9	161.4	127.5
	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	140.7	172.8	131.7
	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	152.3	203.9	141.8

■ : Probability distribution model to be adopted, rainfall equivalent to flood in January 2020
Source: JICA study team



Source: JICA study team

Figure 2-60 Probable rainfall (the Bekasi River basin)

(ii) Upstream basin of Bekasi weir

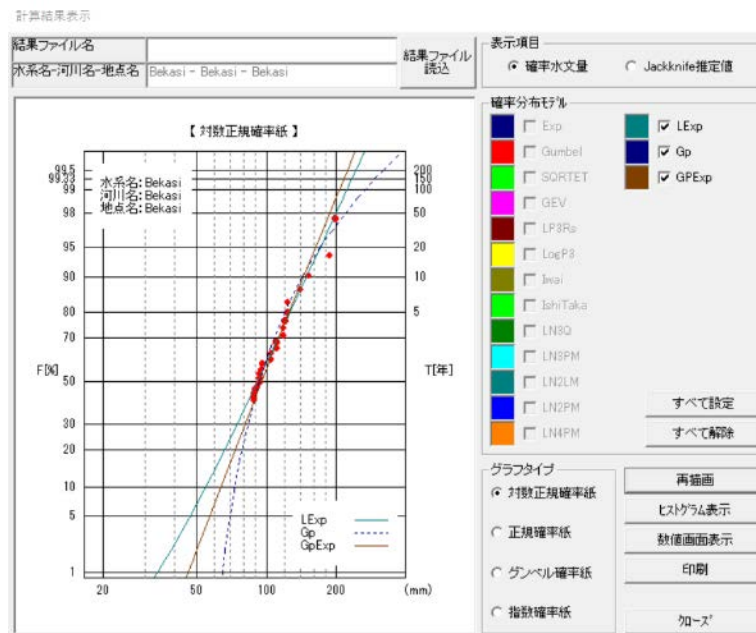
For the basin average daily rainfall in the upstream basin of Bekasi weir, the estimation results of the probable rainfalls based on the POT data are shown in Table 2-56 and Figure 2-61. Lexp that gave the minimum SLSC was adopted as the most suitable distribution model. The probable rainfall of 50-year return period was estimated at 199.8 mm.

Table 2-56 Probable rainfall (Upstream of Bekasi weir)

	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
X-COR(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.986	0.977	0.986
P-COR(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.989	0.988	0.991
SLSC(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.036	0.04	0.061
対数尤度	-	-	-	-	-	-	-	-	-	-	-	-	-	-101.6	-97.6	-97.9
pAIC	-	-	-	-	-	-	-	-	-	-	-	-	-	207.2	201.2	199.7
X-COR(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.976	0.966	0.976
P-COR(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.978	0.981	0.981
SLSC(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.056	0.05	0.094

確率水文量	確率年	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	91.9	93.2	95.2
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	108.3	104.7	109.1
	5	-	-	-	-	-	-	-	-	-	-	-	-	-	126.5	119.9	124.6
	10	-	-	-	-	-	-	-	-	-	-	-	-	-	149.4	143.3	144.1
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	171.4	171.2	162.7
	30	-	-	-	-	-	-	-	-	-	-	-	-	-	184	190.3	173.5
	50	-	-	-	-	-	-	-	-	-	-	-	-	-	199.8	217.7	186.9
	80	-	-	-	-	-	-	-	-	-	-	-	-	-	214.3	246.8	199.1
	100	-	-	-	-	-	-	-	-	-	-	-	-	-	221.1	262.1	205
	150	-	-	-	-	-	-	-	-	-	-	-	-	-	233.5	292.7	215.5
	200	-	-	-	-	-	-	-	-	-	-	-	-	-	242.4	316.8	223
	400	-	-	-	-	-	-	-	-	-	-	-	-	-	263.5	384	241

■ : Probability distribution model to be adopted, rainfall equivalent to flood in January 2020
Source: JICA study team



Source: JICA study team
Figure 2-61 Probable rainfall (Upstream of Bekasi weir)

(iii) The Ciliwung River basin

For the basin average daily rainfall in the Ciliwung River basin, the estimation results of the probable rainfalls based on the POT data are shown in Table 2-57 and Figure 2-62. Lexp that gave the smallest estimation error of the Jackknife method among the models of the minimum SLSC was adopted as the most suitable distribution model. The probable rainfall of 50-year return period was estimated at 133.4 mm.

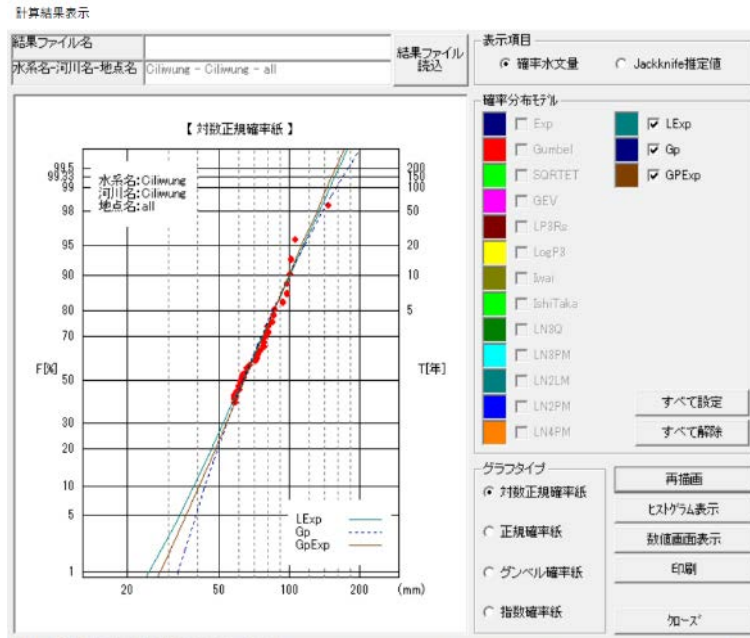
Table 2-57 Probable rainfall (the Ciliwung River basin)

	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
X-COR(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.985	0.984	0.985
P-COR(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.993	0.989	0.992
SLSC(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.036	0.036	0.04
対数尤度	-	-	-	-	-	-	-	-	-	-	-	-	-	-131.8	-130.1	-130
pAIC	-	-	-	-	-	-	-	-	-	-	-	-	-	267.7	266.2	264
X-COR(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.969	0.975	0.969
P-COR(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.99	0.991	0.991
SLSC(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.057	0.046	0.061

確率水文学	確率年	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	62.8	63	63.5
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	73.5	72.6	73.7
	5	-	-	-	-	-	-	-	-	-	-	-	-	-	85.4	84	84.9
	10	-	-	-	-	-	-	-	-	-	-	-	-	-	100.4	99.4	99.1
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	114.8	115.4	112.7
	30	-	-	-	-	-	-	-	-	-	-	-	-	-	123.1	125.2	120.5
	50	-	-	-	-	-	-	-	-	-	-	-	-	-	133.4	138.1	130.3
	80	-	-	-	-	-	-	-	-	-	-	-	-	-	142.9	150.6	139.3
	100	-	-	-	-	-	-	-	-	-	-	-	-	-	147.4	156.7	143.5
	150	-	-	-	-	-	-	-	-	-	-	-	-	-	155.5	168.2	151.2
	200	-	-	-	-	-	-	-	-	-	-	-	-	-	161.3	176.7	156.7
	400	-	-	-	-	-	-	-	-	-	-	-	-	-	175.2	198.2	169.8

■ : Probability distribution model to be adopted, rainfall equivalent to flood in January 2020

Source: JICA study team



Source: JICA study team

Figure 2-62 Probable rainfall (the Ciliwung River basin)

(iv) Upstream basin of Manggarai weir

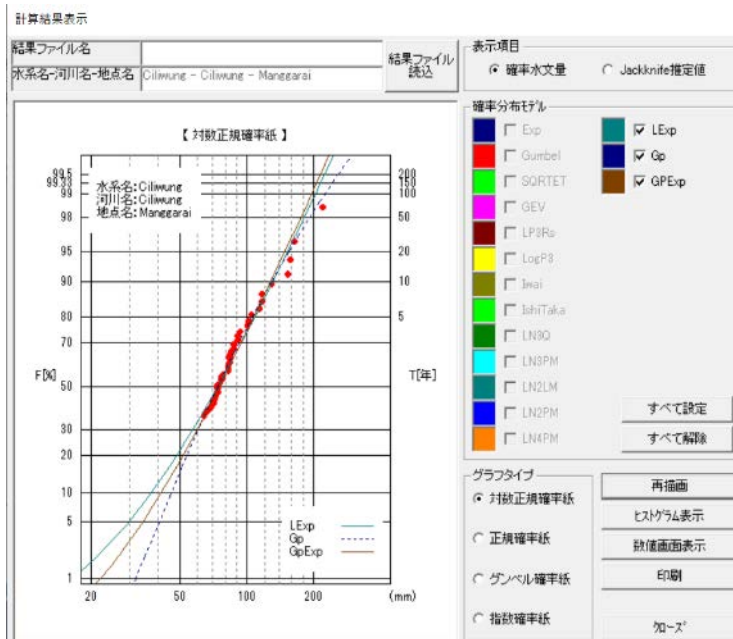
For the basin average daily rainfall in the upstream basin of Manggarai weir, the estimation results of the probable rainfalls based on the POT data are shown in Table 2-58 and Figure 2-63. Gp that gave the minimum SLSC was adopted as the most suitable distribution model. The probable rainfall of 50-year return period was estimated at 192.0 mm.

Table 2-58 Probable rainfall (Upstream of Manggarai weir)

	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp	
X-COR(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.984	0.993	0.984
P-COR(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.989	0.994	0.992
SLSC(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.045	0.026	0.057
対数尤度	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-181	-177.7	-177.9
pAIC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	366	361.3	359.9
X-COR(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.99	0.993	0.99
P-COR(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.988	0.991	0.989
SLSC(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.072	0.034	0.093

確率水文量	確率年	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp	
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	74.2	74.2	75.5
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	90.5	88.5	90.7
	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	108.7	105.7	107.5
	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	131.5	129.5	128.7
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	153.4	155	149
	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	166	170.8	160.7
	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	181.7	192	175.3
	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	196.1	212.9	188.7
	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	202.9	223.2	195
	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	215.3	242.9	206.5
	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	224.1	257.6	214.7
	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	245.2	295.5	234.3

■ : Probability distribution model to be adopted, rainfall equivalent to flood in January 2020
Source: JICA study team



Source: JICA study team
Figure 2-63 Probable rainfall (Upstream of Manggarai weir)

(v) The Cisadane River basin

For the basin average daily rainfall in the Cisadane River basin, the estimation results of the probable rainfalls based on the POT data are shown in Table 2-59 and Figure 2-64. Lexp that gave the minimum SLSC was adopted as the most suitable distribution model. The probable rainfall of 50-year return period was estimated at 220.0 mm.

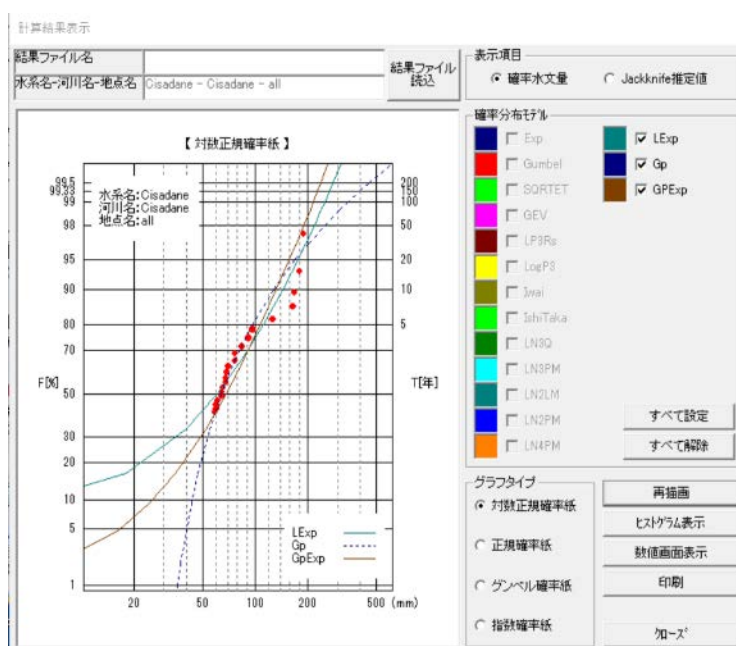
Table 2-59 Probable rainfall (the Cisadane River basin)

	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
X-COR(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.955	0.905	0.955
P-COR(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.956	0.992	0.971
SLSC(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.062	0.072	0.101
対数尤度	-	-	-	-	-	-	-	-	-	-	-	-	-	-101	-94.3	-95.7
pAIC	-	-	-	-	-	-	-	-	-	-	-	-	-	205.9	194.5	195.4
X-COR(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.927	0.851	0.927
P-COR(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.977	0.971	0.974
SLSC(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.097	0.091	0.158

確率水文量	確率年	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	60.8	64.1	68.1
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	85	77.5	86.9
	5	-	-	-	-	-	-	-	-	-	-	-	-	-	111.9	96.5	107.8
	10	-	-	-	-	-	-	-	-	-	-	-	-	-	145.7	129	134.1
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	178.1	172.1	159.3
	30	-	-	-	-	-	-	-	-	-	-	-	-	-	196.7	203.9	173.8
	50	-	-	-	-	-	-	-	-	-	-	-	-	-	220	252.8	191.9
	80	-	-	-	-	-	-	-	-	-	-	-	-	-	241.4	308.6	208.5
	100	-	-	-	-	-	-	-	-	-	-	-	-	-	251.5	339.4	216.4
	150	-	-	-	-	-	-	-	-	-	-	-	-	-	269.8	403.8	230.6
	200	-	-	-	-	-	-	-	-	-	-	-	-	-	282.8	457.1	240.7
	400	-	-	-	-	-	-	-	-	-	-	-	-	-	314.1	617	265

■ : Probability distribution model to be adopted, rainfall equivalent to flood in January 2020

Source: JICA study team



Source: JICA study team

Figure 2-64 Probable rainfall (the Cisadane River basin)

(vi) Upstream basin of Pasar Baru weir

For the basin average daily rainfall in the upstream basin of Pasar Baru weir, the estimation results of the probable rainfalls based on the POT data are shown in Table 2-60 and Figure 2-65. Gp that gave the minimum SLSC was adopted as the most suitable distribution model. The probable rainfall of 50-year return period was estimated at 154.4 mm.

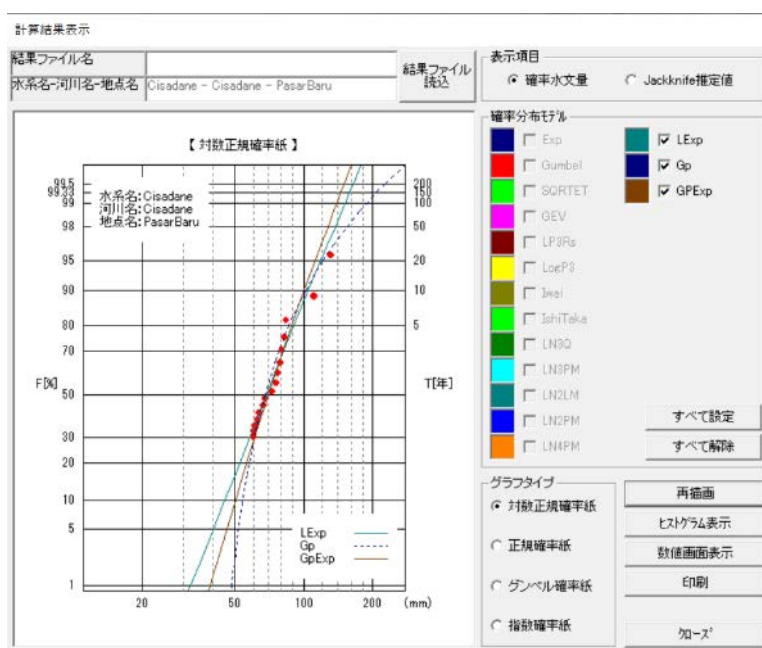
Table 2-60 Probable rainfall (Upstream of Pasar Baru weir)

	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp	
X-COR(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.977	0.985	0.977
P-COR(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.986	0.977	0.987
SLSC(99%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.047	0.045	0.074
対数尤度	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-63.4	-60.5	-60.6
pAIC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	130.7	126.9	125.2
X-COR(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.962	0.975	0.962
P-COR(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.934	0.953	0.947
SLSC(50%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.076	0.054	0.119

確率水文量	確率年	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM	Lexp	Gp	GpExp	
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	68.8	67.7	70
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	79.1	75.5	78.8
	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	90.6	85.9	88.5
	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	105.1	102.1	100.7
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	119	121.6	112.4
	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	127	135	119.1
	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	137	154.4	127.6
	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	146.1	175.1	135.3
	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	150.5	186.1	138.9
	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	158.3	208.1	145.5
	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	163.9	225.5	150.2
	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	177.3	274.4	161.5

■ : Probability distribution model to be adopted, rainfall equivalent to flood in January 2020

Source: JICA study team



Source: JICA study team

Figure 2-65 Probable rainfall (Upstream of Pasar Baru weir)

(vii) Summary of probable rainfall in each basin

The estimated probable rainfalls of POT data are compared in Table 2-61 with those of AMS data that were estimated in 2.1.4(2)(vii). The probable rainfalls of POT data are smaller than those of AMS data for the Bekasi River basin, the upstream of Bekasi weir, and the Ciliwung River basin, and bigger for the other basins. Regarding the SLSC values, the SLSC values of POT data are smaller for the Bekasi River basin and the upstream of Bekasi weir, and bigger in other basins.

Table 2-61 Probable rainfall with POT data (summary of each basin)

Basin		The Bekasi River basin	Upstream of Bekasi weir
1/50		125.0 mm/day	199.8 mm/day
1/100		146.8 mm/day	221.1 mm/day
probability distribution model, SLSC		Gp, 0.039	Lexp, 0.036
Flood in Jan 2020	basin average daily rainfall	138.2 mm/day	151.5 mm/day
	Return period	77-year	11-year
[Reference] AMS data*	1/50	142.5 mm/day	212.4 mm/day
	1/100	163.7 mm/day	244.1 mm/day
	probability distribution model, SLSC	SqrtEt, 0.04	SqrtEt, 0.041

Basin		The Ciliwung River basin	Upstream of Manggarai weir
1/50		133.4 mm/day	192.0 mm/day
1/100		147.4 mm/day	223.2 mm/day
probability distribution model, SLSC		Lexp, 0.036	Gp, 0.026
Flood in Jan 2020	basin average daily rainfall	93.3 mm/day	101.3 mm/day
	Return period	7-year	4-year
[Reference] AMS data*	1/50	138.7 mm/day	180.3 mm/day
	1/100	154.8 mm/day	214.7 mm/day
	probability distribution model, SLSC	LN 2 PM, 0.03	Gev, 0.021

Basin		The Cisadane River basin	Upstream of Pasar Baru weir
1/50		220.0 mm/day	154.4 mm/day
1/100		251.5 mm/day	186.1 mm/day
probability distribution model, SLSC		Lexp, 0.062	Gp, 0.045
Flood in Jan 2020	basin average daily rainfall	91.2 mm/day	78.9 mm/day
	Return period	3-year	4-year
[Reference] AMS data*	1/50	210.8 mm/day	144.9 mm/day
	1/100	256.8 mm/day	169.7 mm/day
	probability distribution model, SLSC	Iwai, 0.029	Gev, 0.03

*[Reference] Probable rainfall using AMS data : see 2.1.4(2)(vii)

Source: JICA study team

2.2 Damage Survey

A damage survey was conducted by interviewing the affected residents in order to understand the damage situation in detail and to provide basic data for the investigation and analysis of the causes of flood damage. The survey was conducted based on the data on damaged areas published by PUPR and DKI, and a total of 150 villages/neighborhoods (Rukun Tetangga, RT) were selected from 8 basins

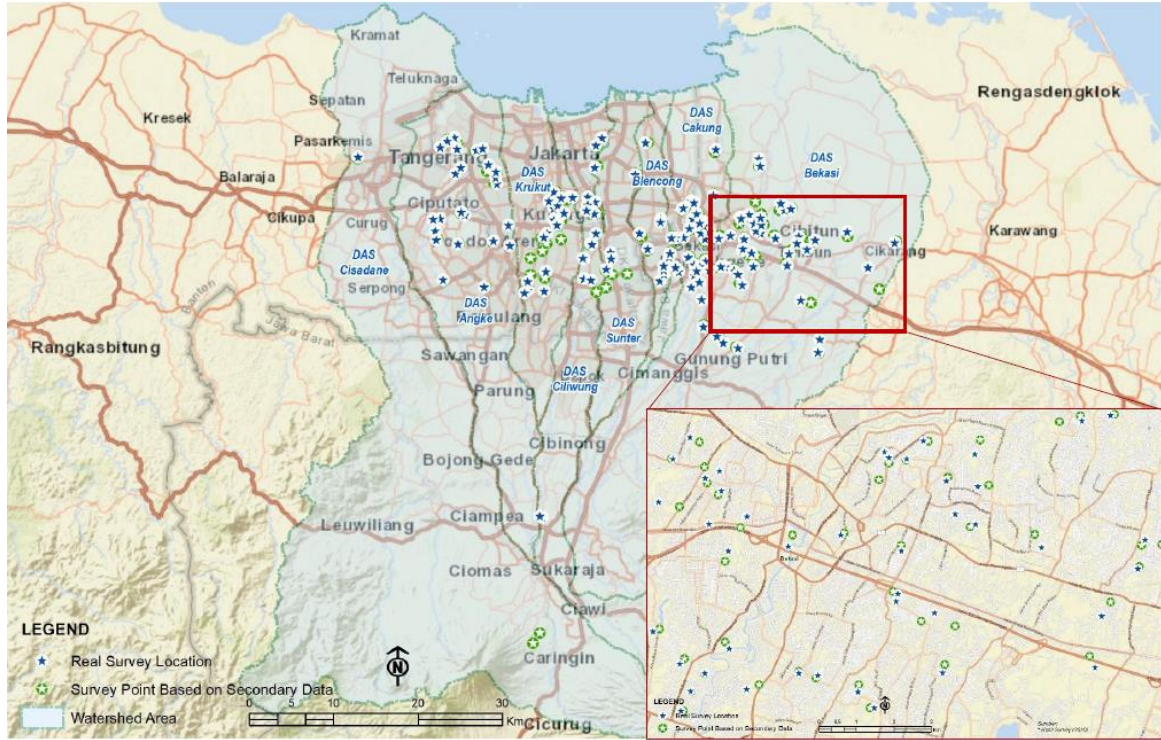


Figure 2-66 Damage Survey Area

The main survey items are: frequency of flooding, inundation depths of the 2020 flood, duration of flooding, and understanding of structural measures and evacuation actions.

As shown below, the surveyed areas are generally flooded about once/year.

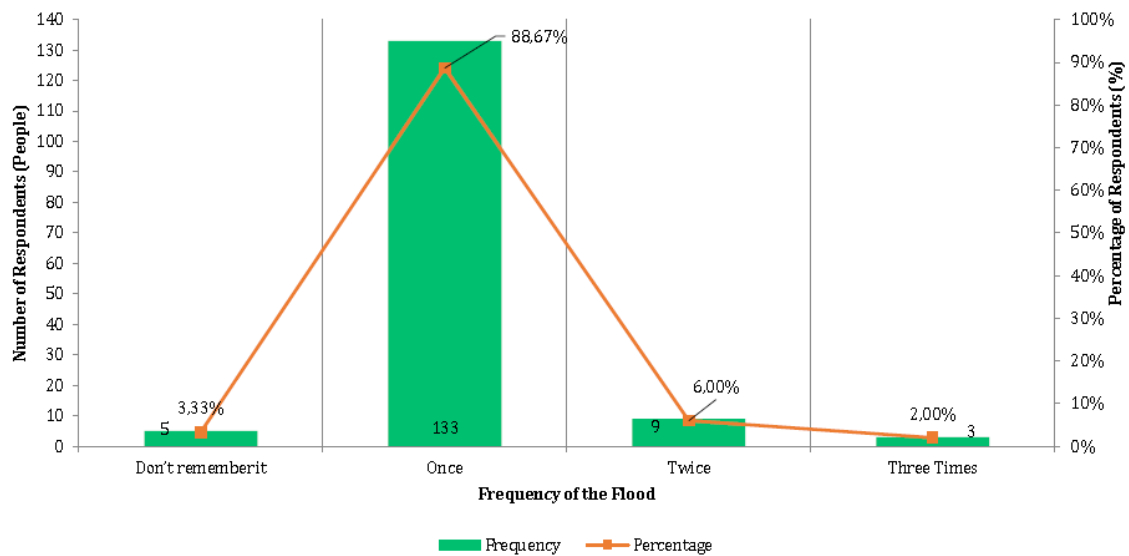


Figure 2-67 Frequency of the Flood

In the 2020 flood, inundation of about 50 cm occurred at many locations, followed by 1 m inundation.

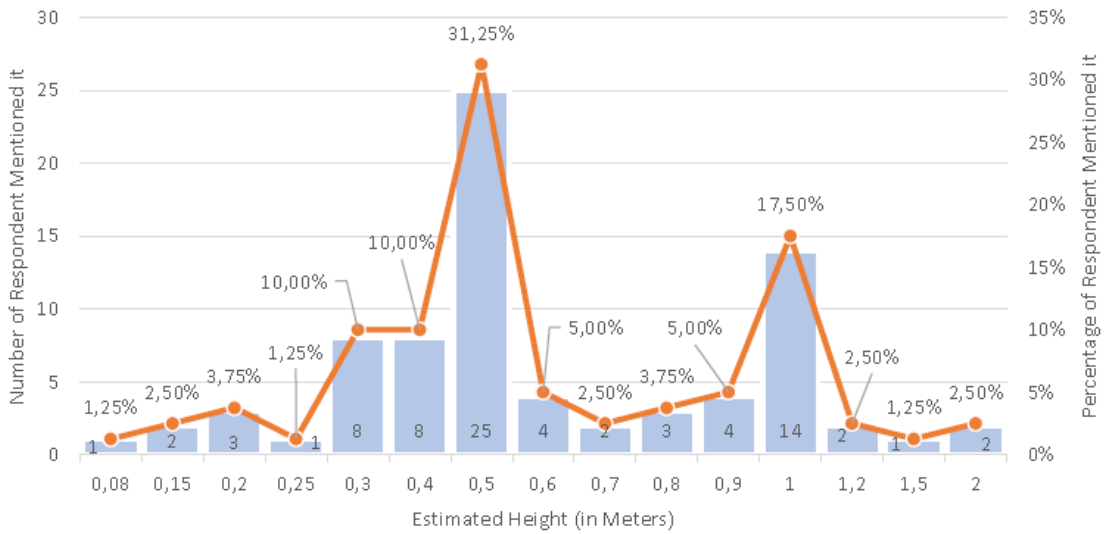


Figure 2-68 Maximum Inundation Depth in 2020 Flood

The most common time when disasters occurred was January 1 from 6 to 8 a.m., followed by 3:00 to 3:30 p.m.

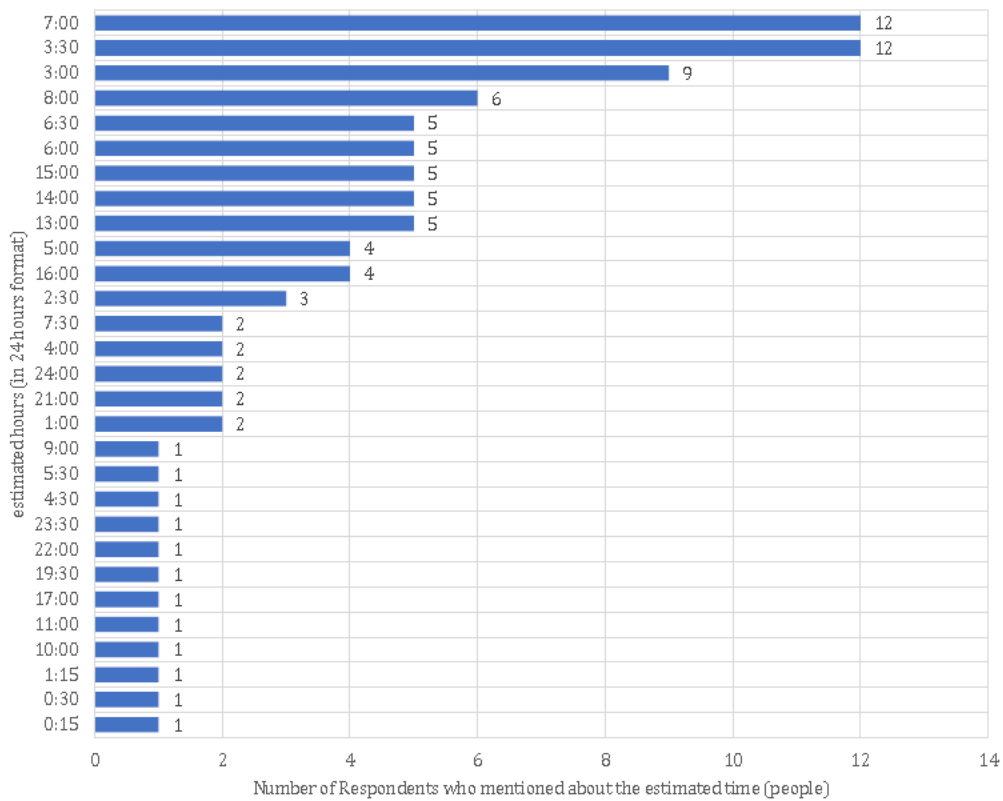


Figure 2-69 Time of Flood 2020

While infiltration, mobile pumps, and rubber boats for evacuation were highly rated as necessary structural measures to be introduced by residents, improved drainage channels were identified as facilities in need of improvement.

Table 2-62 Structure Measures Need to be Introduced

Respondents Opinion (Infrastructure or other activities that still needs to be provided in their neighborhood)	Number of Respondents who mentioned it (*)
bio pore holes	61
water suction pump	33
inflatable rubber boats	31
open spaces / green open spaces / water absorption areas	17
water gate (pintu air)	17
infiltrated wells	15
drainage / water channel / canal	14
trash can/ bin	7
waste bank (bank sampah)	3
tools to mitigate/warn for flooding	3
polder	3
cleaning waste on river	2
dam	2
river excavator / river dredging	2
river tunnel (sodetan)	1
clean water	1
respondents did not answer	13

Table 2-63 Structure Measures Need to be Improved

Respondents Opinion (Infrastructure or other activities that still needs to be improved/added in their neighborhood)	Number of Respondents who mentioned it (*)
increase / enlarge drainage capacity / improve the drainage / making the drainage runs smoothly / adding drainage / revitalizing drainage / cleaning drainage (including water tunnel)	106
adding/elevating river embankments	27
adding water suction pump	27
adding bio pore holes	17
open spaces / green open spaces / water absorption areas	15
adding infiltrated wells	12
adding trash can/bin	7
river normalization	5
widening the riverbank	4
cleaning river	3
adding inflatable rubber boats	3
river dredging	3
cleaning water gate	3
flood early warning	2
improve spatial planning	1
increasing road height	1
improving inlet river	1
land restoration	1
did not answer	1

Regarding evacuation, about 60% of residents said they acted on information from the pre-warning system, with social media being the most common means, and a combination of social media and speaker alerts was also common.

On the other hand, about half of the residents understood evacuation routes, and 63% of the RTs had shelters in place.

2.3 Flood Control Facility

Situation of flood control facilities (pumps and gates) were surveyed to obtain information on facility availability and issues during the 2020 flood and the basis for analysis. The target locations are shown in Table 2-64.

Table 2-64 Number of Target Facilities

Area	Number of Survey facility
DKI Jakarta	215
Bekasi City	78
Bekasi Regency	1
Tangerang City	58
Tangerang Regency	4
South Tangerang City	28
Depok City	10
Bogor Regency	6
Total	400

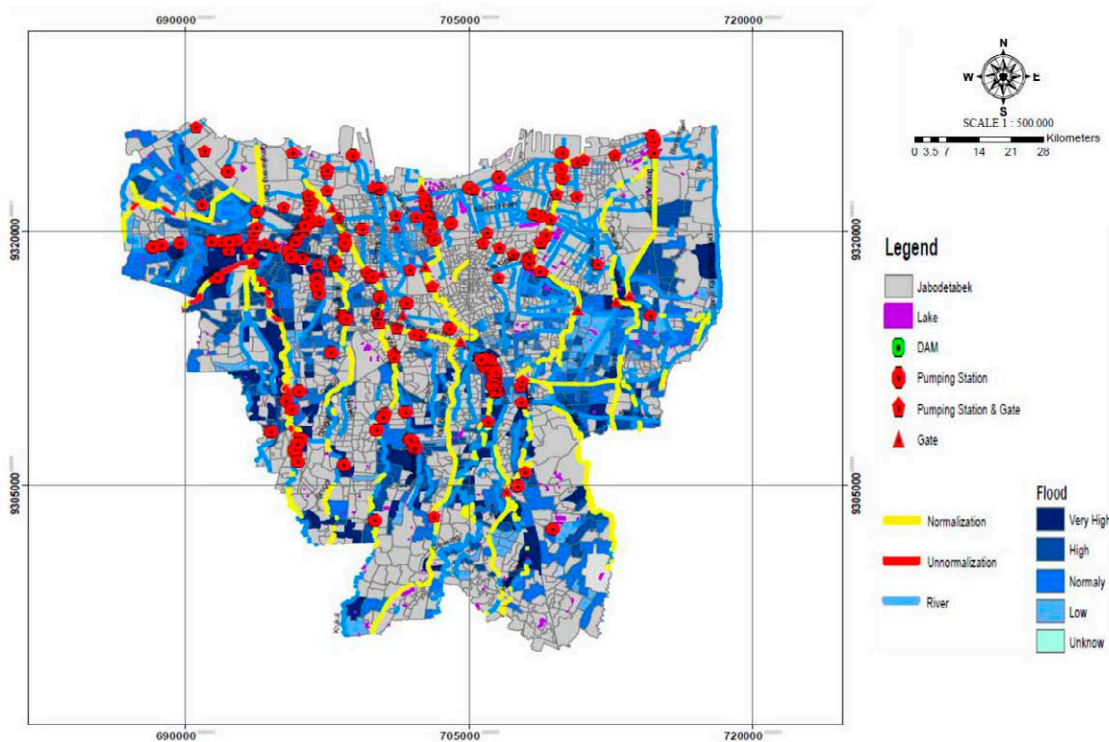


Figure 2-70 Target Location for Survey (DKI Jakarta)

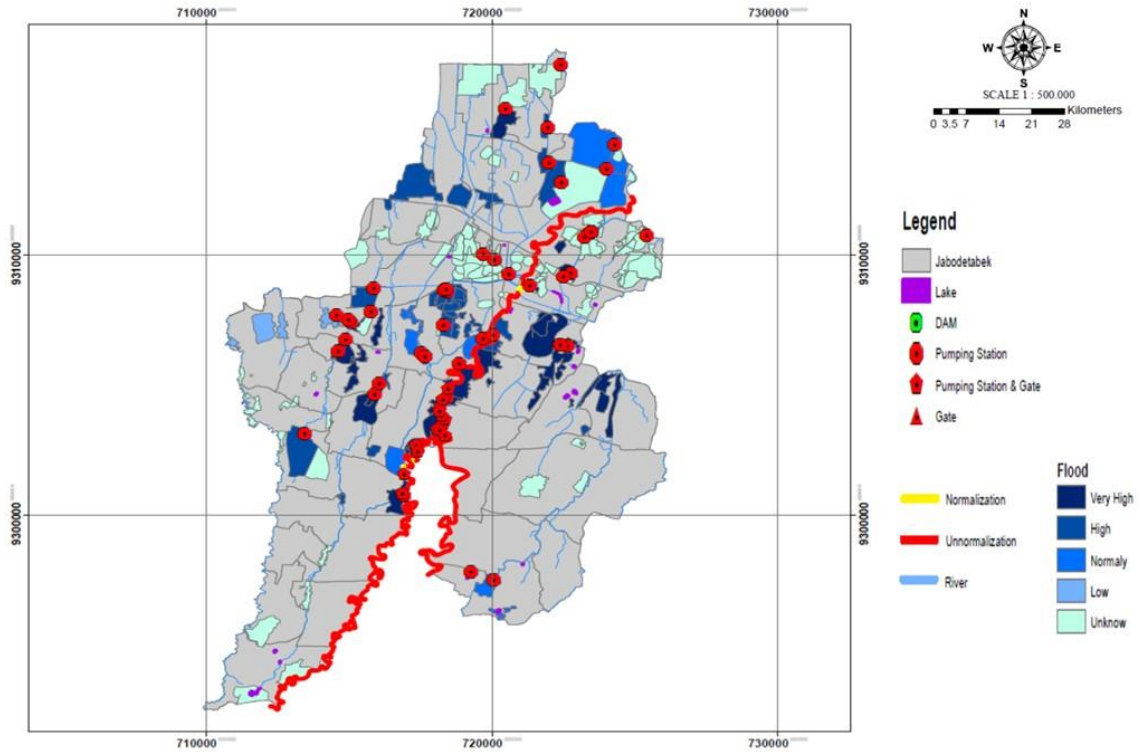


Figure 2-71 Target Location for Survey (Bekasi City)

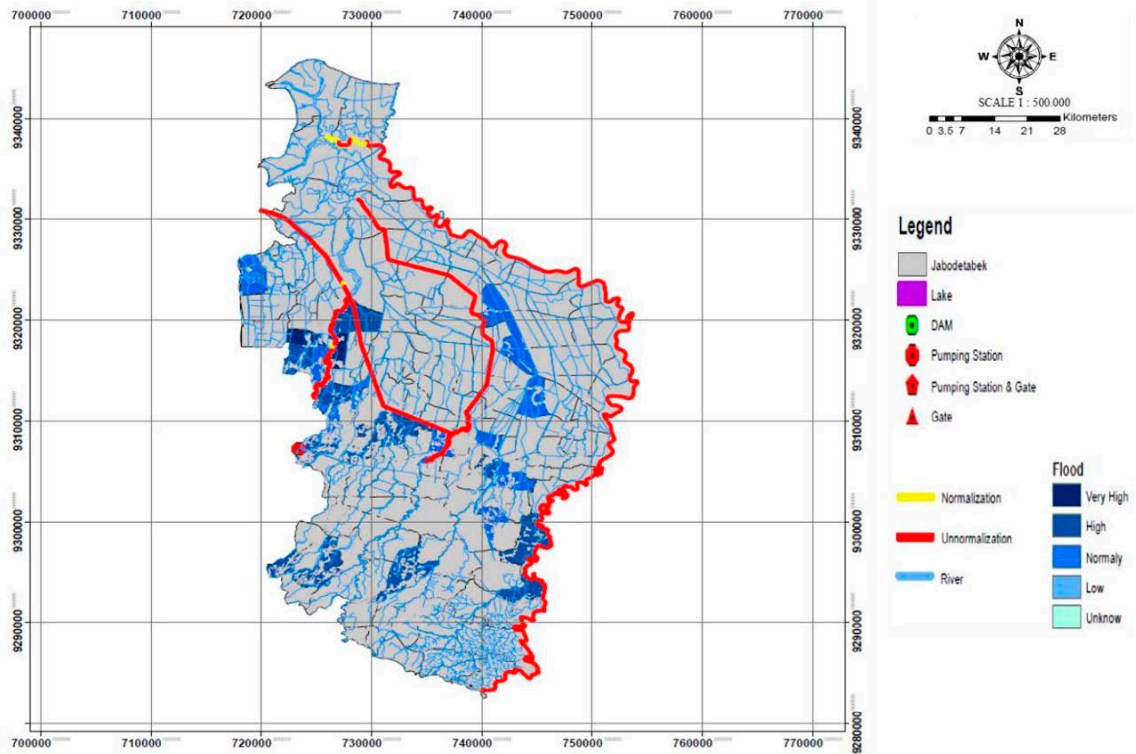


Figure 2-72 Target Location for Survey (Bekasi Regency)

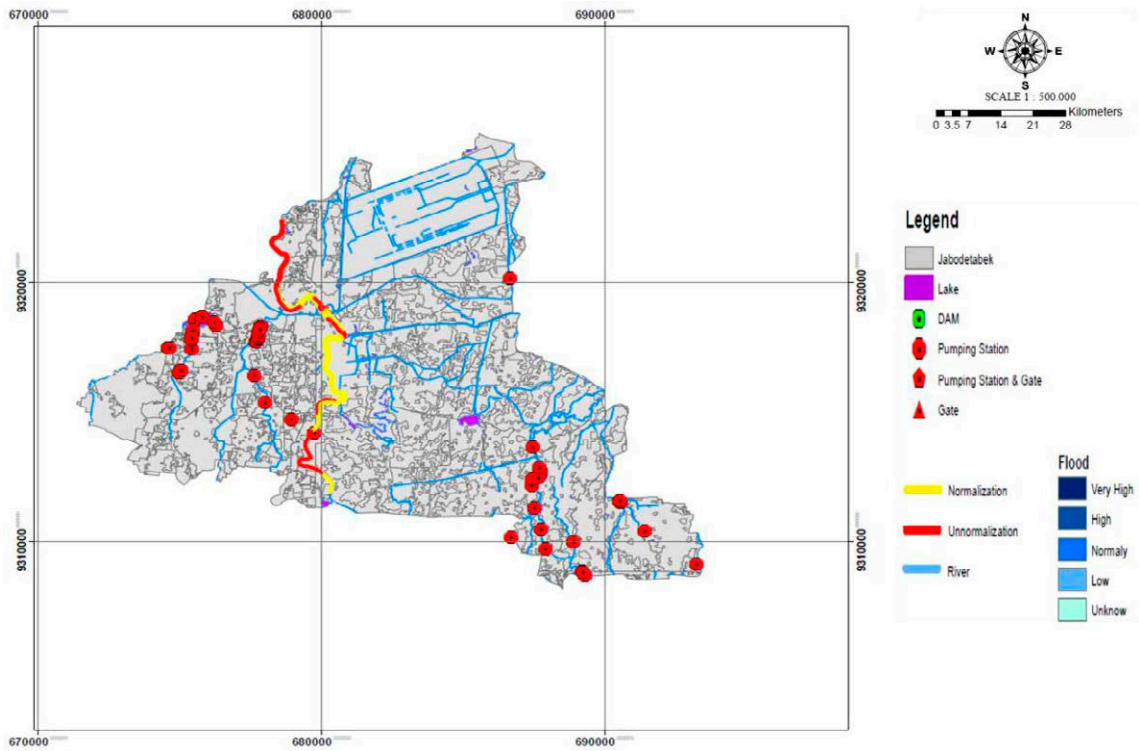


Figure 2-73 Target Location for Survey (Tangerang City)

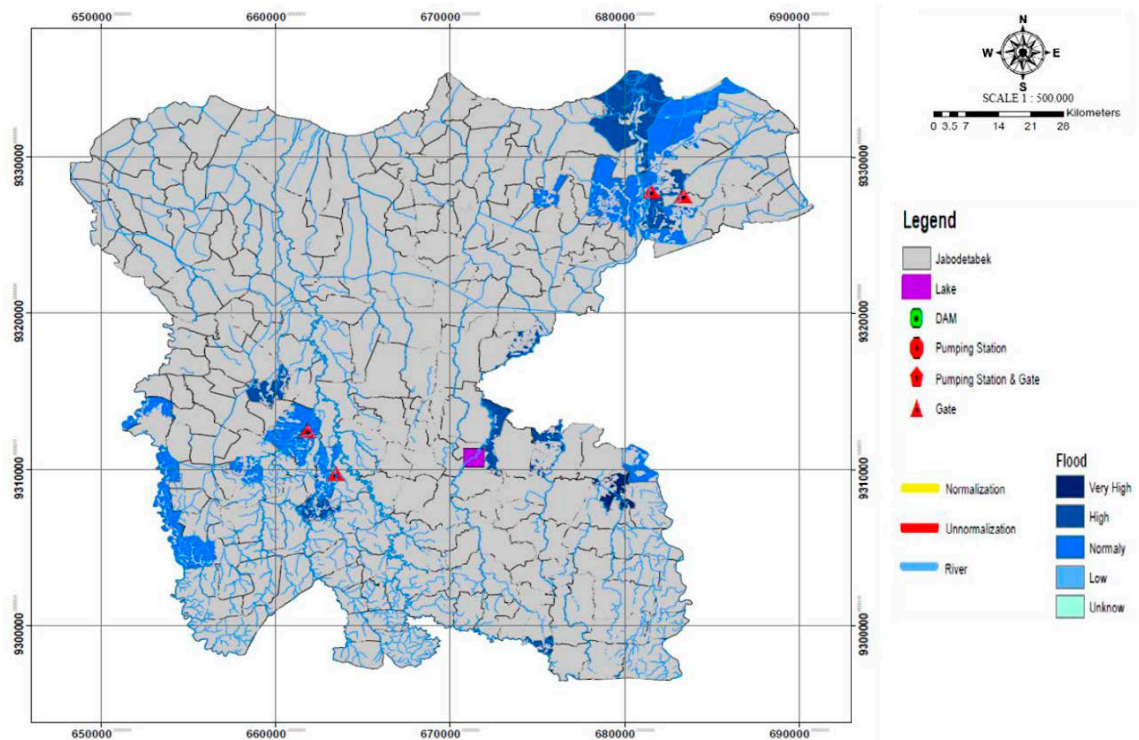


Figure 2-74 Target Location for Survey (Tangerang Regency)

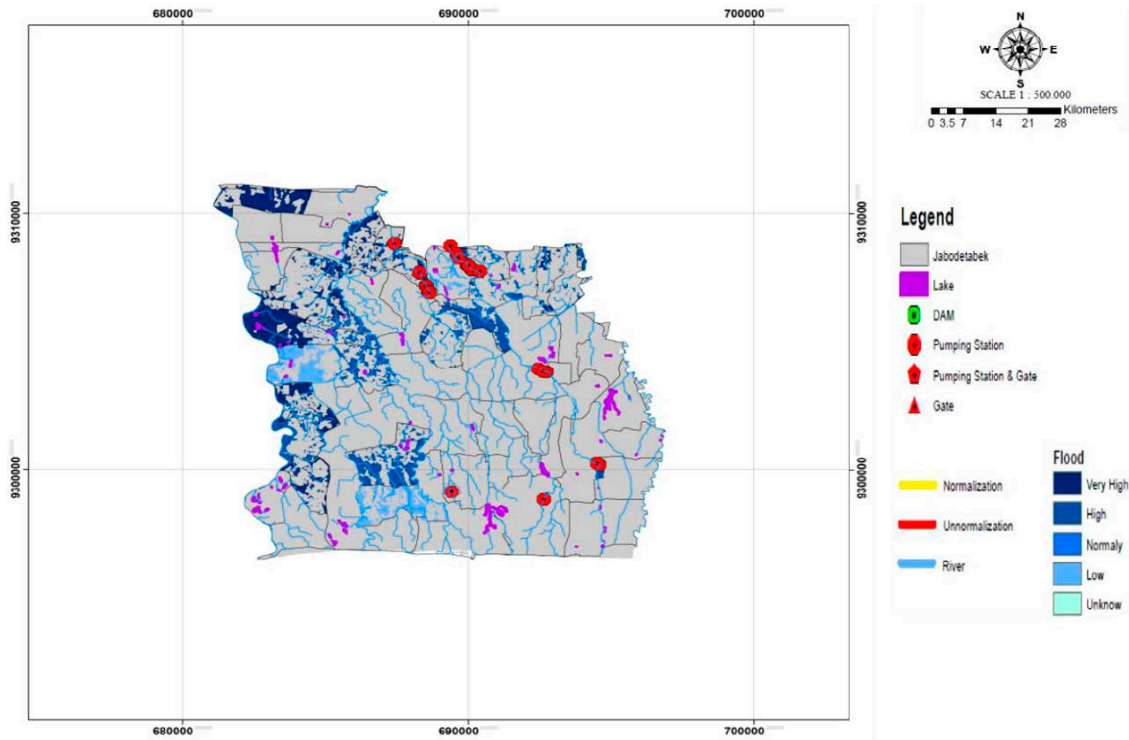


Figure 2-75 Target Location for Survey (South Tangerang City)

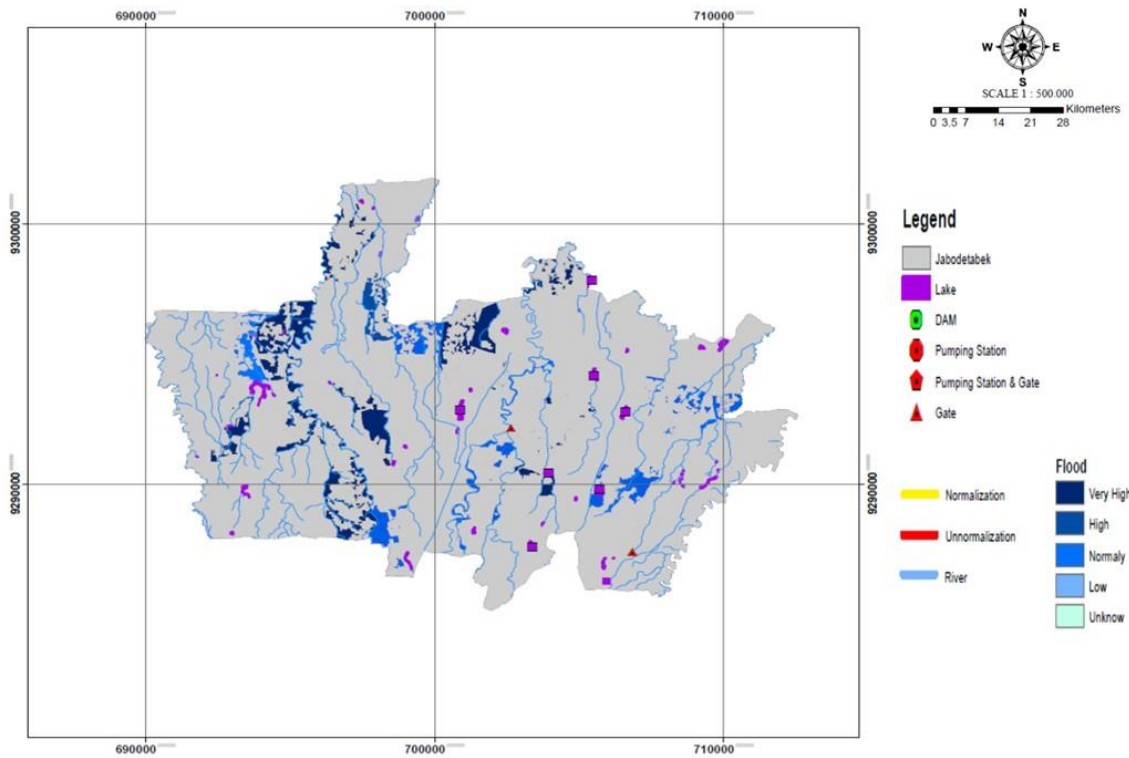


Figure 2-76 Target Location for Survey (Depok City)

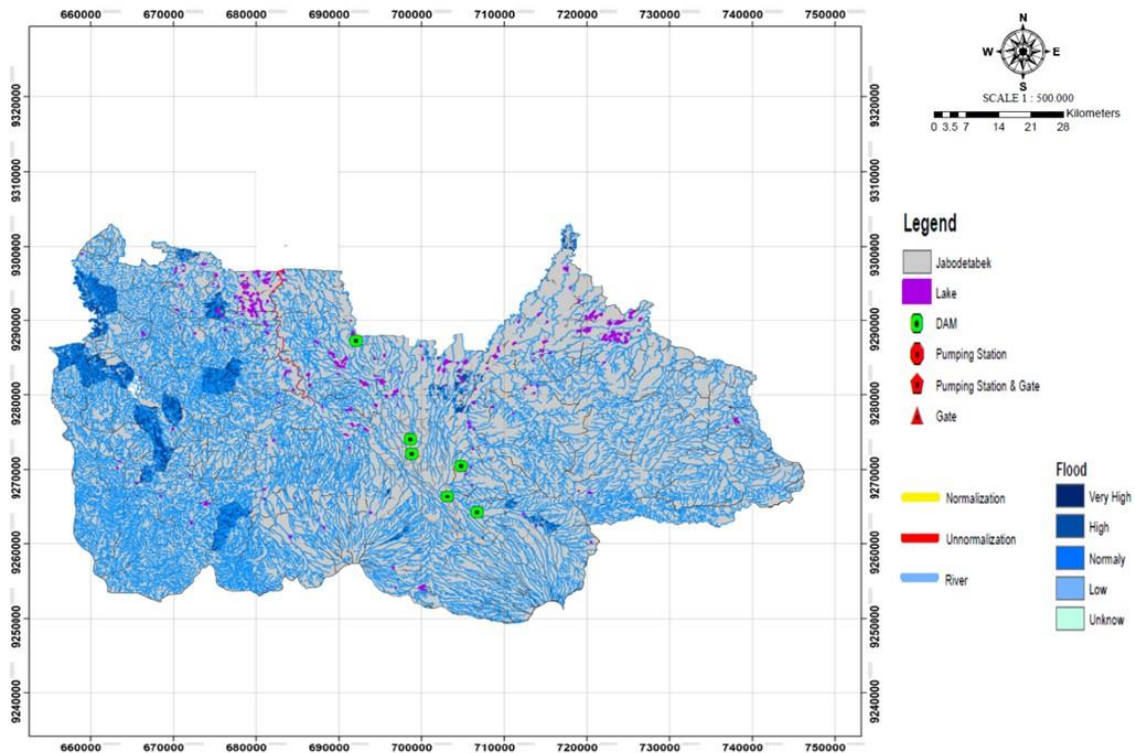


Figure 2-77 Target Location for Survey (Bogor Regency)

The results of hearing from facility managers are as follows.

<DKI Jakarta>

- At the time of the survey, 678 pumps at the 400 sites are in good condition and 23 were in disrepair.
- During the 2020 flood, 141 facilities operated without problems, 3 facilities were damaged, and 37 facilities were affected by the flood and malfunctioned.
- Flood damage occurred in 141 areas, including around 104 flood control facilities

<Tangerang City>

- Thirty-five facilities operated without problems, six facilities were damaged, and 17 facilities, were rendered inoperable by the flooding.
- Flood damage occurred in 51 areas, including around 35 facilities.

<South Tangerang City>

- Thirteen facilities operated without problems, two were damaged, and 15 facilities were affected and malfunctioned.
- Flooding damage occurred in 28 areas, including around 13 facilities.

<Bekasi City>

- Twenty-four facilities operated without problems, three were damaged, and 23 facilities, including this one, were affected and malfunctioned.
- Flooding damage occurred in 41 areas, including around 24 facilities.

The main parts of the affected facilities, such as pump rooms, were flooded, and the main causes of the affected and dysfunctional facilities are as follows.

- The power supply depended on general power distribution from the Electric Power Authority and there were malfunctions in the power supply, including flooding of the switchboards.
- Although the plant was equipped with a generator, it did not function due to inundation caused by the poor installation position of the generator.
- Operators were unable to reach the facility due to flooding.

About half of the flooded areas in each city and prefecture have flood control facilities, highlighting the issue of setting an appropriate facility scale. The operational rules of the facilities were also interviewed to the extent possible, and these rules were reflected in the inundation simulations for the major facilities.

2.4 Recommendations for Inland Water Control in Kemayoran

2.4.1 Necessity of Internal Water Control in Kemayoran

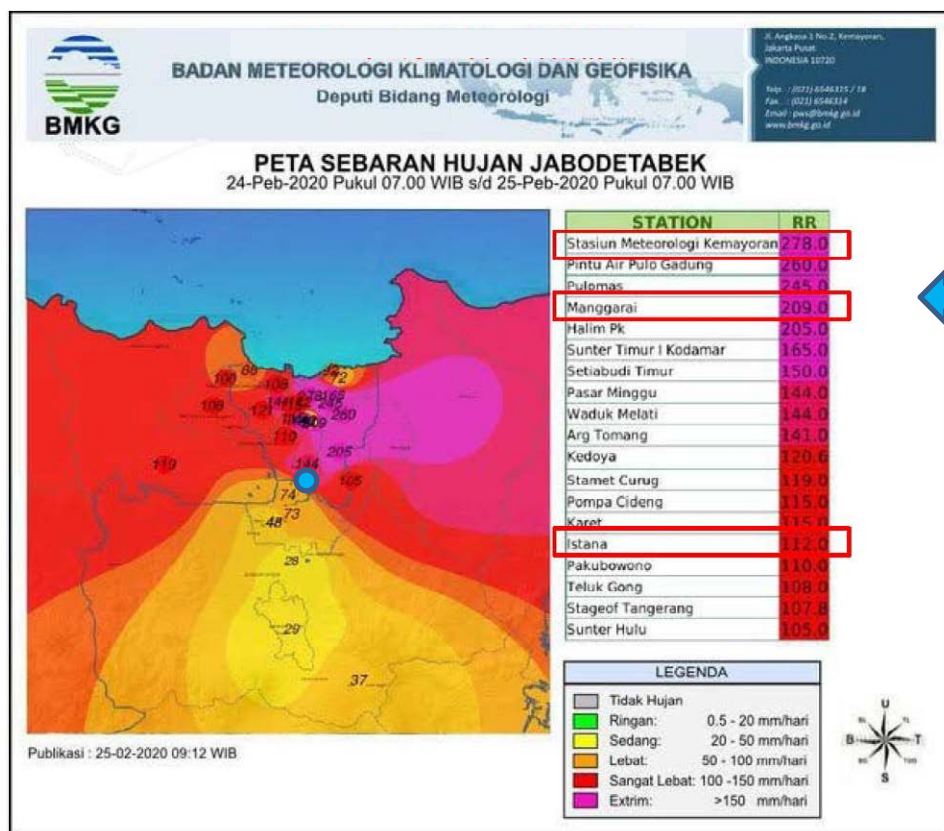
(1) Request for Investigation from SDA, PUPR

A request for cooperation was received from the SDA to verify and make additional proposals on the current situation and countermeasures for flood damage in Kemayoran, a priority countermeasure area of the Government of Indonesia, among the flood damage that occurred in DKI Jakarta and surrounding areas in January 2020.

Therefore, the project team began discussions with Director of River and Coastal, SDA and the BBWS-CC in early February 2020 to discuss internal water control measures for Kemayoran.

(2) Flood damage reoccurred on February 25, 2020

From February 24 to early morning of February 25, 2020, the Kemayoran area recorded 278 mm of rainfall in 24 hours (see Figure 2-78), and flood occurred again.



Source: Indonesian government

Figure 2-78 Rainfall Information (Kemayoran), February 25, 2020

The project team conducted a field survey immediately after the inland flood and summarized the results in a PowerPoint presentation (hereinafter referred to as "PPT") (see Figure 2-79) as follows, which was shared with relevant agencies. A summary of the survey results is presented below.

- The flood water level is predicted to have reached its peak at high tide time of 11:00 on February 25, 2020.
- The Kemayoran area has many lowlands, which are flooded every time with 100mm/day rainfall.
- There are problems with the drainage system in large areas of the Kemayoran region, including flooding of underpasses.
- One of the major causes of internal flooding is predicted to be the high tide level at high tide, which causes the Sentiong River to become an overhead river and

backflow from the Sentiong River into the storm drainage system, likely resulting in flooding.

- Furthermore, it is necessary to consider not only the downstream side of the river, but also the upstream side, including the problems of stormwater drainage channels in the underpass area.



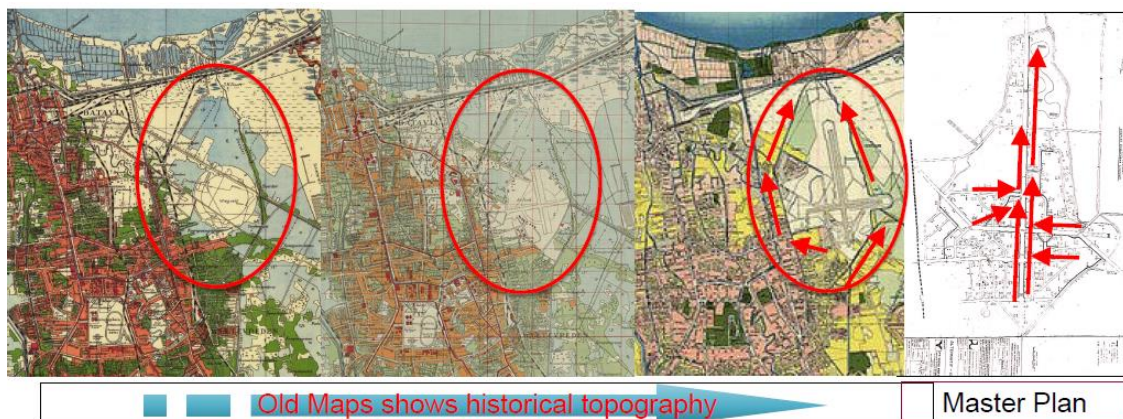
Source: JICA project team

Figure 2-79 Survey result (Kemayoran area)

2.4.2 Content and Issues of Inland Water Control Study in Kemayoran

(1) Topography of Kemayoran

The Kumayoran area has always been a low marshy area near the sea, where an airport was built and artificial drainage channels were constructed. Later, the airport was closed and a drainage system was developed based on urban planning.



Source: JICA project team

Figure 2-80 Old maps and master plan drainage system map of Kumayoran

The current Kemayoran area (454 hectares) includes (8) Jakarta International Exhibition Center, (2) parks, (3) golf course, (6) and (7) housing complexes, (4) and (5) two underpasses, and recently, the athletes' village for the Asian Sports Event (now a temporary anti-corona infection facility) built by PUPR as shown in Figure 2-81.



Source: Kumayoran Management Organization (PPKK) and JICA survey team

Figure 2-81 Zoning Map and Major Facilities Map of Kumayoran

(2) Current status of the drainage system in the Kemayoran area

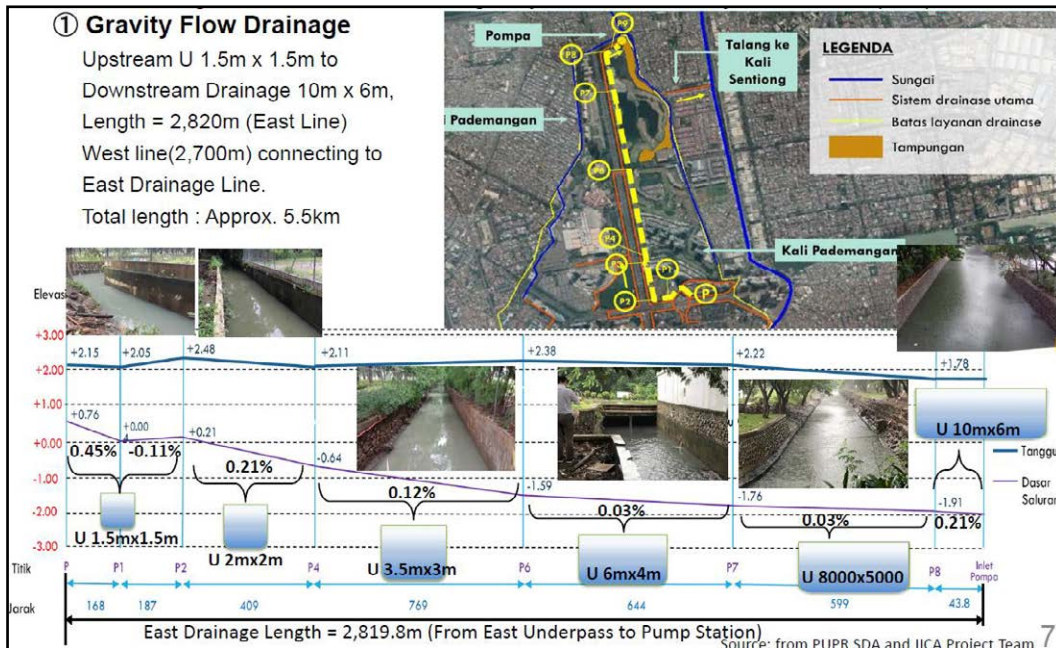
The drainage system in the area flows from the south through the center of the district to a drainage pumping station located at the northern end of the district by natural flow. The drainage pumping station pumps up to a reservoir, which discharges naturally to the Sentiong River. (See Figure 2-82)



Source: SDA, PUPR

Figure 2-82 drainage system in the Kemayoran area

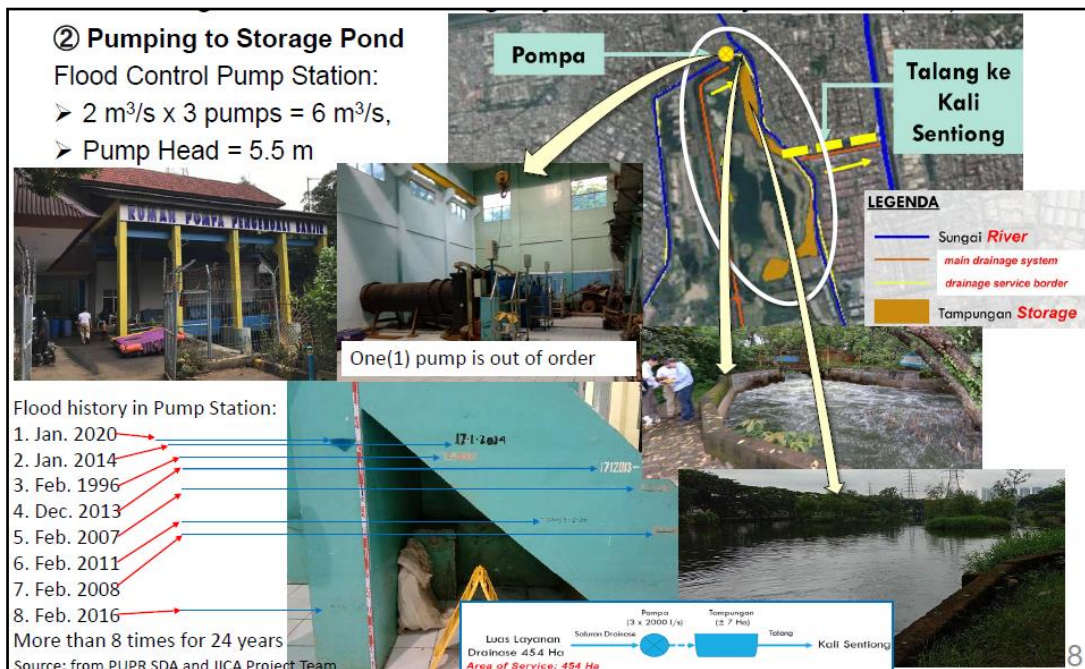
The main drainage channels are approximately 5.5 km long, and these run parallel to both sides of the central avenue. The drainage cross section is 1.5m wide by 1.5m high from the upstream side to approximately 10m by 6m near the drainage pump station. The flow gradient follows the topography of the area. (See Figure 2-83)



Source: SDA, PUPR and JICA project team

Figure 2-83 Drainage channel maintenance status

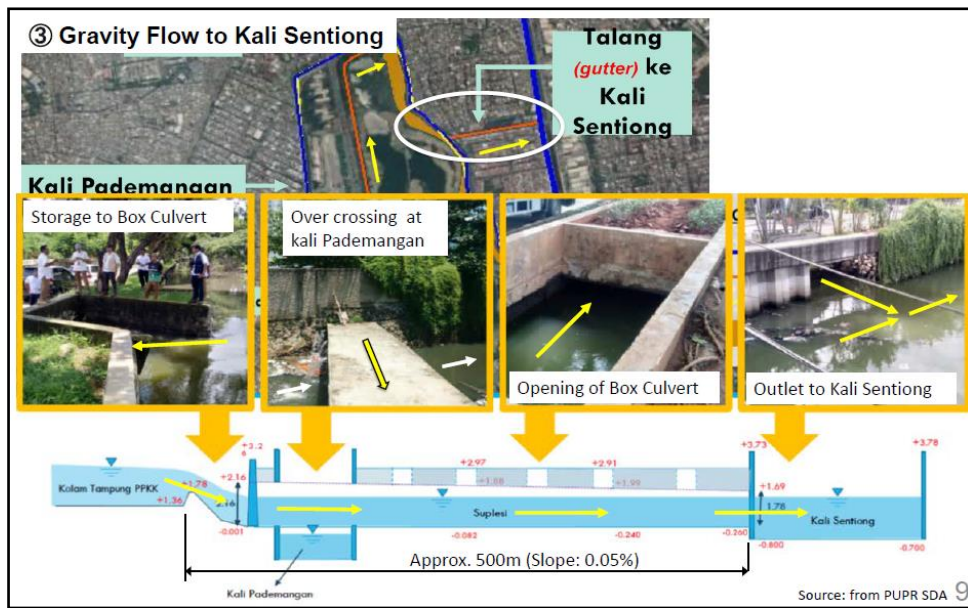
Drainage water coming from the drainage channel is discharged from the drainage pumping station (6m³/sec: 3 units x 2m³/sec, head: 5.5m) to the reservoir. The reservoir is located on the east side of the golf course.



Source: SDA, PUPR and JICA project team

Figure 2-84 Status of drainage pump stations and reservoirs

The system drains naturally from the reservoir through a drainage channel (approximately 500 m long with a slope of 0.005%) to the Sentiong River. The system overflows the adjacent Pademangan River. (See Figure 2 85)



Source: SDA, PUPR and JICA project team

Figure 2-85 Discharge channel flowing from the reservoir to the Sentiong River

(3) Mechanisms and issues during flooding

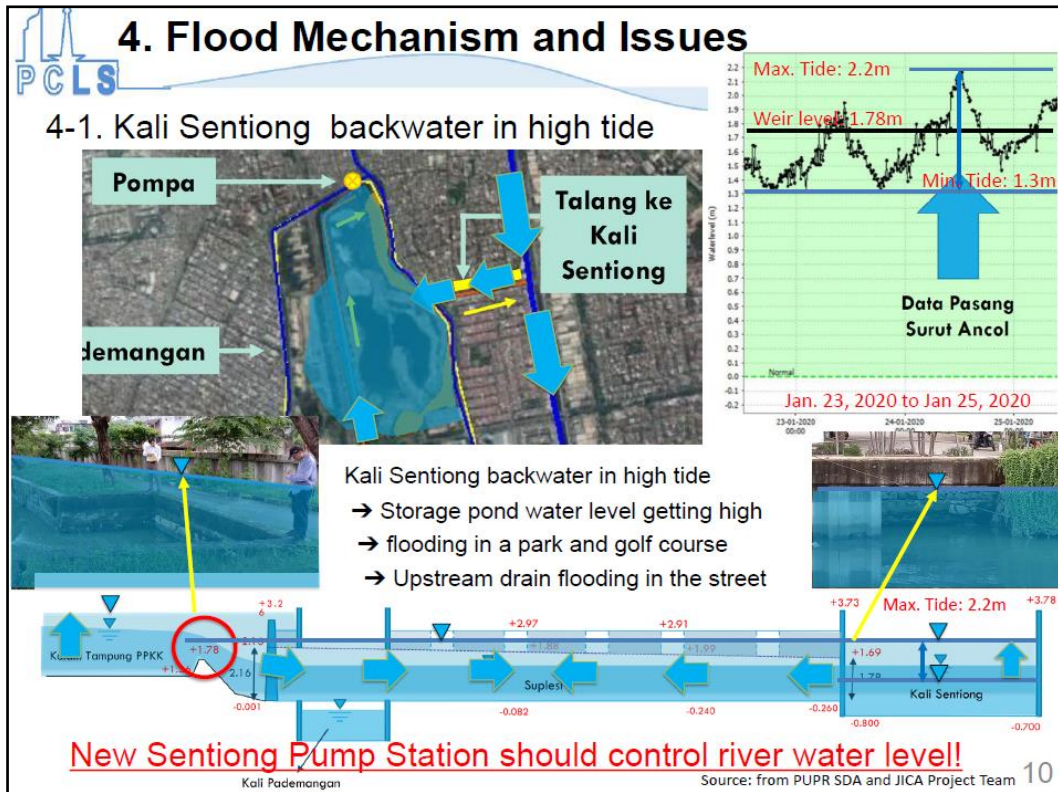
According to the conditions recorded on the wall inside the drainage pump station, the Kemayoran area has been flooded about 8 or more times in the 24-year period from 1996 to 2020 (See Figure 2 86). The basic causes and issues are analyzed as the following 7 main issue items.

- ① The tidal level of the Sentiong River causes a backwater phenomenon at high tide, resulting in insufficient flow capacity. This may be related to land subsidence and climate change.
- ② Insufficient capacity of pumping facilities at the drainage pump station (one pump was out of order at the time of the field survey).
- ③ Lack of regular maintenance of the drainage channel (dredging of the drainage channel is required)
- ④ Upstream inflow due to overflow from surrounding rivers (insufficient maintenance of overflow prevention facilities)
- ⑤ Insufficient flow capacity of drainage system (need to increase flow capacity)
- ⑥ Failure of drainage pumps in underpasses (drainage pumps need to be reconditioned)
- ⑦ Insufficient deployment of mobile pump trucks for emergency response (more mobile pump trucks are desired).

The following sections (i) to (iv) outline the flooding mechanisms and challenges in the Kemayoran District.

(i) Issues due to high tide levels

At high tide, the tidal level rises above the outlet of the Sentiong River from the reservoir, causing a backwater phenomenon. The reservoir cannot be drained, and flooding occurs upstream from the reservoir and drainage pump station. (See Figure 2 86)

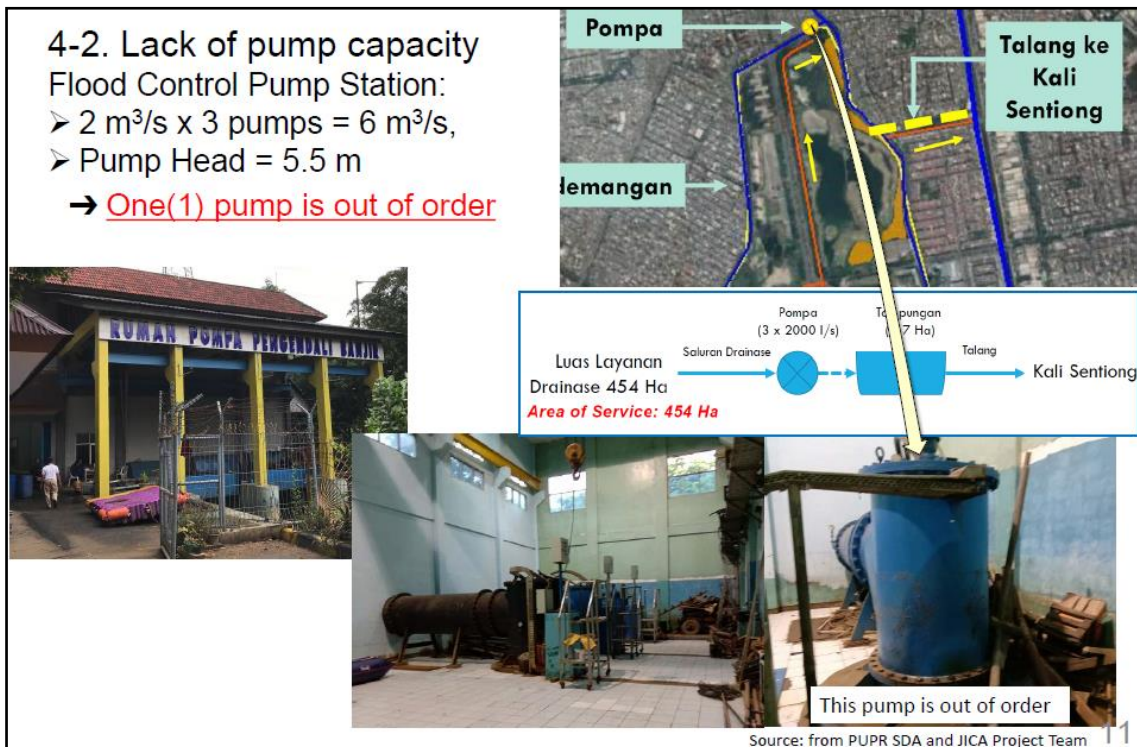


Source: SDA, PUPR and JICA project team

Figure 2-86 Flood mechanism of the spillway flowing from the reservoir to the Sentiong River

(ii) Insufficient capacity of drainage pumping stations

As of February 2020, one pump was broken and unusable. The pump needs to be repaired, but in addition, the drainage capacity needs to be strengthened. (Results of a schematic inspection study) (See Figure 2-87)



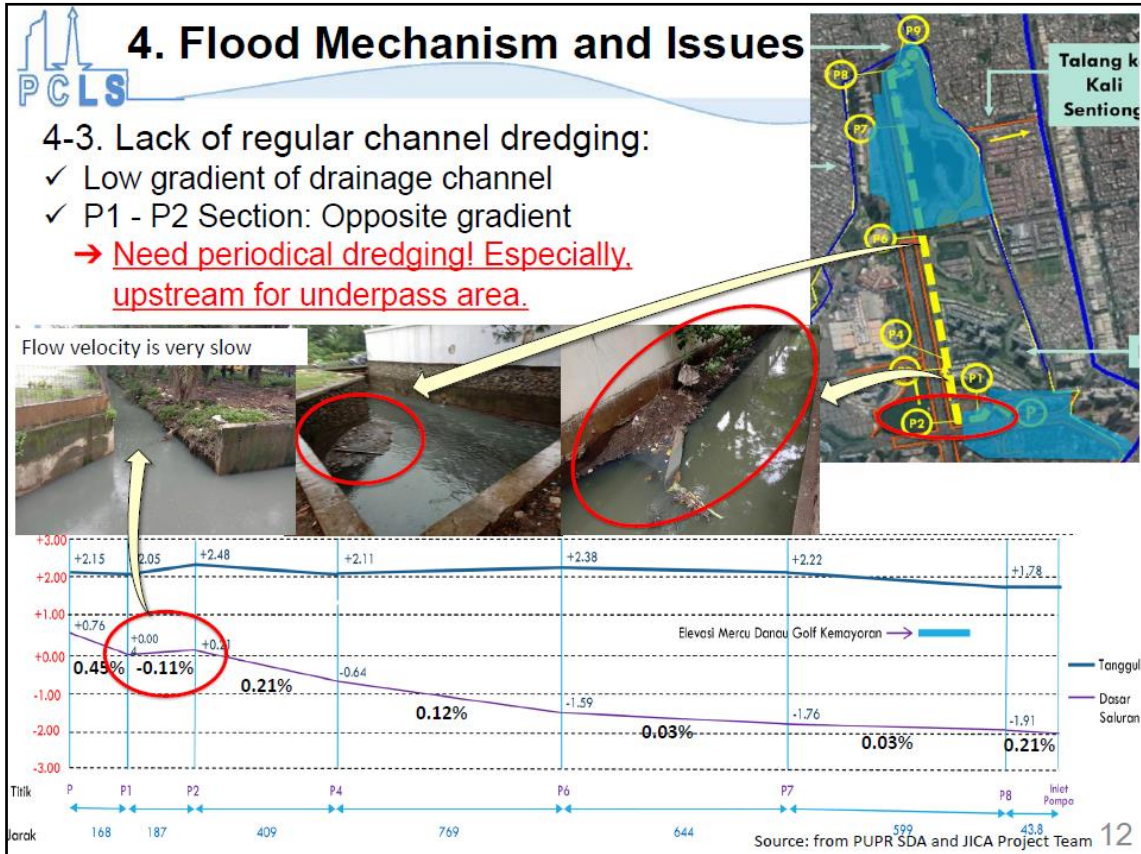
Source: SDA, PUPR and JICA project team

Figure 2-87 Location and current status of drainage pump stations

(iii) Drainage channel maintenance and issues

Drainage channels are not regularly maintained and are littered with sediments and obstructions that interfere with flow capacity. (See Figure 2-88)

The drainage system should be re-planned and re-aligned due to the existence of back-sloped parcels upstream of the drainage channel.



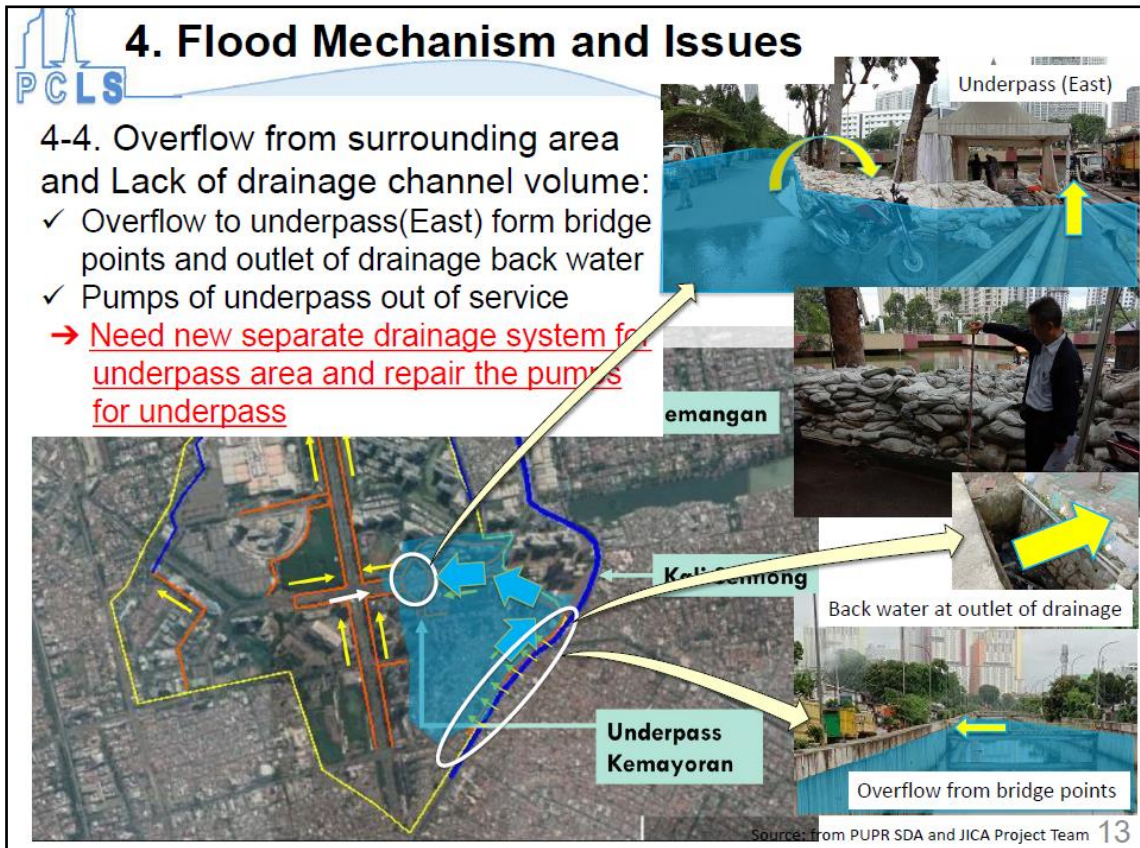
Source: SDA, PUPR and JICA project team

Figure 2-88 Drainage channel conditions and issues

(iv) Issues due to inflow into the upstream underpass and backflow from the levee drain

The underpass is flooded every time due to inflow from surrounding areas. Retaining walls to prevent overflow and drainage pumps need to be re-equipped. (See Figure 2-89)

The drainage outlets to the surrounding rivers are not equipped with flap gates, resulting in backflow and internal flooding. Therefore, the drainage system needs to be reviewed.



Source: SDA, PUPR and JICA project team

Figure 2-89 Sandbags to prevent overflow into the underpass and backflow from surrounding rivers

(4) Response and proposed inland water measures by the Indonesian government
The Indonesian government (PUPR and DKI Jakarta) is implementing and planning the following inland water measures.

- ① Rehabilitate drainage channels (ensure planned flow capacity)
- ② Installing gates at the reservoir to block backwater
- ③ Improve drainage system by closing the south gate during high tide levels, etc.
- ④ Optimize reservoir utilization during rainy seasons

As shown in Figure 2-90 and Figure 2-91, a total of eight internal water measures are planned by the Government of Indonesia. The specifics of these measures are summarized and described in “2.4.3 Recommendations and Draft Inland Water Control in Kemayoran”.

1. Normalisasi saluran drainase (Normalization of drainage channels)
 2. Pemasangan pintu di tampungan agar muka air pasang dapat tidak mempengaruhi muka air tampungan (Installation of gate at the reservoir so that high tide water will not influence into the reservoir)
 3. Operasi pintu di bagian selatan sistem drainase (ditutup pada saat pasang) (Operation of drainage system at the south gate (closed when high tide happens))
 4. Optimalisasi pola operasi tampungan khususnya pada musim hujan (Optimizing reservoir operation patterns especially in the rainy season)
- Total ①~⑧ plans were recommended by PUPR



Source: SDA, PUPR

Figure 2-90 Measures taken by the Indonesian government

5-1. Actions from January to February in 2020 by The SDA PUPR, Suku Dinas SDA North and Central

RENCANA PENANGANAN JANGKA PENDEK

① Inventarisasi Data-data Eksisting
①: investigation of existing conditions

② Water Management
② Dredging of pond

③ Koordinasi dengan para Mitra
③: Coordination with related agencies

④ Pembersihan Saluran
④: Channel dredging

Pengerukan sedimentasi pada saluran utama

Pengerukan sedimentasi pada outlet

Channel dredging and cleaning

Pembukaan tutup beton saluran u-ditch

Penanggulangan saluran tersumbat

Perutupan tanggul yang jebol

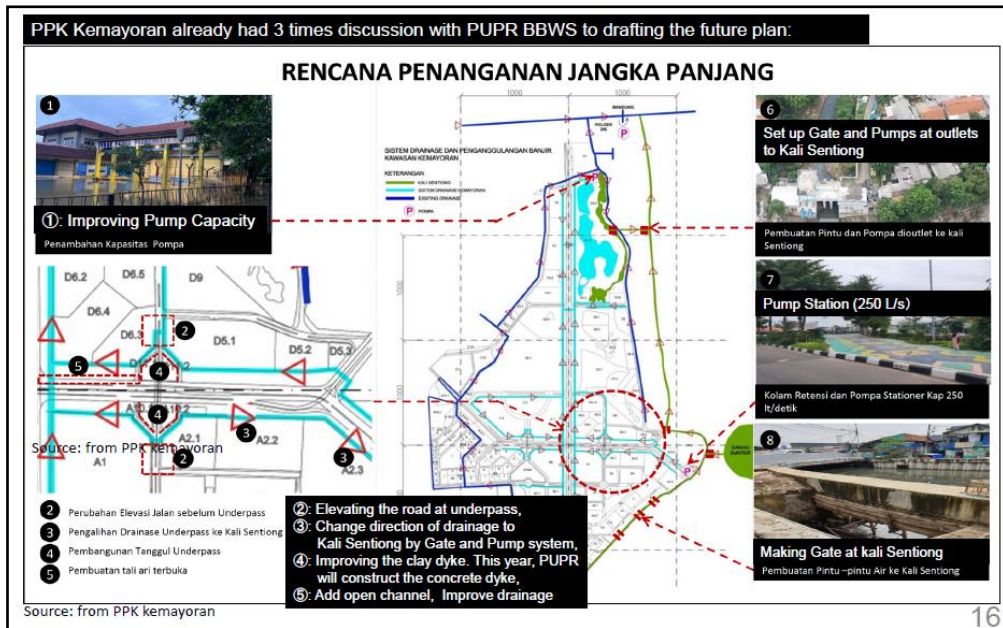
Pembuatan tanggul sementara

Channel dredging and cleaning

Source: from PPK kemayoran

Source: SDA, PUPR

Figure 2-91 Status of inland water measures by the Indonesian government from January to February 2020

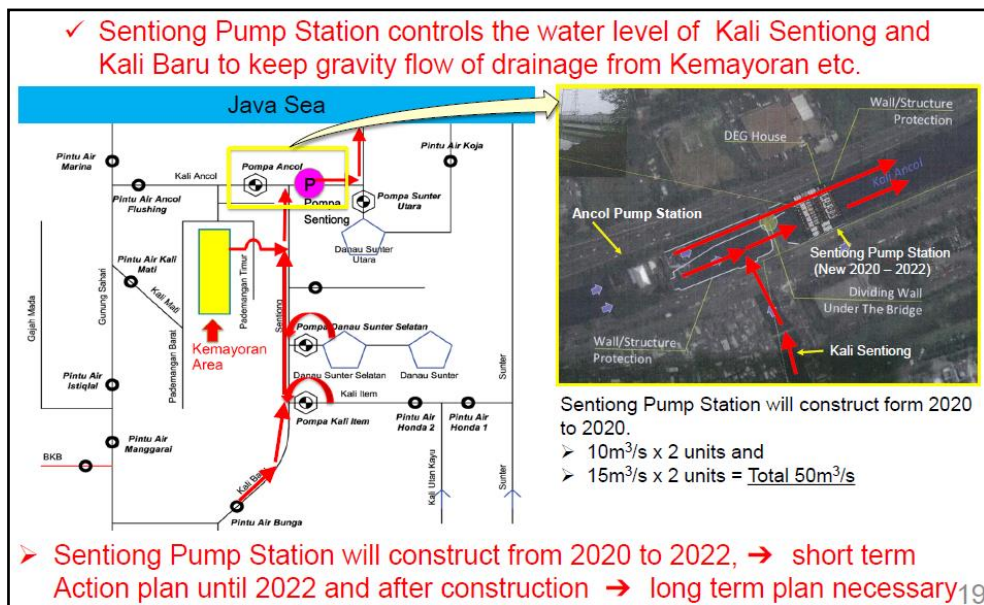


Source: SDA, PUPR

Figure 2-92 Overview of the government's plan to control inland water

2.4.3 Recommendations and Draft Inland Water Control in Kemayoran

The construction of the Sentiong drainage pumping station, which is being implemented by the Indonesian government, is scheduled to be completed in 2022, and it is expected to prevent the Sentiong River from reaching a high tide level during high tides. In addition, it is expected to enable systematic control of the inland water level in the area surrounding Kemayoran. An overview of the project is shown in Figure 2-93.



Source: SDA, PUPR and JICA project team

Figure 2-93 Sentiong drainage pumping station (under construction)

Figure 2-94 shows the implementation plan (Recommended by PUPR), the proposal that was verified and agreed to by the JICA survey team, and the additional items proposed (Recommended by JICA).

(1) Action Plan (Tentative)
Based on Reviewing all information's, followings are recommended;

No.	Issues	Recommendations	Agency	Budget (IDR)	Recomm ended by PUPR	Recomm ended by JICA
1.	Kali Sentiong backwater in high tide	⑥ Construction of Sentiong Pump Station ① Set up Gate and Pumps at outlets to Kali Sentiong or, ② Gate and Mobile Pump at outlets	PUPR PUPR PUPR	600 bil.	- ● -	- - ●
2.	Lack of pump capacity (One(1) pump is out of order)	③ Improving Pump Capacity ④ Repairing one pump	PUPR PUPR		● -	- ●
3.	Lack of regular channel dredging (Upstream has low gradient → sedimentations and Stagnant)	⑤ Dredging of Drainage by DKI Jakarta	DKI Jakarta	Suku Dinas SDA	●	●
4.	Overflow from surrounding area	⑥ Elevating the road at underpass, ⑦ Change direction of drainage to Kali Sentiong by Gate and Pump system (250L/s) ⑧ Improving the clay dyke. This year, PUPR will construct the concrete dyke ⑨ Gate for drainage outlet at kali Sentiong	PUPR PUPR PUPR PUPR		● ● ● ●	● ● ● ●
5.	Lack of drainage channel volume	⑩ Add open channel to Improve drainage Same items of ⑦	PUPR		●	●
6.	Underpass pumps are out of service	⑪ New Pumps for Underpass (East and West)	PUPR		-	●
7.	Not enough mobile pump	⑫ Procurement mobile pump vehicle for backwater and quick recover of underpass	PUPR		-	●

21

Source: JICA project team

Figure 2-94 List of Issues and Proposed Items

The schedule for implementation was also compiled and recommended, as shown in Figure 2-95.

Action Plan	2020	2021	2022	2023 -
⑥ Construction of Sentiong Pump Station	APBN Multi Year Contract			
① Set up Gate and Pumps at outlets to Kali Sentiong or,	Budget	DED	Construction	
② Gate and Mobile Pump at outlets	Budget	DED	Construction	
③ Improving Pump Capacity of flood control pump station	Budget	DED	Construction	
④ Repairing one pump	Budget	Repair		
⑤ Dredging of Drainage by DKI Jakarta				
⑥ Elevating the road at underpass,	Construction			
⑦ Change direction of drainage to Kali Sentiong by Gate and Pump system (250L/s)	Budget	DED	Construction	
⑧ Improving the clay dyke. → The concrete dyke	Construction			
⑨ Gate for drainage outlet at kali Sentiong	Budget	DED	Construction	
⑩ Add open channel to Improve drainage	Budget	Construction		
⑪ New Pumps for Underpass (East and West)	Budget	DED	Construction	
⑫ Procurement mobile pump vehicle for backwater and quick recover of underpass	Budget	Procurement		

Source: JICA project team

Figure 2-95 Schedule for implementation of the proposed inland water measures (draft)

2.5 Proposal for Bekasi River Detailed Design Value Engineering (VE)

The Government of Indonesia implemented Value Engineering (VE) in March 2020 to reduce construction costs in order to promote river improvement works based on the results of the Detailed Design of the Bekasi River Improvement Project, 2015. Minister Basuki of the Ministry of Public Works and Housing (PUPR) asked the JICA Study Team to review the VE results in view of the flood disaster that hit Bekasi city in January 2020. In response to this request, the JICA Study Team evaluated the results, including the results of the detailed design, and presented the evaluation results and proposals to the PUPR in June 2020.

The study results are as follows.

2.5.1 Summary of Detailed Design Summary, 2015

(1) Project Area

The project area is from the confluence of the Cikeas and Cilenugsi rivers to the Cikarang-Bekasi-Laut Canal (CBL) with total length of 33,476 km long:

- CBL : 11,418 km
- CBL-Bekasi Weir : 11,021 km
- Bekasi Weir – Confluence : 11,037 km

(2) Design Scale

- Upstream of Bekasi Weir : 25-year flood ($Q_{25} = 663 \text{ m}^3/\text{s}$)
- Downstream of Bekasi Weir: 50-year flood ($Q_{50} = 738 \text{ m}^3/\text{s}$)

Figure 2-1 shows the Bekasi river improvement plan in the Detailed Design, 2015.

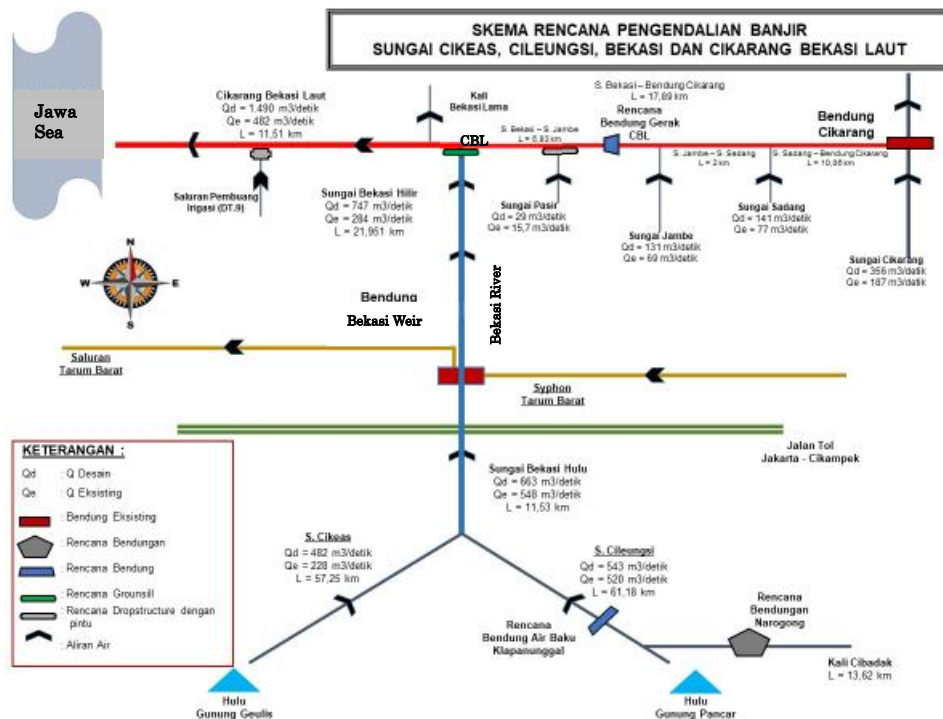


Figure 2-96 Conceptual Diagram of the Bekasi River Improvement Project

(3) Design Concepts of the Project

Upstream Section of Bekasi Weir

Adding and raising of concrete retaining walls. No river channel excavation is conducted.

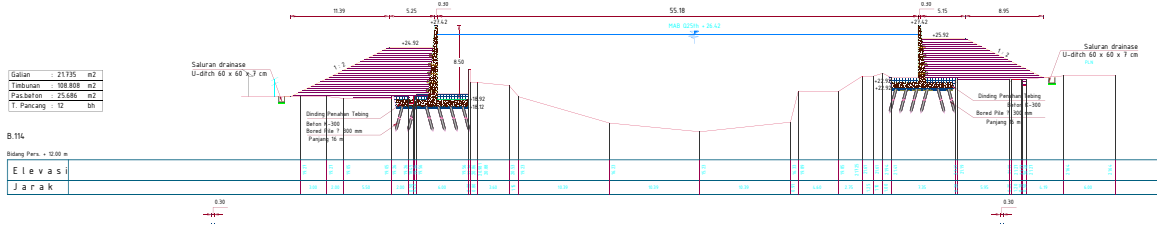


Figure 2-97 Typical Cross Section of the Bekasi River Upstream Section

Downstream Section of Bekasi Weir

River improvement by about 2m low channel excavation and concrete retaining wall. The river channel bed is widened to 40 m.

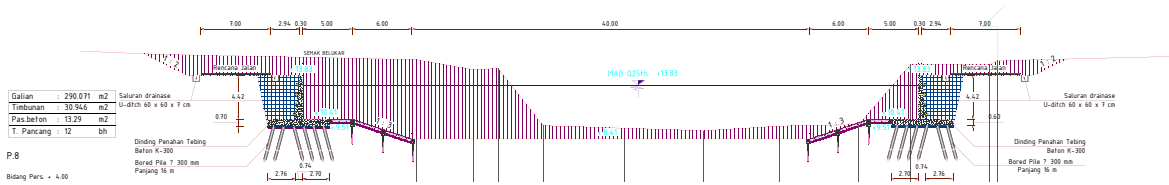


Figure 2-98 Typical section of the Bekasi River Upper Basin

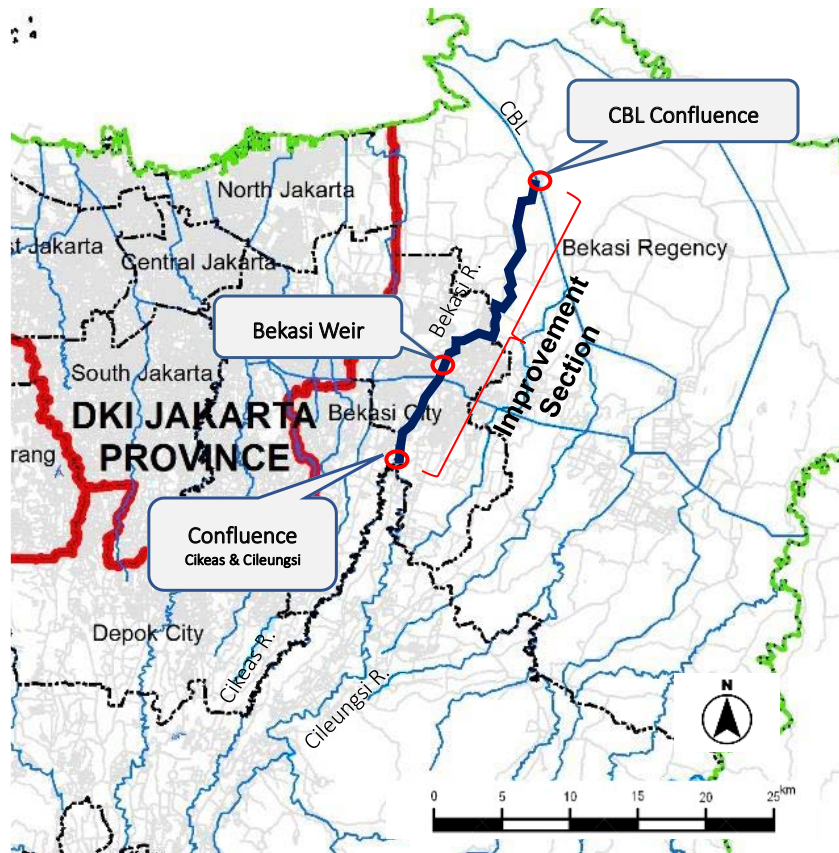


Figure 2-99 General Plan of River Improvement Section (excluding CBL)

2.5.2 Value Engineering (VE) Results

The VE went no further than proposing measures for reducing the cost, maintaining the current concept of planning and design.

Especially focusing on the construction cost of the foundation pile that accounts for 75% of the total direct construction cost, the VE proposed to reduce its cost by changing the diameter of the pile and the angle of the pile.

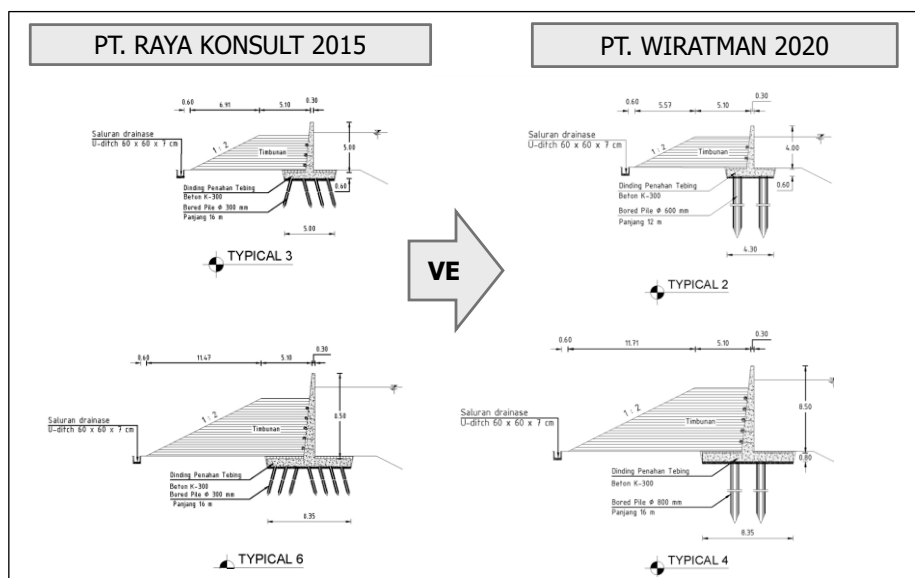


Figure 2-100 Example of Design Change, proposed by VE

The design change of the foundation pile enabled the cost reduction of 150 billion rupiah, about 20% of the total construction cost.

Table 2-65 Savings from VE

Item	PT. Raya Konsult		PT Wiratman
	2015	2020	2020
Pekerjaan Persiapan	6.190.700	7.107.041	7.107.041
Pekerjaan Tanah	31.236.274.128	35.859.835.757	35.859.835.757
Pekerjaan Penahan Tebing	622.900.377.639	715.101.460.041	564.907.779.473
Beton K300 ready mix	55.454.965.518	63.663.353.294	63.663.353.294
Pembesian	58.224.679.094	66.843.037.065	66.843.037.065
Lapisan beton lantai kerja	3.000.947.848	3.445.145.106	3.445.145.106
Lapisan pasir	364.155.618	418.057.563	418.057.563
Bekisting	9.239.864.891	10.607.540.324	10.607.540.324
Pekerjaan drainase, U ditch 60 cm	4.573.755.000	5.250.757.578	5.250.757.578
Pipa PVC dia 1"	483.950.425	555.584.276	555.584.276
Kerikil	149.826.807	172.004.019	172.004.019
Geotextile	2.788.064.959	3.200.751.508	3.200.751.508
Pemasangan Bore Pile	488.620.167.480	560.945.229.307	410.751.548.739
Estimasi Biaya Ruas Bekasi Hulu (Rp.)	654.142.842.467	750.968.402.839	600.774.722.271

Selisih biaya

: 20%

2.5.3 Evaluation Results and Proposals of the JICA Study Team

While the VE proposed only the measures for the reduction of the construction cost, the JICA Study Team reviewed the overall Detailed Design and proposed necessary improvements in the planning and design aspects.

(1) Overall River Improvement Plan and Design

(i) Extension of Project Area

The current improvement area covers the river reaches from the mouth of the river to the confluence of the CBL and the Bekasi River to the confluence of the Cikeas/Cileungsi River. In January 2020, flooding occurred in the upper reaches of the confluence of the tributaries due to overtopping of floodwater from the dikes, which caused severe damage in this area. In addition, there is a result of hearing survey in the field that similar flood damages frequently occurred at the same location in the past.

Then, the JICA Study Team proposed to extend the project area up to the section where the river dikes are connected to the mountains so that the flood does not flow into the inland (In response to this proposal, BBWS CiliCis is currently conducting design for river improvement in the upper reaches of the tributaries).

(ii) Design Flood Discharge

In the Detailed Design 2015, the target flood control safety level is set to a 25 year-flood, and the design flood discharge is set as follows:

- Upstream of Bekasi Weir : 25-year Flood : 663 m³/s
- Downstream of Bekasi Weir : 25-year Flood : 738 m³/s

However, the observed flood discharge at the Bekasi weir site on January 1, 2020 was 927 m³/s, which is much large than the designed flood discharge. Therefore, it is important to analyze and revise the design rainfall and design discharge prior to the commencement of the construction. In addition, the impacts of climate change, such as increase of rainfall and sea level rise, should be taken into account when evaluating the design discharge.

(iii) Longitudinal Profile (Upstream of Bekasi Weir)

Since the current riverbed in the upstream of the Bekasi weir was formed by sedimentation due to the impounding river water at the Bekasi weir, the current riverbed is much higher than the crest of the fixed weir (EL. 10.6m), as shown in Figure 2-101. It is considered that the current riverbed can be lowered to a line that connects the top of the crest of fixed weir and the riverbed elevation at the confluence of the tributaries (Cikeas and Cileungsi Rivers). In this way the riverbed can be lowered by about 2~3 m from the current riverbed. By lowering the riverbed, it is expected that the design high water level also can be lowered to almost the same level as the existing ground surface, and that the lowering design high water level will ease the treatment of the inland water and make the high concrete retaining wall unnecessary.

In order to change the river bed profile, it is necessary to check the elevation of the existing siphon of the West Tarum channel, which is located upstream of the weir, and to examine impacts of the river bed lowering on the structure. It is also necessary to confirm the stability of the foundations of existing river structures such as bridges and revetments along river channels as well as to protect riverbanks.

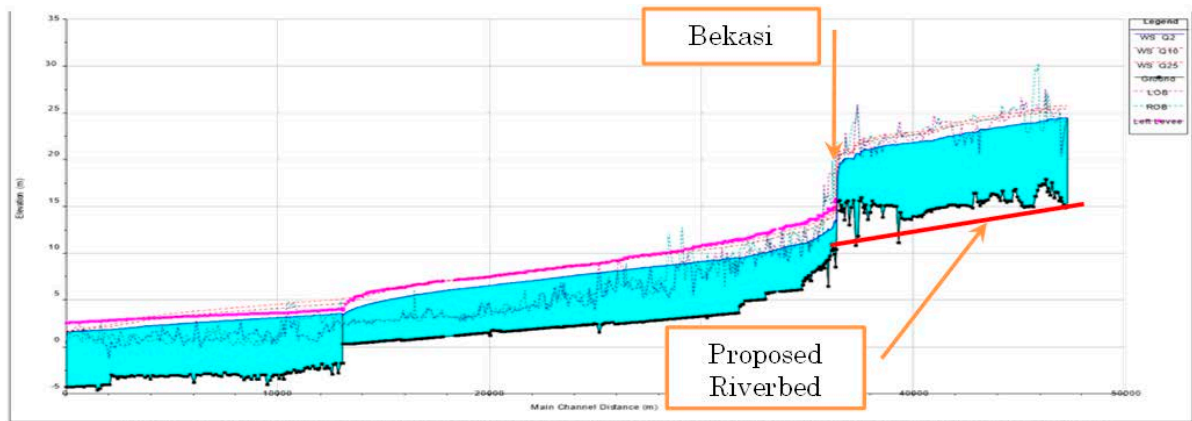


Figure 3.53. Profile of the water surface in Bekasi-CBL river with normalization of Bekasi river, B = 40m, CBL B = 100 m

Figure 2-101 Change of the Design River Profile; Upstream Section of Bekasi Weir

(iv) Longitudinal Profile (Downstream of Bekasi Weir)

At the confluence with CBL, there is a 1.8 m level gap of river bed between Bekasi river and CBL. In order to lower the design high water level and to minimize the height of the wall and the construction cost, it is recommended to lower the riverbed and make the riverbed gradient steeper as shown in Figure 2-102.

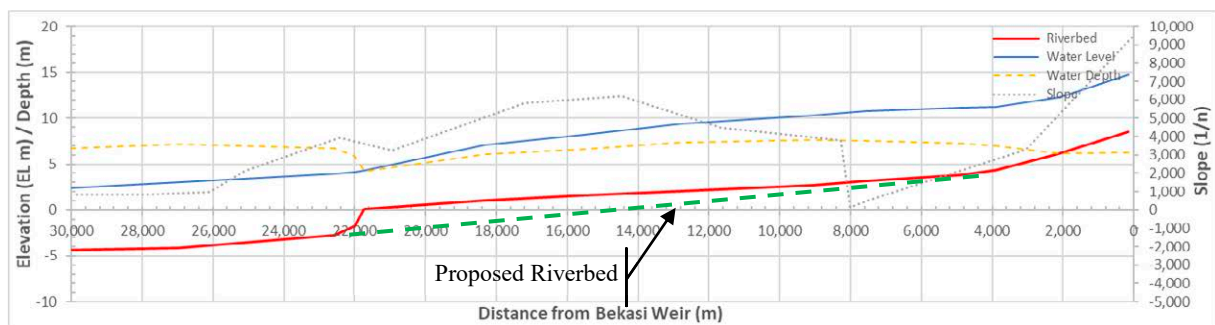


Figure 2-102 Changing the Design River Profile along Downstream Section of Bekasi Weir

(v) Width of the channel (upstream of Bekasi Weir)

Extreme variation in the width of the water surface are observed in the upstream and downstream channel sections. Usually, river width should be designed, so that it gradually becomes wider towards downstream. However, in the Detailed Design 2015, the river width was designed to gradually widen toward upstream, following the current river channel width. It is also necessary to widen the river channel at bend portions in consideration of the rise of the water surface at such location.

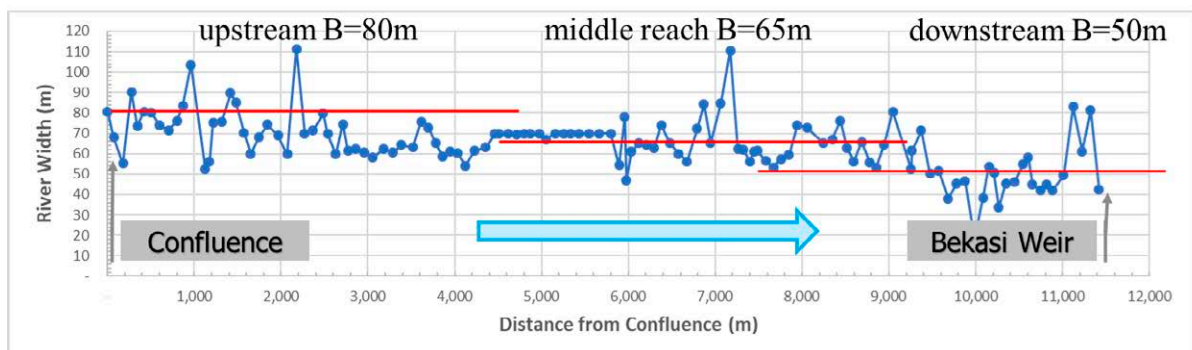


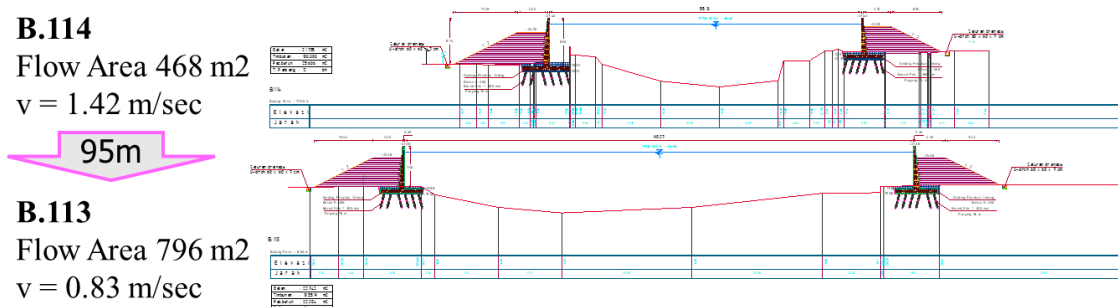
Figure 2-103 Design Channel Width along Upstream Section of Bekasi Weir

(vi) Channel section (upstream of Bekasi Weir)

The basic concept of the river improvement plan for the upstream section of Bekasi Weir is to add concrete retaining walls (with foundation piles to ensure stability) or to raise up the existing wall, to confine a 25-year flood, without widening channel or dredging riverbed. The maximum height of this concrete retaining wall is 18.5 m. Floods have been controlled only by this thin retaining wall. Once the retaining wall breaks, the flood flows into the inland at a tremendous speed, and there is a risk of causing enormous damage.

In addition, there is a large variation in the flow area of each section, and there is no continuity in the cross-sectional shape (Rapid change in flow area. E.G. B. 114: $A = 468 \text{ m}^2$, B. 113: $A = 796 \text{ m}^2$). Therefore, a stable river flow from upstream to downstream may not be ensured. It is supposed that the hydraulic calculations may be incorrect or drawings may be incorrect.

In addition, as shown in Figure 2-104 エラー! 参照元が見つかりません。, there is a section in which a retaining wall is unnecessarily provided even though the ground height is enough high. These retaining walls may be unnecessary or can be replaced by small embankments.



● Unnecessary Concrete Parapet Wall

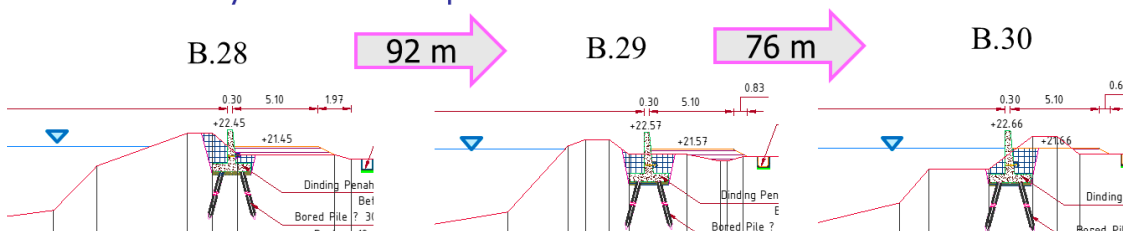


Figure 2-104 Design Channel Sections of Upstream of Bekasi Weir

(vii) Channel section (downstream of Bekasi Weir)

The same channel cross section has been applied from the downstream of the Bekasi weir to the confluence with CBL regardless of the riverbed gradient and flow conditions. The proposed channel cross section consists of a low water channel of 40 m wide, 2 m deep, 1: 3.0 bank slope, and a high water channel of 5 m wide berms and concrete retaining walls on the both banks of the channel, as shown Figure 2-106. It is necessary to change the cross-sectional shape according to the characteristics of the river.

For example, there is a section where a concrete retaining wall may be unnecessary (sections from STA P -5 to STA P 21 can be converted to an embankment without acquiring new land). A more effective and economical river channel plan can be made by carefully examining the cross-sectional shape in consideration of the surrounding ground condition and topography instead of a uniform cross-sectional section.

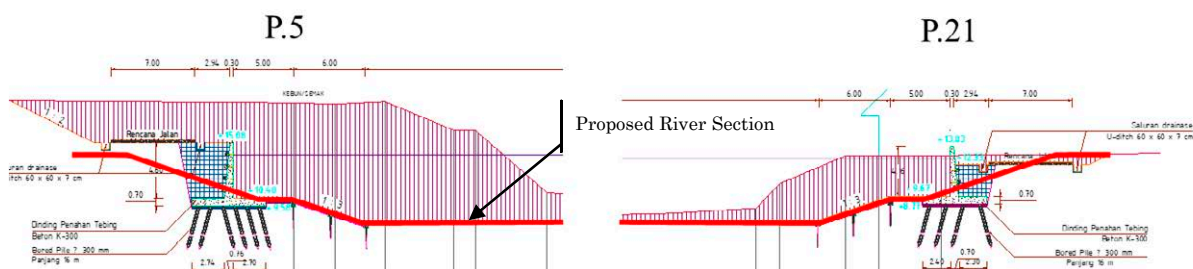


Figure 2-105 Design of the downstream section of Bekasi Weir: Channel section

The design concept of river cross section with high concrete retaining walls (4 m to 7 m) has been proposed along the downstream section from STA.P 135 to the confluence with CBL (about 14 km). Since the construction cost of the concrete wall is a major part of the project cost, it is recommended to reexamine the design of river cross sections in this section.

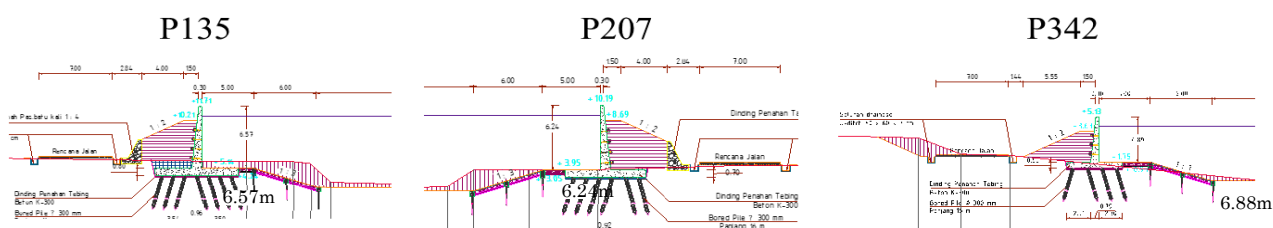


Figure 2-106 Example of High Concrete Retaining Wall Design

(2) SOP of Bekasi Weir during flooding

The peak flood discharge at Bekasi Weir can be forecast from the discharge of water level gauging stations at Cikeas and Cileungsi rivers. The outflow, therefore, from the weir to the downstream can be controlled (including preliminary discharge) before flood comes by applying the proposed standard operation procedure (SOP) for the flood gates at the time of flood. (Refer to Section 5.6.4 for detailed examination)

Notes for establishing a new SOP for Bekasi weir are:

- Since the proposed SOP applies water level lowering and sedimentation flashing in the upstream of Bekasi Weir to secure a flood retarding space, it is necessary to study the stability of upstream river structures due to the lowering of riverbed and the amount of sediment passing through the weir.
- The existing water level monitoring system at Cileungsi and Cikeas rivers shall be repaired/improved and the telemetry system for gate operation to transfer water level and discharge data from the Cikeas and Cileungsi rivers to Bekasi Weir in real-time shall be established.
- The peak flood discharge at the Bekasi weir shall be estimated in consideration of the flood concentration time and used as information for pre-release. This information can be used not only for the operation of Bekasi Weir floodgates but also for flood early warnings in the watershed.
- During the flood on January 2020, the existing Cikeas WLGS was submerged and peak discharge could not be recorded. The station need to be moved to a location where they can be measured even in the event of a major flood, or their monitoring equipment needs to be rebuilt to measure higher water level.
- It is necessary to provide the water supply system for Bekasi city during lowering upstream water level as mentioned the proposed SOP (refer to Chapter 5.6.4).



Figure 2-107 Telemetry System for Proposed SOP

2.5.4 Proposal

The review results by JICA Study Team on the current flood control plan and design are summarized as follows:

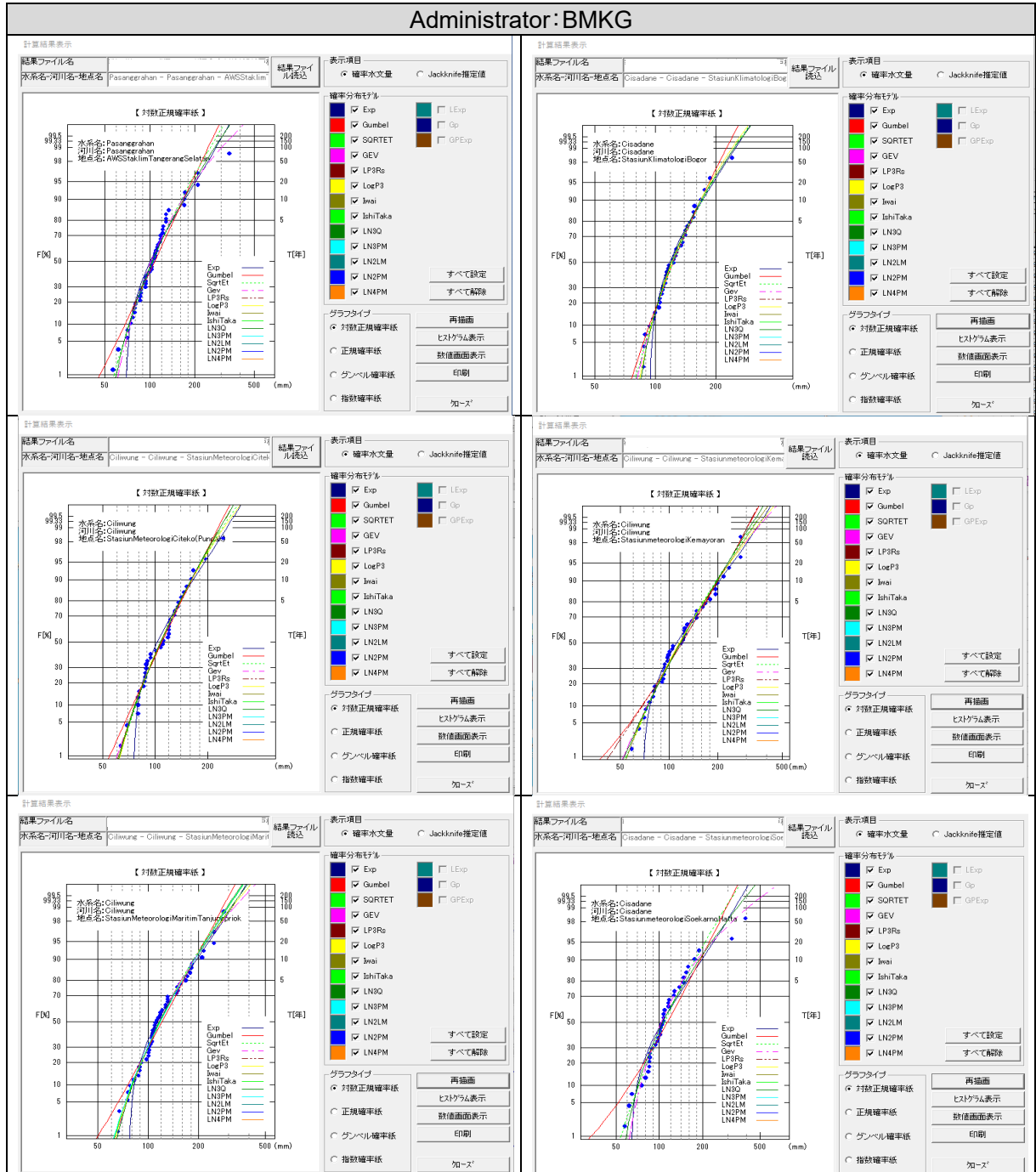
- Since the flood on January 1, 2020 was the largest scale in the past records, it is necessary to review the current overall flood control plan and river improvement design of the entire Bekasi River including the re-estimate of the design flood discharge.
- The height of existing concrete retaining wall has been constructed remarkably high from the ground elevation. Once the retaining wall breaks, the flood flows into the inland at a tremendous speed, and there is a risk of causing enormous damage. The design high water level should be lowered as much as possible, and weak river bank structures such as concrete retaining walls should be avoided, and such structures shall be replaced to more resilient structures.
- River channel profile shall be reexamined for lowering the design high water level. Especially in the upstream section of Bekasi weir, the river bed is clearly rising due to sedimentation. When the optimized longitudinal profile of riverbed is employed, it is necessary to provide a sediment flashing measure to maintain the design riverbed profile.
- The upstream end of the river normalization works should be extended up to the portion where flooding started.
- The current plan and design shall be reviewed and modified taking these issues into account during construction.
- The SOP of the Bekasi Weir flood gate in the event of a flood should require such an operation as to minimize the effect of the backwater of the Weir and to lower the water level in the event of a flood in the upstream section.
- In order to realize the optimum operation of the Bekasi Weir flood gate, it is considered effective to closely monitor the upstream runoff and conduct pre-lease before a flood comes. For this purpose, a water level (runoff) monitoring system at the Cikeas and Cileungsi rivers and telemetry system which transfers data in real time should be installed.

- Although the current plan was designed with the return period of 25 years, it is also necessary to prepare flood control measures of the return period of 50 years in accordance with the Ministerial Order/PERATURAN MENTERI NOMOR 28/PRT/M/2015 and Indonesia's Flood Control Guidelines/Guidelines for Flood Control and DPU in 1996.

Attachment 2-1 Evaluation of daily rainfall probability at each station

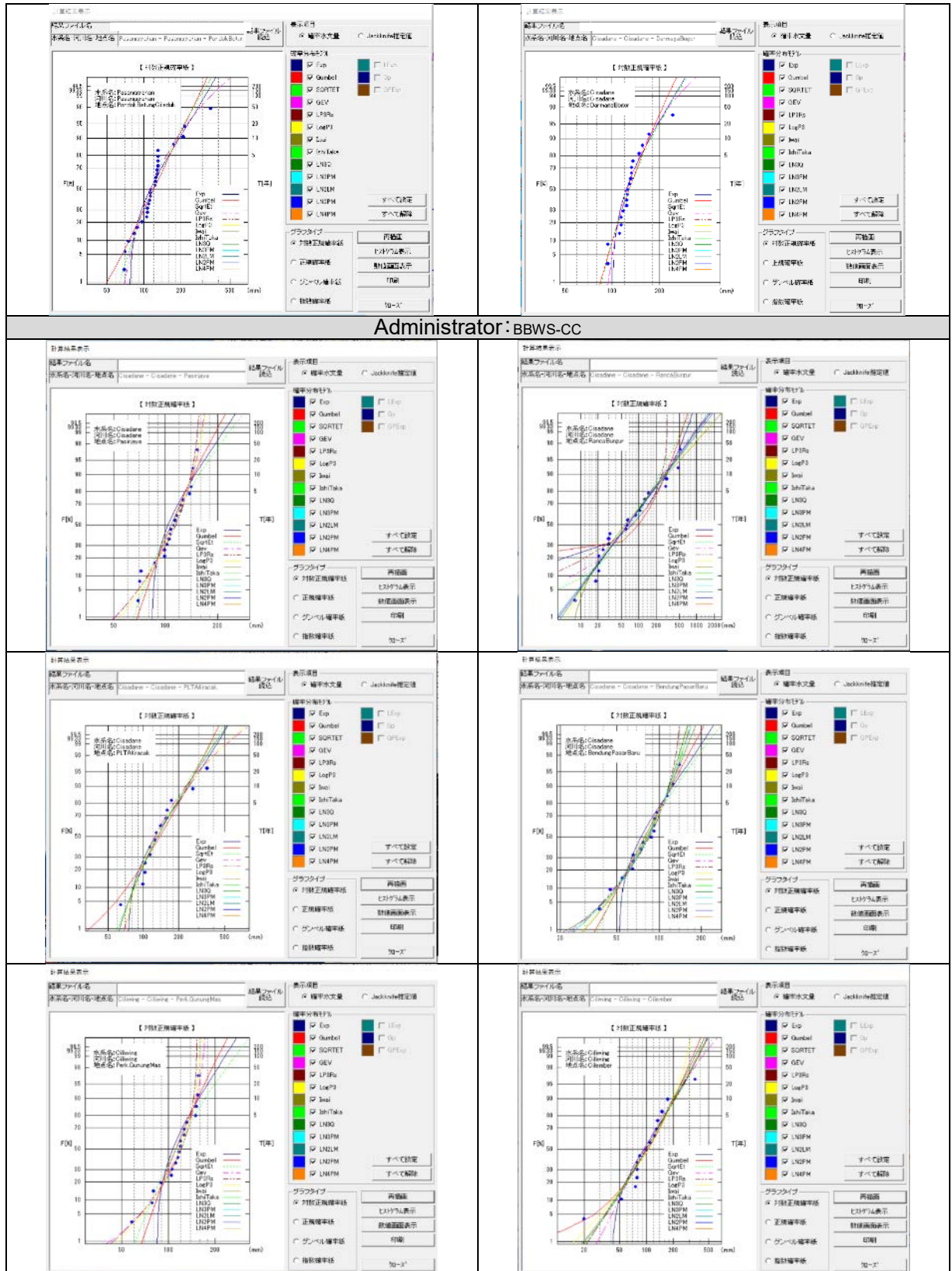
Evaluation of daily rainfall probability at each station was examined based on the collected historical rainfall data to confirm the validity of observed data. The hydrological statistics utility Ver.1.5 (Japan Institute of Country-ology and Engineering) was used to calculate the probable rainfall.

Figure 1 shows evaluation of daily rainfall probability at each station.



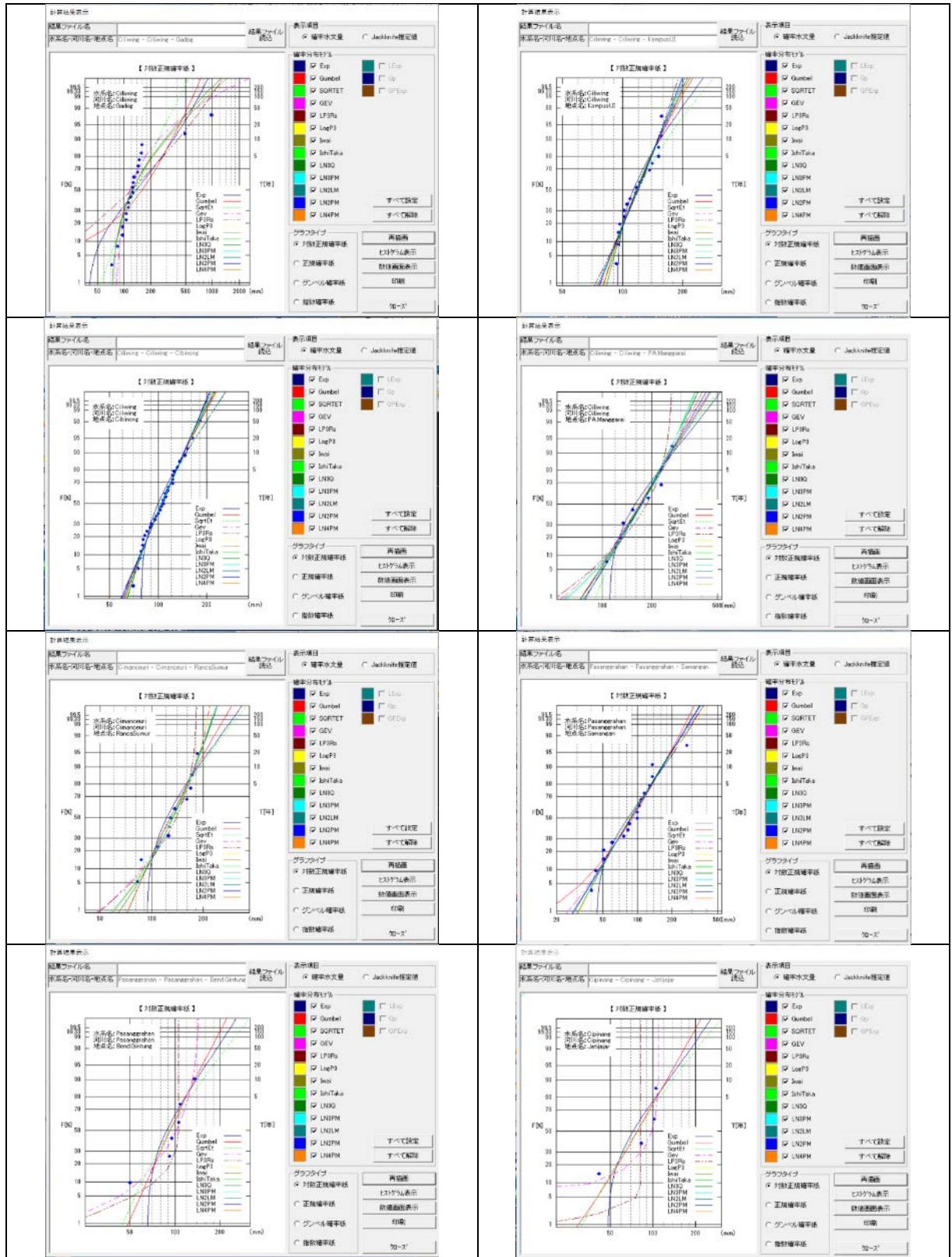
Source: JICA study team

Figure 1(1/8) Evaluation of daily rainfall probability at each station



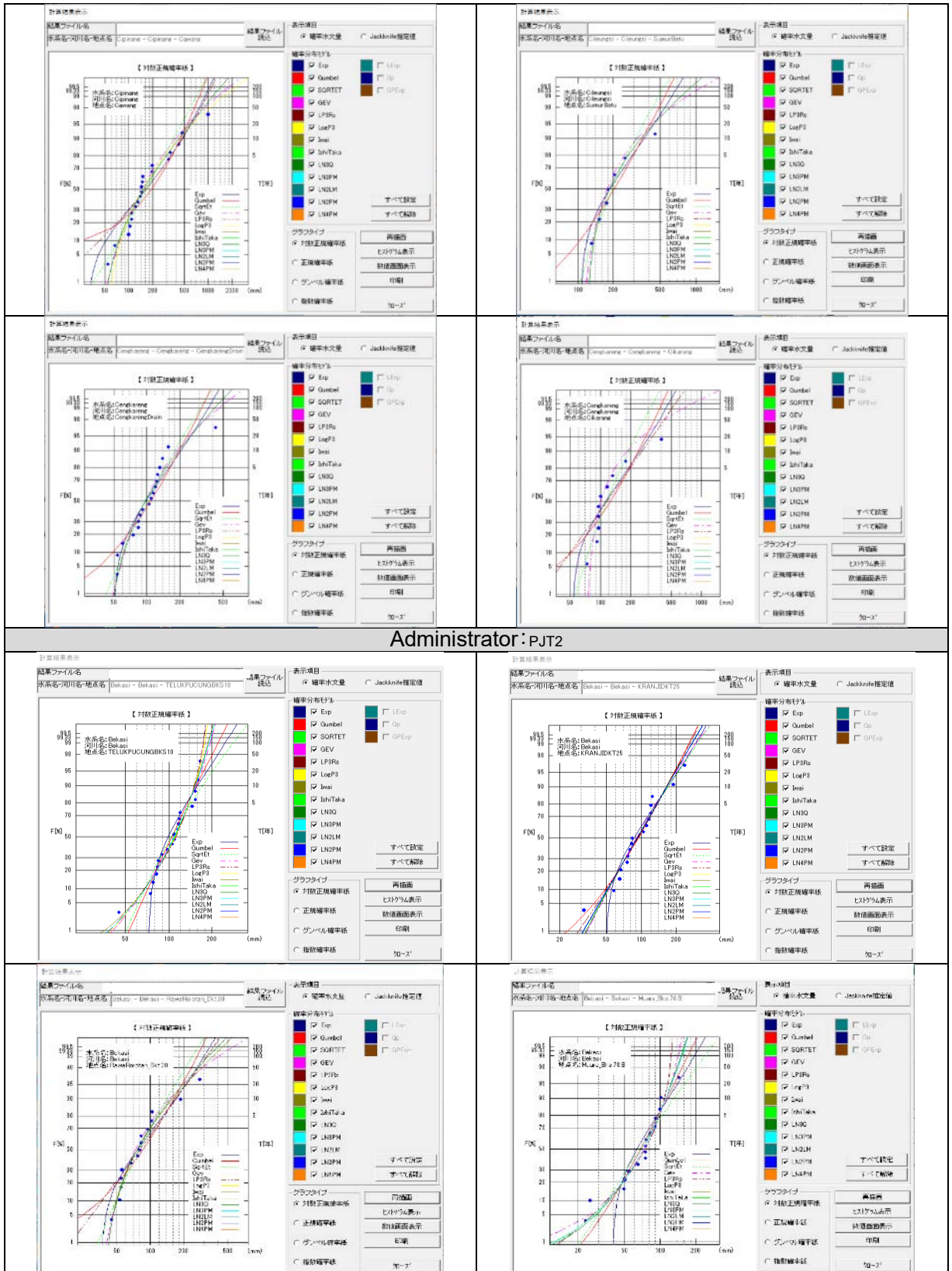
Source: JICA study team

Figure 2(2/8) Evaluation of daily rainfall probability at each station



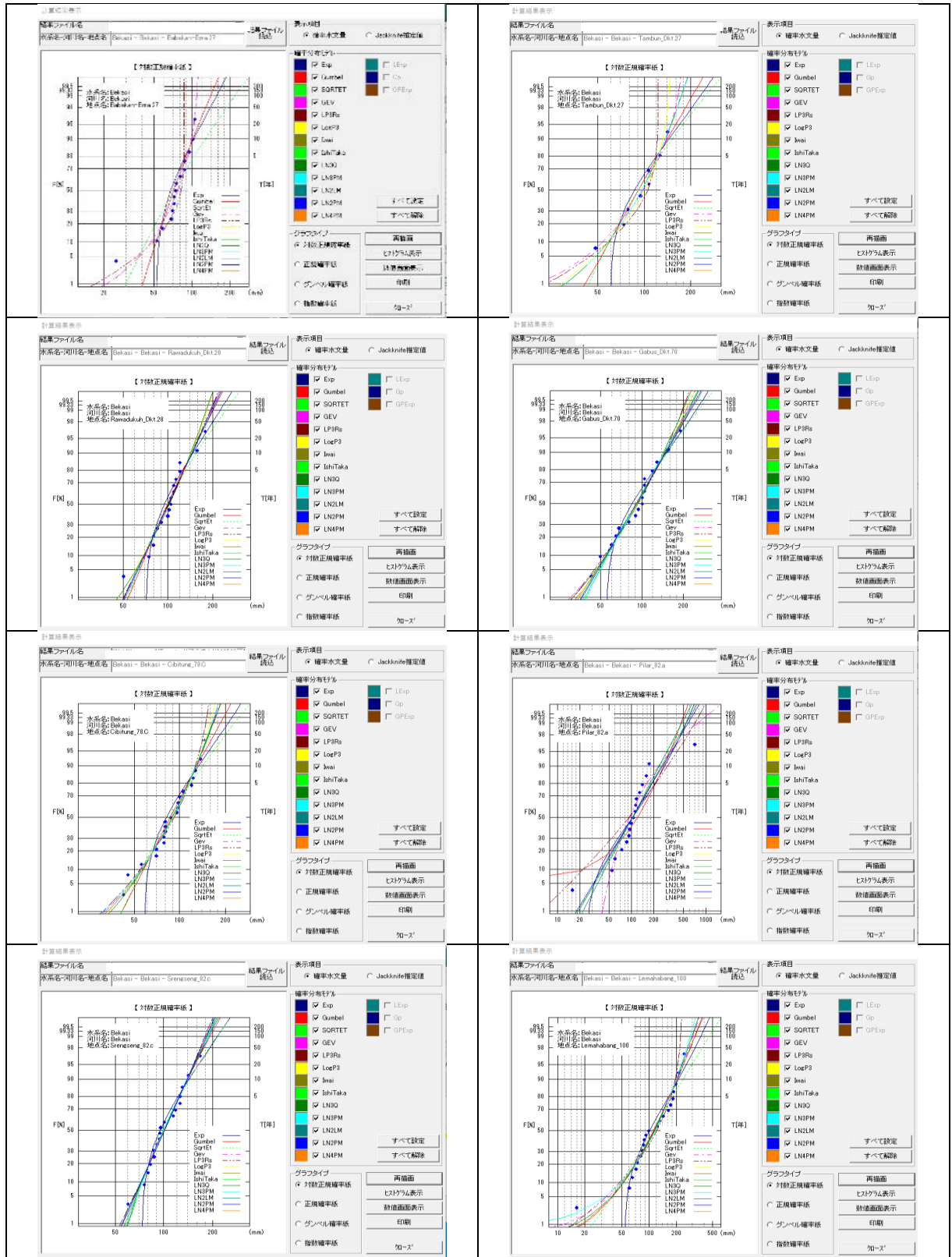
Source: JICA study team

Figure 3(3/8) Evaluation of daily rainfall probability at each station



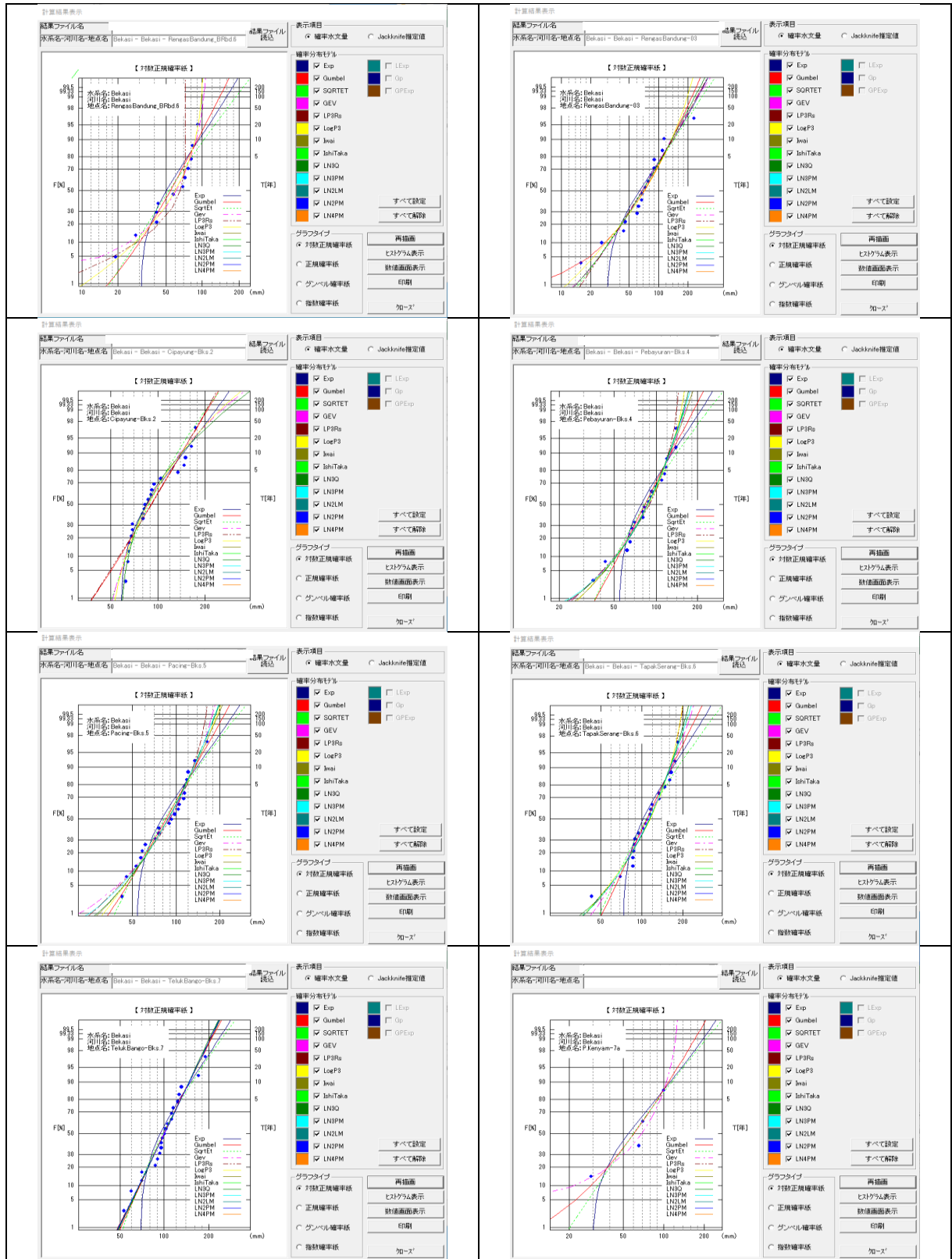
Source: JICA study team

Figure 4(4/8) Evaluation of daily rainfall probability at each station



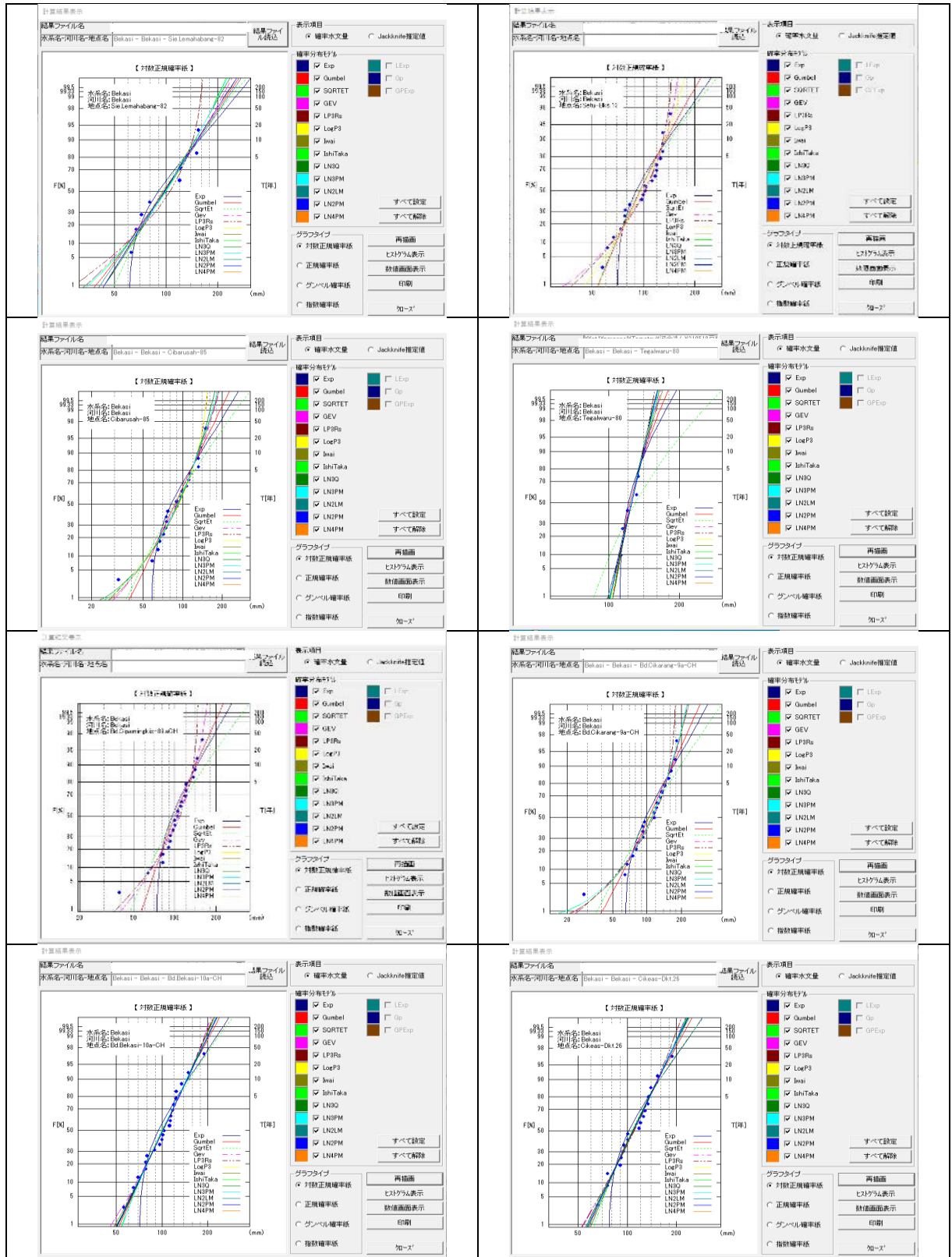
Source: JICA study team

Figure 5 Evaluation of daily rainfall probability at each station



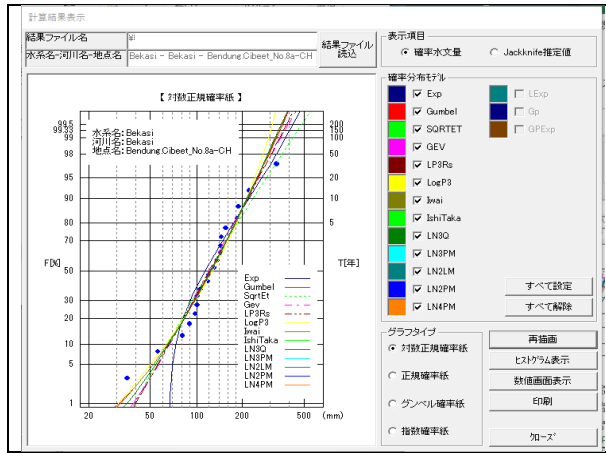
Source: JICA study team

Figure 6 Evaluation of daily rainfall probability at each station



Source: JICA study team

Figure 7 Evaluation of daily rainfall probability at each station



Source: JICA study team

Figure 8(8/8) Evaluation of daily rainfall probability at each station

Chapter3 Cisadane River flood control measures

3.1 General

The master plan of the Cisadane River was prepared by "Study on Comprehensive River Water Management Plan in JABOTABEK, 1997, JICA". The master plan covered only the 20 km section from the river mouth to the Pasar Baru Weir. The urban area upstream of the Pasar Baru Weir was not included because the river section has sufficient flow capacity. Later, in 2013, the contents of the Master Plan were re-examined in the Ciliwung River Basin Flood Control Study under the Project for Capacity Development of Jakarta Comprehensive Flood Management, Indonesia, JICA, and the concept of flood control plan for the Ciliwung River was significantly changed in response to changes in local conditions. In this reexamination, two significant changes to the plan were proposed, namely (1) the cancellation of the Ciliwung-Cisadane Floodway (diversion of 600 m³/s of water from the Ciliwung River to the Cisadane River) and (2) the cancellation of the Angke Floodway, resulting in significant changes in the design discharge of the Cisadane River, which were not mentioned in the flood control study.

After this change of plan, BBWS Ciliwung-Cisadane had carried out the detailed design for the river reach from the river mouth to the upstream (upstream section of Pasar Baru Weir in 2010 and downstream section of Pasar Baru Weir in 2015), by its own budget. These designs covered a 65 km river reach from the river mouth (through approximately 40 km upstream of the Pasar Baru dam) and the Ciliwung-Cisadane Floodway had already been excluded. The work type is different in the upstream and downstream sections. The works in the upstream section will consist of small-scale embankment (concrete retaining wall) and revetment construction, and those in downstream section will consist mainly of embankment construction. As pointed out in the 1997 master plan, the flood damage in this reach was caused by the delay in operating the gates of the Pasar Baru weir and other problems, as well as inland water problems.

A meeting on the flood disaster in JABODETABEK in January 2020 was held on June 16, 2020 between Bappenas, DGWR and BWWS Ciliwung-Cisadane of PUPR, Bappeda and DSDA of DKI Jakarta, and JICA, and following the request of Minister Basuki, JICA decided to review the Master Plan. Finally, SDA, PUPR decided to add the Cisadane flood control project to the Blue Book's request.

Since the detailed design was carried out after the above plan change of the Ciliwung River by JICA, this study reviewed the detailed design, especially focusing on the following points:

- Rainfall and runoff analysis using BMKG data and compared with past survey results.
- Collection of historical large-scale inundation data
- Reexamination of the master plan based on the SOBEK inundation analysis result by PUSAIR including inland water treatment and the operation of Pasar Baru Weir Flood Gate.

**Excerpt from Minutes of Meeting
on June 16, 2020**

(3) Cisadane River

It is expected for the project team to prepare Master Plan in Cisadane River, since current work only covered partial area. Information of ongoing projects in the river shall be shared to the project team.

Contents of the Blue Book

**Cisadane River Flood Control Project (Upstream, midstream, and downstream, including the Cirarab and Sabi rivers)
Citeureup River Dam FS, SID, DED**

3.2 Overview and Current Status of the Cisadane River

3.2.1 Overview of the Cisadane River Basin

The Cisadane River is the largest river in the JABODETABEK region, originating from Mt. Kendeng (1,764 m), Mt. Perbakti (1,699 m) and Mt. Salak (2,211 m) and flowing into the Java Sea through the city of Tangerang.

Mountainous areas located in the upstream area account for 1/3 of the river basin. In the upstream and midstream areas, the river forms a valley with deep erosion, and in the downstream area it meanders down the alluvial coastal plain, with natural dikes formed along the river channel. Overall river improvement works have not yet been carried out, but only revetment works and partial embankments in irrigated areas.

Tangerang city, the largest city in the basin, is located on a river terrace at an altitude of more than 12.5 m. The floodplain extending from the downstream of the Pasar Baru Weir to the coastal area is used for farmland, mainly paddy fields. In recent years, the urban area of Jakarta has expanded into Tangerang City, which is developing as a satellite city of Jakarta. Large-scale residential complexes have been developing in the watershed. It is also the manufacturing center of Indonesia, with over 1,000 factories including those of many foreign companies.

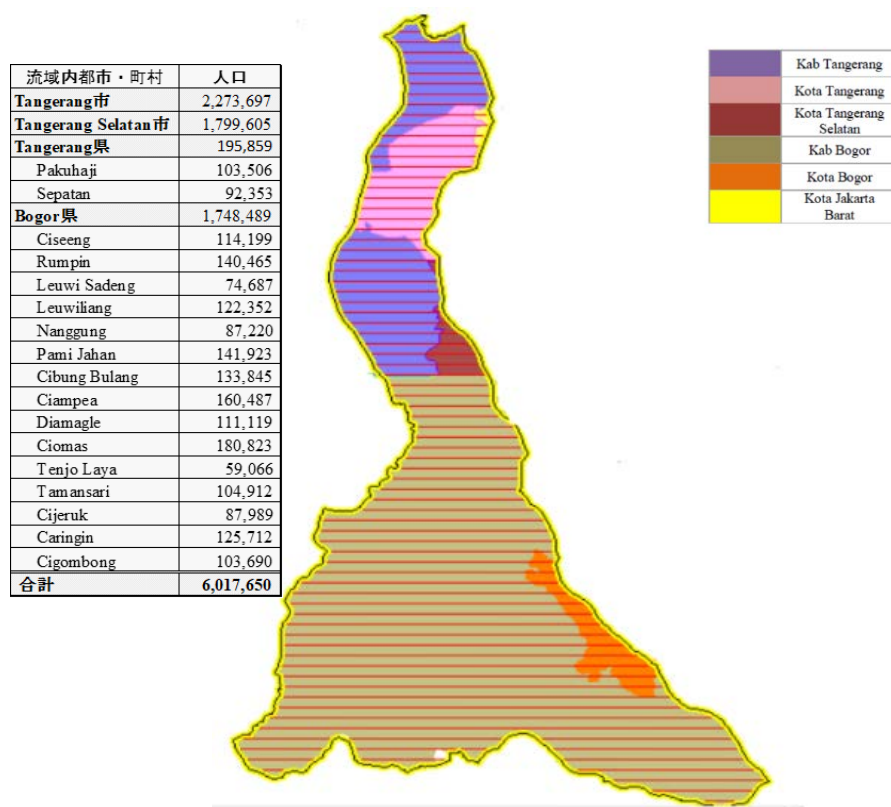


Figure 3-1 Province and population of the basin

The Cisadane River Basin is shown in Figure 3-2. The basin features are as follows.

Major Branch Rivers	: Cilaus, Ciartan, Clanten, and Cikaniki rivers	
Catchments	: 1,411 km ²	
River Extension	: Approximately 133 km.	
Annual Precipitation (1997 MP)	: Coastal plain	1,800 mm/year
	Hilly area	2,500 mm/year
	Mountain Area	3,500 mm/year

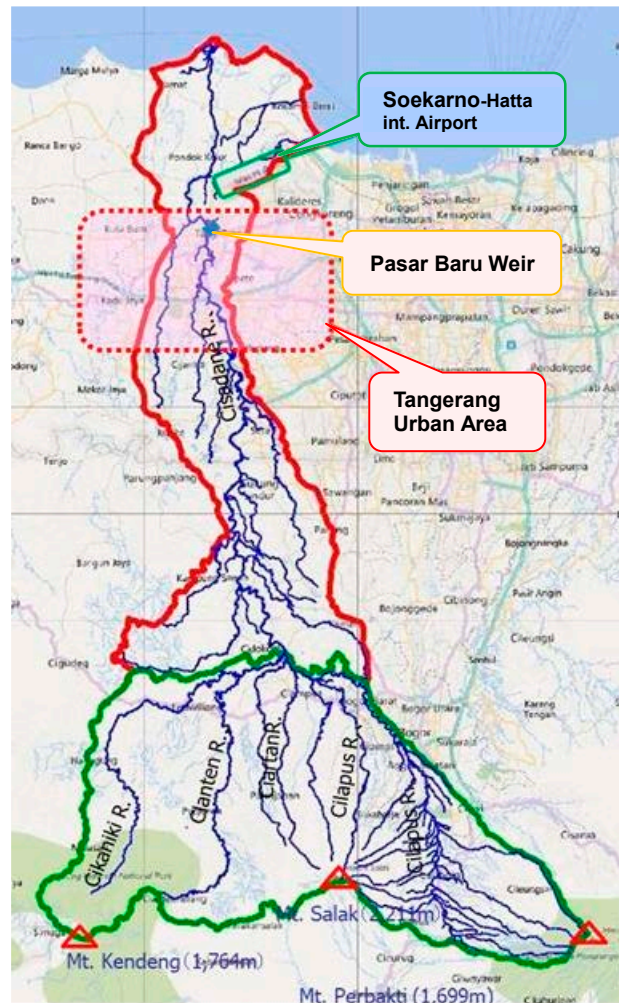


Figure 3-2 Cisadane River Basin Chart

(1) Riverbed Gradient

The riverbed gradient of the Cisadane River is summarized as follows (see Figure 3-3).

- Estuary - Pasar Baru Weir 1/3,200
- Pasar Baru Weir - 55 km from the river mouth 1/2,100
- 55 km from mouth of river - 60 km from river mouth 1/260
- 60 km from mouth of river - 100 km from river mouth 1/180
- > 100 km from river mouth Steeper than 1/50



Figure 3-3 Cisadane Riverbed Gradient

(2) Flow Capacity

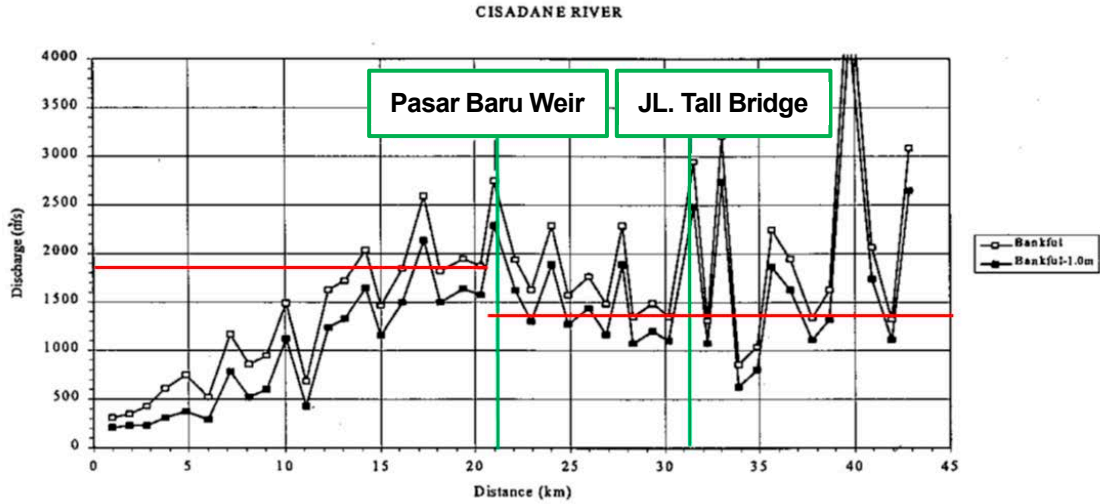
The flowing capacity of the Cisadane River was evaluated in the 1997 MP and 2015 DD as follows.

(i) Evaluation of 1997 MP

- Estuary - Pasar Baru Weir 200~2,500 m³/s
- Pasar Baru Weir - Tall Bridge 1,000~2,000 m³/s

(ii) Evaluation of 2015 DD

- Pasar Baru Weir - Tall Bridge 700 m³/s or more
- Upper Tall Bridge 1,500 m³/s or more
- After completion of the river improvement as designed in the project (2010 DD for the upstream section of the Pasar Baru weir and in the upstream section, 2015 DD for the downstream section of Pasar Baru weir, it is supposed that downstream section), the Cisadane river will be improved with a flow capacity of 50- year flood discharge (1,391.54 m³/s for the upstream section of and Weir and 1,496.24 m³/s for the downstream section) of weir.



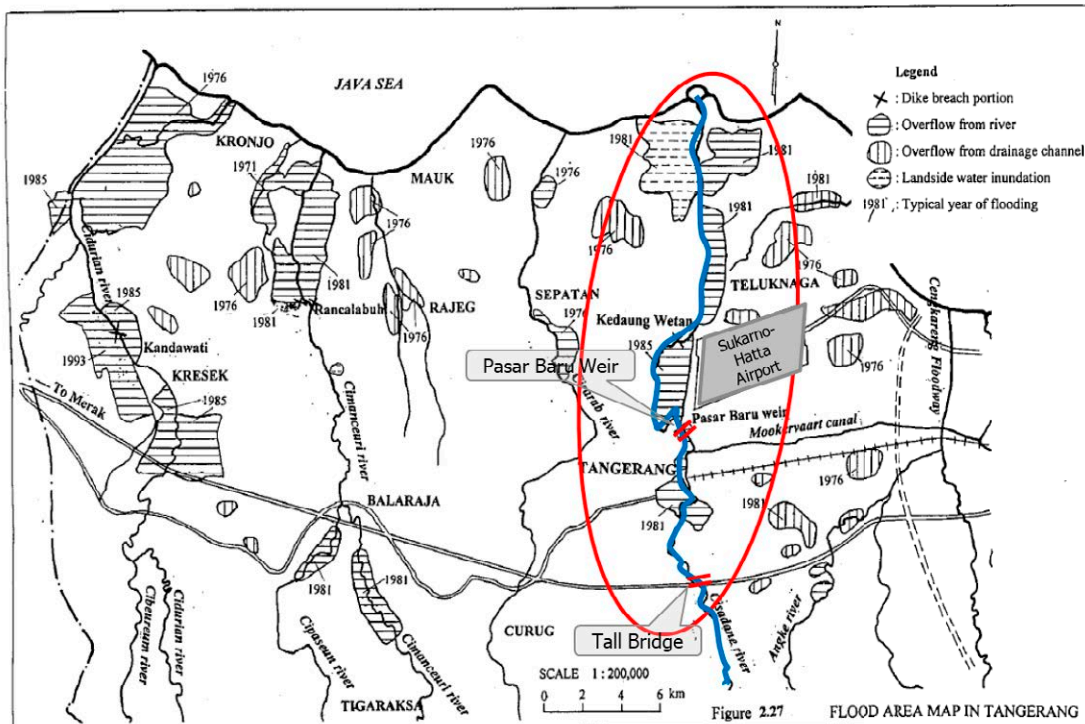
Source: The Study on Comprehensive River Water Master Plan in JBOTABEK, 1997, JICA

Figure 3-4 downflow capability chart

(3) Flood Area

In the 2020 floods, no severe flooding from the Cisadane River was observed, but inland water inundation along the Cisadane River and river flood from the Sabi River, tributary of the Cisadane in Tangerang City were reported. The flooded area in Tangerang city was between the Sabi River and the Cisadane River.

Figure 3-5 is a flooded area map of the 1976, 1981 and 1985 floods compiled in the 1997 MP. Inundation mainly occurred in the downstream of the Pasar Baru weir. In this study, however, It is verified that the flooded areas have been expanding in urbanized areas upstream of the Pasar Baru weir (refer to Section 3.4.1).



Source: The Study on Comprehensive River Water Master Plan in JBOTABEK, 1997, JICA

Figure 3-5 Flooding area of the Cisadane River (Tangerang Province)

3.2.2 Past Flood Protection Plan

The following plans and designs have been prepared for the Cisadane River basin. The 1997 MP was funded by JICA, and other planning and design activities were funded by the local government.

- a) 1997 : Master Plan of Cisadane River(JICA)
- b) 2010: Detail Desain Pengendalian Banjir Kali Cisadane Hulu (Upper Pasar Baru Dam DD)
- c) 2015: Detail Desain Pengendalian Banjir Sungai Cisadane Hilir (downstream DD, Pasar Baru weir)
- d) 2019: SID EMBUNG DI HULU WILAYAH SUNGAI CISADANE (Embung Ciburial and Bendungan Citeureup)

BBWS CiliCis has been implementing some partial improvement works based on these plans. The outline of each plan/design is as follows.

(1) 1997: Master Plan of Cisadane River

(i) Scope of Works

- River improvement for the 16.8 km river reach from the mouth of the river. It was judged that there is no need of river improvement for the river reach from the 16.8 km point to the Pasar Baru weir.
- 600 m³/s join the upstream of the Cisadane River from the Ciliwung River via the Ciliung Floodway,
- 135 m³/s join the downstream of the Cisadane River from the Angke River via the Angke Floodway.
- Downstream from the Angke River, it merges 135 m³/s through the Angke Floodway.

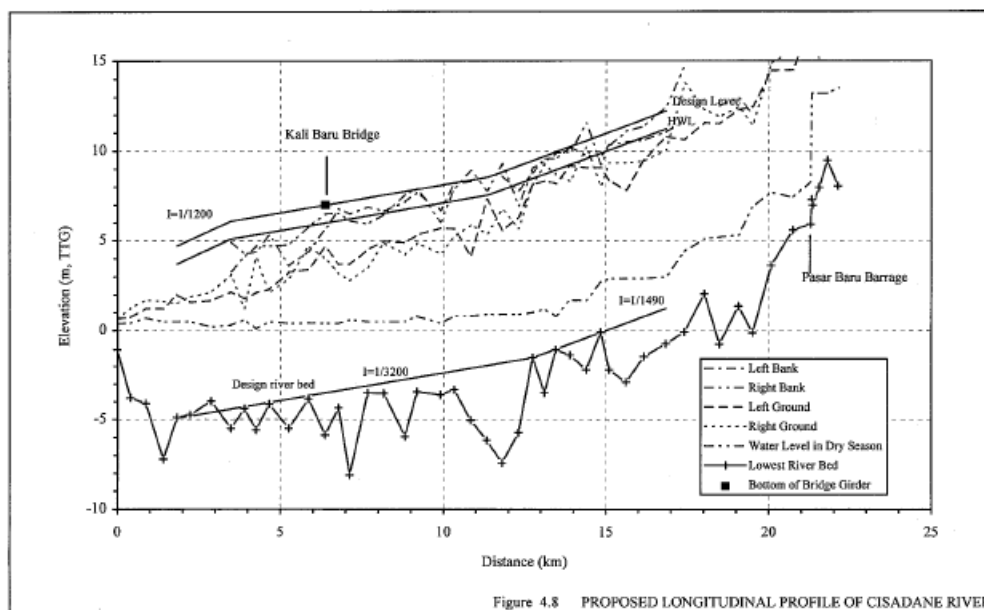


Figure 3-6 Areas of Renovation and River Profile

(ii) Project Scale

- Cisadane River's 50 year-flood discharge 1,600m³/s

- Ciliwung Floodway 100 year-flood discharge 600m³/s
- Angke Floodway 50 year-flood discharge 135m³/s
- Design Discharge for downstream of the Pasar Baru weir 1,900m³/s

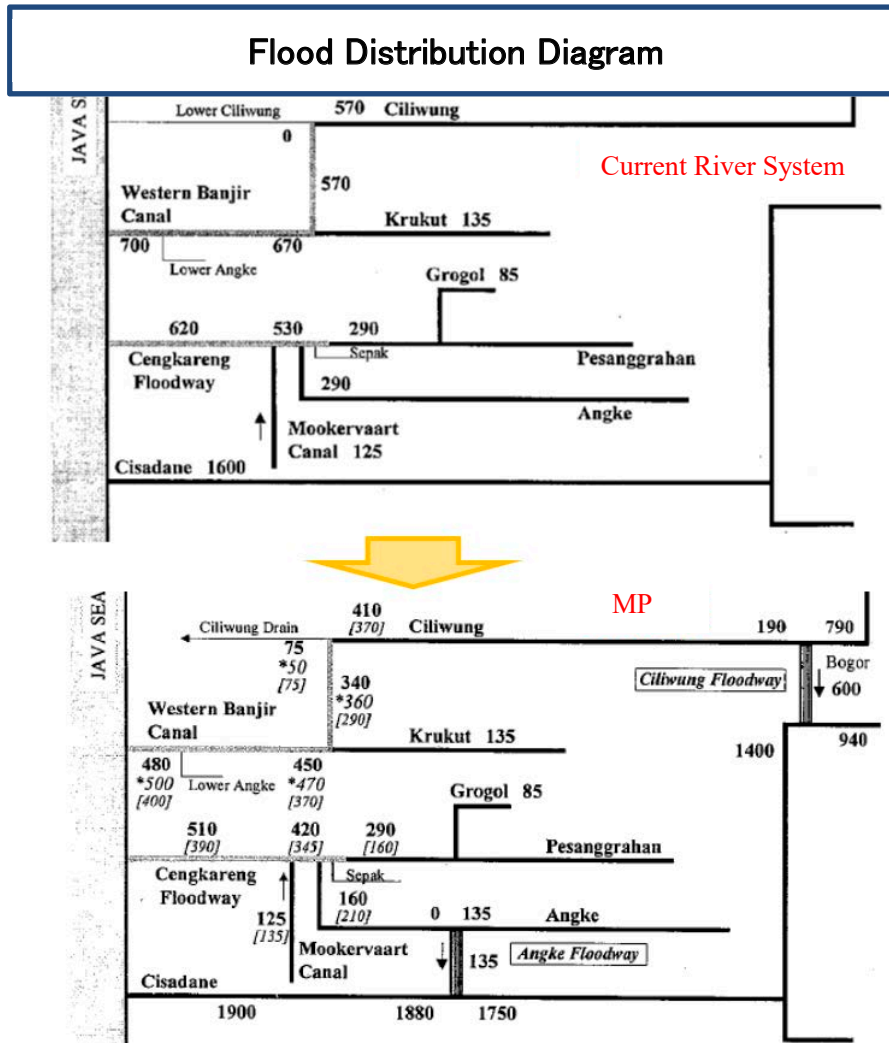


Figure 3-7 Flood Distribution Diagram for 1997 MP

(iii) Proposed Works

- Widening and embankment along downstream river channel of Pasar Baru Weir
- Repair of the Pasar Balu Weir Flood Gate
 - Repairing/Replacing a damaged gate
 - Replacement of the generator
 - If the gate can be operated normally, it is judged that the flood water can be safely released down.

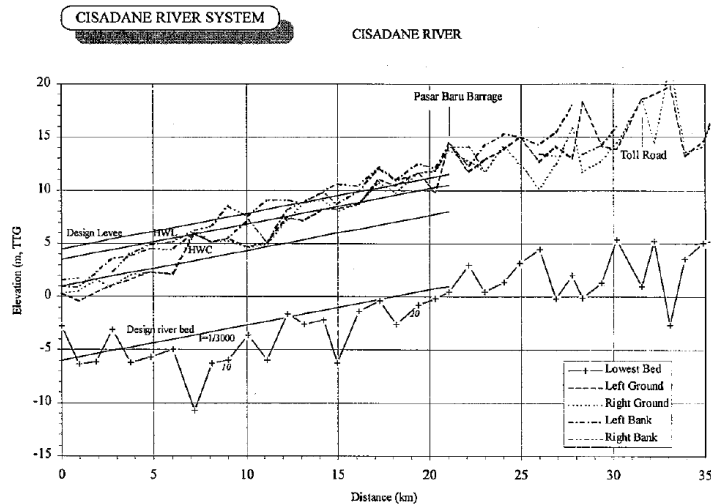


Figure 3-8 Rehabilitation Project of Pasar Baru Downstream at 1997 MP

- (2) 2010: Detail Design Pengendalian Banjir Kali Cisadane Hulu (Upper Pasar Baru Weir DD)
 - (i) Current Status and Issues

Since river flood inundation have occurred frequently in the Cisadane River basin in the past, provision of flood mitigation measures is urgently required. BBWS CiliCis has determined that, in particular, the downstream section of the Pasar Baru Weir and the 10 km section upstream of the Pasar Baru Weir section (Zone I) have insufficient flow capacity, and there is a risk of flood inundation by the river discharge of approximately 700 m³/s.

The causes of the flooding in Zone I were evaluated as below.

- a) Sediment has been accumulated due to the Pasar Baru weir, and the river flow capacity is insufficient in some sections.
- b) It is difficult to secure the sufficient width of the river because the land within the boundary of the river is used for roads and houses.
- c) Some sections have low riverbank elevations and are at risk of flooding (especially around Gerendeng Plasa).
- d) The confluence treatment of tributaries and drainage channels which are flowing into urban areas is not properly carried out.
- e) The water level upstream of Pasar Baru weir is always maintained at 10 m above the river bed. The raised water level makes it difficult to drain inland water from drainage outlets during rainstorms.
- f) During the rainy season, garbage flows into drainage channels in residential areas, making them not functioning.
- g) In the upper reaches of the river, green areas have been converted into settlements or sand/gravel mining sites. The amount of flood runoff is increasing with the change of land use.

As described above, there are river flood damages at limited areas and inland water inundation in the Cisadane River basin as described in a) to c), and their countermeasures are proposed in the detailed design.

(ii) Improvement Section

40 km long section upstream of Pasar Baru Weir

(iii) Project Scale

50-year Flood (Q_{50} : 1,391.54 m³/s)

(iv) Project Features

The river is divided into the following three (3) zones within the target area, and the following improvement methods are proposed:

(A) Zone I: 10.15 km from Pasar Baru Weir to Jakarta-Merak TOL Bridge.

- Targets the densely urbanized areas of Tangerang City
- Installation of sheet pile revetments in areas with insufficient drainage capability
- Installation of gates at the junction of drainage channels.
- Provision of proper maintenance and management of drainage channel

(B) Zone II: Jakarta-Merak TOL Bridge to Serpong-Cisauk Bridge

- In areas with flood problems (residential areas in Gading Serpong) measures including provision dikes have already been undertaken, no flood damage has been reported.
- The ground level on both sides of the river is relatively high compared to the river water level, and the whole river has sufficient flow capacity.
- Since some riverbanks are prone to collapse (sliding collapse), concrete revetments are provided to ensure safety against bank slope failure (in particular at Desa Pakulonan and Pakulonan Barat).

(C) Zone III: Serpong-Cisauk Bridge to Jampan Atas Village (In this section, gravel mining is carried out on the riverbed.)

- As there is no problem of flooding, no structural measures will be taken.
- However, the riverbank that is high and consisting of silty soil may cause slope failure (sliding).

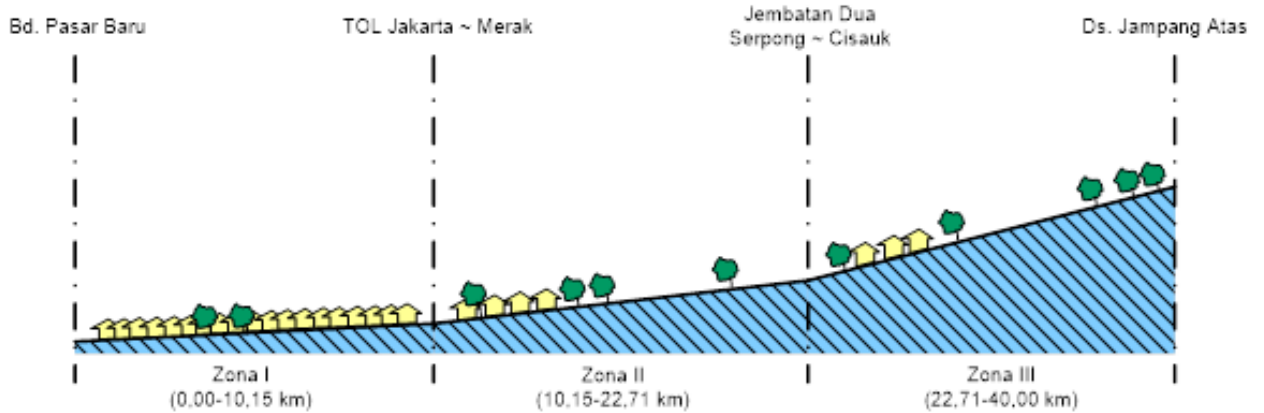
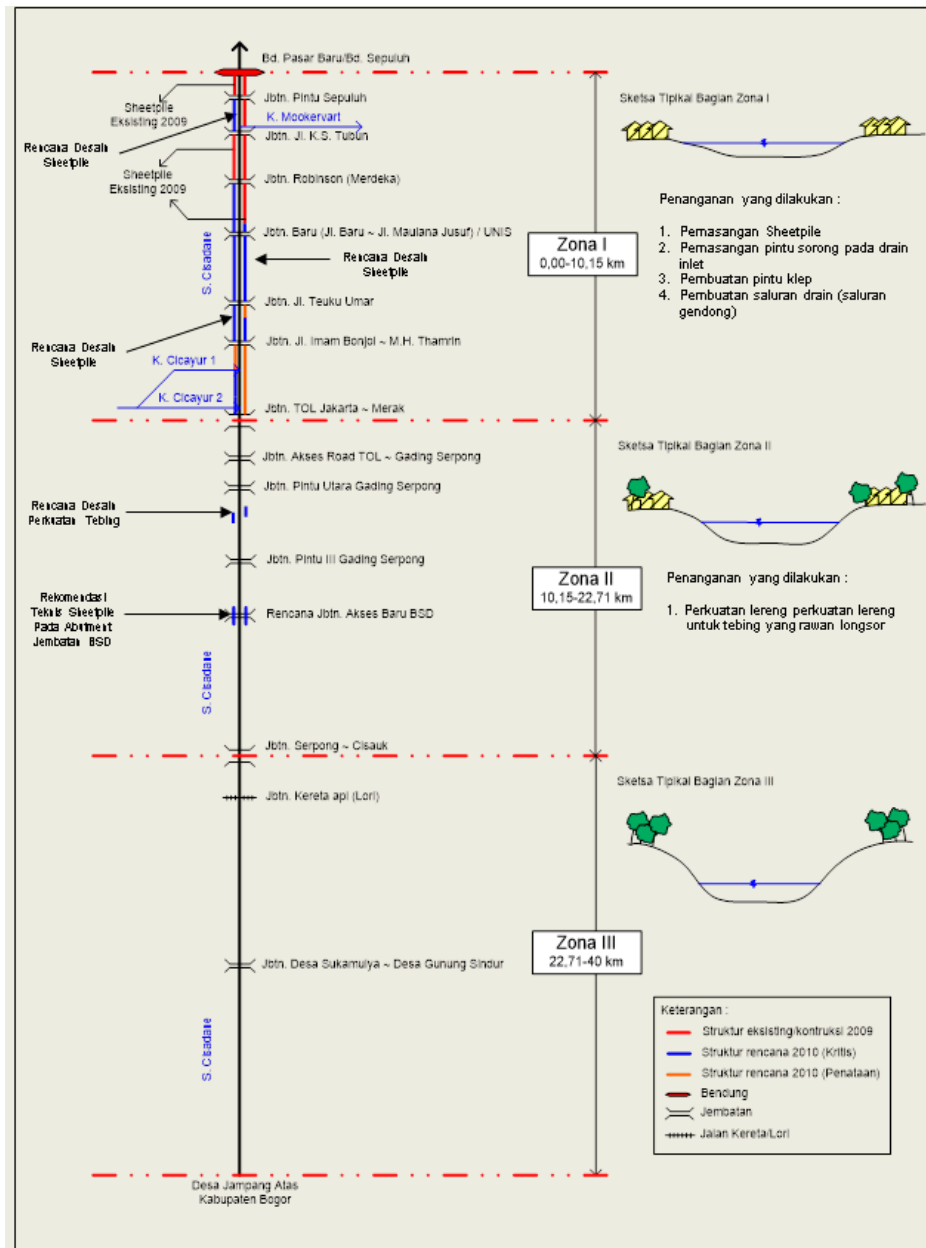


Figure 3-9 Planning Concepts for River Improvement in 2010 DD

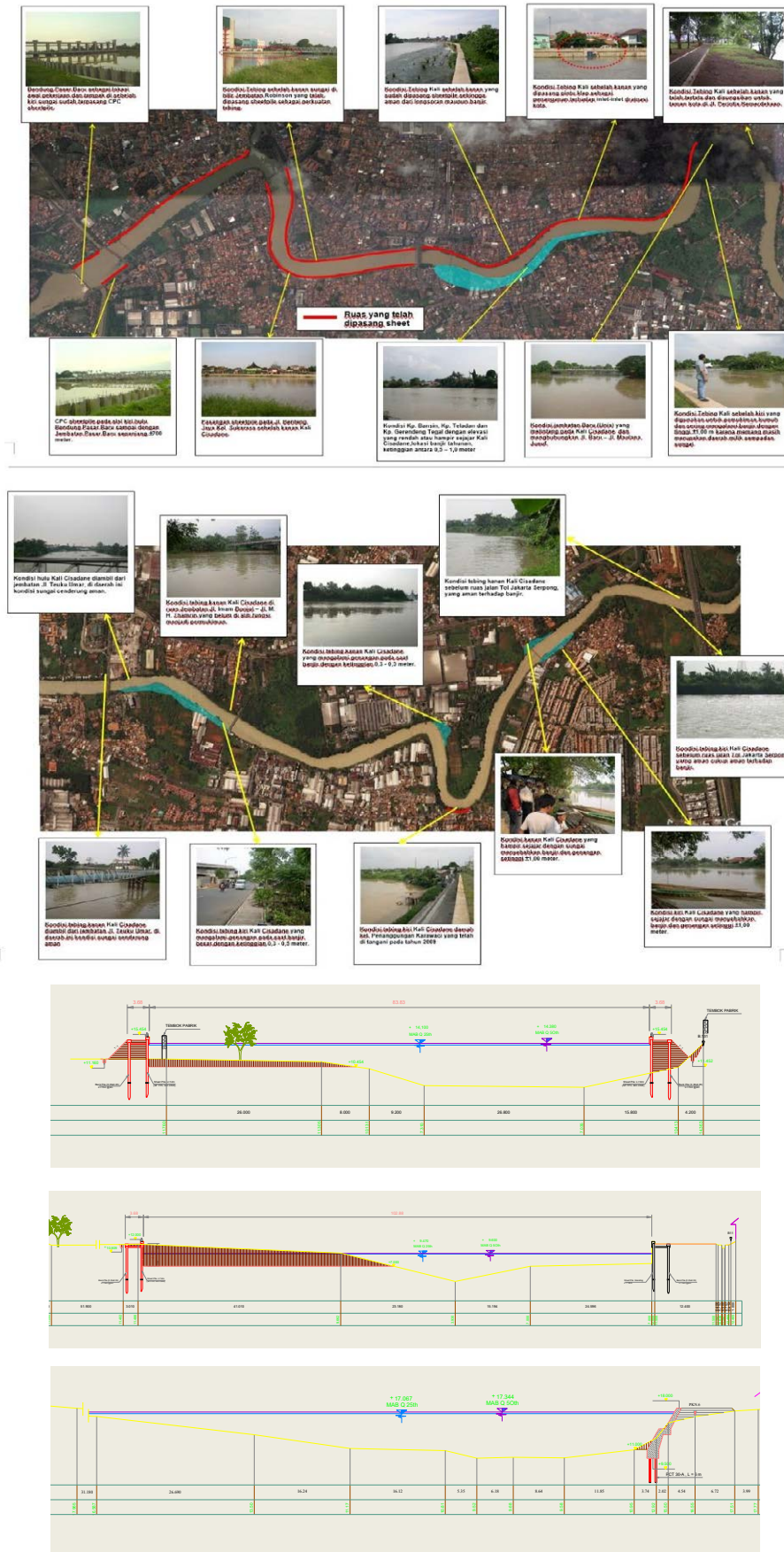


Figure 3-10 Location and Sections of River Improvement Works (upstream of Pasar Baru Weir)

(3) 2015 : Detail Desain Pengendalian Banjir Sungai Cisadane Hilir
(DD downstream of Pasar Baru Weir)

(i) Improvement Section

25 km section from the river mouth to the Pasar Baru Weir

(ii) Project Scale

50 Year-Flood (Q_{50} : 1,425 m³/s)

(iii) Project Components

The improvement section is divided into 4 segments, and the design of facilities was carried out based on the planning concept of each segment.

(A) Measures for Segment 1 (0.0 ~ 1.5 km)

Segment 1 is a 1.5 km section km upstream from the river mouth of the Cisadane River. Since the foundation of this section consist of very soft sandy soil, the sheet pile revetment cannot be applied in this section. In the design, the following two kinds of embankment materials are proposed for the embankment.

[Type 1] Limestone (Calcareous sand/soil)

[Type 2] Soil material brought in

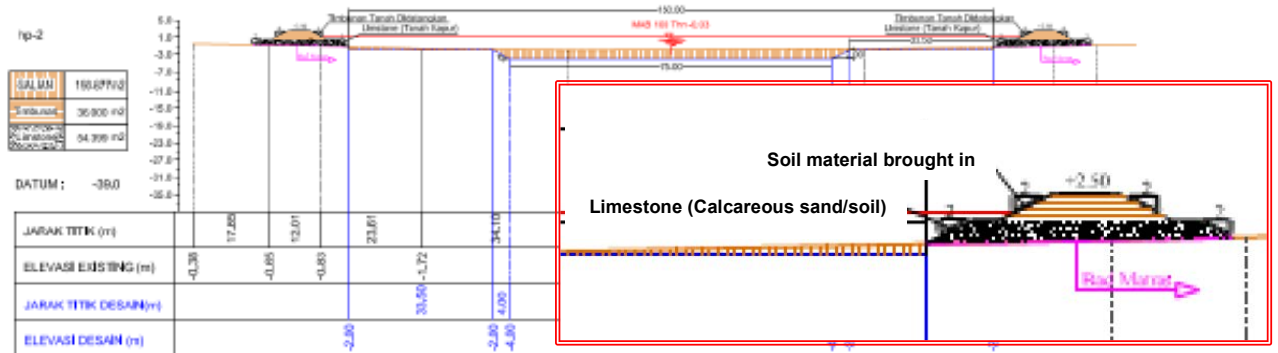


Figure 3-11 Concept of Segment 1

(B) Measures for Segment 2 (1.5 km to 5 km)

In segment 2, the embankment is constructed using dredged/excavated soil, and the slope is reinforced with sodding. The slope is 1: 2. The problems found in the field investigations along Segment 2 are as follows:

- Damaged sheet pile for river bank protection (small scale) are still remaining at several locations.
- Due to continuous bank erosion, sliding of the bank slope is observed at several locations.

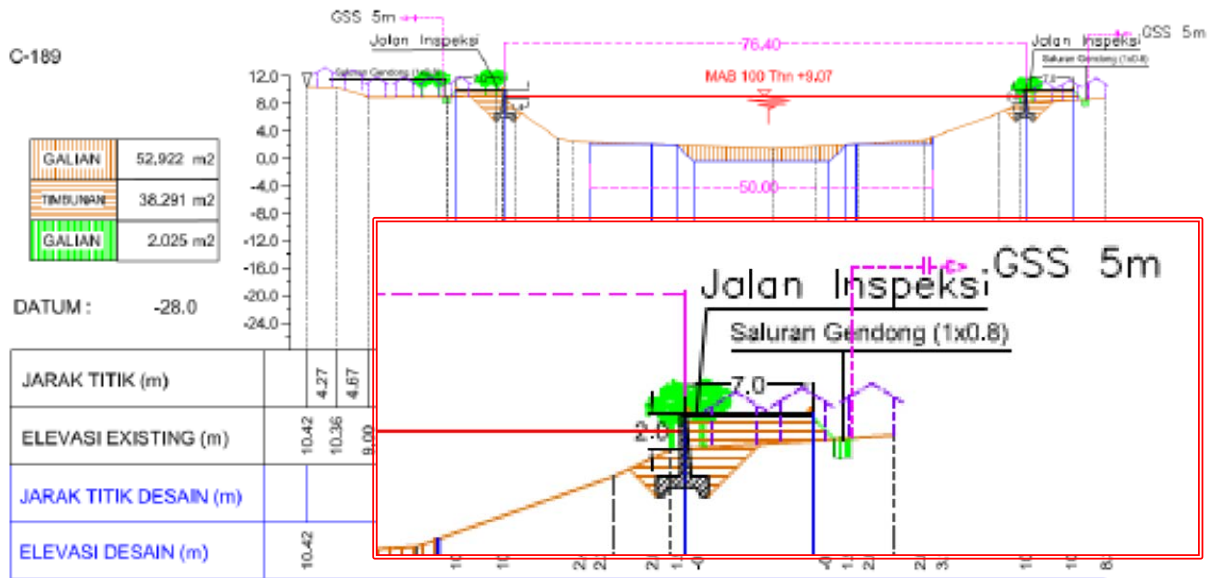


Figure 3-14 Concept of Segment 4

In addition to these river channel improvements, the several measures are proposed such as the construction of a retention ponds for inland water at downstream section and the treatment of the confluence with Sabi River, which joins at the downstream of the Pasar Baru weir.

(4) Retention Ponds

In the floodplain at downstream of the weir, a retention ponds are planned as one of the measures to control runoff and to prevent inland water inundation due to the rise of river water level. In order to avoid the problem of land acquisition, paddy fields have currently been selected as the construction sites.

The following functions are expected to be realized in the retention ponds.

- a) To conserve the drainage basin in the future (considering future development).
- b) Preventing sediment flew in to the Cisadane River (functioning as a Sand-trap).
- c) To reduce peak flood discharge in an area along the downstream of Pasar Baru weir where is habitual inundation area.

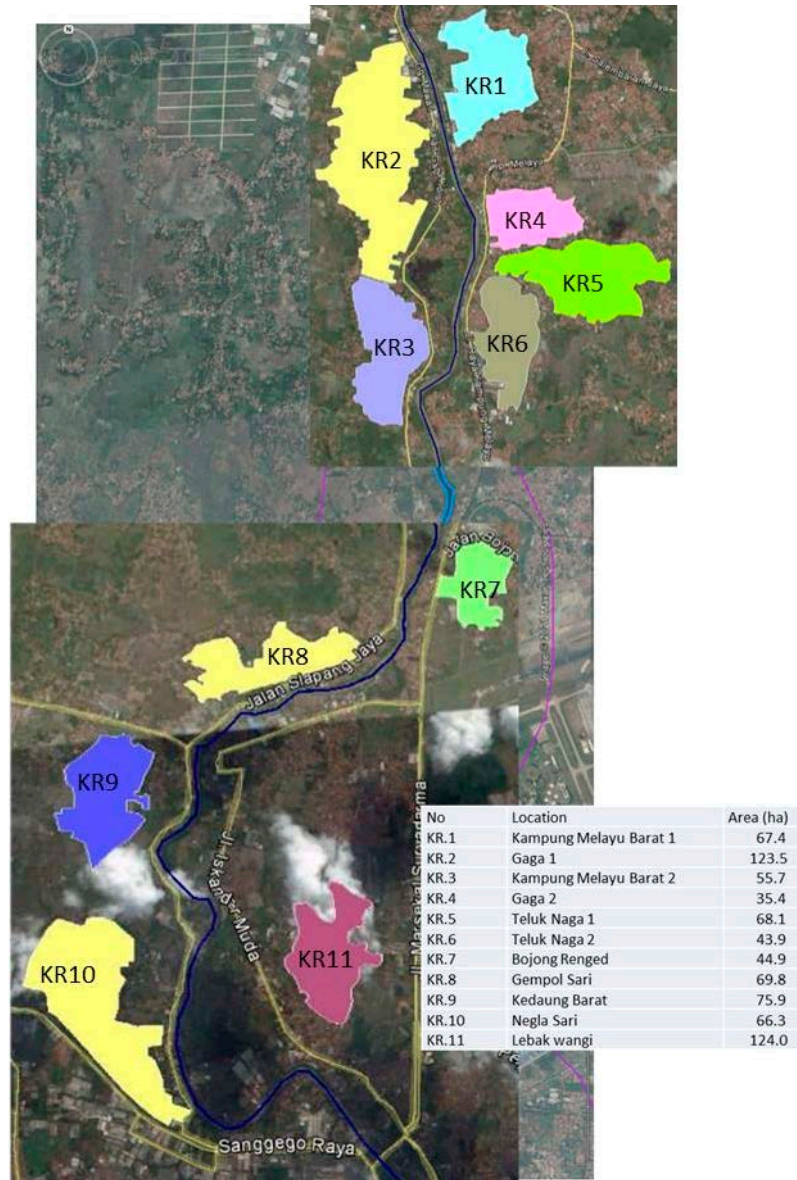


Figure 3-15 Flood Control Project in the Downstream of Pasar Baru Weir

- (5) SID EMBUNG DI HULU WILAYAH SUNGAI CISADANE (Embung Cibural and Bendungan Citeureup), 2019 (Study-Inspection-Design on Potential Reservoir Sites in the Cisadane River: Cibural Reservoir and Citeueup Dam, 2019)

BBWS CiliCis had been examining a dam site in the Cisadane River basin that could be constructed for water use and flood control, and finally proposed the Citeureup Dam. Although flood control is included in the purposes of the dam, its effect has not been considered in the present river improvement channel plan.

Design feature of Citeureup Dam was as follows.

- Catchment Area: 15.24 km²
The upstream of the Citeureup Dam is hilly areas with an altitude of 700 m, covered by extensive plantations and paddy field.
- Objectives of dam: irrigation, municipal water, hydropower, flood control, tourism
- Dam: Height: 69 m, Crest length: 324 m,

- Reservoir: Effective capacity: 11 million m³, Dead water capacity: 711,000 m³
- Water intake: 0.760 m³/s (Water supply: 0.562 m³/s, irrigation (180 ha of existing rice fields): 0.198 m³/s)
- For power generation, no reservoir water is not allocated and generating power using intake water for irrigation and municipal water supply (dependent power generation). The generated power at the plant is connected to the PLN network.
- The dam type is a zoned fill dam consisting of core, filter, and random (outer layer). Crest Width 12 m, Upstream Slope 1: 3, Downstream Slope 1: 2.75
- The spillway is connected to the tributary on the right bank.
Overflow crest length: 20 m, Height of the overflow weir: 3 m, Width of crest: 8 m, and Chute channel length: 165 m. Overflow weir and chute were designed in Q 1000. The wall height of the channel corresponds to PMF (> 0.75 m).
Energy dissipater: USBR IV type (corresponds to the design discharge: Q₁₀₀), width: 8 m, length: 24 m.
- Connected to a hydropower plant via a 1.50 m diameter penstock.

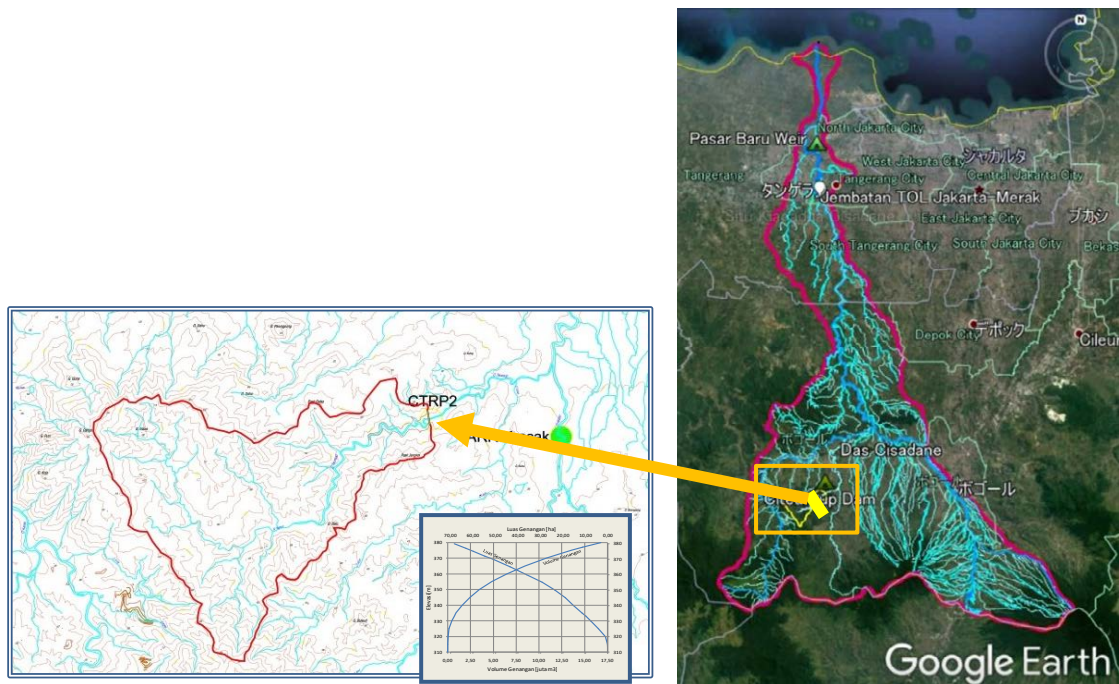


Figure 3-16 Location Map of Citeureup Dam

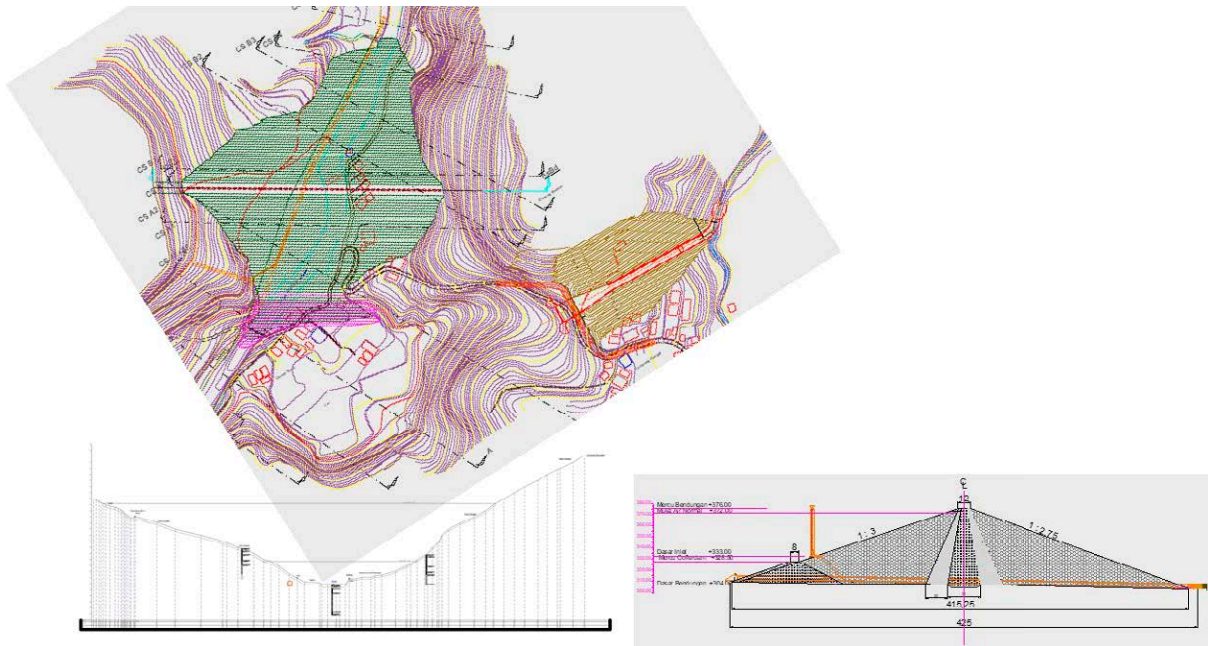


Figure 3-17 Plan-Section-Profile of Citeureup Dam

3.2.3 Flood Control Project Conducted by BBWS CiliCis and their Budget

The flood control projects carried out by BBWS CiliCis in the Cisadane River from 2015 to 2019 are shown in the table below. Almost all of them were revetment works using concrete sheet piles.

Table 3-1 Project for Flood Control Project under BBWS CiliCis for Cisadane River (2015 - 2019)

No	Location	Length of completion		Work Components
		Right bank (km)	Left bank (km)	
1	Lokasi 1 Tanjung Burung	0,648		Sheetpile
2	Lokasi 2 Tanjung Burung	0,342		Sheetpile
3	Lokasi 3 Tanjung Burung	0,319		Sheetpile
4	Lokasi 4 Box Culvert Kali Sabi	0,201	0,337	Pasangan Batu Kali
5	Lokasi 5 Kel. Mekarsari	2,035		Retaining Wall dan Steel Sheetpile
6	Lokasi 6 Kampung Baru, Kel. Koang Jaya		1,037	Retaining Wall dan Steel Sheetpile
7	Lokasi 7 Jembatan Unis sampai Jembatan Robinson	1,685		Concrete Sheetpile
8	Lokasi 7a Kampung Cacing		0,348	Concrete Sheetpile
9	Lokasi 8 Kel. Panunggangan Barat		0,915	Concrete Sheetpile
10	Lokasi 9 Paspamres (Grup C), Kel. Lawanggantung		0,12	Pasangan Batu & Bronjong
11	Taman Gajah	2,15		Sheetpile
12	Kelurahan Bojong (GJA)		0,67	Sheetpile
13	Perumahan Cibodas		0,25	Sheetpile
TOTAL (km)		7,38	3,677	11,057

Budget for flood control projects scheduled in 2020-2024 by BBWS CiliCis are shown in the table below.

Table 3-2 BBWS CiliCis budget bill for 2020 – 2024

No.	Programs/activities/outputs/packages/SUB-Packages	Ta. 2020	Ta. 2021	Ta. 2022	Ta. 2023	Ta. 2024	Rp. Million
							百万円
RENSTRA FLOOD CONTROL ACTIVITIES IN BANTEN PROVINCE YEAR 2020-2024							11,518.5
1	Cisadane River Flood Control (continued)	50,000	50,000	50,000			1,111.1
2	Cimanceuri River Flood Control		50,000	50,000	50,000	50,000	1,481.5
3	Flood Control in Sabi River, Cirarab River	50,000	50,000	50,000	50,000	50,000	1,851.9
4	Restoration and Arrangement of the Cisadane River		50,000	20,000	20,000		666.7
5	Situ-Situ Revitalization in Tangerang District	40,000	40,000	30,000	20,000	20,000	1,111.1
6	Situ-Situ Revitalization in South Tangerang City	40,000	40,000	30,000	20,000	20,000	1,111.1
7	Situ-Situ Revitalization in Tangerang City	40,000	40,000	30,000	20,000	20,000	1,111.1
8	Revitalization and Arrangement of Situ Patrasana		100,000	70,000			1,259.3
9	Revitalization and Arrangement of Situ Garugak		60,000	80,000			1,037.0
10	Rehabilitation of the Gintung Dam		60,000	15,000	15,000	15,000	777.8

3.2.4 Budget for Projects

The detailed design for the 50-year flood has already been completed and BBWS CiliCis has now started the construction works partially in accordance with the design. The total construction cost is Rp. 1,458 million (about 11.7 billion yen) for the Pasar Baru weir downstream project and Rp. 338 million (about 2.7 billion yen) for the Pasar Baru weir upstream project.

Table 3-3 Pasar Baru weir upstream river improvement project

REKAPITULASI RENCANA ANGGARAN BIAYA
PEKERJAAN DETAIL DESAIN PENGENDALIAN BANJIR KALI CISADANE HULU
Lokasi : Kota & Kabupaten Tangerang, dan Kabupaten Bogor

NO.	JENIS PEKERJAAN	JUMLAH BIAYA (Rp)
I	PEKERJAAN PENDAHULUAN	748,337,000.00
II	PEKERJAAN NORMALISASI KALI	319,036,869,200.00
III	PEKERJAAN BANGUNAN OUTLET DRAINASE (MAJOR INLET)	2,724,404,480.20
IV	PEKERJAAN BANGUNAN UTILITAS OUTLET DRAINASE (MINOR INLET)	1,691,796,201.64
V	PEKERJAAN SALURAN MINOR DRAINASE L total = 13.775,48 m	6,097,999,690.00
VI	PEKERJAAN REVETMENT BETON (Kp. Pakulonon Barat & Kp. Pakulonon)	7,380,531,822.29
	TOTAL	337,679,938,304.04
	P P n (10 %)	33,767,993,830.40
	GRAND TOTAL	371,447,932,134.44
	DIBULATKAN	377,447,932,000.00
Terbilang : Tiga Ratus Tujuh Puluh Tujuh Miliar Empat Ratus Empat Puluh Tujuh Juta Sembilan Ratus Tiga Puluh Dua Ribu Rupiah		

Table 3-4 Pasar Baru weir downstream river improvement project

VI.4 Rekapitulasi Rencana Anggaran Biaya

No	Uraian Pekerjaan	Jumlah Harga (Rp)
1	2	3
I	PENDAHULUAN	2,737,406,300
II	PEKERJAAN TANAH	198,173,013,130
III	PEKERJAAN KONSTRUKSI PERKUATAN TEBING	913,561,099,048
IV	PEKERJAAN JALAN INSPEKSI	242,482,800,000
V	PEKERJAAN SALURAN DAN PINTU AIR	101,440,900,000
	TOTAL	1,458,395,218,478
	PPN 10%	145,839,521,848
	GRANDTOTAL	1,604,234,740,326
	DIBULATKAN	1,604,235,000,000

3.3 Evaluation of the existing Cisadane River project

3.3.1 Evaluation of Existing Plan

Floods caused by river water have occurred frequently in the Cisadane River basin in the past. Therefore, it is strongly required to mitigate flood damages immediately. BBWS CiliCis has evaluated that, in particular, the lower section downstream of Pasar Baru Weir and about 10 km section upstream of Pasar Baru Weir (Zone I) have insufficient flow capacity, and there is a potential risk of inundation by a flood of about 700 m³/s.

The concept of the ongoing Cisadane river improvement project under BBWS CiliCis is established to address these issues. The downstream of the Pasar Baru weir is an alluvial plain and dikes are provided as flood control measures. On the other hand, the river in the upstream of the weir flows in a hilly area, forming a deep river channel of which river banks are generally high enough although low banks are seen at some portions. Therefore, countermeasures for the upstream section consists of provision of dikes together with inland water treatment measures at the low portions.

The Sabi River, which joins in the alluvial plain (downstream of the Pasar Baru Weir), is one of the causes of flooding in Tangerang city (especially in the urbanaized area). BBWS CiliCis and the Tangerang City Government emphasized the importance of flood control measures for the Sabi River and proposed confluence treatment measures in the 2015 detailed design. In addition, they have been studying a runoff control plan (retention pond) and a river bypass plan of Sabi River.

When these plans/design were reviewed, some problems were found in the treatment method of the confluence point of the Sabi River and the Cisadane River. Therefore, the improvement of the existing confluence treatment plan is proposed in this study (to be listed in the Japanese yen loan).

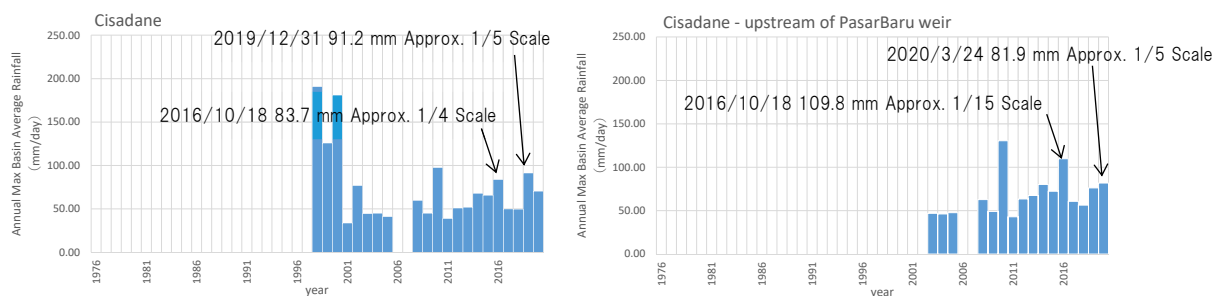
3.3.2 Project Scale

Tangerang City (capital of Banten State, population 2.3 million) and South Tangerang City (population 1.8 million), located in the basin, are megacities adjacent to DKI Jakarta. The Indonesian standard (PUPR Ministerial Order 28/PRT/M/2015) has set target safety levels depending on the size and importance of cities. The target safety level, namely the project planning scale for the Cisadane River is the return period of 50 years, which has been also adopted in the current river improvement plans. Therefore, if there is no need to change the design

discharge, the target safety level will be achieved when the construction proposed in the detailed design in 2010 and 2015 is completed as designed.

In order to confirm the necessity of the revision of the planned design discharge, the rainfall and runoff of the January 2020 flood were examined including the recent rainfall records.

Regarding rainfall records, no significant heavy rainfall has been observed in the basin since the 2015 DD (see Figure 3-18). It was also found that the probable rainfalls estimated from the rainfall data collected in this study are less than those of the current plan and design (2015 DD: See Table 3-5).



Note: reprinted from Chapter 2.1.2 (6)

Figure 3-18 Basin Average Rainfall (All Cisadane river Basin, PasarBaru River Basin),

Table 3-5 Probable Rainfall in Cisadane River Basin

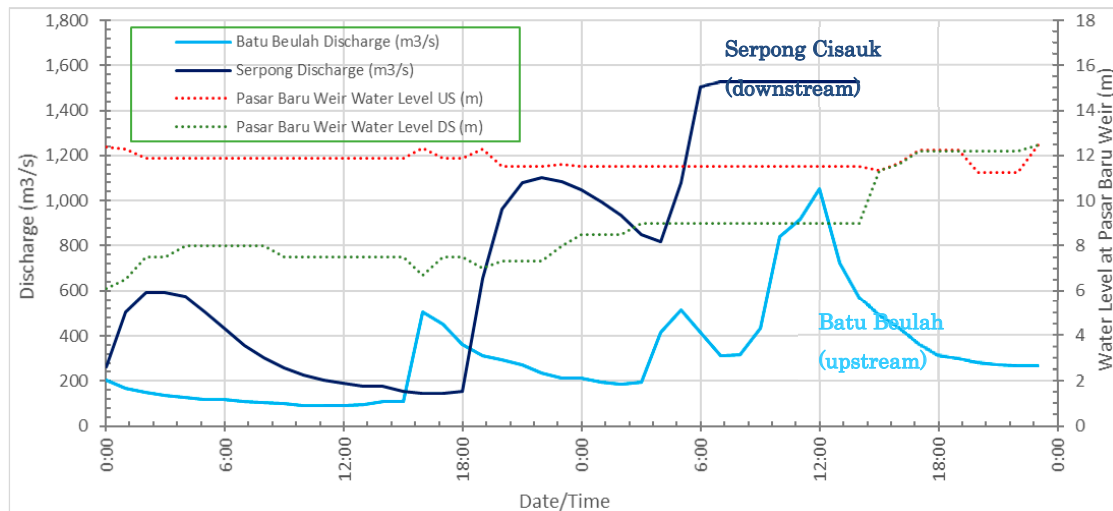
watershed		Pasar Baru Basin
1/50 scale		144.9 mm/day
1/100 scale		169.7 mm/day
probability distribution model		Gev,0.03
Previous Examination	1/50 scale	185.7 mm/day
	1/100 scale	206.8 mm/day
	Notes	Source: 2015 DD, Function: Gumbel, L-moments: 5 stations, Sample: 2005 ~ 2014, Rainfall: Estimation of basin average by Thiessen method based on the probability rainfall at stations

Note: reprinted from Chapter 2.1.2 (6)

The flood discharge observed during the 2020 flood is summarized in Table 3-6 and Figure 3-19.

Table 3-6 Flood Discharge of the Cisadane River during Flood on January 2020

Station	A (km ²)	Jan 2020 (m ³ /s)	DD2015 (DS) (m ³ /s)		
			25-year	50-year	100-year
Pasar Baru	1,271		1,163	1,313	1,478
J. Serpong Cisauk	1,144	1,528	1,110	1,256	1,416
Desa J. Atas	1,027		1,010	1,245	1,405
Batu Beulah	861	1,051			



Source: BBWS CiliCis observation data

Figure 3-19 Observed Flood Discharge and Water Level in 2020 Flood

Although the flood discharge on 1st of January 2020 could be observed at two stations, Serpong Cisauk and Batu Beulah. However, only the observed discharge at the Batu Beulah station was used for the evaluation of the flood discharge of 2020 flood because the discharge data at Serpong Cisauk was judged to not have been accurately measured for the following reasons:

- The observed data at Serpong Cisauk after 6:00 became constant, and no peak was observed after 14:00 (it is considered that the station was submerged at this time). In addition, at 6:00 the discharge exceeded the flow capacity of the Pasar Baru weir, which is located downstream of the station, and the accuracy of the rating curve that is used for the conversion from water level to discharge was also judged questionable.
- The discharge hydrograph of Serpong, which is located downstream of Batu Beulah, rose earlier than the one of Batu Beulah. The time axis may have shifted.
- Judging from the interview result with the Kota Tangerang BPBD and the results of the damage survey, the flood in and around the Cisadane River basin in 2020 was considered to have been a moderate to large flood which occurs occasionally.

Figure 3-20 shows a summary of the discharge of the January 2020 flood at the Batu Beulah water level gauging station and the results of runoff analysis in the 2015 DD. As shown in the figure, the magnitude of the discharge at Batu Beulah corresponds to a 30 to 35 year-flood. This result suggests that the rainfall data collected in this study do not accurately represent the flood discharge.

This fact suggested that there is a problem in the accuracy of observed rainfall in the Cisadane river basin (the observed rainfall does not represent the actual rainfall correctly, maintenance of rain gauges is poor, etc.). It is desirable to install a rainfall observation system that is capable of accurately observing areal rainfall. Furthermore, maintenance or reestablishment of water level gauging stations and calibration of the rating curves also strongly required.

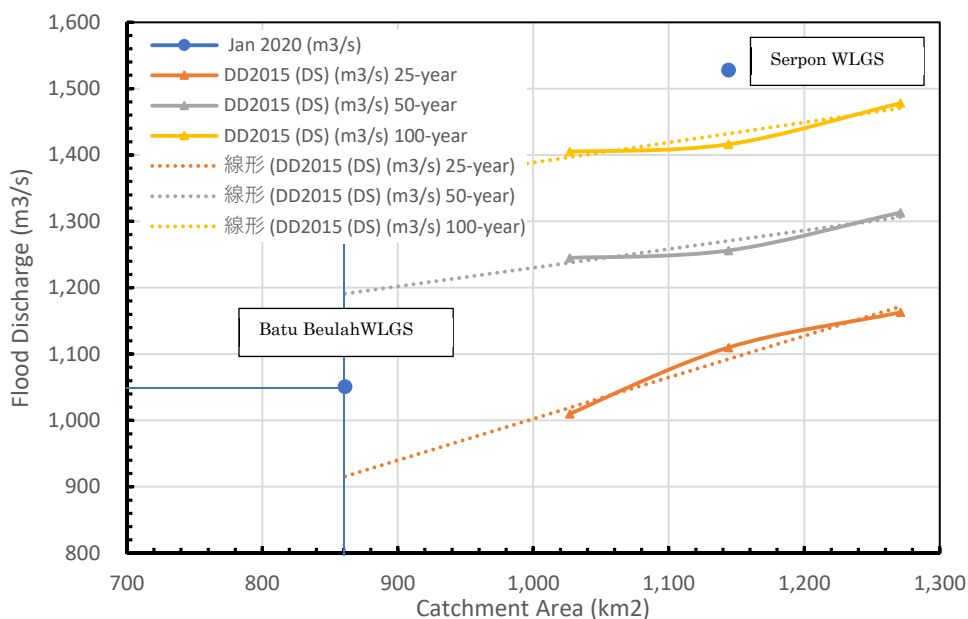


Figure 3-20 Assessment of runoff at the Batu Beulah Water Level Station (January 2020 flood)

As a result of the above examination, it was judged that the rainfall probability calculated in this study could not be used because the reliability of the rain data was too low (the probable discharge would become small), thus it was decided to follow the past runoff analysis result (2015 DD) for the design discharge.

3.3.3 Policy on Flood Control Plan for the Cisadane River

Following measures were taken in the current river improvement plan for the Cisadane River, and no major problems were found in the plan itself.

- Plans for a 50-year probability flood.
- The downstream of the Pasar Baru weir is an alluvial plain, and dikes are provided as flood control measures. A plan of retention ponds is also being prepared to cope with inland water inundation after the dike construction.
- The river in the upstream of the weir flows in a hilly area, forming a deep river channel of which river banks are generally high enough although low banks are seen at some portions. Therefore, countermeasures for the upstream section consists of provision of dikes together with inland water treatment measures at the low portions.

In addition, as described in the section on the project scale of 3.4.2, as a result of collecting and analyzing rainfall data including the January 2020 flood, it was found that heavy rainfall had not been observed since 2015 when the implementation design was carried out. Therefore, it was judged that the results of the runoff analysis at 2015 D/D (downstream of Pasar Baru) could be applied without revising the design discharge (For more information, see 2.1.4 Hydrological Analysis.). Therefore, if the project is carried out as it is, the Cisadane River will be able to cope with the 50-year flood, which is the target scale of the project.

On the other hand, BBWS CiliCis and the Tangerang provincial and municipal authorities considered the flooding of the Sabi River as the main cause of flooding in the area between the Sabi and Cisadane rivers, and wanted to proceed with the improvement works of the Sabi River

as soon as possible, and considered this measure as a major concern. At the time of the flood in January 2020, no major flood damage caused by the flood of the mainstream of the Cisadane River was reported, but flood damage caused by the one of the Sabi River, one of its tributaries, was recorded (3,619 houses flooded).

Measures against flooding along the Sabi River, including future upgrades, are discussed below, although measures against flooding along the Sabi River were also discussed in the 2015 DD. Namely the measures of the current plan have been designed for the 25-year design discharge, but a future upgrade plan (targeting the same 50-year return period) that aims to ensure consistency with the main river is presented below:

3.4 Sabi River Flood Control Plan

3.4.1 Overview of the Sabi River Basin and the Necessity of Project

The Sabi River, a tributary of the Cisadane River, is an urban river, with river basin area of 54 km² and a river length of 20 km, running through the central part of Tangerang City and joins the Cisadane River on the left bank of the main river ownstream of the Pasar Baru Weir.

Tangerang is the manufacturing center of Java Island and has more than 1,000 factories, including those of many foreign companies. In recent years, Jakarta's urban area has expanded into Tangerang, and continues to develop as a satellite city of Jakarta. In particular, the Sabi River basin has a high density of residential houses, many industrial estates and commercial facilities have been constructed, and assets continue to accumulate year by year, resulting in rapid development. As a result, the river improvement works have not kept up with the rapid development of the area.

The coastal areas of the Cisadane River basin was damaged by the January 2020 flood, but in the urban areas only inland water inundation and river flood along the tributary, Sabi River (especially upstream of the box culvert of irrigation canals) were reported. There was no extensive flood inundation along the Cisadane River in the upstream of the Pasar Baru Weir in January 2020 although there were flood damages in 2014 and 2017.

On the other hand, many floods have been recorded along the Sabi River. In recent years, floods occurred on February 2, 2020 and February 19, 2021. BBWS CiliCis and Tangerang City recognize that the flood damage in Tangerang City is caused by the frequent floods at Sabi River and that provision of countermeasures to solve the flood problem in the city are an urgent issue.

In response to this, BBWS CiliCis carried out the 2015 DD which included a study on flood control measures for the Sabi River. In the DD report, following three factors were listed as the main causes of flooding of the Sabi River.

- Effect of backwater from the Cisadane River,
- Insufficient flow capacity of the box culvert under an irrigation canal located 400 m upstream of the confluence point, and
- Insufficient flow capacity of river channel.

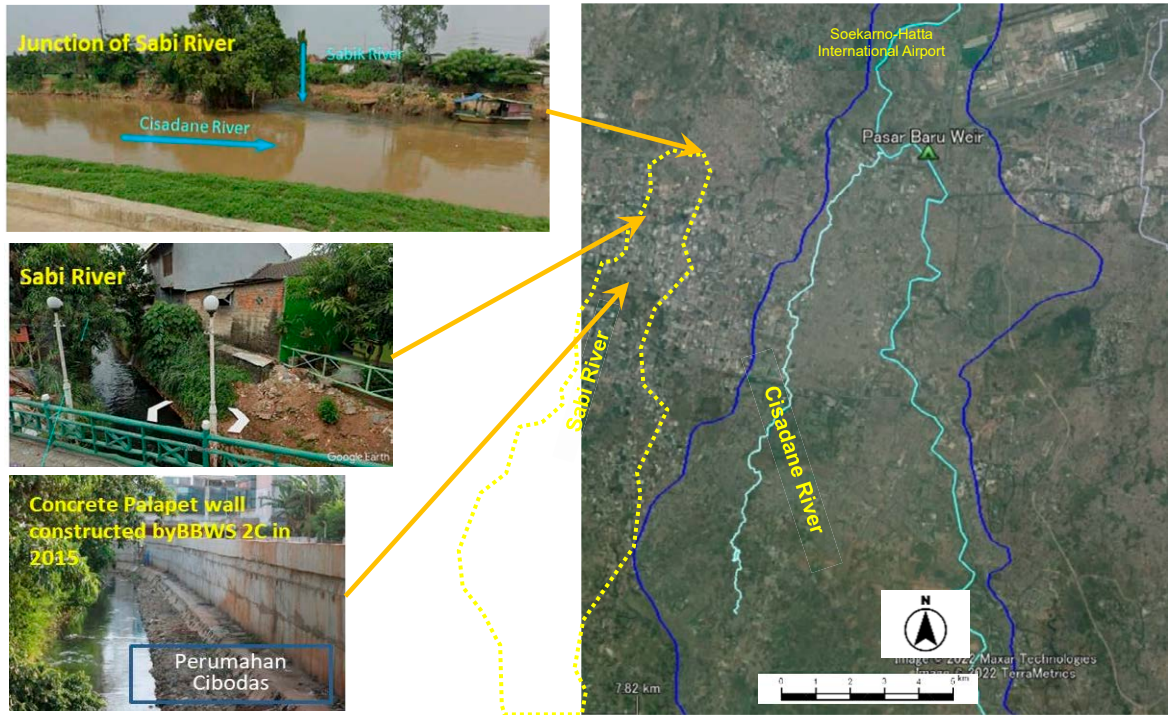


Figure 3-21 Current state of the Sabi River

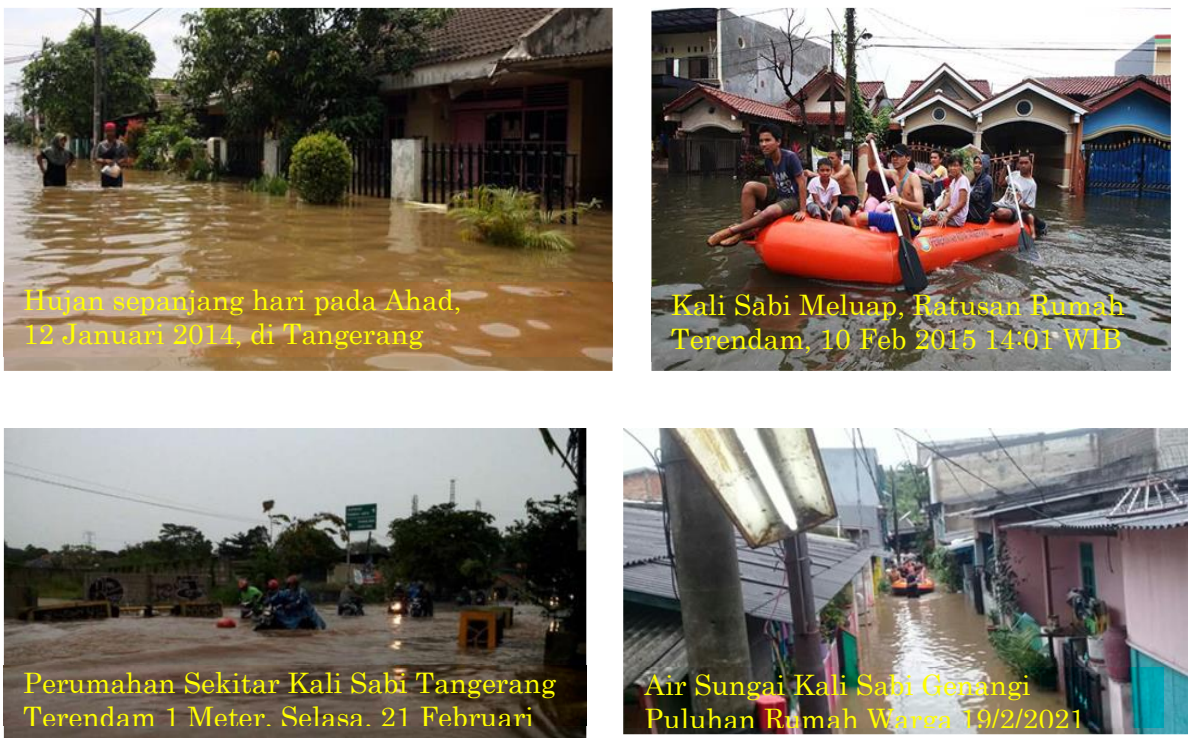


Figure 3-22 Inundation of the Sabi River Basin

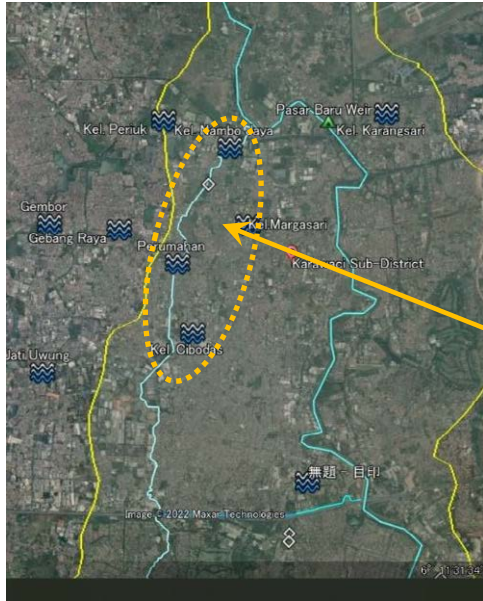


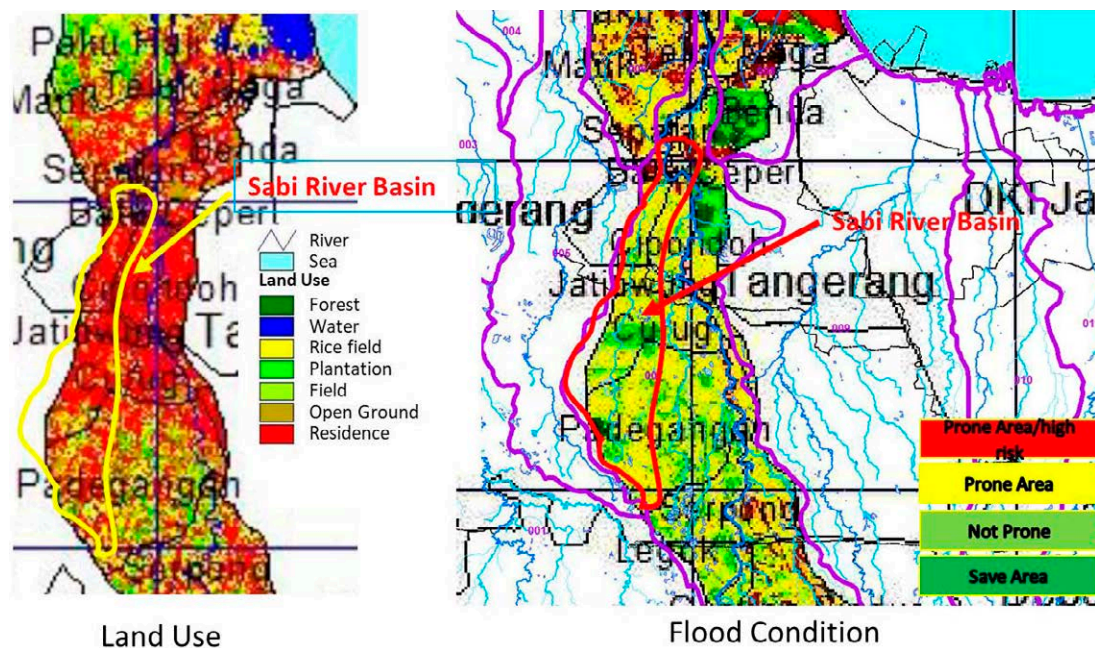
Figure 3-23 flood site in January 2020

Table 3-7 Flooded areas in the Cisadane-Sabi River basin (January 2020 flood)

LAPORAN LOKASI BANJIR DI KOTA TANGERANG															
Tanggal 01 s/d 07 Januari 2020															
BPBD Kota Tangerang															
NO	WILAYAH KERJA	KECAMATAN	KELURAHAN	LOKASI RT/RW	TITIK BANJIR	JUMLAH KORBAN BANJIR				KETINGGIAN AIR	PENYEBAB BANJIR / GENANGAN	KONDISI SAAT INI	JUMLAH POSKO	KETERANGAN	
						RUMAH YANG TERENDAM	JUMLAH KK	Korban MD	JIWA						
1	UPT CIBODAS	CIBODAS	Panunggangan Barat	RW01	4	1796			700	±60 s/d 300 CM	LUAPAN KALI SABI DAN CURAH HUJAN TINGGI	SURUT	1		
			Uwung Jaya	RW17		1105				±60 s/d 250 CM	LUAPAN KALI SABI DAN CURAH HUJAN TINGGI	SURUT			
			Jeluwang	RW02, RW05		40				±20 s/d 50 cm	LUAPAN KALI SABI DAN CURAH HUJAN TINGGI	SURUT			
			JUMLAH TOTAL	4		2941	0	0	700						
2	UPT CIBODAS	TANGERANG	Tanah Tinggi	RW04, RW11	10	145				±20 s/d 50 cm	LUAPAN SUNGAI CISADANE DAN CURAH HUJAN TINGGI	SURUT	1		
			Sukasari	RW03, RW04, RW05		45				±20 s/d 50 cm	LUAPAN SUNGAI CISADANE DAN CURAH HUJAN TINGGI	SURUT			
			Bukan Indah	RW04						±20 s/d 30 cm	LUAPAN SUNGAI CISADANE DAN CURAH HUJAN TINGGI	SURUT			
			Babakan	RW05		36				±20 s/d 30 cm	LUAPAN SUNGAI CISADANE DAN CURAH HUJAN TINGGI	SURUT			
			Cikokol	RW01, RW02, RW08		36				±20 s/d 30 cm	LUAPAN SUNGAI CISADANE DAN CURAH HUJAN TINGGI	SURUT			
JUMLAH TOTAL	10	262	0	0	0										
3	UPT CIBODAS	KARAWACI	Nambo Jaya	RW01, RW02, RW03, RW04, RW05	13	1159	1163		3519	±60 s/d 300 CM	LUAPAN KALI SABI DAN CURAH HUJAN TINGGI	SURUT	1		
			Pasar Baru	RW03		97				±20 s/d 50 cm	LUAPAN SUNGAI CISADANE DAN CURAH HUJAN TINGGI	SURUT			
			Margasari	RW03		52				±20 s/d 50 cm	LUAPAN SUNGAI CISADANE DAN CURAH HUJAN TINGGI	SURUT			
			Bugel	RW11			20			±20 s/d 50 cm	LUAPAN KALI SABI DAN CURAH HUJAN TINGGI	SURUT			
			Sukajadi			112				±20 s/d 50 cm	LUAPAN KALI SABI DAN CURAH HUJAN TINGGI	SURUT			
			Gerendeng			20				±20 s/d 50 cm	LUAPAN SUNGAI CISADANE DAN CURAH HUJAN TINGGI	SURUT			
			Koang Jaya			335				±20 s/d 50 cm	LUAPAN SUNGAI CISADANE DAN CURAH HUJAN TINGGI	SURUT			
			Bojong Jaya			100				±20 s/d 50 cm	LUAPAN SUNGAI CISADANE DAN CURAH HUJAN TINGGI	SURUT			
			Pabuaran			1031				±20 s/d 250 cm	LUAPAN KALI SABI DAN CURAH HUJAN TINGGI	SURUT			
			Tumpang												
JUMLAH TOTAL	13	2906	1183	0	3549										
LAPORAN LOKASI BANJIR DI KOTA TANGERANG															
Tanggal 01 s/d 07 Januari 2020															
BPBD Kota Tangerang															
NO	WILAYAH KERJA	KECAMATAN	KELURAHAN	LOKASI RT/RW	TITIK BANJIR	JUMLAH KORBAN BANJIR				KETINGGIAN AIR	PENYEBAB BANJIR / GENANGAN	KONDISI SAAT INI	JUMLAH POSKO	KETERANGAN	
						RUMAH YANG TERENDAM	JUMLAH KK	Korban MD	JIWA						
1	UPT PERIUK	PERIUK	Gembor	Jembatan Rajahon Total Perisada	13	-	-		-	±20 s/d 60 cm	LUAPAN KALI SABI DAN CURAH HUJAN TINGGI	SURUT	1		
			Gebang Raya	GARDEN CITY RW12, RW22, RW25		179				±20 s/d 60 cm	LUAPAN KALI SABI DAN CURAH HUJAN TINGGI	SURUT			
			Periuk Jaya	PERUMAHAN PERIUK ATIKA RW03, RW05, RW06			3495			9624	±60 s/d 300 cm	LUAPAN KALI SABI DAN CURAH HUJAN TINGGI			SURUT
			Periuk	RW01		333	333			1208	±50 s/d 100 cm	LUAPAN KALI SABI DAN CURAH HUJAN TINGGI			SURUT
			Sangiang Jaya	RW08, RW05, RW10		201				350	±50 s/d 100 cm	LUAPAN KALI SABI DAN CURAH HUJAN TINGGI			SURUT
			JUMLAH TOTAL	13		713	3828	0	11182						
2	UPT PERIUK	JATI UWUNG	Jatike	RW05	4					±20 s/d 60 cm	LUAPAN KALI SABI DAN CURAH HUJAN TINGGI	SURUT	1		
			Gandasari	RW05, RW06		181	100			275	±20 s/d 60 cm	LUAPAN KALI SABI DAN CURAH HUJAN TINGGI			SURUT
			Manis Jaya	RW04, RW05		179					±20 s/d 60 cm	LUAPAN KALI SABI DAN CURAH HUJAN TINGGI			SURUT
JUMLAH TOTAL	4	360	100	0	275										

Source: Rekap Data Banjir Di Kota Tangerang 1-7 januari, BPBD Kota Tangerang, 2020

According to an analysis by Bogor Agricultural University (see Figure 3-24), the Sabi River basin, especially the upper basin of the confluence with Cisadane River which has been already developed as residential/industrial area is classified as flood prone area.



Source :PEMETAAN KAWASAN RAWAN BANJIR DI DAERAH ALIRAN SUNGAI CISADANE MENGGUNAKAN SISTEM INFORMASI GEOGRAFIS INSTITUT PERTANIAN BOGOR, 2008

Figure 3-24 Land Use and Flood Frequency in the Sabi River Basin

As mentioned above, the Sabi River basin, which have been already densely developed as residential, commercial land and industrial areas, has been suffering from habitual flood inundation. In addition, development of disaster prevention infrastructures has not kept up with the rapid development of this area, and the elimination of flood damage in the Sabi River is a pressing issue for PUPR and Tangerang City government.

3.4.2 Project Scale

As for the project scale of the improvement works of the Sabi River, a tributary of the Cisadane River, has been applied the 25-year-flood, considering the current status (initial stage) of river improvement projects. In the future, however, it is expected to be upgraded to the 50-year flood in consideration of the consistency with the Cisadane River mainstream.

3.4.3 Estimation of Damages of Flood on January 2020

The amount of flood damage in the Sabi River basin was estimated assuming that a flood of the same scale as the January 2020 flood occurred. The following damage was reported in the Sabi River basin during the January 2020 flood.

Table 3-8 Number of Inundated Houses and Affected People (Jan. 2020)

	Inundated houses	Affected people
Kecamatan periuk (left side of kali sabi)	713	11,182
Kecamatan karawaci (right side of kali sabi)	2,906	3,549

Source: Rekap Data Banjir Di Kota Tangerang 1 -7 januari, BPBD Kota Tangerang

The amount of damage is estimated from the number of inundated houses and affected people in the table above. It is assumed that a flood of the same scale as the January 2020 flood will cause damage of about 4 billion yen (refer to Chapter 4 for the calculation method and conditions).

Table 3-9 Amount of Damage (in the same scale flood as the Jan. 2020 flood)

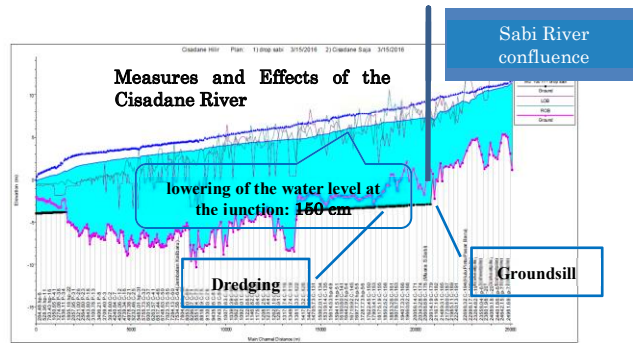
	amount of damage (1 million rupiahs)	Yen value (1 million yen)
I. direct damage		
(a) building damage	280,501.6	2,337.5
(b) property damage	70,230.0	585.2
(c) damage to infrastructure	77,161.0	643.0
Sub Total I.	427,892.6	3,565.8
II. indirect damage		
(a) Loss of revenue (commercial and industrial units)		
(i) Commercial Unit	31,435.1	262.0
(ii) Industrial Unit	11,881.0	99.0
(b) Decrease in revenue of water suppliers		
(i) Household	265.4	2.2
(ii) Non-household	14.8	0.1
(c) Decrease in revenue of electric power companies	1,261.9	10.5
Sub Total II.	44,858.2	373.8
Total	472,750.8	3,939.6

Note) See Chapter 4 for details such as the method of calculating the amount of damage and the basic unit price.

3.4.4 Proposal in 2015 Detailed Design

The proposal in the 2015 DD aims to reduce damage by eliminating the effects of backwater from the Cisadane River and increasing the flow capacity of box culverts in irrigation canals. Specifically, it proposes the following measures:

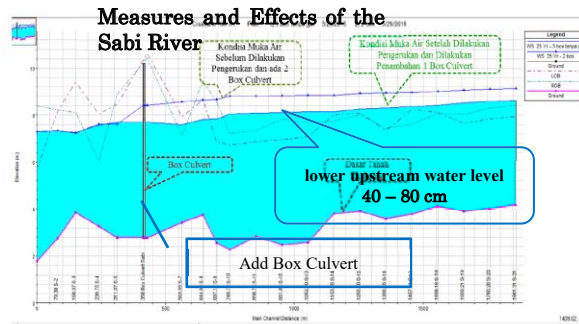
- d) Decrease in flood level of the Cisadane River:
In order to minimize the influence of backwater, dredging of the Cisadane River downstream of the confluence point and the installation of a ground sill (with a drop) in the Cisadane River upstream of the confluence point were carried out.
- e) Add box culvert:
To eliminate the bottleneck effects of existing small bottleneck box culverts (B3m x H5m x 2 units), a new box culvert (B9m x H5m) is added to eliminate the bottleneck problems.



Tabel V-3 Perbandingan/Persandingan antara kondisi eksisting(sebelum dilakukan pengerukan) dan setelah dilakukan pengerukan/normalisasi



Existing Box Culvert



Gambar V-20 Perbandingan Profil Memanjang Muka Air Banjir Q25 Setelah Dilakukan Penambahan Box Culvert Vs Kondisi Eksisting Pada Sungai Sabi

Source: Detail Desain Pengendalian Banjir Sungai Cisadane Hilir ”, 2015, BBWS CiliCis, PUPR

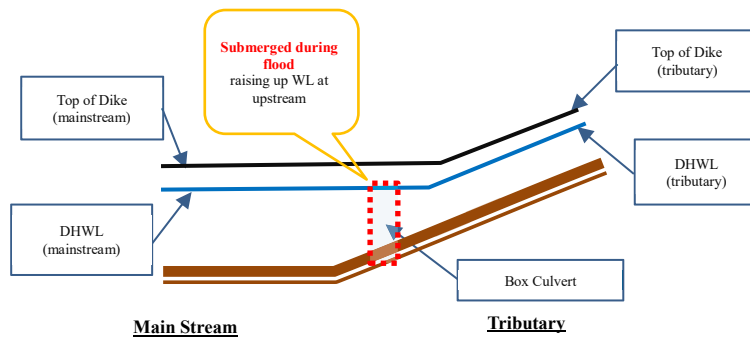
Figure 3-25 Proposed Measures

3.4.5 Issues to Point Out in Detailed design

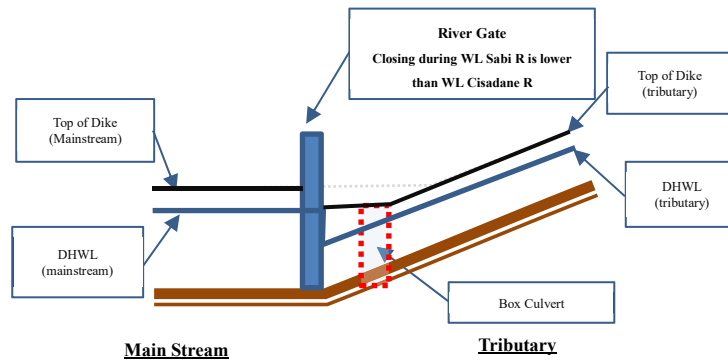
(1) Lowering of Cisadane River Flood Water Level

The design high water level of the Cisadane River at the confluence after the completion of the river improvement works of the main river is set at EL 7.5 m, and in this case, the water surface is expected to be at the same height as the top of the box-culvert, thus the flow condition in the box-culvert is expected to be a pipe flow. Considering this flow condition in the box-culvert, the design discharge cannot flow down, and the upstream water level will be as high as it is now. To cope with this, the height of the box culvert has to be raised up, but the height of the box culvert cannot be heightened because the existing irrigation canal has restricted the elevation of the top of box-culvert. Therefore, in order to avoid the influence of backwater from the Cisadane River, it is necessary to lower the flood water level of the Cisadane River or to eliminate the influence of backwater to the Sabi River by the tributary treatment.

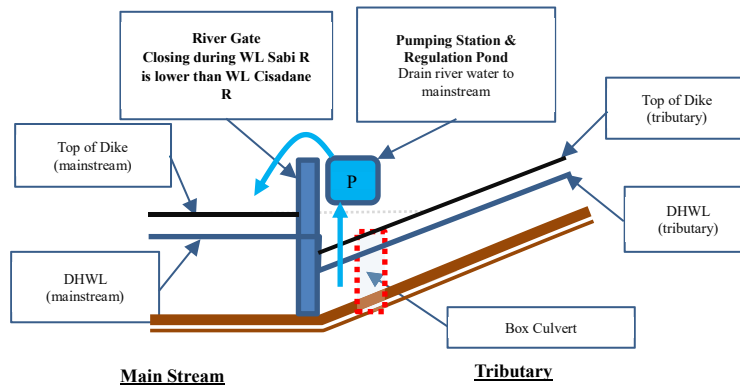
There are three types of tributary treatment methods: (1) Back Water Dike system, (2) Semi-back Water Dike system, and (3) Self-flow Dike system (Dike independent from back water). Since the box culvert is located just upstream of the confluence with the Cisadane River, the method (1) and (2), in which the water level of the tributary is affected by the main river, are not suitable. In this case, (3) Self flow Dike system is suitable. In the self-flow dike system, a river gate is provided at the confluence point, and the height of the bank of the tributary is decided by the discharge of the tributary. In order to drain the tributary water when the gate is closed, a pump station and a regulation pond are also provided.



(1) Back Water Levee System



(2) Semi-back Water Levee System



(3) Self-flow Levee System

Figure 3-26 Tributary Treatment Systems

(2) Additional Box Culvert:

Since an irrigation canal and roads are existing above the box-culvert, it would be very difficult to construct a new box culvert under these structures (about 65 m including roads) without blocking the canal flow and the road traffics. Temporary works, in particular, requires special technics that ensure the safety of existing canals and roads.

To avoid this difficulty, it is considered two methods, namely (1) Relocation of the existing canal and roads to the downstream and (2) Construction of new box-culverts by open-cut construction. In this study, both methods have not been considered since the large-scale canal and roads relocation works, the compensation to farmers during the construction period

(17,000 ha of paddy fields) and the land acquisition for the irrigation canal relocation will be additionally required.

As the construction method of the additional box-culvert construction, Shield Tunneling Method, NATM, Pipe-Roof method, Box Jacking Method, and a combination of these methods could be applied.

Among them, NATM, a tunnel excavation method, is anticipated that it will be difficult to maintain the top portion because sufficient cover-soil (3 m or more) cannot be secured. In Shield Tunneling Method, the cross section will be circular, and since the total length of the 3 boxes is about only 200 m, it can be assumed that the construction cost would be uneconomical when a shield machine is made and carried in. In the case of applying Box Jacking Method, a precast box culvert is inserted, so the box culvert laying is completed when the excavation is completed, but in the case of the Shield Tunneling Method, the concrete box culvert shall be constructed after the excavation is completed. Therefore, when both methods can be adopted depending on the construction conditions, there are more cases in which the "jacking method" is generally adopted from a view point of economical efficiency.

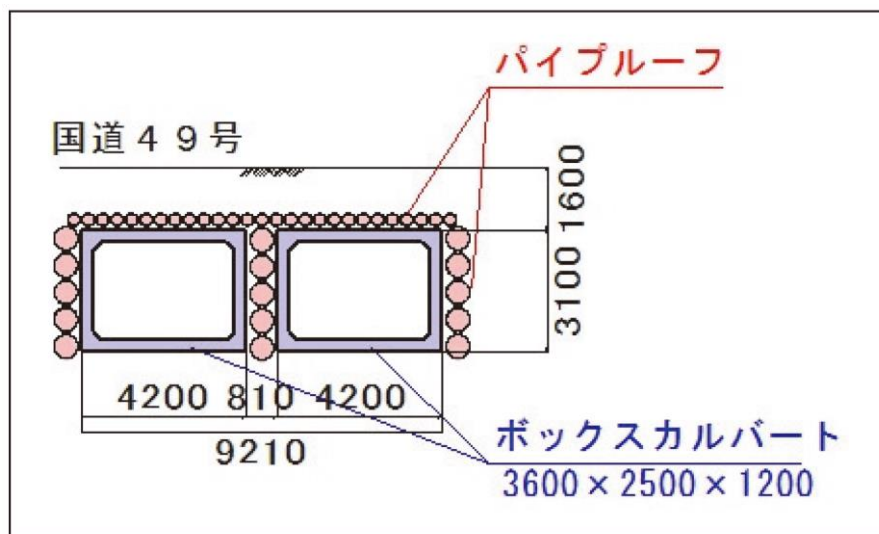
When Box Jacking Method applied, cutting edge jacking method in which the excavation is carried out by man power has advantageous, because the Jacking machine is custom-ordered and expensive when a box culvert is constructed by a general closed type jacking method using machine excavation.

In addition, the pipe roof method, installing steel pipes like roofs, will be applied to minimize the impact to the irrigation canal and road traffic, because the required thickness of cover soil for Box Jacking (generally 1.5 D (D: excavation diameter)) cannot be secured.

The pipe roof method is a method adopted as a subsidence prevention measure for upper part structures and underground facilities when constructing underground structures. Steel pipes are inserted and installed at regular intervals or continuously along the outer circumference of the excavation section of a tunnel to increase the shear strength of the ground and also serve as earth retaining sheet piles.

Considering these conditions, the construction cost is about three times as much as that of the conventional open-cut method. However, considering the reliability of the construction and the safety of the use of irrigation canal and road traffic during the construction as well as the common use period, the box jacking method with pipe roof is the most suitable.

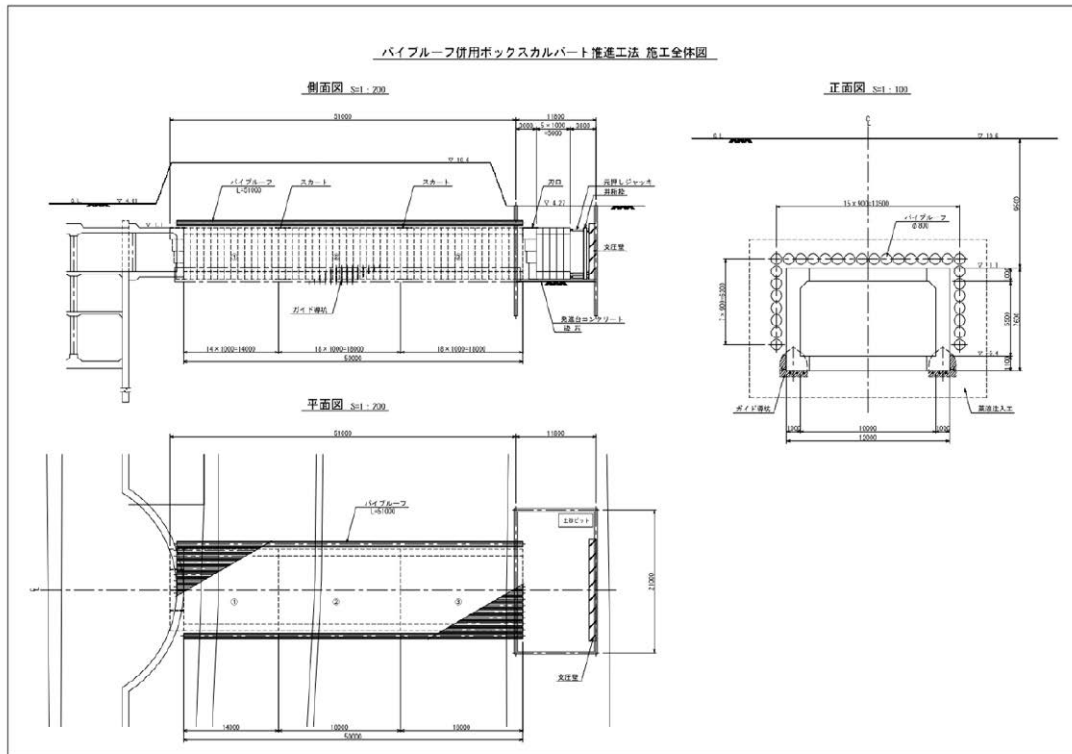
A construction example in Japan are shown in Figure 3-27 and Figure 3-28.



Source: About the national road crossing promotion work of the Korigawa drainage in the Anogawa area. Shibata Regional Development Bureau Rural Development Department, 2018

Figure 3-27 Example of combined use of pipe roof method and box propulsion method

This method has been also applied for the installation of box culverts under Tamurin Road at Dukuh Atas Station of Jakarta MRT in Indonesia.



Source: Preparatory Research for Jakarta Transportation and Urban Structure Development Project (PPP Infrastructure Project) modelled on the district around Duquatas Station in the Republic of Indonesia, JICA, 2013

Figure 3-28 Construction Diagram of Box Jacking Method with Pipe Roof

3.4.6 Proposed Measures

The optimal plan consists of a combination of the following three measures, namely confluence treatment, bypass channel, and runoff control.

(1) Confluence Treatment (Self-flow Levee method)

- **River improvement:** Construction of dikes from the main river to the box culverts to accommodate runoff discharge form the tributary basin.
- **River gates (backwater protection):** B 10 m x H 6 m x 2 (height to prevent backwater from Cisadane River)
- **Regulation Pond:** reservoir capacity 125,000m³
- **Pumping station:** 20 m³/s (assuming that the time difference between the flood peak of the Main River and the flood peak of the Sabi River is about 10 hours)
- **Additional box culvert:** B3m x H5m x 3 units (pipe roof + box propulsion)
- **Construction cost:** Approximately 2 billion yen (RP. 2.400 Trillion)

According to the Tangerang city government, the proposed site for the regulation pond is currently a wasteland, but an application for the construction of an industrial park has been submitted to the city government. Therefore it is necessary to make adjustment on the land use before the project implementation.

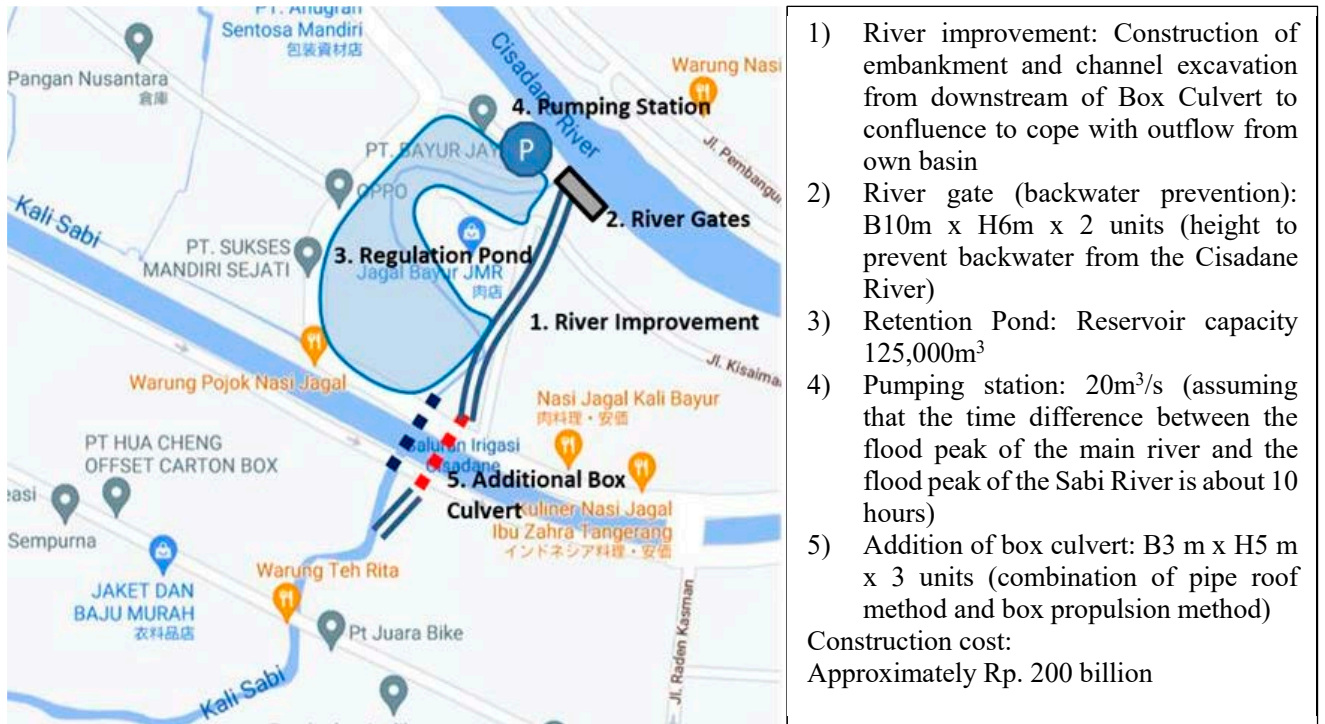


Figure 3-29 confluence point processing in one's own way

Table 3-10 Construction Cost of Confluence Treatment of the Sabi River

	Unit	Unit Cost (JPY)	RP-CL 1	
			Quantities	Amount (mil. JPY)
1. Preparatory Works				337
2. Main Works				1,687
2.1 Excavation	m3	800	175,000	140
2.2 Embankment	m3	1,500	10,500	16
2.3 Revetment	m2	10,000	15,429	154
2.3 Intake Weir				
Concrete		30,000	1,200	36
Gate : Roller	m2	2,000,000	120	240
Flap	m2	4,000,000		-
2.4 Release Gates				
Concrete	m3	30,000		-
Gate : Roller	m2	2,000,000	25	50
2.5 Additional Box Culvert	m	2,000,000	300	600
2.6 Pomp System (Q=20m3/s)	L.S.	70,000,000		70
Monitoring & Telemetry System	L.S.			100
2.6 Misceleneoue Works				281
Total				2,025
			in Rupiah	242,963

(2) Bypass Channel Plan

In order to reduce the discharge of flood water, the construction of a bypass channel connecting the middle reach of the Sabi River to the Cisadane River along the highway is

currently planned between the BBWS CiliCis and Tangerang City. It is one of the measures that should be implemented because it is expected to have a certain effect, and it can also be expected to reduce the work scale of the confluence treatment.

The amount of water diversion is as shown in Figure 3-30. A 43 m³/s from the flood discharge of 85.3 m³/s is diverted to the Cisadane River via the Cicayur Barat Channel. By implementing these measures, it will become possible to enhance the current countermeasures of the 25-year flood (125 m³/s) to those of the 50-year flood (140 m³/s). However, this project has been suspended because it is difficult to solve the issues of land acquisition and compensation and Tangerang City can not proceed with the project alone due to administrative restrictions (issue of the cost allocation by the prefecture and the city: because the proposed bypass route is passing Tangerang regency).



Gambar 5.3. Skematik Konsep Penanganan By Pass Kali Sabi

Source: LAPORAN AKHIR Perencanaan Teknis By Pass Kali Sabi-Sungai Cisadane, PUTR Kota Tangerang, 2017

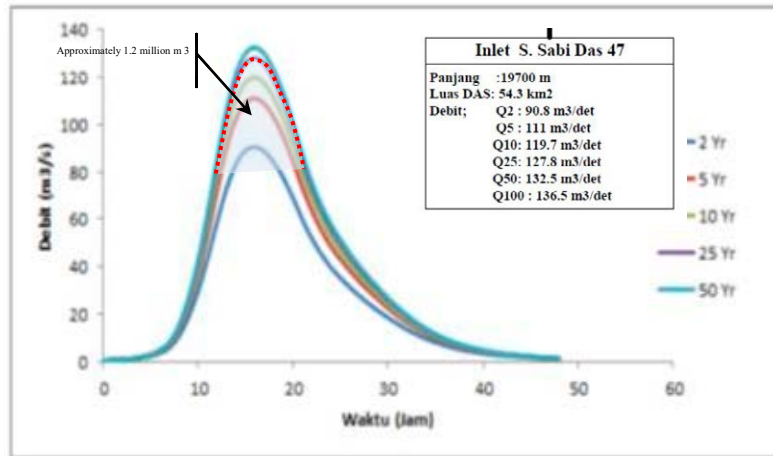
Figure 3-30 Sabi River Bypass Project

(3) Flood regulation by Retarding Basins

In the basin of the Sabi River where private houses and factories are concentrated, three candidate sites of retarding basins were selected as shown in Figure 3-31. The total storage capacity of these three retarding basins can be expected to be approximately 1.5 million m³, which is effective to reduce the 25 probability flow rate of 128 m³/s to 80 m³/s (almost the same effect as the bypass plan).



Figure 3-31 Proposed Locations for Rearding Basins in Sabi River Basin



Gambar V-19 Hidrograph banjir yang ada pada muara sungai sabi

Figure 3-32 Flood Peak Cut by Retarding Basins

(4) Effect

The implementation of the confluence treatment work will enable the Sabi River to safely accommodate the 25-year discharge. In addition, the construction of both the Sabi-Cisdane Bypass and the retarding basins will further enable the Sabi River to cope with the 50-year flood.

As described in "(3) Calculation of the amount of damage caused by the January 2020 flood," about 4 billion yen of damage is expected due to a flood of the same level as the flood of January 2020. The huge damage might be enough for confirming the effectiveness of this Sabi River project.

3.5 Preliminary Environmental Impact Evaluation

A preliminary environmental impact assessment was conducted based on the JICA Environmental Checklist (River and Sabo) for the project implementation.

In the Sabi River confluence treatment project, the construction area is not so wide (only 4 ha) and there is only warehouse but no residences. From this, it can be judged that the impact on social and natural environments is not so large. However, since the work will be conducted near the main road, it is necessary to pay attention to the traffic safety and the surrounding environment (dust, noise, etc.) during the construction stage.

3.6 Measures to Enhance the Safety of Cisdane River against Flood

The planning and design of Cisdane river improvement works have already been carried out for the 50-year flood discharge that meets the targeted safety level. No significant flooding (heavy rainfall) has been observed in the basin since 2015, when the design was conducted, and results of rainfall analysis applying the latest observed rainfall data (up to 2020) show that the estimated probable rainfalls are smaller than those in the design. Therefore, the current design flood discharge can be applied in the flood control master plan for the Cisdane River.

However, with the development of Tangerang city in recent years, the population and assets in the watershed have increased remarkably, and the importance of this area has increased and improvement of the safety level against disasters is strongly required. In response to this situation,

a retarding basin is proposed in this study for the purpose of regulating the river discharge as a measure to improve the safety level against flood damages of the Cisadane River.

At the confluence of the Cibadas and Cisadane Rivers, 65 km from the rivermouth, there is a large area currently used for flood plain and paddy fields that is suitable for a large-scale retarding basin.

The feature of the proposed retarding is as follows:

- a) Location : Flood plains and paddy fields 65 km from the river mouth
- b) Catchment Area : 950km²
- c) Impounding Area : 60ha
- d) Storage capacity : 3 million m³ (depth 5 m in average)

By constructing this retarding basin, the design discharge can be reduced by approximately 100 m³/s, and the flood control safety level can be increased from the current 50-year-flood to the 75-year-flood. By storing water at the end of the rainy season, it is also expected to produce some of Tangerang's municipal water during the dry season.

To improve flood safety level from the 50-year flood to the 100-year flood, a flood retarding basin with a capacity of about 6.5 million m³ is required. The construction of the retarding basin can be started without waiting for the completion of the other river improvement works because it can perform its effects independently.

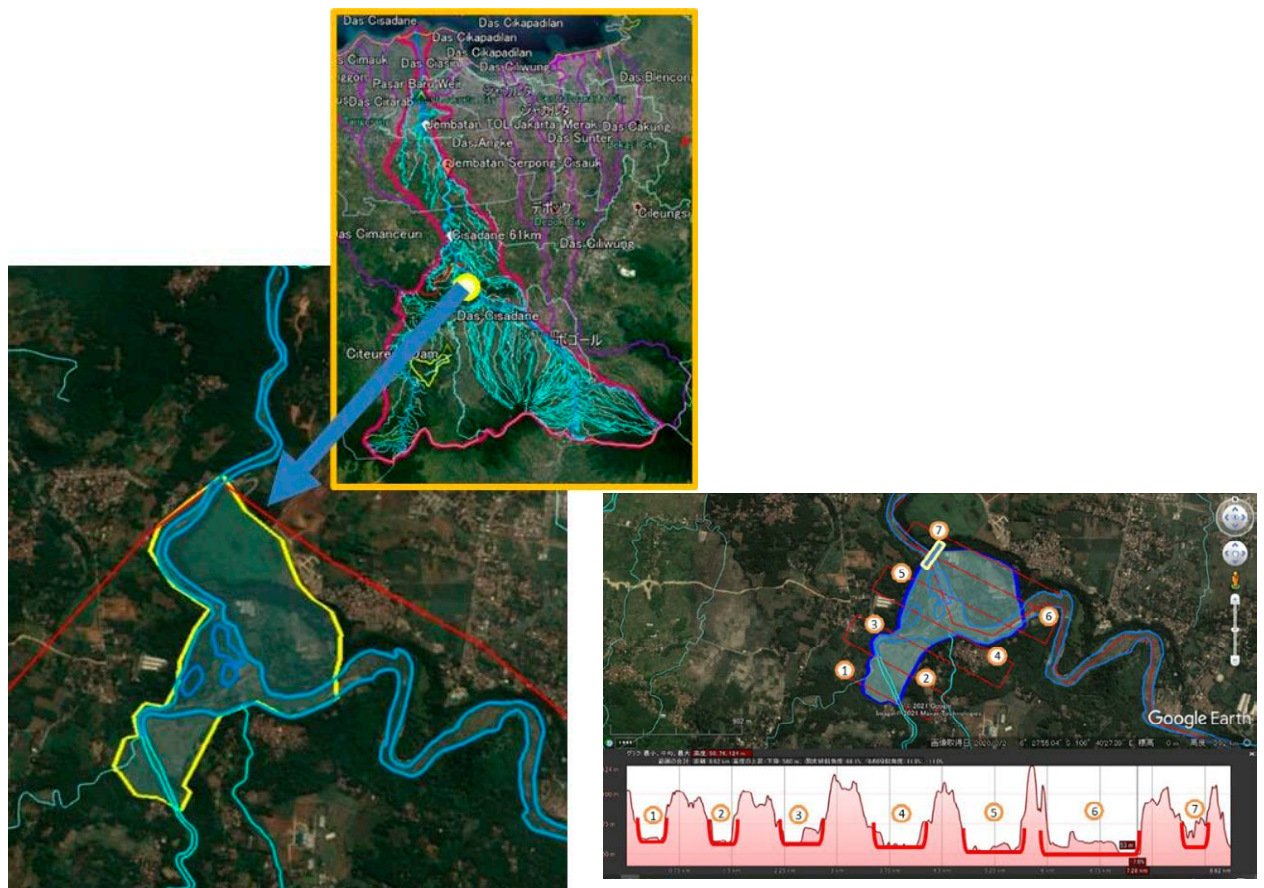


Figure 3-33 Cisadane River Retarding Basin Area Map

Attachment 3-1 Basis for calculating the cost of the Sabi River flood in January 2020

I. Amount of direct Damage

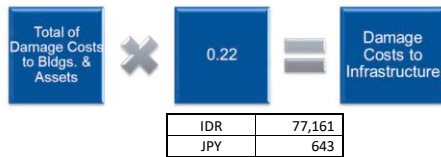
(a) Damage to the buildings

Inundation depth (m)	Area Ratio (%)	Households				Damage Ratio	Damage (mil. Rupiah)			
		Permanent House	Non-permanent House	Shop/Office	Manufacture		Permanent House	Non-permanent House	Shop/Office	Manufacture
	100.0%	3,619.0	724.0	254.0	4.0		175.000	119.000	1,320.000	19,500.000
-0.2	5.9%	213.9	42.8	15.0	0.2	3.2%	1,198	163	634	148
0.2 - 0.5	12.2%	440.6	88.1	30.9	0.5	9.2%	7,094	965	3,755	874
0.5 - 2.0	29.1%	1,052.3	210.5	73.9	1.2	11.9%	21,915	2,981	11,602	2,699
2.0 - 5.0	33.9%	1,227.7	245.6	86.2	1.4	26.6%	57,150	7,775	30,255	7,039
5.0 - .	18.9%	684.4	136.9	48.0	0.8	58.0%	69,471	9,451	36,778	8,556
									IDR	280,502
									JPY	2,338

(b) Damage to the asset

Inundation depth (m)	Area Ratio (%)	Households				Damage Ratio		Damage (mil. Rupiah)			
		Permanent House	Non-permanent House	Shop/Office	Manufacture	HH Goods	Commerce /Industry (Assets & Inventory)	Permanent House	Non-permanent House	Shop/Office	Manufacture
sum		3,619.00	724.00	254.00	4.00			35	24	13	29
-0.2	5.9%	213.89	42.79	15.01	0.24	2.1%	15.5%	157	22	31	1
0.2 - 0.5	12.2%	440.61	88.15	30.92	0.49	14.5%	36.0%	2,236	307	147	5
0.5 - 2.0	29.1%	1,052.33	210.52	73.86	1.16	32.6%	72.0%	12,007	1,647	702	24
2.0 - 5.0	33.9%	1,227.72	245.61	86.17	1.36	50.8%	137.5%	21,829	2,995	1,564	54
5.0 - .	18.9%	684.44	136.93	48.04	0.76	92.8%	186.3%	22,231	3,050	1,181	41
									IDR	70,230	
									JPY	585	

(c) Damage to the infrastructure



II. Amount of Indirect Damage

(a) Loss of revenue (industrial / commercial unit)



(i) Commercial Unit

Inundation depth (m)	Area Ratio (%)	No. of Commercial Unit	Average No. of Employee per unit	Value Added Amount (Rp/Employee/day)	Flood Duration Suspension + Stagnation/2	Damage Amount (mil Rp)	
sum		254.00					
-0.2	5.9%	15.01	10	600,000	6.00	540	
0.2 - 0.5	12.2%	30.92	10	600,000	8.80	1,633	
0.5 - 2.0	29.1%	73.86	10	600,000	12.60	5,584	
2.0 - 5.0	33.9%	86.17	10	600,000	20.60	10,650	
5.0 - .	18.9%	48.04	10	600,000	45.20	13,028	
						IDR	31,435
						JPY	262

(ii) Industrial Unit

Inundation depth (m)	Area Ratio (%)	No. of Commercial Unit	Average No. of Employee per unit	Value Added Amount (Rp/Employee/day)	Flood Duration Suspension + Stagnation/2	Damage Amount (mil Rp)	
sum		4.00					
-0.2	5.9%	0.24	180	800,000	6.00	204	
0.2 - 0.5	12.2%	0.49	180	800,000	8.80	617	
0.5 - 2.0	29.1%	1.16	180	800,000	12.60	2,110	
2.0 - 5.0	33.9%	1.36	180	800,000	20.60	4,025	
5.0 - .	18.9%	0.76	180	800,000	45.20	4,924	
						IDR	11,881
						JPY	99

(b) Loss of revenue from water utilities



(i) Household

Inundation depth (m)	Area Ratio (%)	No. of Affected Users	Average Water Soled/User/ Day	Water Sales Tariff	Flood Duration Suspension + Stagnation/2	Damage Amount (mil Rp)
sum		3,619.00				
-0.2	5.9%	213.89	0.642	5,538	6.00	5
0.2 - 0.5	12.2%	440.61	0.642	5,538	8.80	14
0.5 - 2.0	29.1%	1,052.33	0.642	5,538	12.60	47
2.0 - 5.0	33.9%	1,227.72	0.642	5,538	20.60	90
5.0 - .	18.9%	684.44	0.642	5,538	45.20	110
					IDR	265
					JPY	2

(ii) Non-household

Inundation depth (m)	Area Ratio (%)	No. of Affected Users	Average Water Soled/User/ Day	Water Sales Tariff	Flood Duration Suspension + Stagnation/2	Damage Amount (mil Rp)
sum		258.00				
-0.2	5.9%	213.89	0.270	735	6.00	0
0.2 - 0.5	12.2%	440.61	0.270	735	8.80	1
0.5 - 2.0	29.1%	1,052.33	0.270	735	12.60	3
2.0 - 5.0	33.9%	1,227.72	0.270	735	20.60	5
5.0 - .	18.9%	684.44	0.270	735	45.20	6
					IDR	15
					JPY	0

(c) Loss of revenue from electrical utilities

Inundation depth (m)	Area Ratio (%)	No. of Affected Users	Average Electricity Sold (kWh/customer/day)	Electricity Sales Tariff (Rp/kWh)	Flood Duration Suspension + Stagnation/2	Damage Amount (mil Rp)
sum		4,601.00				
-0.2	5.9%	213.89	23.000	735	6.00	22
0.2 - 0.5	12.2%	440.61	23.000	735	8.80	66
0.5 - 2.0	29.1%	1,052.33	23.000	735	12.60	224
2.0 - 5.0	33.9%	1,227.72	23.000	735	20.60	428
5.0 - .	18.9%	684.44	23.000	735	45.20	523
					IDR	1,262
					JPY	11

		1.0yen = Rp.	120.0
I. Amount of direct Damage			
(a) Damage to the buildings		280,501.6	2,337.5
(b) Damage to the asset		70,230.0	585.2
(c) Damage to the infrastructure		77,161.0	643.0
Sub Total I.		427,892.6	3,565.8
II. Amount of Indirect Damage			
(a) Loss of revenue (industrial / commercial unit)			
(i) Commercial Unit		31,435.1	262.0
(ii) Industrial Unit		11,881.0	99.0
(b) Loss of revenue from water utilities			
(i) Household		265.4	2.2
(ii) Non-household		14.8	0.1
(c) Loss of revenue from electrical utilities			
		1,261.9	10.5
Sub Total II.		-	-
Total		427,892.6	3,565.8

Chapter4 Study on Acceleration of Flood Control MP in JABODETABEK

4.1 Overall Workflow

Countermeasures against flood in DKI Jakarta (hereinafter referred to as “DKI”) were examined according to the workflow shown in Figure 4-1.

The current situation in DKI was summarized and the priority development areas were selected. After setting the planning targets, the optimum plan for priority development areas was set.

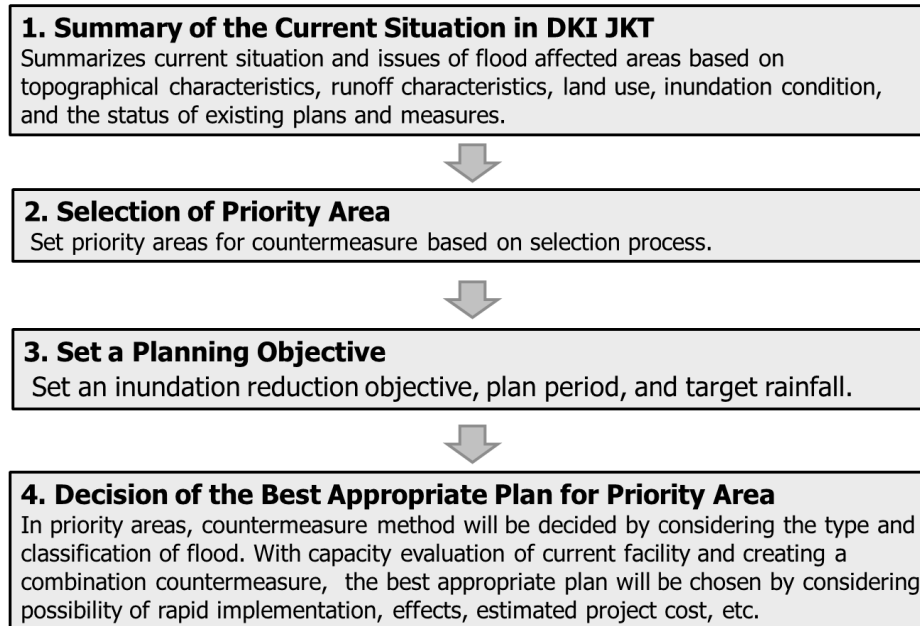


Figure 4-1 Overall Workflow

4.2 Summary of Existing Drainage MP

4.2.1 Existing Plans

Table 4-1 summarizes the existing drainage plans of DKI. The drainage plan is based on the “Flood and Drainage Master Plan” of 1973, which included a plan for East-West Banjir canals and six polder plans, and the 1991 “Study on Drainage and Sewerage Development Plan in Jakarta (JICA)”, which covered the entire DKI, and formulated the DKI urban drainage plan. Subsequently, in 2004, “The Western Java Environmental Management Project: WJEMP” examined the implementation design in the flood-prone areas based on the flood damage in 2002. Furthermore, in 2011, an implementation plan for the development of drainage channels connecting to major rivers was formulated. Currently, the city drainage channel in DKI is being developed in accordance with the 2011 MP.

Table 4-1 Summary of Existing Drainage MP

Year	Name	Area	Design Scale	Outline
1973	Flood and Drainage Master Plan	DKI JKT	25-year scale flood	Formulating plans for east and west flood way, and six polders
1991	Study on Drainage and Sewerage Development Plan in Jakarta (JICA)	DKI JKT	2 to 25-year scale flood	Formulation of drainage master plan in DKI JKT 32 drainage channels improvement of 6 drainage zones, 3 new drainage channels and 2 drainage pumping stations
1997	Integrated Water Management in Jabodetabek (JICA)	Jabodetabek	–	Review of Flood Control and Drainage MP in Jabodetabek Small Scale Improvement Plan of Urban Drainage in DKI JKT and Tangerang City Area
2004	The Western Java Environmental Management Project: WJEMP	DKI JKT	5 or 10 year scale flood	1) Drainage Management for Jakarta -Strategic Action Program Development: TA DKI 3-9 Development of drainage plans for 78 frequently inundated areas in Jakarta, and implementation design for priority/short-term plans (targeting about 15 districts)
		Jabodetabek		2) Outline Plan for Major Drainage and Small Lakes Management in Jabodetabek-Bopunjur Area: TA Pusat 3-10 Review of flood and drainage countermeasures for the entire Jabodetabek region, including Jakarta City, and establishment of a new implementation policy for future and runoff control measures using a group of retention.
2011	Masterplan of Settlement Drainage in DKI Jakarta	DKI JKT		43 drainage zones have been set, and an implementation plan for the improvement of drainage channels surrounded by the West and East Floodway (covering the 8-year period from 2013 to 2020) has been developed.

4.2.2 Transition of Drainage Zones

Figure 4-2 shows the transition of the drainage zones based on the existing plans.

The 1973 MP divided the inner side of the East-West Banjir Canal into six drainage zones (polders). The 1991 plan divided the entire DKI into six drainage zones. In the 2004 plan, which was based on the six drainage zones in 1991, the area on the left bank side of the West Banjir Canal and the left bank side of the Cenkareng and Pesanggrahan River were divided into eight drainage zones. The 2011 plan subdivided the area into 43 drainage zones based on the existing drainage plan.

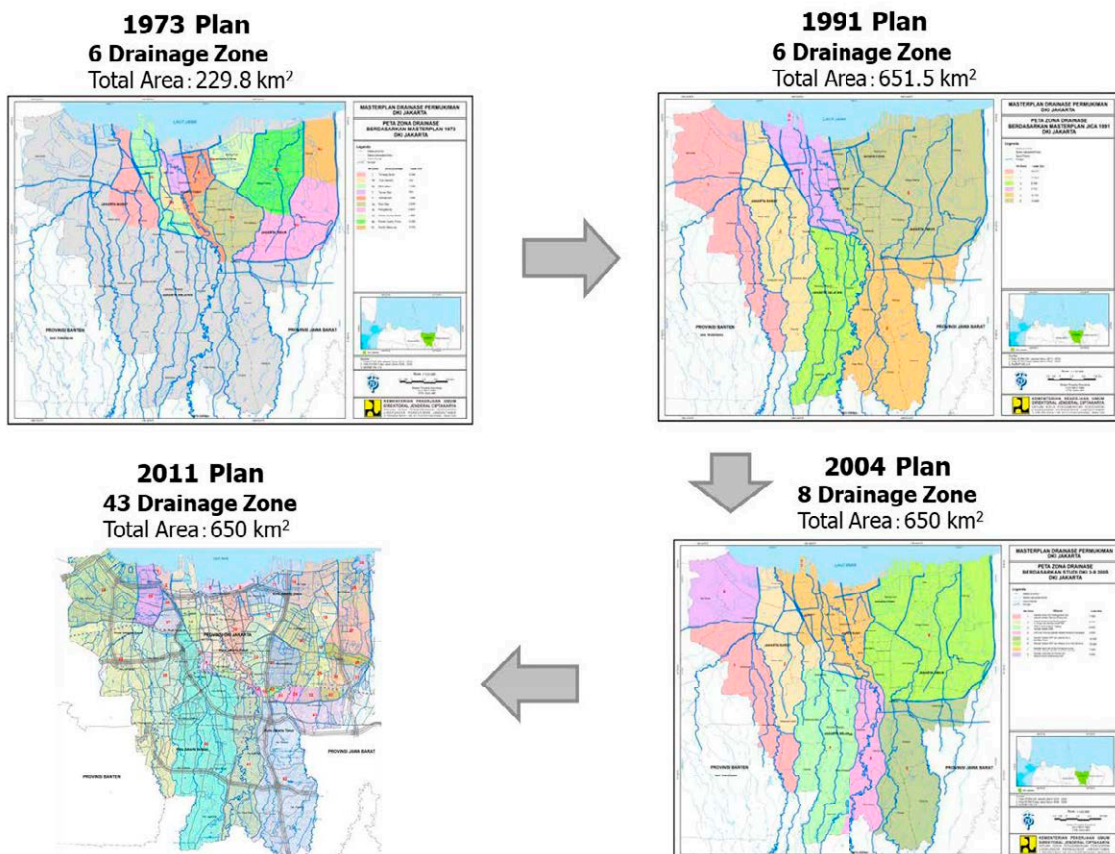


Figure 4-2 Transition of Drainage Zones

4.3 Major Flood Disasters in Recent Years

A summary of the major floods that have occurred since 2000 is shown in Table 4-2. The table shows the rainfall, water level and inundation conditions on the Ciliwung River, which flows through the center of DKI.

A large scale of flood disasters has occurred approximately once every five years in the Ciliwung River Basin, such as floods in 1996, 2002, 2007, 2013 and 2020. It is identified that flood disaster will occur in case an intermittent rainfall at the upstream area lasts from approximately 4 to 13 days.

In the January 2020 flood, in addition to the inundation damage in the north area of the East-West Banjir Canal, heavy rainfall occurred especially in the south area, causing flood damage along the major rivers.

Table 4-2 Major Flood Disaster in Recent Years

Year of Occurrence	Duration of Rainfall (hr)	Average Rainfall in Basin at Manggarai Gate Point					Manggarai Gate Point Peak WL (m)	Disaster Condition	Inundation Area (km ²)	Casualty (person)
		1hour (mm)	6hour (mm)	24hour (mm)	48hour (mm)	168hour (mm)				
1-6 Jan. 1996	102	31.8	64.6 (1/3)	130.5 (1/7)	156.9 (1/4)	296.7 (1/4)	9.70	Overflow, Inland Water	—	—
26 Jan.-2.Feb.2002	164	16.6	59.9 (1/2)	132.4 (1/8)	194.9 (1/10)	397.8 (1/15)	10.50	Overflow, Inland Water	87	25
30 Jan. - 6 Feb. 2007	153	21.5	86.6 (1/20)	179.5 (1/60)	254.6 (1/70)	445.6 (1/30)	10.61	Overflow, Inland Water	300	80
8-20. Jan. 2013	305	21.6	54.4 (1/1.2)	90.7 (1/1.7)	161.6 (1/4)	334.5 (1/6)	10.00	Dike Break, Overflow, Inland Water	140	20
31 Dec.2019 - 1 Jan.2020	approx. 48	—	—	101.3* (1/6)	159.0* (1/4)	—	9.65	Dike Break, Overflow, Inland Water	140	61

* Duration of rainfall is the duration of average rainfall at Manggarai including non-rain time for less than 6 hours.

*Average rainfall values in Basin at Manggarai for January 2020 flood are on a daily rainfall basis.

*() indicates a probability evaluation

* Inundation area is a record in DKI Jakarta.

* Inundation area in January, 2013 is estimated based on field survey by JCFM (JICA, 2013).

*Casualty is a record in websites

Details of the floods in 2002, 2007, 2013 and 2020 are provided on the next pages.

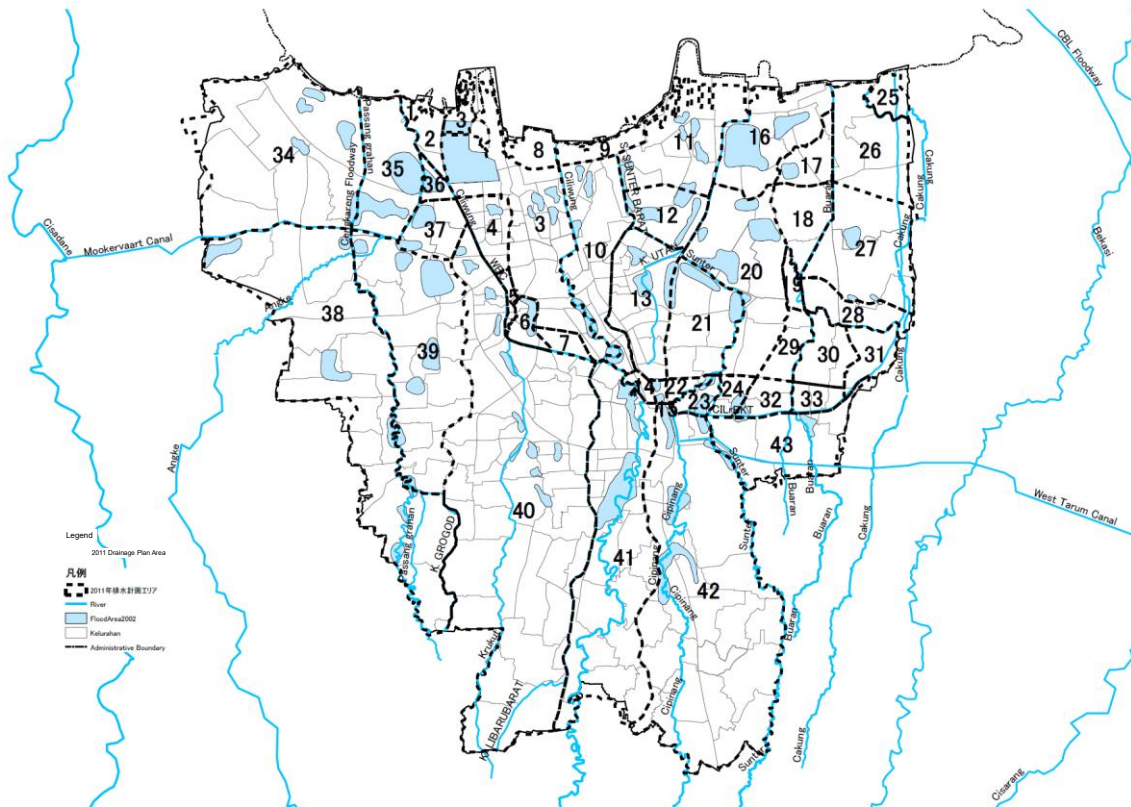
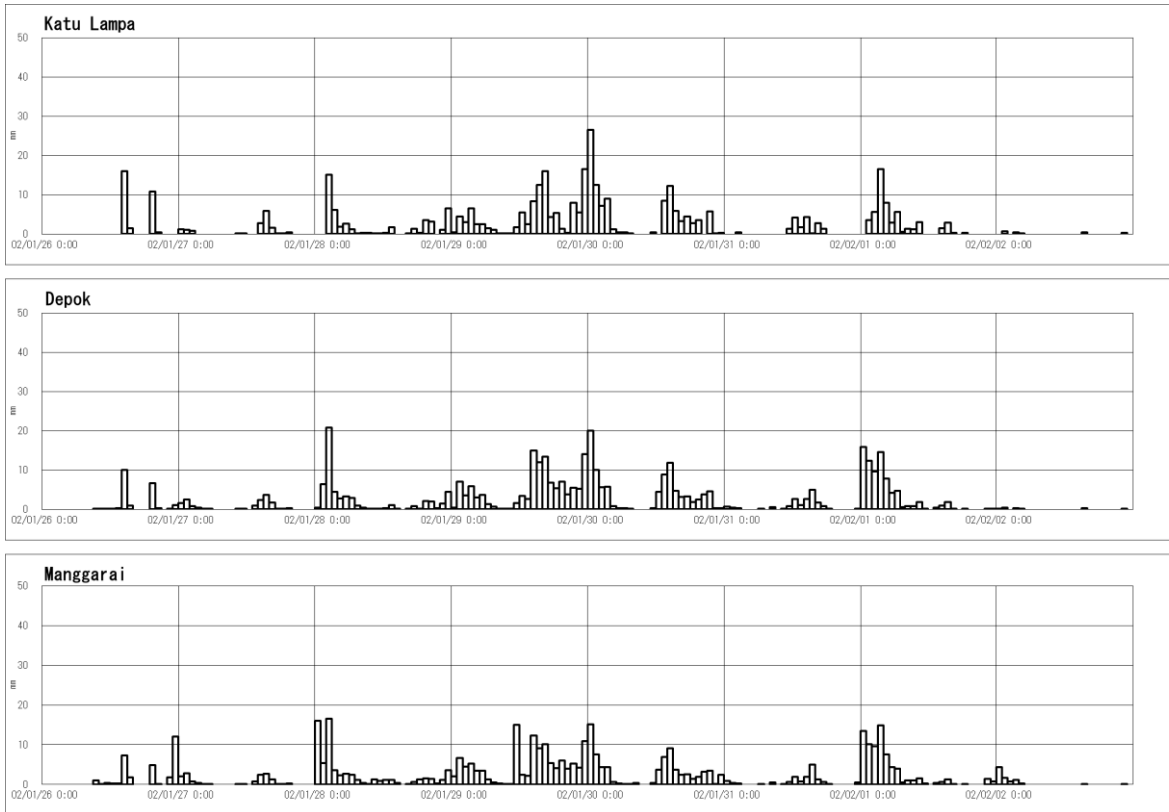


Figure 4-4 Inundation Area in DKI during February 2002 Flood

Rainfall depth



Water level

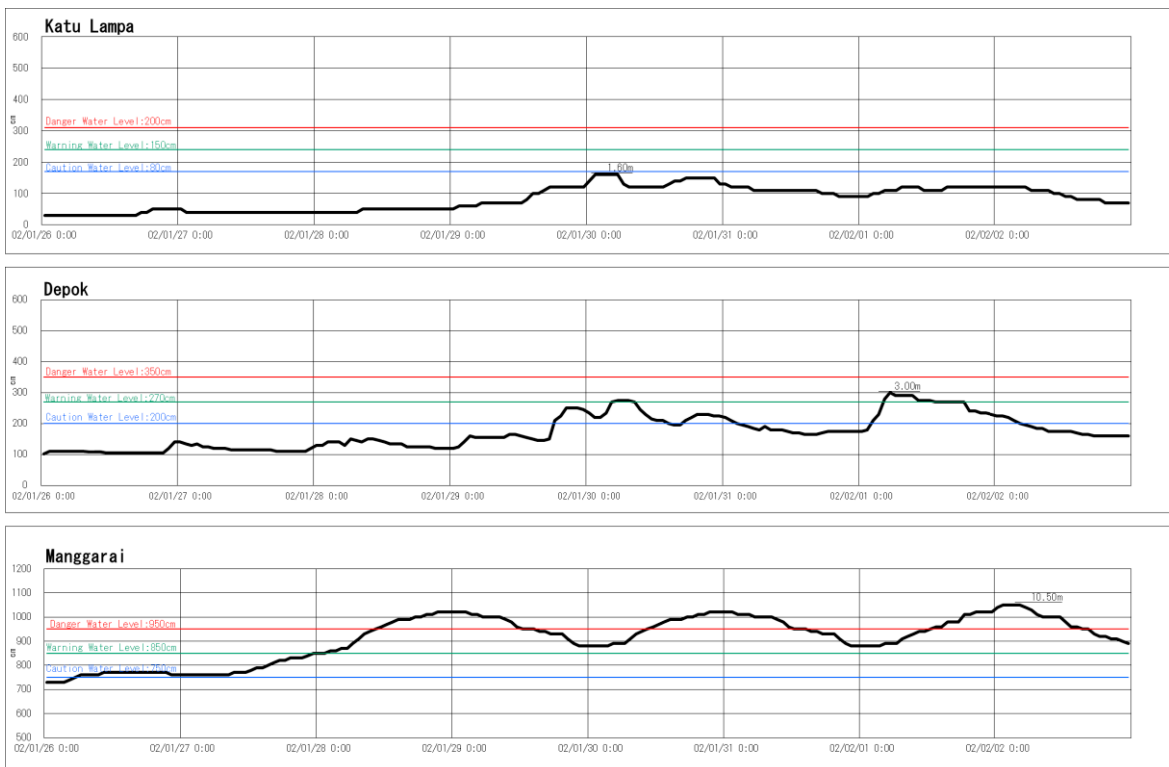


Figure 4-5 Rainfall and Water Level Hydrograph (February 2002 Flood)

4.3.2 2007 Flood

In February 2007, the Jakarta metropolitan area was severely damaged by flood. Figure 4-6 shows the actual inundation in DKI. Due to this flood, the flooded area was 300 km², which was about 45% of the Jakarta metropolitan area. Figure 4-8 shows the rainfall and water level hydrograph at the major stations of the Ciliwung River. At this time, the peak water level at Manggarai Gate was EL. 10.61 m which is the largest record, and exceeded dangerous water level for approximately 1.5 days. In addition, the damage situation during the 2007 flood is shown in Figure 4-7.

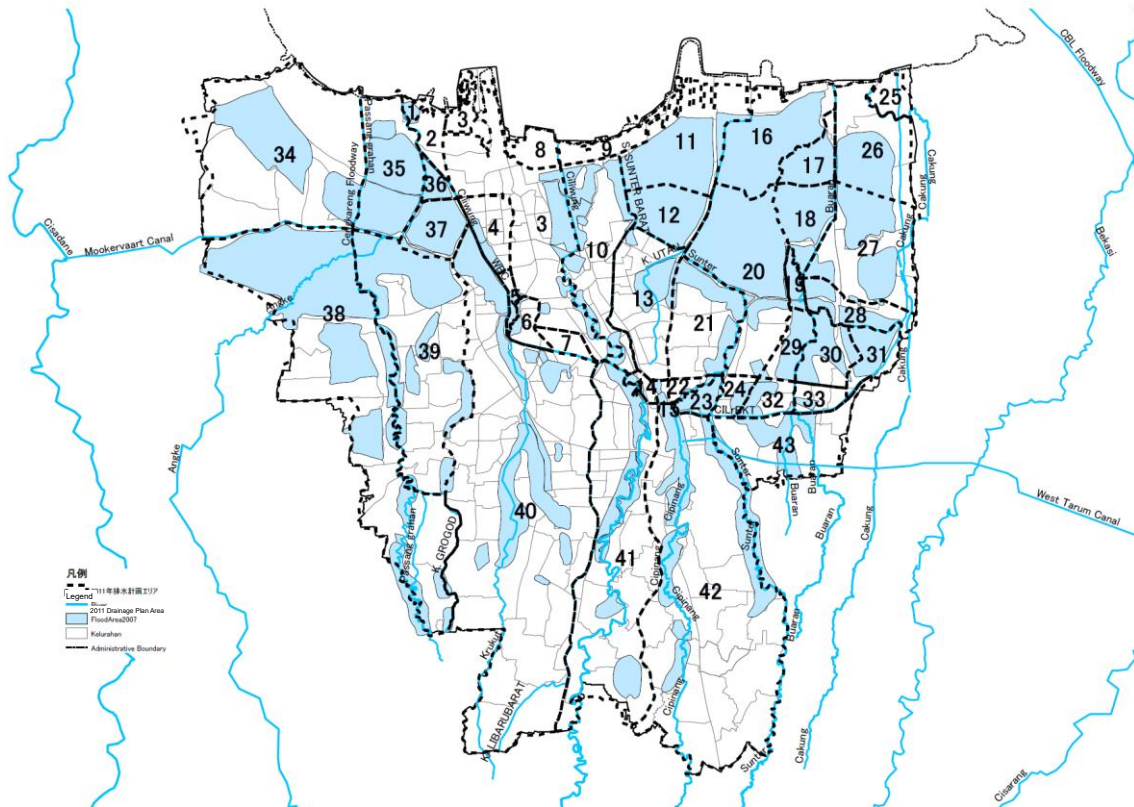


Figure 4-6 Inundation Area in February 2007 Flood



Banjir Kanal Barat (04.02.07)

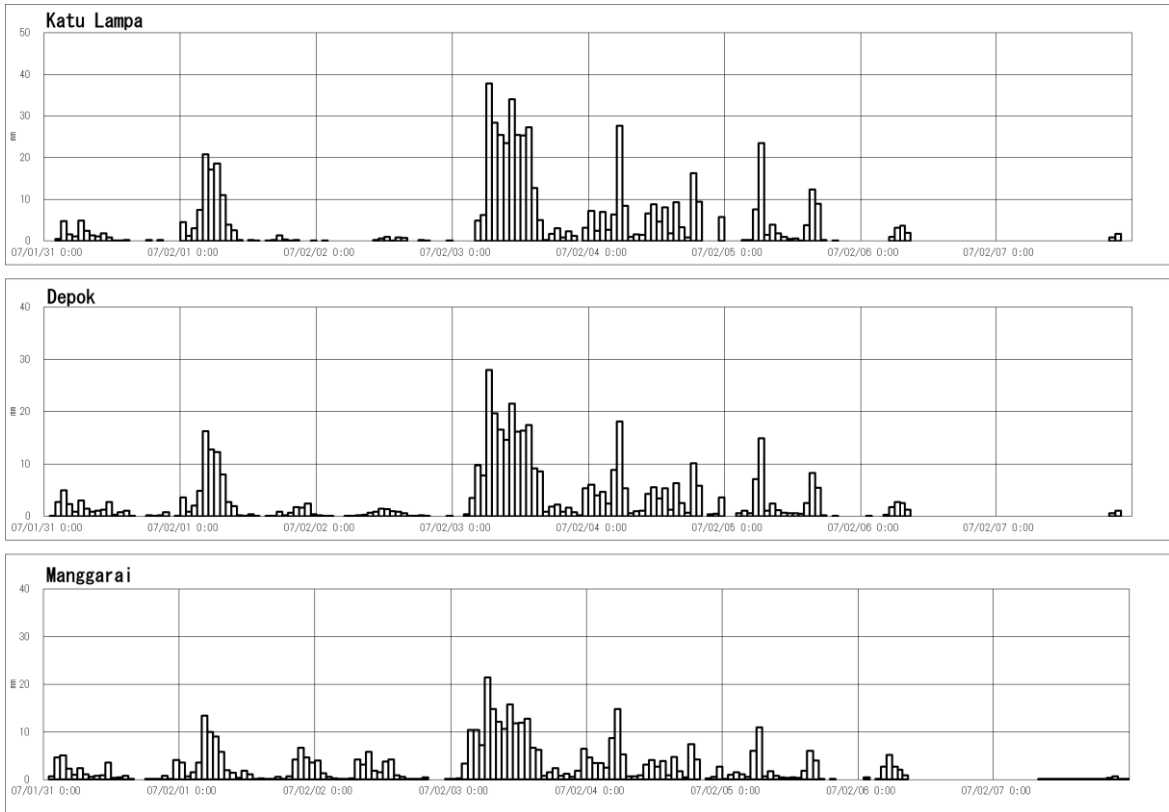


Banjir Kanal Barat Undepas Duku Atas ke Hilir (04.02.07)



Figure 4-7 Damage situation during February 2007 Flood

Rainfall depth



Water level

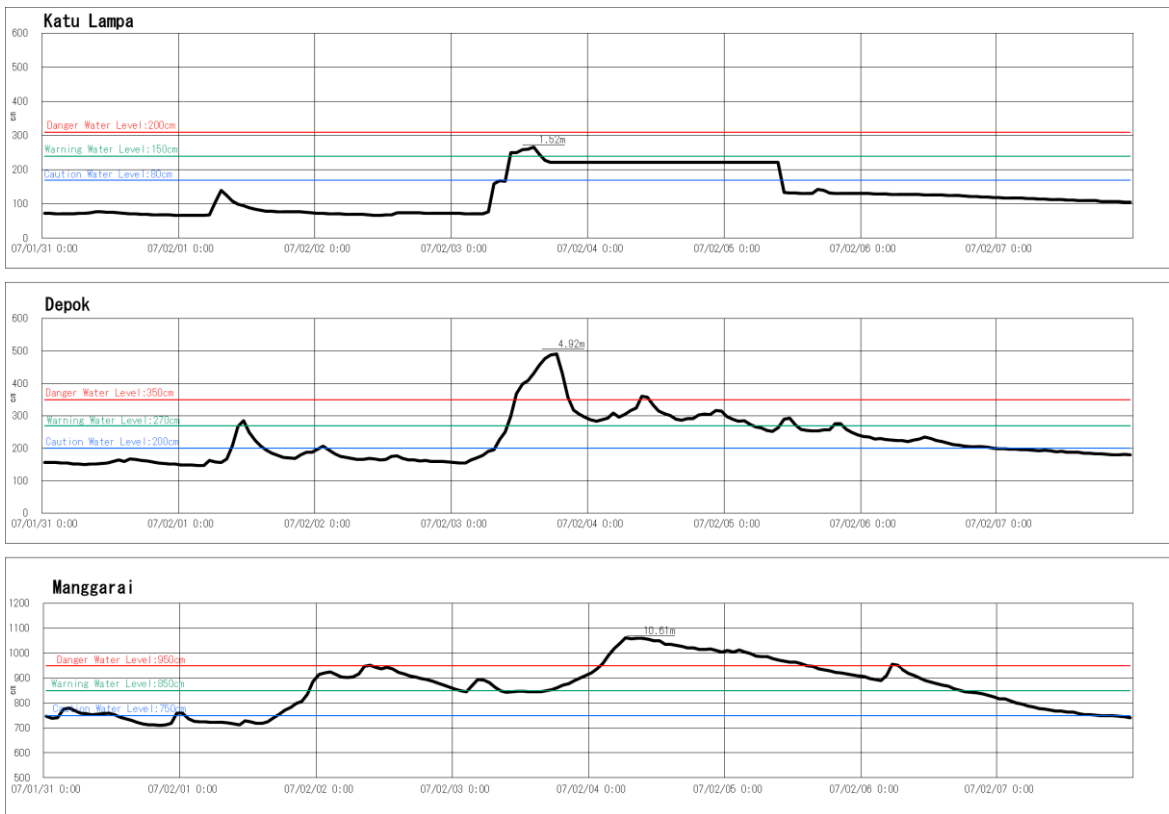
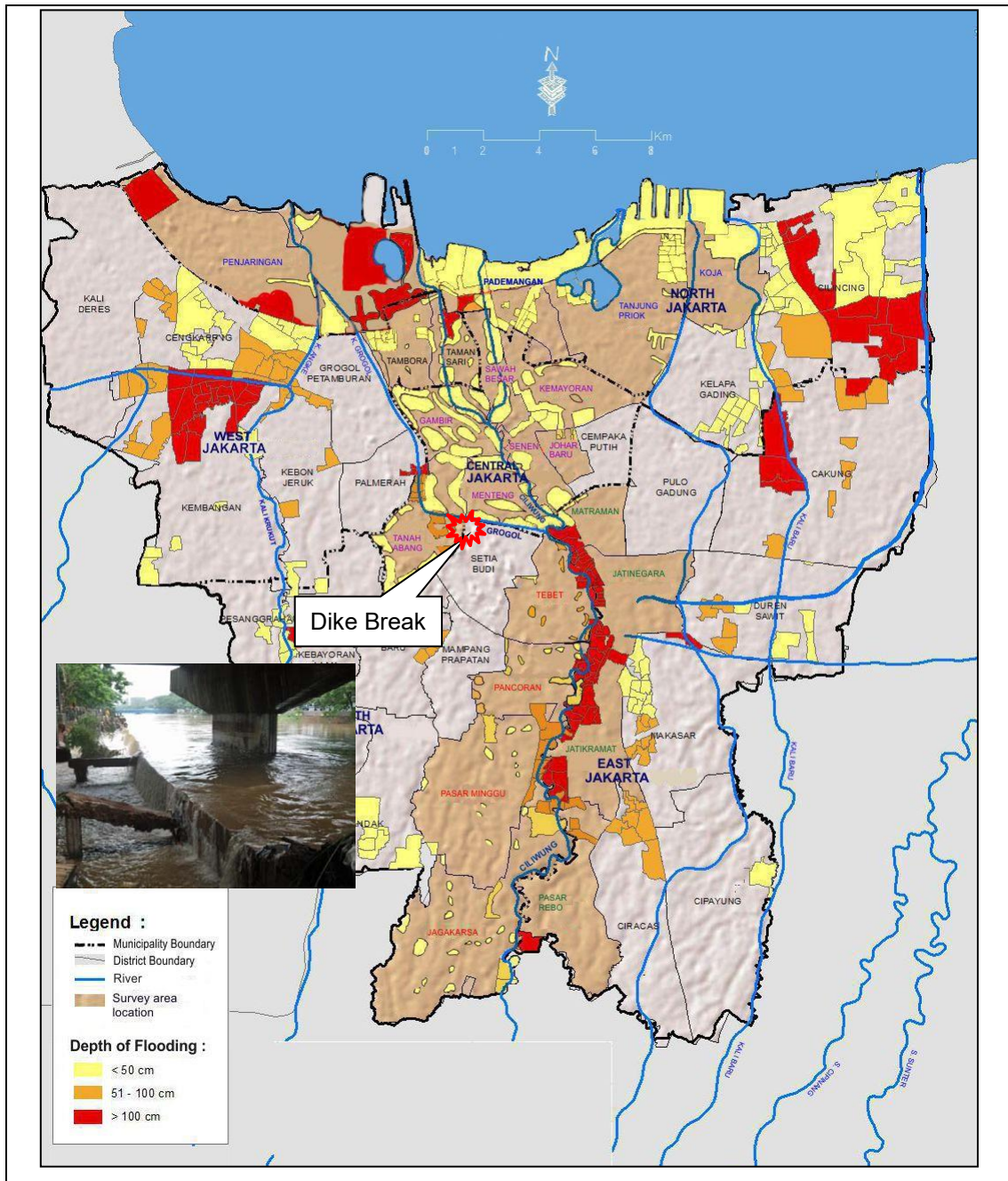


Figure 4-8 Rainfall and Water Level Hydrograph (February 2007 Flood)

4.3.3 2013 Flood

The January 2013 flood in Central Jakarta caused a catastrophic disaster when flood water flowed into the central area of DKI Jakarta, where the embassy and presidential palace are located, up to the lowland area along the coast due to the dike break at Jl. Latuharhari. Approximately 21% of DKI (inundation area of 140 km²) was inundated as shown in Figure 4-9.

At Manggarai Station, the peak water level of 10 m was recorded on January 17, exceeding the danger water level for about 4 hours.



Source: The Project for Capacity Development of Jakarta Comprehensive Flood Management in Indonesia (JICA, 2013)

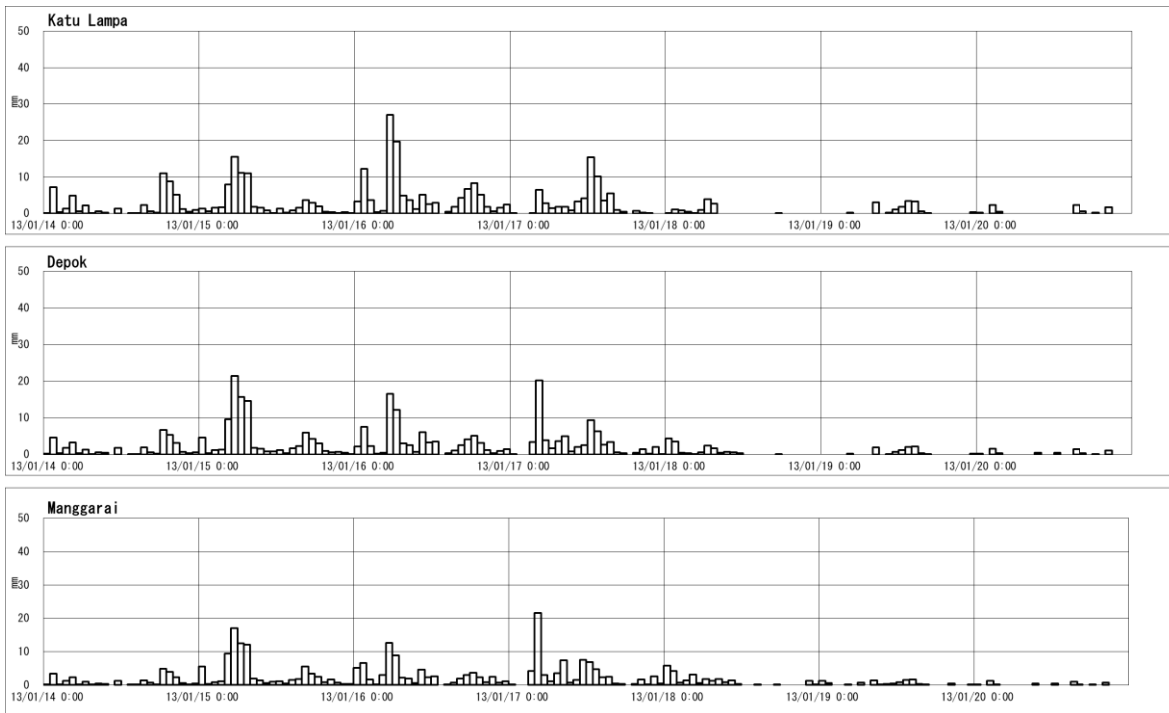
Figure 4-9 Inundation Area and Dike Break at West Banjir Canal



Source: The Project for Capacity Development of Jakarta Comprehensive Flood Management in Indonesia (JICA, 2013)

Figure 4-10 Damage situation during January 2013 Flood

Rainfall depth



Water level

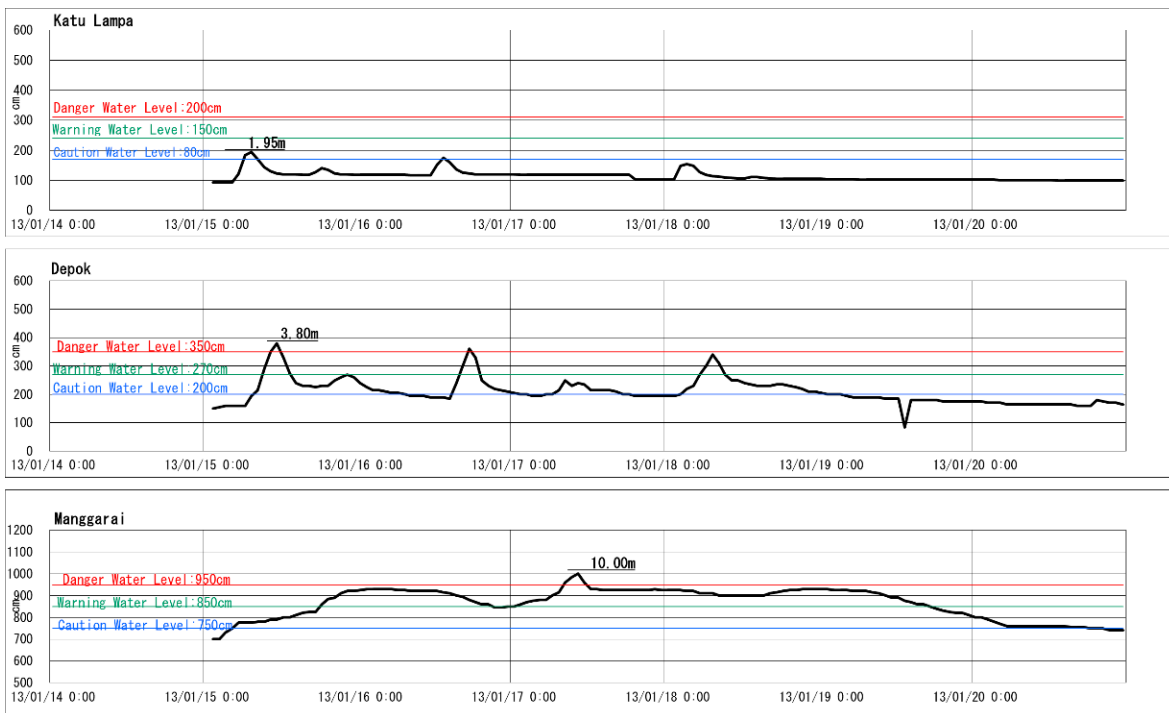


Figure 4-11 Rainfall and Water Level Hydrograph (January 2013 Flood)

4.3.4 2020 Flood

The flood that occurred on January 1, 2020 caused inundation damages in various parts of the Jakarta metropolitan area. In DKI, in addition to the damage in the inner area of the East-West Banjir Canal, heavy rains occurred especially in the area south of the East-West Banjir Canal, causing flood damage along major rivers. The flood inundated approximately 21% of DKI (Inundation area of 140 km²) as shown in Figure 4-12.

Figure 4-14 shows the rainfall and water level conditions at the major stations of the Ciliwung River. At Maranggai Station, the water level exceeded the warning level before dawn on January 1, and the peak water level reached up to 9.65 m on January 2, exceeding the danger water level. The water level then began to decrease, and by the afternoon of January 2, it was below the warning water level.

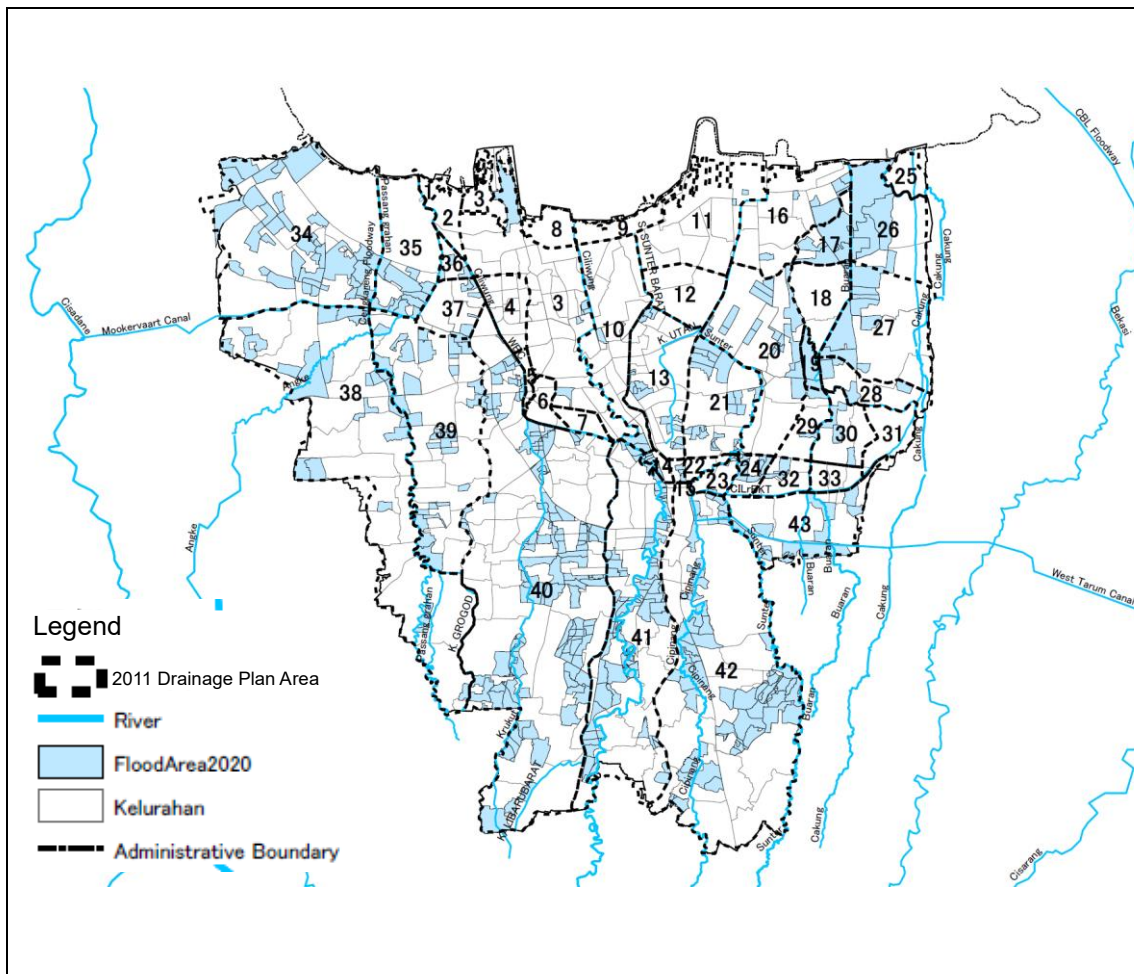


Figure 4-12 Inundation Area in January 2020 Flood

Daily rainfall in the Ciliwung Cisadane WS on 12/31/2019

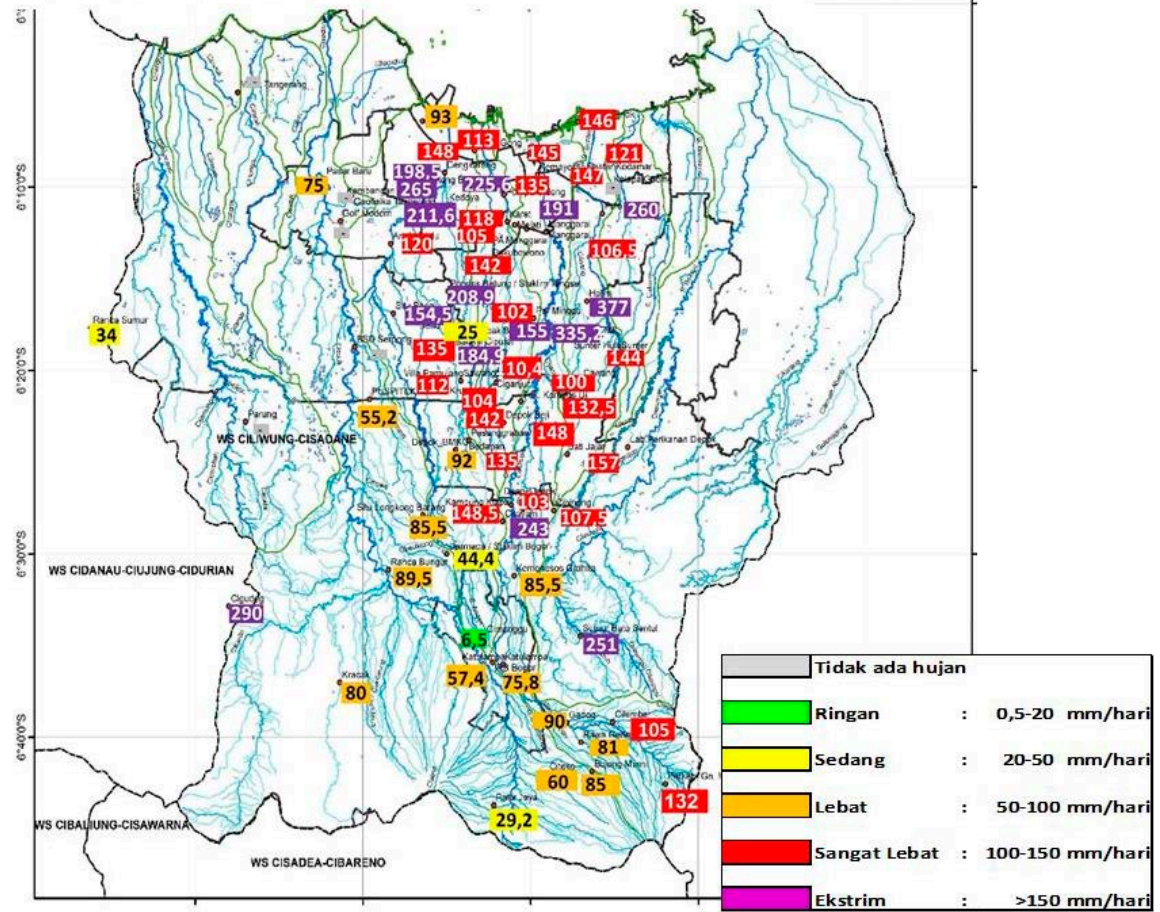
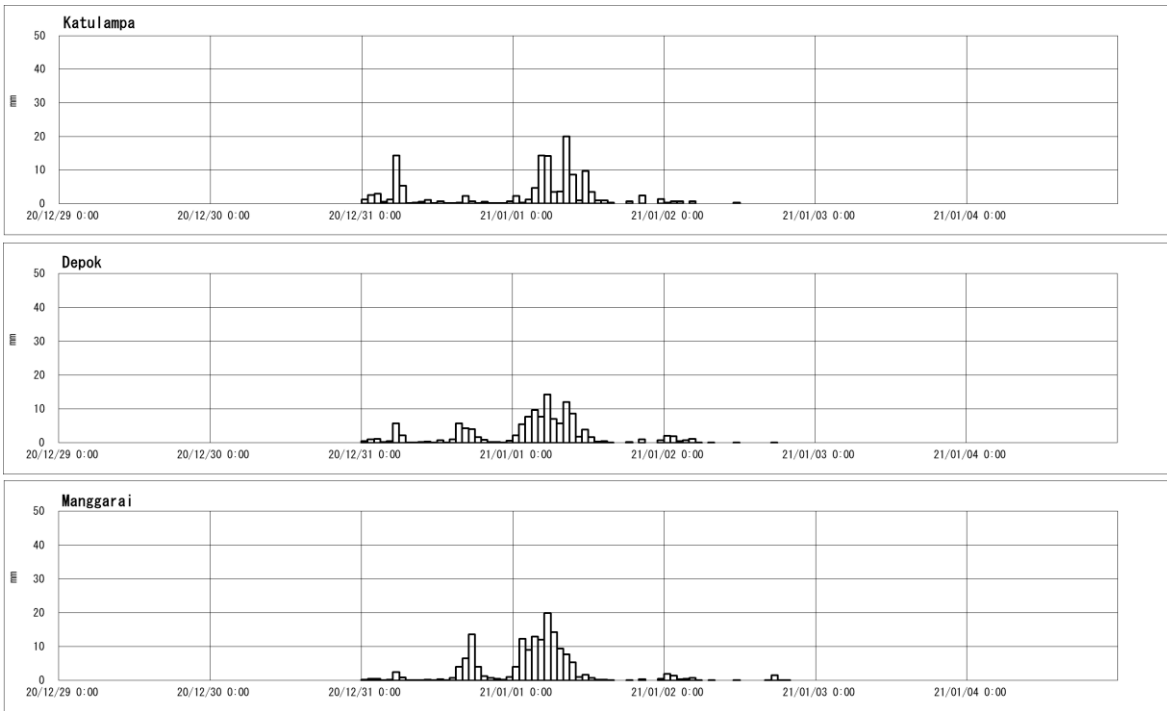


Figure 4-13 Rainfall Distribution in January 2020

Rainfall depth



Water level

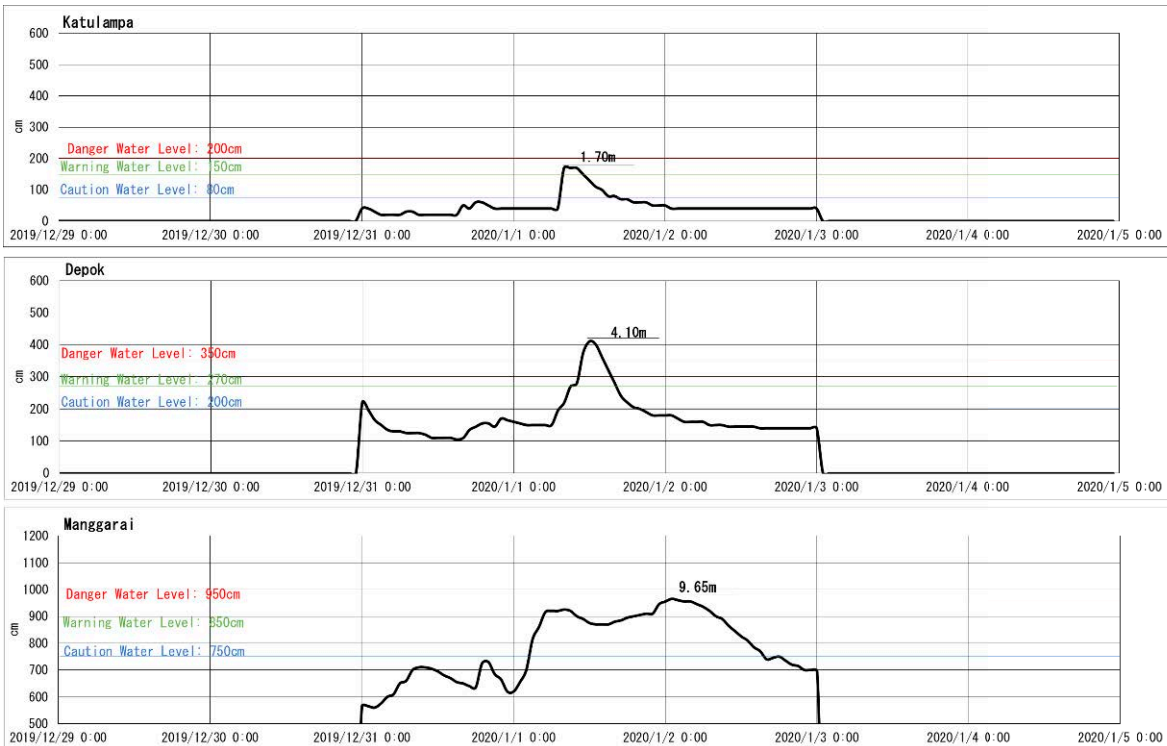


Figure 4-14 Rainfall and Water Level Hydrograph (January 2020 Flood)

4.4 Priority Area Selection Policy

After summarizing the recent floods (4 floods) and organizing their characteristics, districts (areas) that are important to be developed in DKI will be selected.

- ① For DKI, the 2007 flood was the largest, with a probability scale of approximately 100-year flood (the inundation damage was also the largest). Therefore, it is necessary to select the priority development areas and implement countermeasures to prevent the 2007 flood disaster from happening again.
- ② The spatiotemporal distribution of rainfall in the 2020 flood is significantly different from that of 2007 (partially concentrated rainfall is observed, the rainfall is more pronounced in the upstream areas, etc.) and areas other than the seven polders have also been severely damaged. Therefore, consideration must also be given to the 2020 flood, and it is necessary to consider measures that do not have adverse effects (negative impacts) in the downstream area.

Based on the above, the selection of the priority development areas (Section 4.5 below) will be carried out according to the flow described in Figure 4-15.

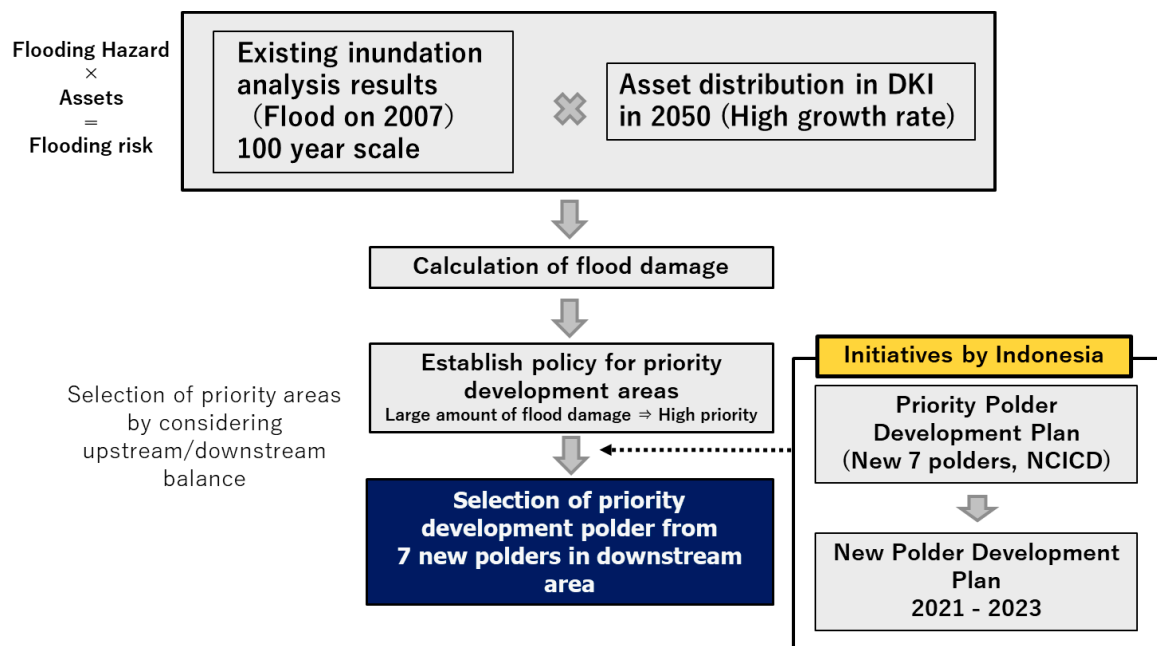


Figure 4-15 Flow of Priority Area Selection

4.4.1 Inundation Map of Floods in Recent Years

Figure 4-16 shows a comparison of the inundation areas of the four recent floods (2002, 2007, 2013 and 2020).

Among the recent floods, the 2007 flood caused the greatest inundation damage. In the 2020 flood, the damage is greater in the upstream of the river due to the different spatio-temporal distribution of rainfall.

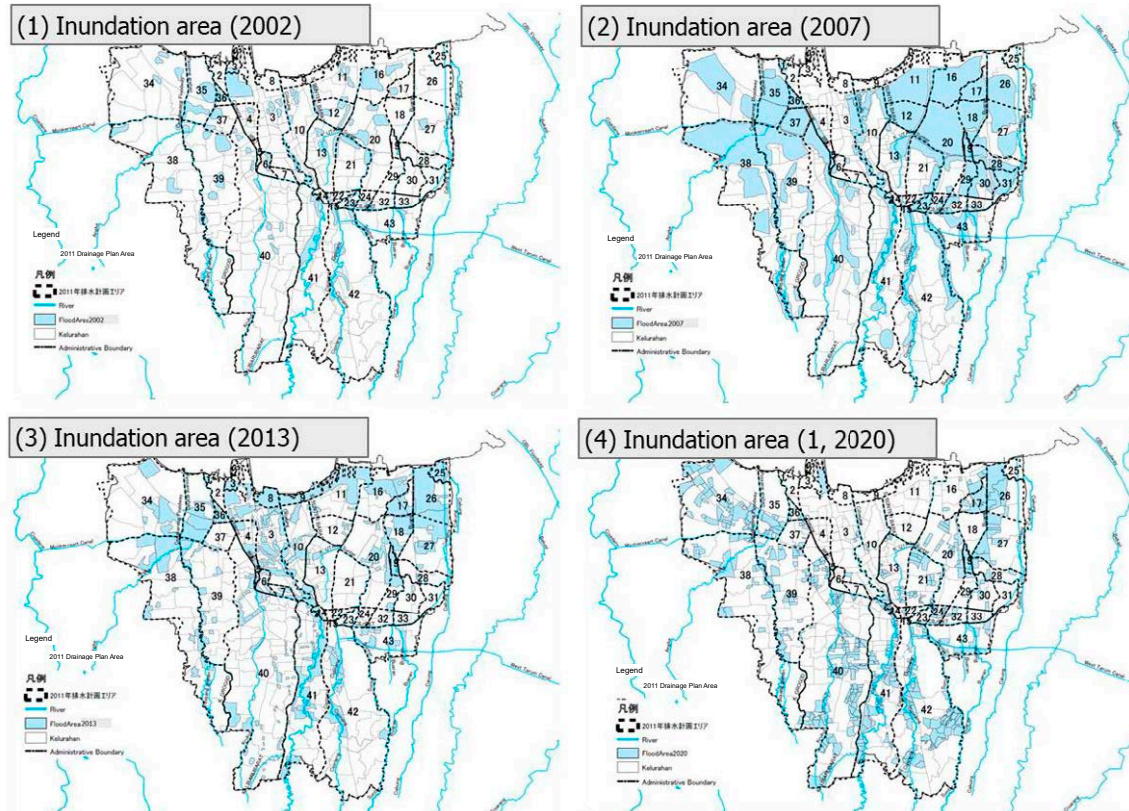


Figure 4-16 Inundation Area of Floods in Recent Years

4.4.2 Comparison of Actual Inundation Areas of 2007 and 2020 Floods

A comparison of the 2007 and 2020 floods (Figure 4-17) shows that the upstream area of the East-West Banjir Canals was more severely flooded in the 2020 flood than in the 2007 flood.

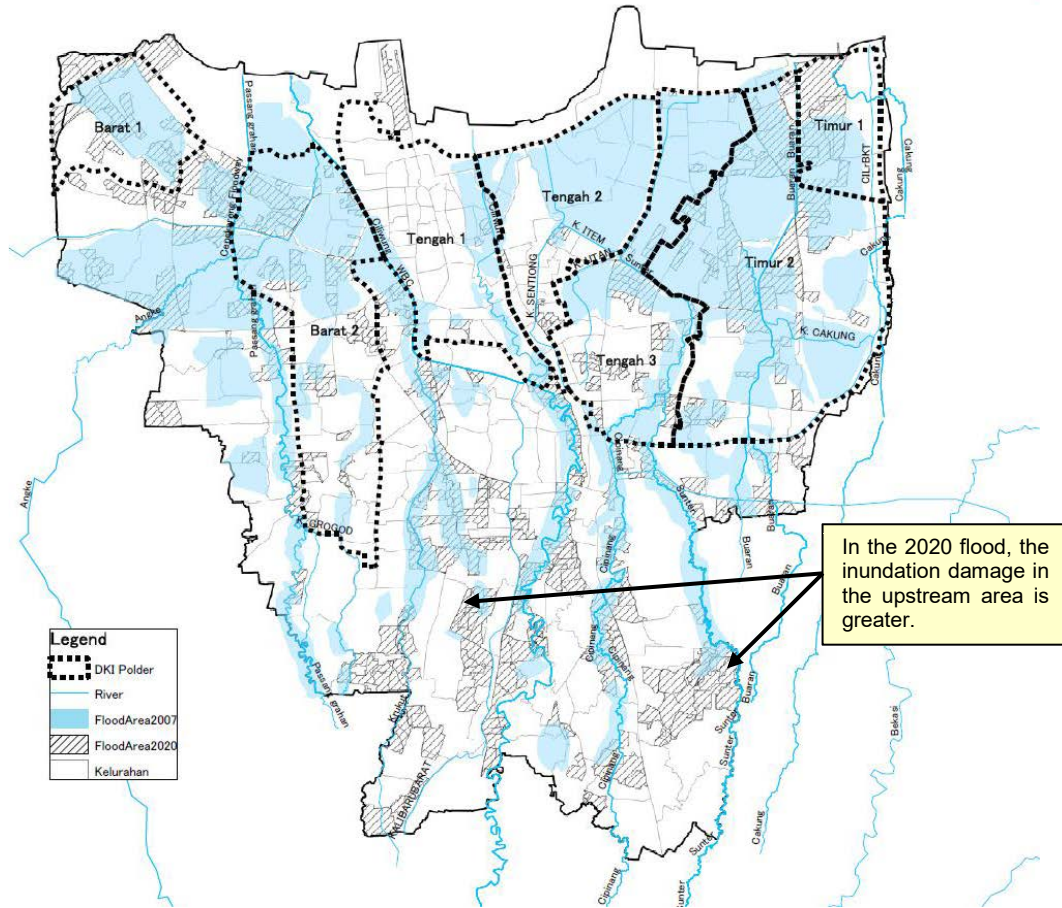


Figure 4-17 Comparison of Inundation Areas of 2007 and 2020 Floods

4.4.3 Characteristics of the 2007 Flood

The 2007 flood has the highest inundation damage among the floods that have occurred in recent years and is considered as a past disaster flood.

In February 2007, the Jakarta metropolitan area was severely damaged by flooding and about 45% of DKI was inundated.

At this time, the peak water level at Manggarai Gate was EL. 10.61 m which is the largest record, and exceeded dangerous water level for approximately 1.5 days. The average rainfall in the basin of Manggarai is about 254 mm/48h, which is equivalent to a flood that occurs about once every 60 years.

Table 4-3 Rainfall and Water Level during the 2007 Flood

Year of Occurrence	Duration of Rainfall (hr)	Average Rainfall in Basin at Manggarai Gate Point					Manggarai Gate Point Peak WL (m)	Disaster Condition	Inundation Area (km ²)
		1hour (mm)	6hour (mm)	24hour (mm)	48hour (mm)	168hour (mm)			
30 Jan. - 6 Feb. 2007	153	21.5	86.6 (1/20)	179.5 (1/60)	254.6 (1/70)	445.6 (1/30)	10.61	Overflow, Inland Water	300

(): Rainfall probability evaluation

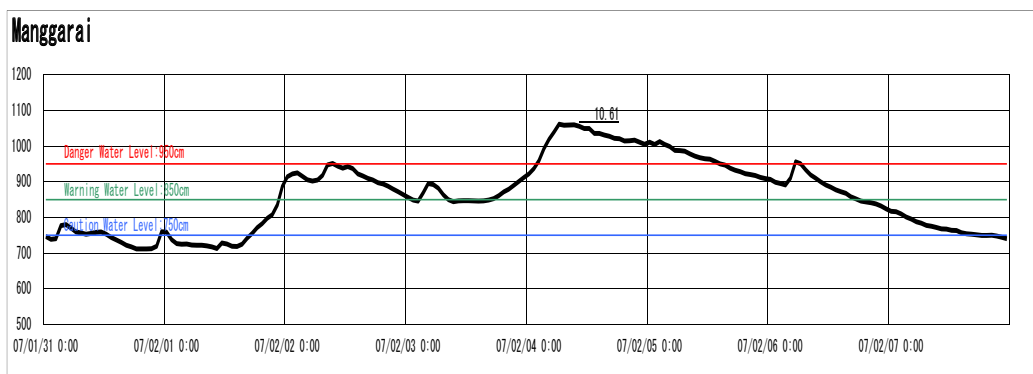


Figure 4-18 Time series of Water Level at Manggarai Station

4.4.4 Distribution of assets and population density in DKI

Figure 4-19 shows the distribution of assets and population density in DKI. It can be seen that the population and assets are concentrated in the downstream of DKI. It is necessary to prioritize the development considering that the damage in the downstream area is also significant.

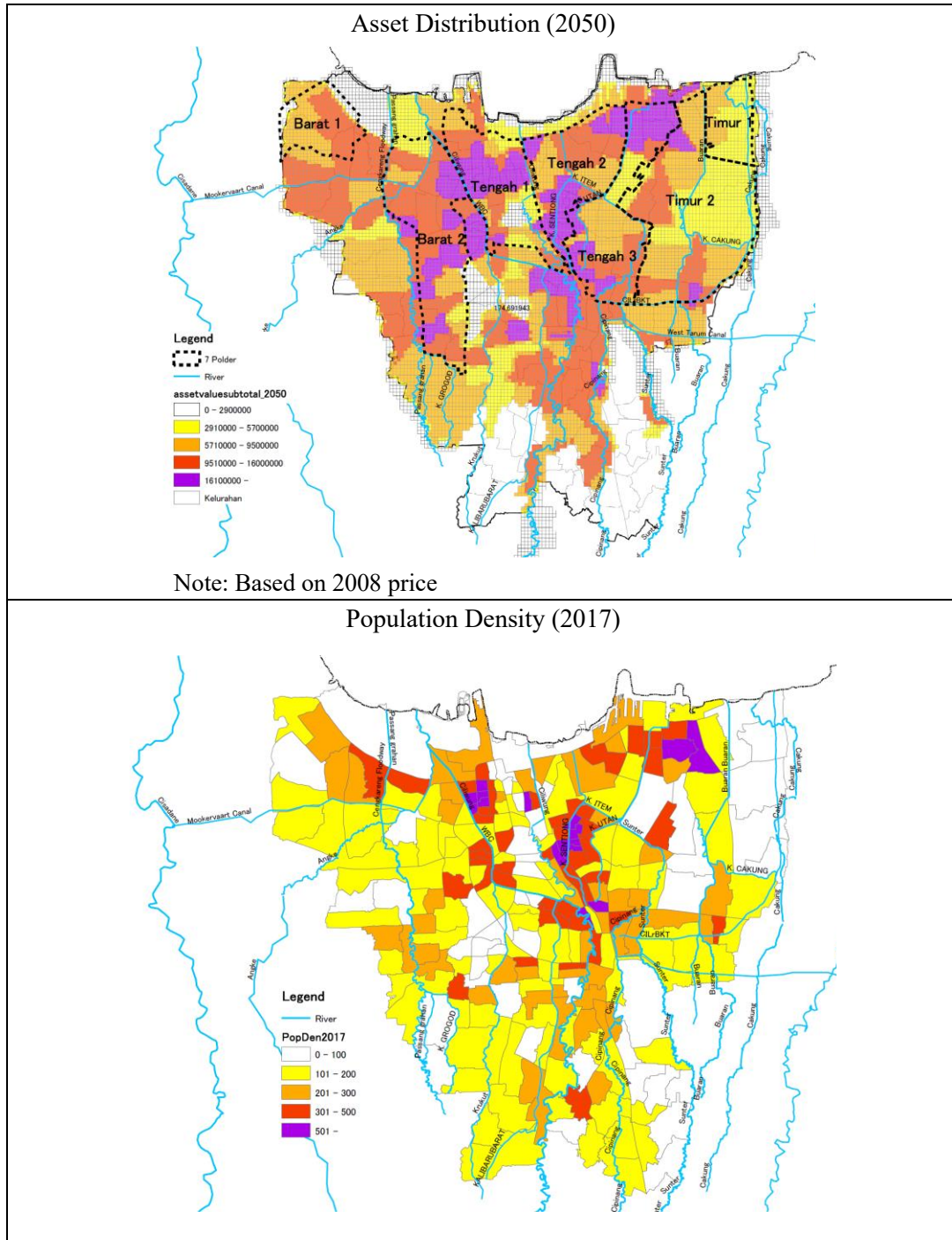


Figure 4-19 Distribution of Assets and Population Density in DKI

4.5 Priority Area Selection

4.5.1 Distributed Run-off Inundation Analysis Model

(1) Outline of the Inundation Analysis Model

The existing inundation analysis model is divided into a runoff area and an inundation area, and the kinematic wave method is applied to the runoff area, while the 2D unsteady flow calculation is applied to the inundation area. Figure 4-20 shows a conceptual diagram of the analytical model. Table 4 4 also summarizes the conditions of the analytical model.

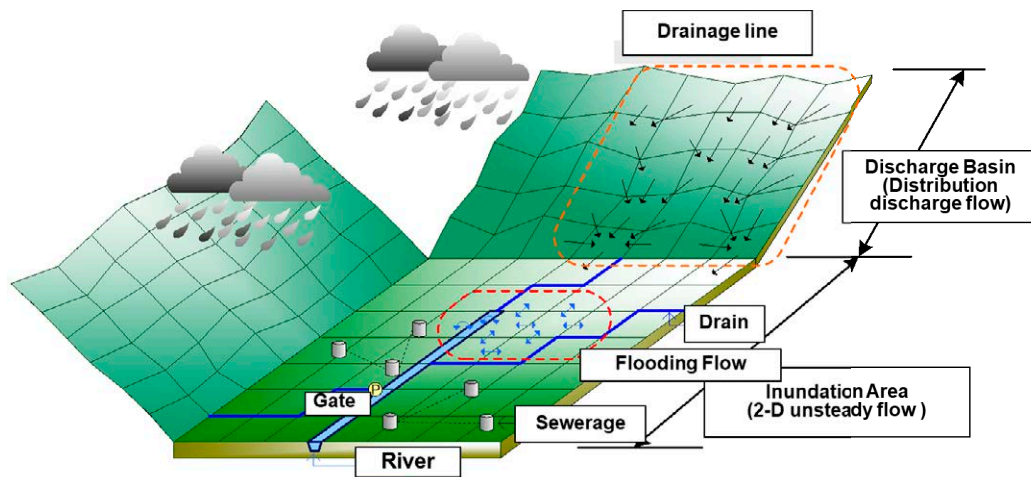


Figure 4-20 Conceptual Diagram of the Analysis Model

Table 4-4 Outline of Analysis Model

Items		Conditions	Remarks
Land Feature	Basic mesh	Run-off Area: 230 m (7.5") Inundation Area: 230 m (7.5")	
	Inundation area land feature	Formulated based on 1/5000 Topographic map (2008) and GPS data	
	Run-off area land feature	Formulated based on 1/25000 Topographic map (2008)	
	Land use (inundation area)	Formulated based on DKI land use map (2008)	
	Land use (run-off area)	Formulated based on Jabodetabekpunjur land use map (2009)	
Analysis Model	River	One dimensional unsteady flow model (Dynamic Wave)	
	Inundation area	Two-dimensional unsteady flow model (Dynamic Wave)	
	Run-off area	Distributed run-off model (Kinematic Wave)	
Built-in Model	Condition on the river	Bridges, gates, pumps	
	Inundation land feature mesh	Drainage canals, banks, culvert	
	Intervals of river and floodplain land feature mesh	Overflows, gates, pumps	
River	Cross-sectional surface The water level of the downstream end Upstream end/inflow volume	Current river in 2011, identify 100 m and 200 m pitch in 2008 Junction point with the Java Sea: Tide level data of Tanjung Priok Run-off volume of distributed run-off model (Kinematic Wave)	
Facilities	Banks	Main local roads and railways over 50 cm	
	Drainage canals	Secondary affluent	
	Others		
Overflow	Coefficient of overflow	Settled considering the side overflow by formula	
	Overflow Height	Current dike height	
	Overflow point	All intervals are targeted	
Pump operating condition		Follow the operation rules of each pump station	
Rainfall distribution		Hyetograph of the flood in February 2007 (provided dimensionally by Thiessen method)	

Source: The Project Team

(2) Analysis Model Diagram

Figure 4-21 shows the mesh division diagram of the analysis model. The analysis model is divided into about 28,300 meshes (16,700 meshes in the runoff area and 11,600 meshes in the inundation area) over the entire area, with a size of 230 m x 230 m each grid. Figure 4-22 shows an enlarged view of the inundation area model.

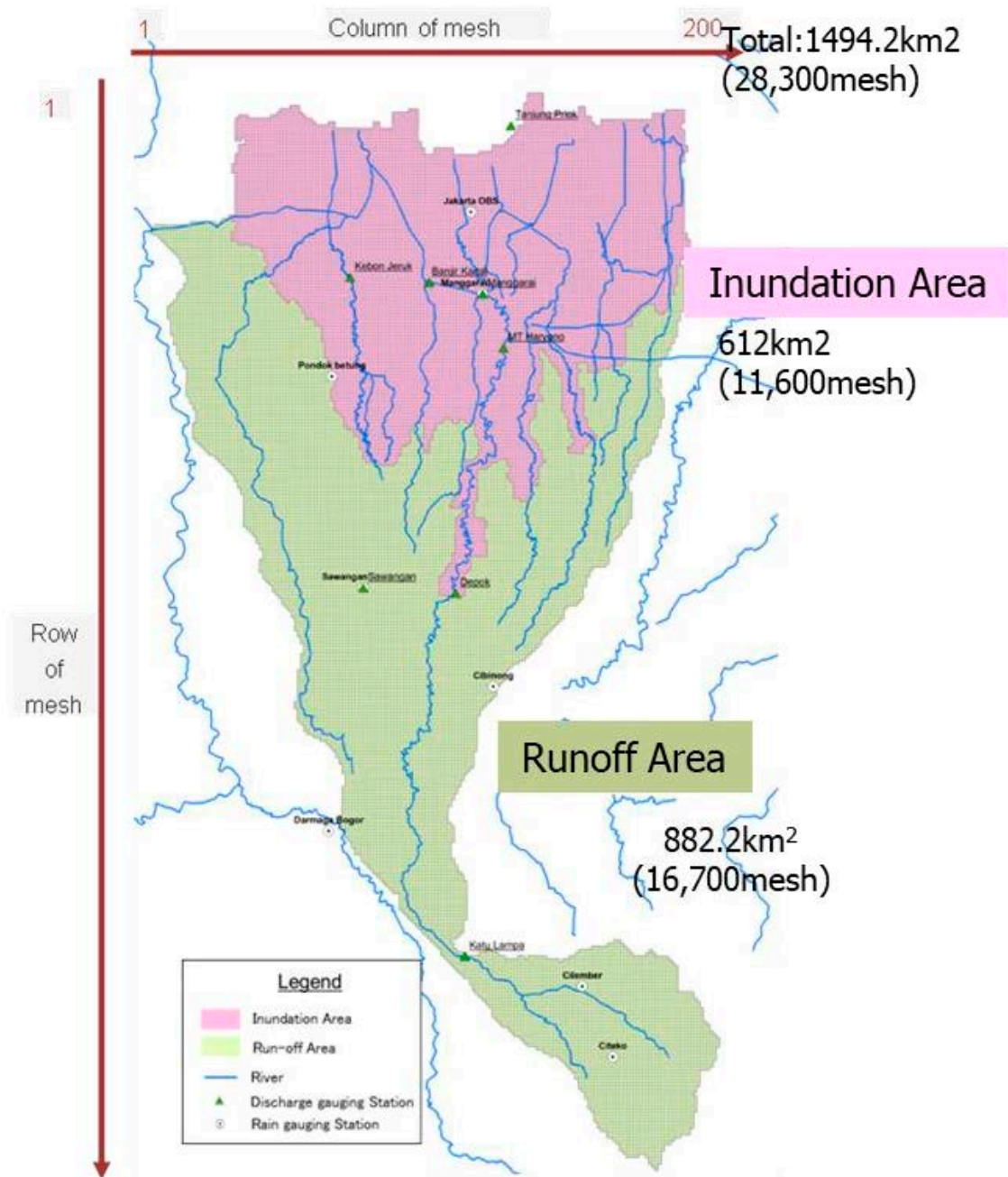


Figure 4-21 Mesh Division of the Model

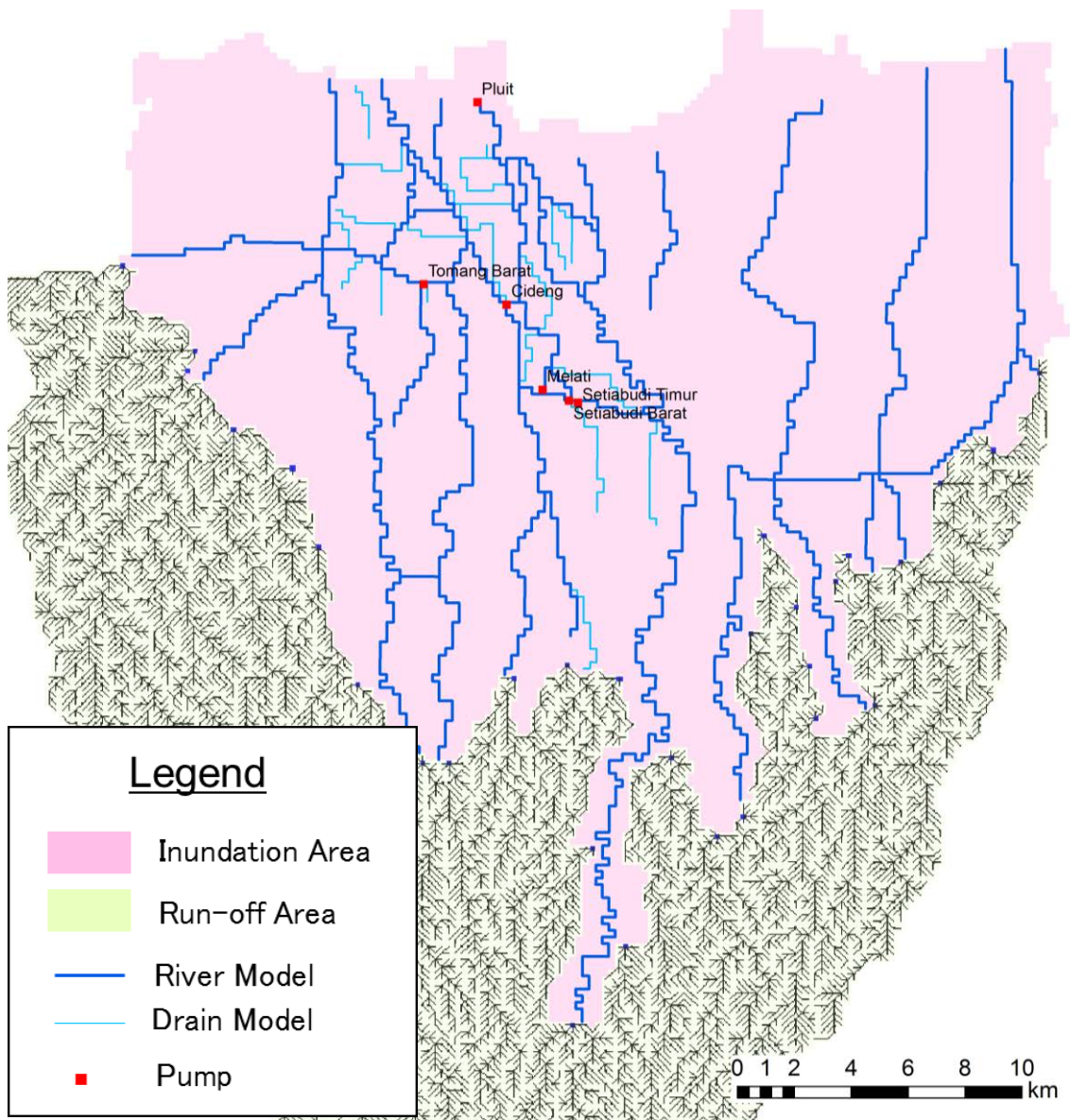


Figure 4-22 Model Diagram of the Inundation Area

(3) Model Validation

The inundation analysis model was validated using the February 2007 flood. The validation results are shown below.

(i) Water Level/Flow Rate Hydrograph

The model was validated using the observed discharge at Depok Station and observed water level at Manggarai Station. The simulated discharge from the runoff analysis and simulated water level from the inundation analysis were compared to the observed data.

The results are shown in Figure 4-23 and Figure 4-24, covering the peak flow rate and water level. It was confirmed that the data were well reproduced, as the waveforms are almost similar.

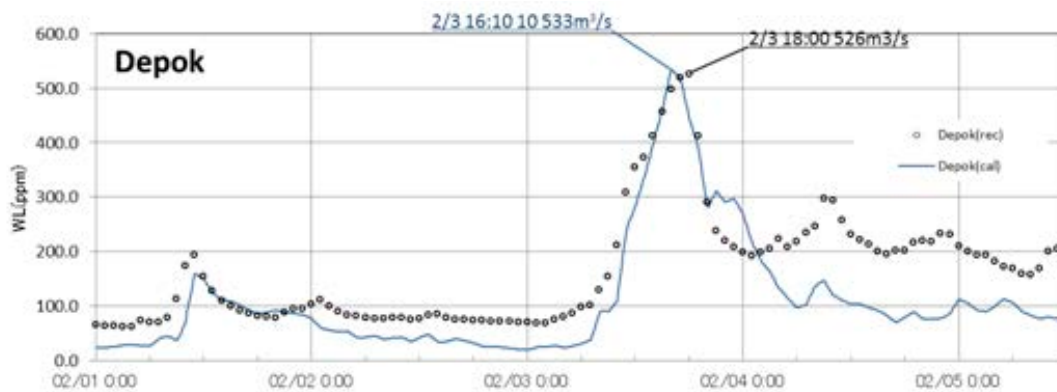


Figure 4-23 Flow Rate Hydrograph (Depok Station)

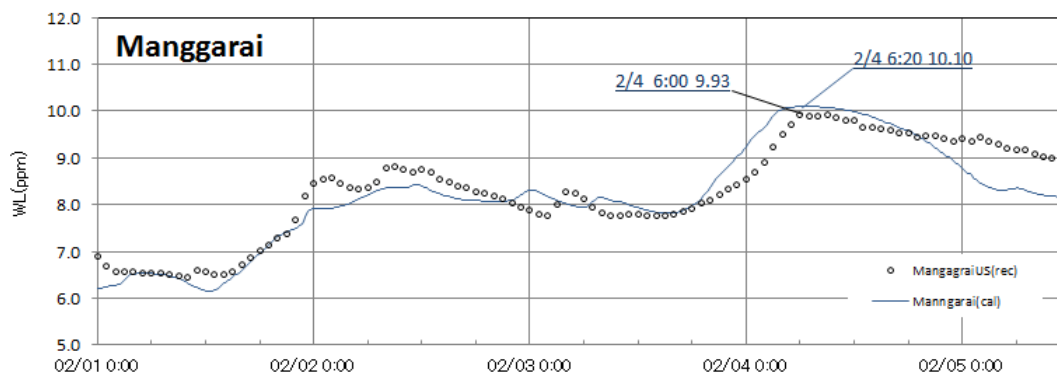


Figure 4-24 Water Level Hydrograph

(ii) Maximum Inundation Depth

A comparison of the simulated results for the inundation area (maximum inundation depth map) and actual inundation of DKI is shown in Figure 4-25.

The actual inundation area is about 300 km², while the simulated inundation area is 262 km², which is about 90% of the actual result. Based on these results, it can be said that it was almost reproduced.

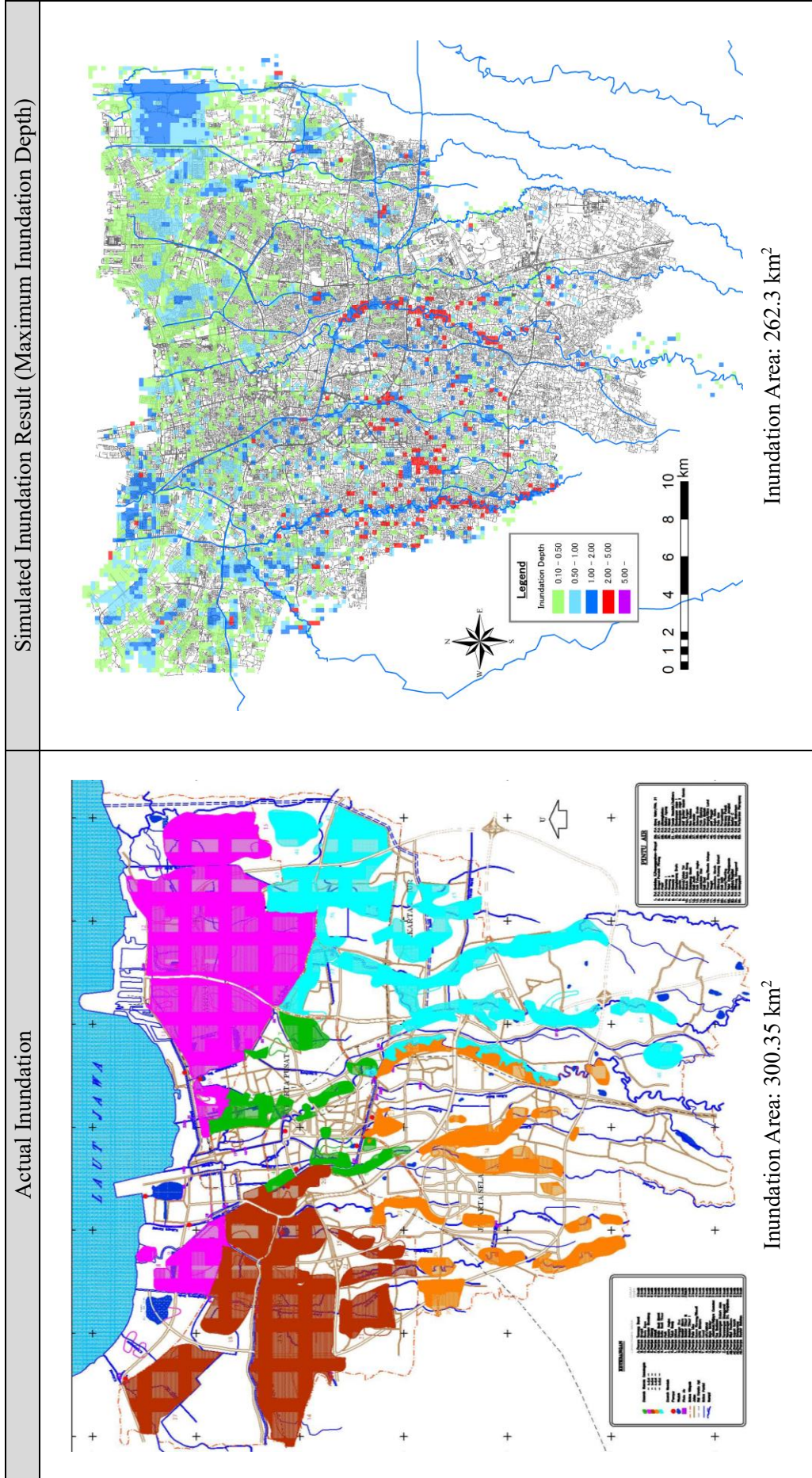


Figure 4-25 Inundation Results and Maximum Inundation Depth

4.5.2 Inundation Analysis Conditions

The inundation analysis conditions for the selection of priority areas are shown in Table 4-5.

The planning scale was set to 100 years, which is the planning scale of major rivers in 1997 MP and is a standard for large cities in Indonesia, as described below in Section 4.7. The rainfall magnitude in the 2007 flood, which was the largest flood in the past, was adopted and the rainfall duration was set to 48 hours based on the characteristics of the watershed (channel length of 119 km) and the response characteristics of the major floods.

Table 4-5 Inundation Analysis Conditions

Item	Condition
Topography	2008
Facilities	2012 (Reflecting future maintenance after 2012)
Flood Hydrograph	February 2007
Rainfall Magnitude	1/100 year
Rainfall Duration	48 hours
Extension Ratio	1.06 times (1/100 Rainfall 270 mm/48h, Actual 254.6 mm/48h)

4.5.3 Flood Inundation Analysis Results

The results of the inundation analysis based on the analysis conditions in Table 4-5 are shown in Figure 4-26. The analysis was conducted based on a 100-year scale, which is the scale of river embankment maintenance of NCICD.

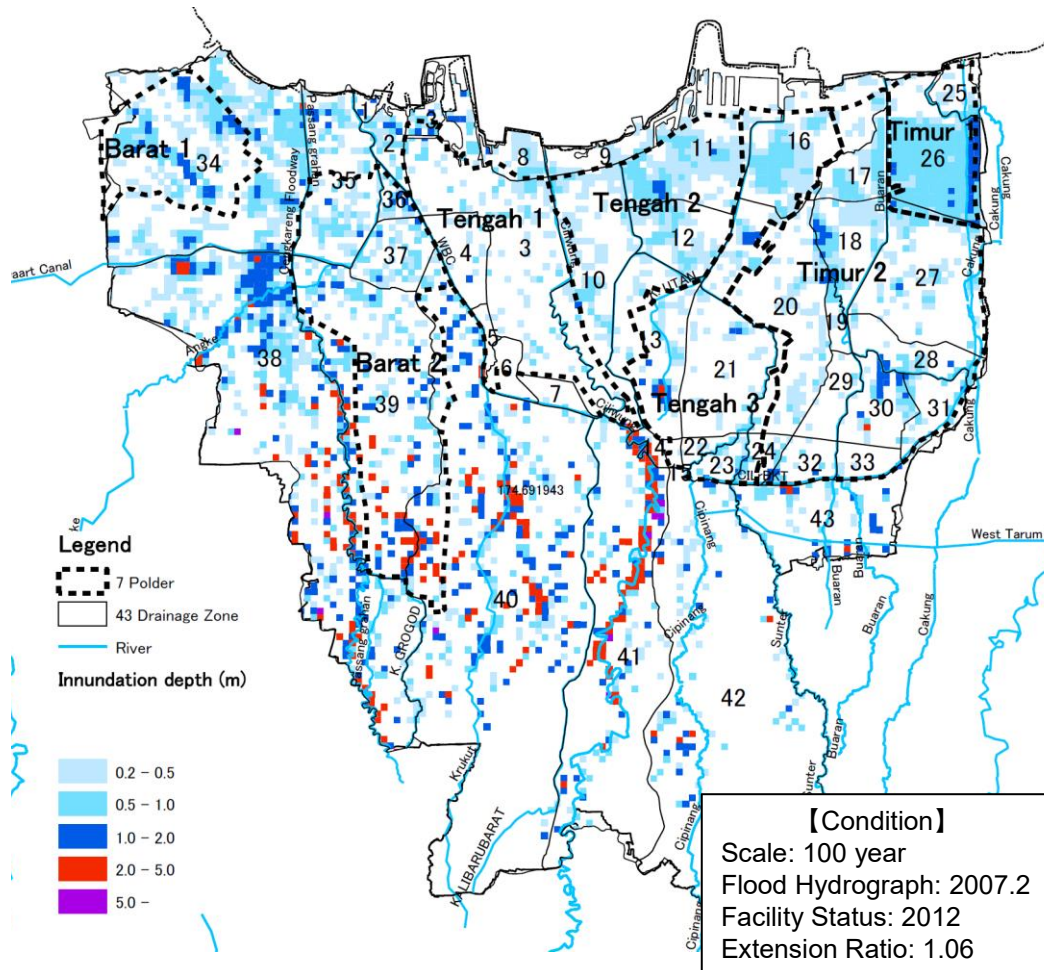


Figure 4-26 Flood Inundation Analysis Results in 2007 (expanded to 100-year scale)

4.5.4 Inundation Damage

Flood risk is assessed by calculating the amount of flood damage based on the results of inundation analysis and asset distribution (2050). The total damage calculation is shown below.

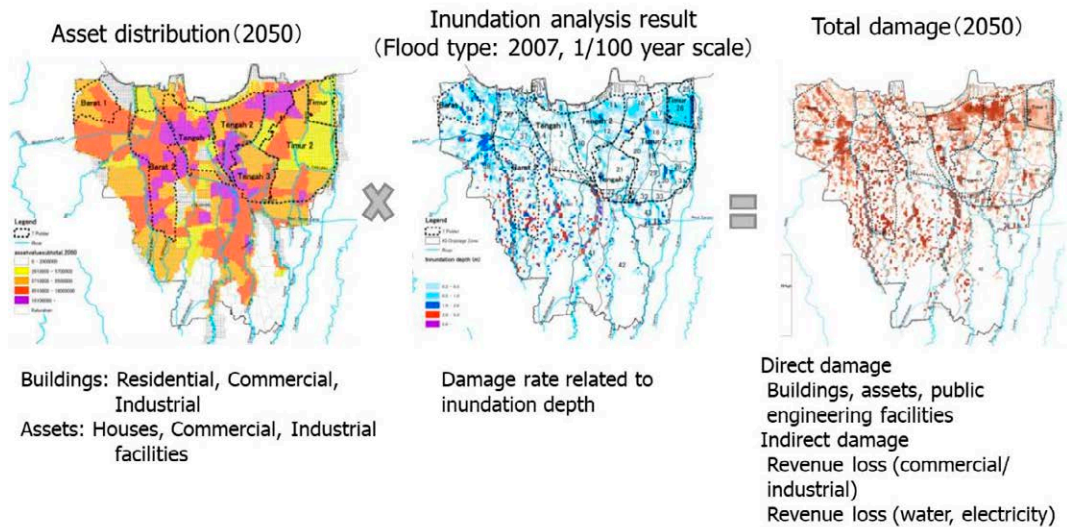


Figure 4-27 Calculation of Total Inundation Damage

(1) Direct and Indirect Damages from Flooding

Flood damage consists of direct damage and indirect damage.

Direct damage covers damage to residential and commercial buildings and business premises such as factories, damage to household goods, business depreciation and inventory assets, and damage to public engineering facilities such as roads.

Indirect damage includes the decrease in output due to the suspension or stagnation of production at business establishments, and the decrease in sales due to the suspension of electricity and water services among public and utility services.

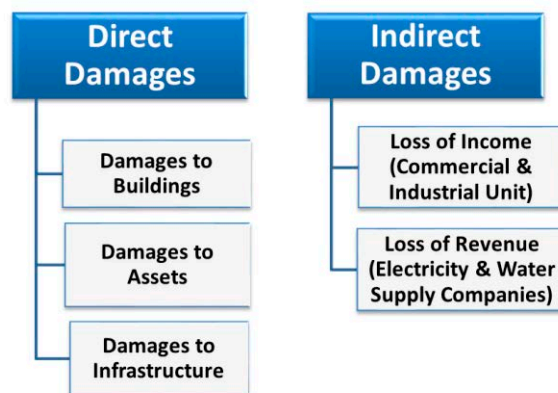


Figure 4-28 Direct and Indirect Damages from Flooding

(2) Assumptions

The amount of damage was calculated based on the following conditions.

- All prices used in this study are based on the year 2008, and the same prices were used to estimate damage for 2050.
- The supporting asset data and valuations were based on available statistical data.
- Damage coefficients and the extent of damage caused by flooding were taken from the Ministry of Land, Infrastructure, Transport and Tourism's Flood Control Economic Survey Manual.

(3) Damage to Buildings

Damage to buildings was calculated by multiplying the building value and the damage rate by inundation depth.

Table 4-6 Number of Buildings by Region and Type (2008)

Municipality	Residential Bldg.	Commercial Bldg.	Industrial Bldg.*
Jakarta Selatan	511,843	35,902	108
Jakarta Timur	580,351	40,707	332
Jakarta Pusat	213,821	14,998	75
Jakarta Barat	526,458	36,927	565
Jakarta Utara	348,800	24,466	786
DKI Jakarta	2,181,272	153,000	1,866

Source: Based on Jakarta in Figures 2010, Housing Statistics of DKI Jakarta Province (Housing Census 2000)

* Large and Medium Scale Manufactures

Table 4-7 Average Floor Area and Unit Cost of Buildings per Type

Bldg. Type	Average Floor Area (m ²)	Unit Value per m ² (000 Rp/m ²)
Permanent House	70	2,500
Non-permanent House	70	1,700
Shop/Office	300	4,400
Manufacture	3,000	6,500

Source: JICA Study Team

Table 4-8 Damage Rates

Flood Level	Damage Rates
Less than 20cm	0.032
20-49cm	0.092
50-99cm	0.119
100-199cm	0.266
200-299cm	0.580
More than 300cm	0.834

Source: Based on Manual of Economic Study of Floods, MLIT Japan

(4) Damage to Assets

Asset damage is calculated by multiplying the unit price of each asset by the damage rate by inundation depth.

Table 4-9 House Assets

Type of House	Estimated Value (000 Rp/household)
Permanent House	35,000
Non-permanent House	24,000

Source: Based on Cost of Living Survey 2007

Table 4-10 Commercial/Industrial and Merchandise Assets

	Assets (000Rp/capita)	Inventories (000 Rp/capita)
Commercial Unit	13,200	13,200
Industrial Unit*	29,000	29,000

Source: Based on the Annually Large and Medium Manufacturing Establishment Survey

* Large and Medium Scale Manufacture

Table 4-11 Damage Factors

Flood Level	Damage Rates (HH Goods)	Damage Rates **(Commerce/Industry)
Less than 20cm	0.021	0.099
		0.056
20-49cm	0.145	0.232
		0.128
50-99cm	0.326	0.453
		0.267
100-199cm	0.508	0.789
		0.586
200-299cm	0.928	0.966
		0.897
More than 300cm	0.991	0.995
		0.982

Source: Based on Manual of Economic Study of Floods, MLIT Japan

**

The Upper: Assets

The Lower: Inventories

(5) Damage to Infrastructures

Damage cost to infrastructures is calculated by multiplying the amount of damage costs to general assets (buildings and assets) by the ratio of the damage amount of infrastructure.



Road network in Jakarta is vulnerable to flooding. The amount of damage to the infrastructure is considered to be the cost of restoration to the damaged part.

The ratio of infrastructure damage to general asset damage was set as shown in Table 4-12 with reference to the Japan Hydraulic Economic Survey Manual.

Table 4-12 Ratio on Infrastructure Damage to General Asset Damage

	Roads	Urban Sanitation	Public Services	Total
Percentage (%)	13.2	0.2	8.6	22.0

Source: Based on Manual of Economic Study of Floods, MLIT Japan

(6) Indirect damage caused by floods

Indirect damage covers loss of income (commercial/industrial unit), decrease in revenue of water utilities, and decrease in revenue of electric power companies.

(i) Loss of income (Commercial and Industrial Units)

Revenue loss (commercial/industrial unit) is calculated by multiplying the unit labor cost by the duration of flooding by inundation center



Table 4-13 Unit Rates for Commercial and Industrial Units

	Average No. of Employee/Unit	Value Added Amount (Rp/Employee/day)	Flood Duration
Commercial Unit	10	600,000	Table 4-14
Industrial Unit	180	800,000	

Source: The Annually Large and Medium Manufacturing Establishment Survey/Jakarta in Figures 2010

Table 4-14 Flood Duration

	Less than 20cm	20-49cm	50-99cm	100-199cm	200-299cm	More than 300cm
Suspension	3.0	4.4	6.3	10.3	16.8	22.6
Stagnation	6.0	8.8	12.6	20.6	33.6	45.2

Source: Based on Manual of Economic Study of Floods, MLIT Japan

(ii) Loss of Revenue in Water Supply Companies

The amount of revenue loss for water utilities is calculated by multiplying the basic unit of the revenue loss by the duration of flooding for each inundation center.

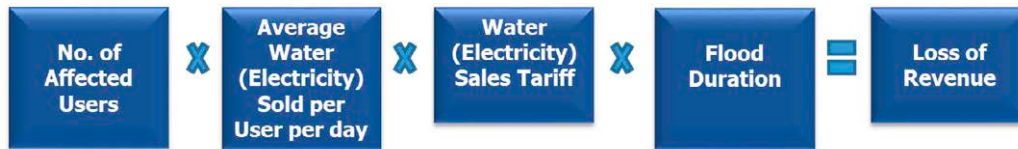


Table 4-15 Loss of Revenue in Water Supply Companies

User	Water Vol. Sold (m ³ /user/day)	Number of User (000units)	Water Sales Tariff (Rp/m ³)
Household	0.642	677	5,538
Non-household	0.270	101	3,873

Source: Based on PAM Jaya

(iii) Loss of Revenue in Electricity Supply Companies

The amount of revenue loss for the electric power companies is calculated by multiplying the basic unit of the revenue loss by the duration of flooding for each inundation center.

Table 4-16 Loss of Revenue in Electricity Supply Companies

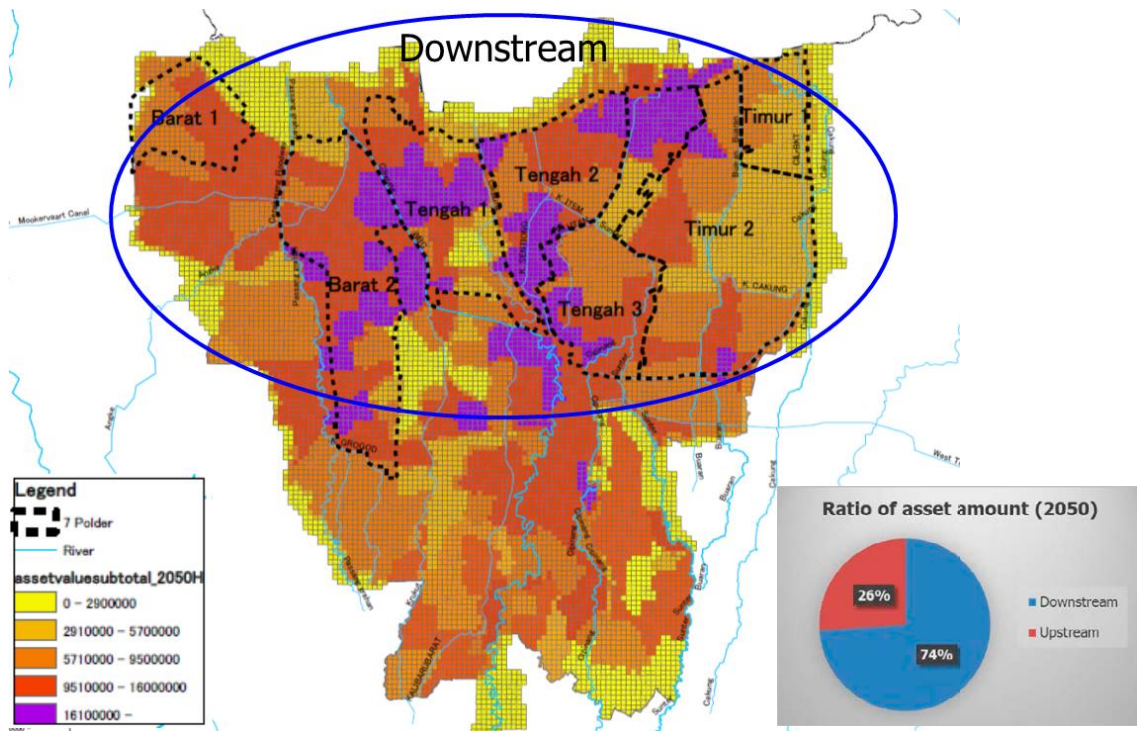
User	Electricity Sold (kWh/customer/day)	Number of PLN Customer (000units)	Electricity Sales Tariff (Rp/KwH)
Household	9	3,246	694
Business/Offices	111	259	763
Manufacture	2.116	11	662
Others	49	57	1,457
Average	23	3,573	735

Source: Based on PT. PLN (Persero)

(7) Asset Distribution and Damage Distribution

(i) Asset Distribution in 2050

Figure 4-29 shows the asset distribution in 2050. The assets of the DKI are estimated to be about 11 trillion yen in 2050. The assets in the downstream region is about 8 trillion yen, occupying around 74% of the total asset of DKI, while that in the upstream region is about 3 trillion yen.



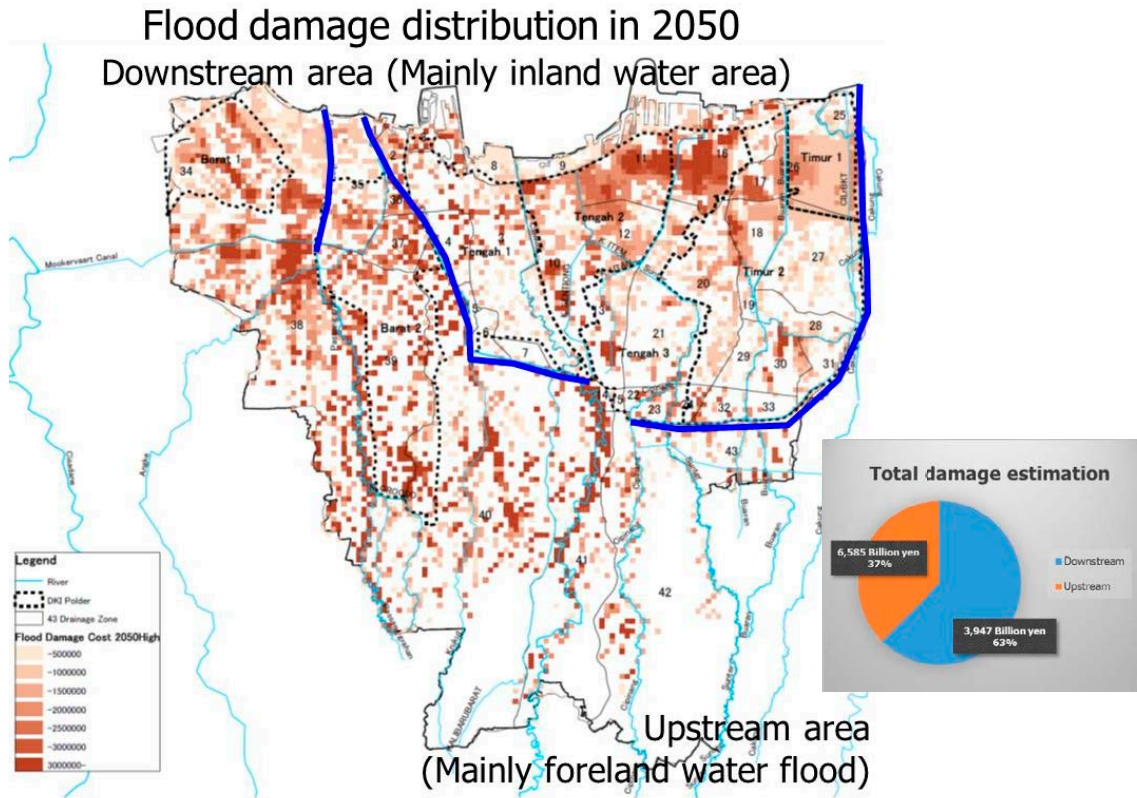
Note: Based on 2018 price

Figure 4-29 Asset Distribution in 2050

(ii) Damage Distribution Map (Total Damage in 2050)

The total inundation damage (for meshes with inundation depths of 0.1 m or more) is calculated based on the assets distribution map of 2050 and inundation analysis results.

The distribution of inundation damage is shown in Figure 4-30. The damage in the downstream area is about 660 billion yen (63%), while that in the upstream area is about 390 billion yen (37%). Therefore, it is necessary to prioritize the downstream areas.



Note: Based on 2018 price

Figure 4-30 Flood Damage Distribution Map

4.5.5 Existing/Planned Major Drainage Facilities

(1) Pumping Capacity in the New Polder on the Indonesian Side

Table 4-17 summarizes the capacity of the pumping stations in the new polder to be developed on the Indonesian side. The location map of each pump station is shown in Figure 4-31.

The planned pumping stations include those based on the maintenance plan in NCICD and those planned for the implementation in DKI.

Table 4-17 List of Pump Capacity

New polder	Pump Station	Pumpage (m ³ /s)		
		Existing	New	Plan
Barat 1	Tanjungan	12		12
	Kamal	—	30	20
Barat 2	Waduk Tomang Barat	11		11
	Polder Green Garden	—	15	15
	Lower Angke	—		110
Tengah 1	Pasar Ikan	31		31
	Pluit	49		49
	Muara Karang	—	4	18
Tengah 2	Ancol	13		13
	Sunter Utara	12		12
	Sunter Selatan	15		15
	Sentiong	—	50	63
Tengah 3	Sunter Timur 3 Rawa Badak	15.5		15.5
	Polder Kelapa Gading		16.5	16.5
	Polder Pulomas		12	12
	Sunter	—	—	196.5
Timur 1	Banglio	6		6
	Marunda	—		135
Timur 2	Kelapa Gading	4	16.5	20.5
	Aneka Elok	2		2
	Polder Marunda JGC		7	7
	Cakung	—	—	494

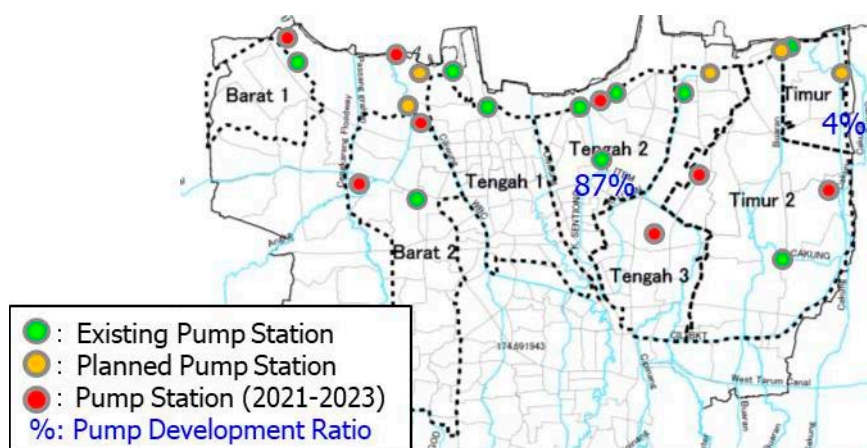


Figure 4-31 Pump Development Status of New Polder (2023)

(2) Plans in Progress by DKI (Development Project, 2021-2023)

The plan (development project) being carried out by DKI was compared with the flood results map of January 2020.

Figure 4-32 shows the maintenance projects being undertaken by DKI in response to 2021 Flood. 8 reservoirs, 9 polders and other facilities, 6 dredging maintenance and bypass points are planned to be constructed by 2023.

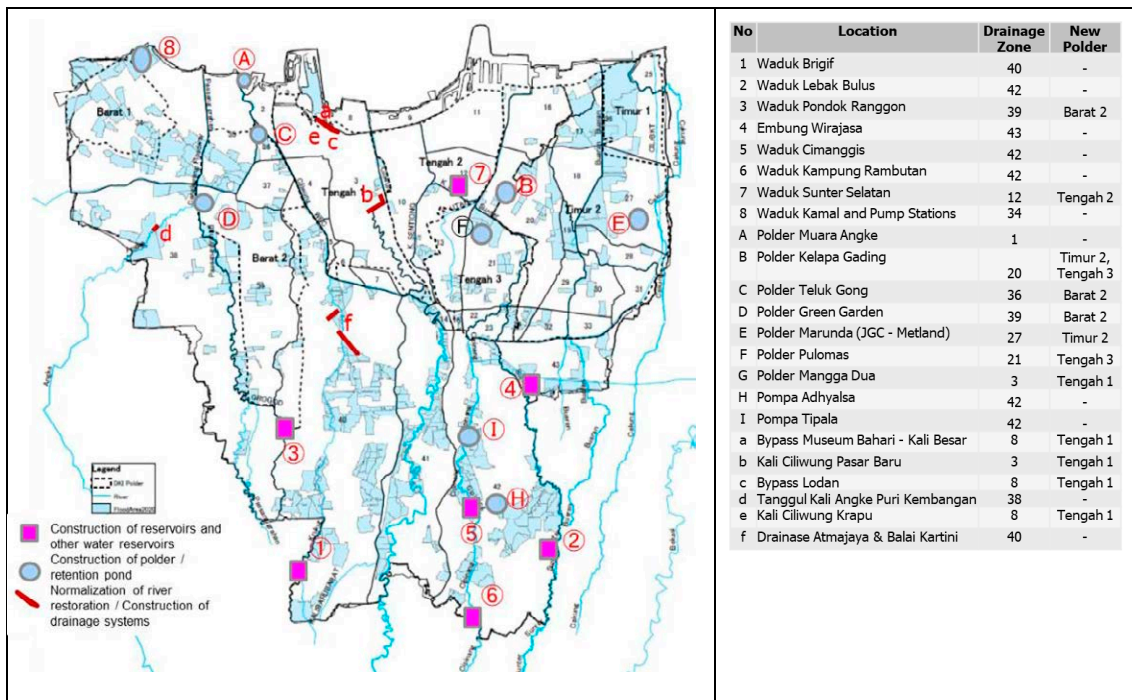


Figure 4-32 Location map of Facilities to be developed in DKI based on actual flooding in January 2020

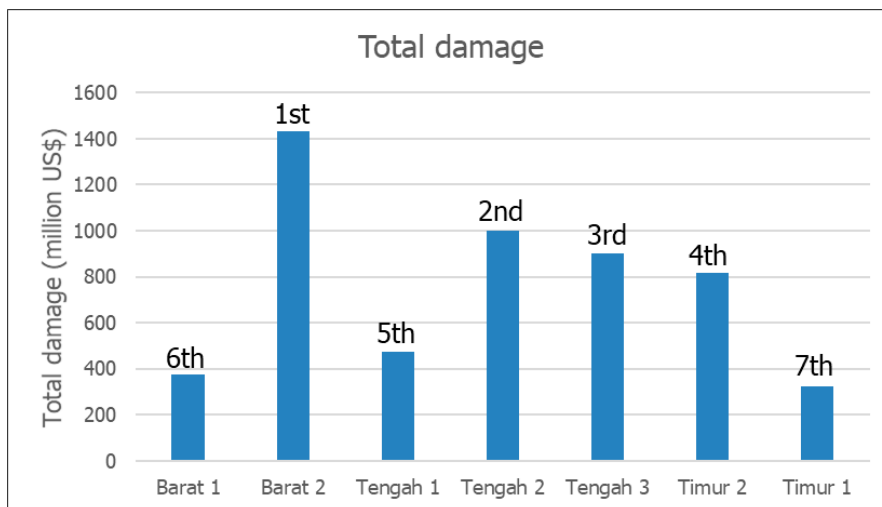
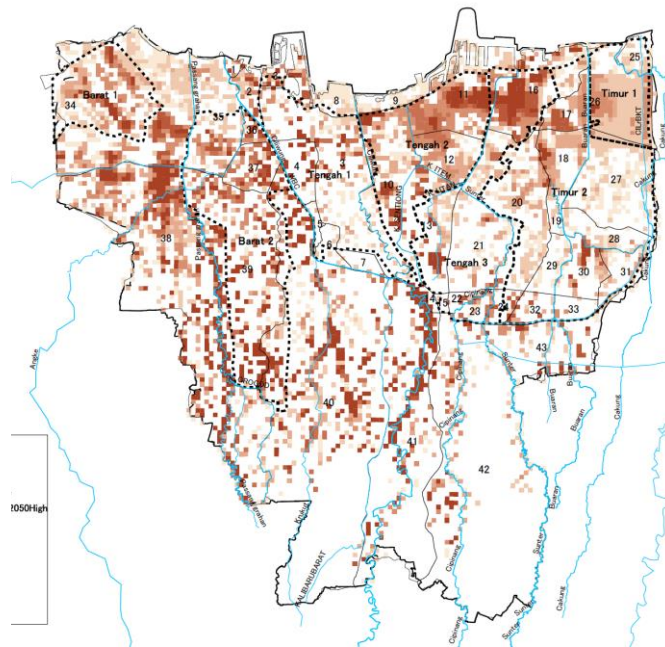
4.5.6 Priority Areas Downstream (New Polder)

Priority areas in the downstream areas (new polder) will be selected based on the amount of flood damage within each new polder and the status of facility maintenance (pump maintenance rate) within the new polder.

(1) Assessment of flood damage of new polders (2050)

The damage amount of the seven polders within the new polders were summarized in Figure 4-33. In the new polder, the damage amount of Barat 2, Tengah 2, Tengah 3 and Timur 2 are large and the damage reduction effect is high.

However, for Tengah 2, the damage is expected to be reduced as a new pumping station will be constructed by 2023.



Note: Based on 2018 price

Figure 4-33 Assessment of Flood Damage of New Polders (2050)

(2) Assessment of flood damage of new polders (2050)

As of 2023, the development ratio of pumps in the new polder is shown in Table 4-18, and the development ratio of Barat 1, Tengah 1 and Tengah 2 is high at over 90% with priority given to the Indonesian side.

The pump development rates are calculated based on the expected drainage capacity of 2023.

Table 4-18 Pump Development Ratio in the New Polder System

New Polder	Area (km ²) (A)	Necessary Pump Capacity* ² (m ³ /s) (B)	Current Pump Capacity (m ³ /s) (C)	Scale of new Pumps to be completed in 2021-2023 (m ³ /s) (D)	Pump scale in 2023 (m ³ /s) (E)=C+D	Pump Development ratio (%) (F)=E/B	Shortage (%) (G)=1.0-F	Ranking of Development rate
Barat 1	19.7	32	12	30	42	131%	0%	1
Barat 2	53.4	136	11	15	26	19%	81%	4
Tengah 1	42.3	※1 98	80	4	84	85%	15%	3
Tengah 2	37.2	103	40	50	90	87%	13%	2
Tengah 3	44.3	240	15	28.5	43.5	18%	72%	5
Timur 1	16.6	141	6	0	6	4%	96%	7
Timur 2	77.6	※3 524	6	23.5	29.5	6%	94%	6
Total	291.1	1,274	170	151	321	25%	75%	

*1: Cideng Pump St.: 50 m³/s is not included.

*2: Source: Jakarta Polder Systems - SSA- STRATEGY STAGE A POLDERS- NCICD (2020.3)

*3: Capacity of Timur2 (Cakung) is estimated based on unit pump capacity of Tengah 3 in Sunter.

(3) Selection of Priority Areas Downstream (New Polder)

The priority areas were selected based on (1) amount of damage in the new polder and (2) the rate of pump maintenance in the new polder.

- The amount of damage in the new polder is in descending order of damage amount: Barat 2, Tengah 2, Tengah 3, Timur 2, Tengah 1, Barat 1 and Timur 1.
- The maintenance rate of pumps in Indonesia is very high at more than 85% for Barat 1, Tengah 1 and Tengah 2 and priority is given to the maintenance of these pumps.
- Considering the above two points, the top three priority areas are Barat 2, Tengah 3 and Timur 2, where the amount of flood damage is large and the pump maintenance rate on the Indonesian side is low.

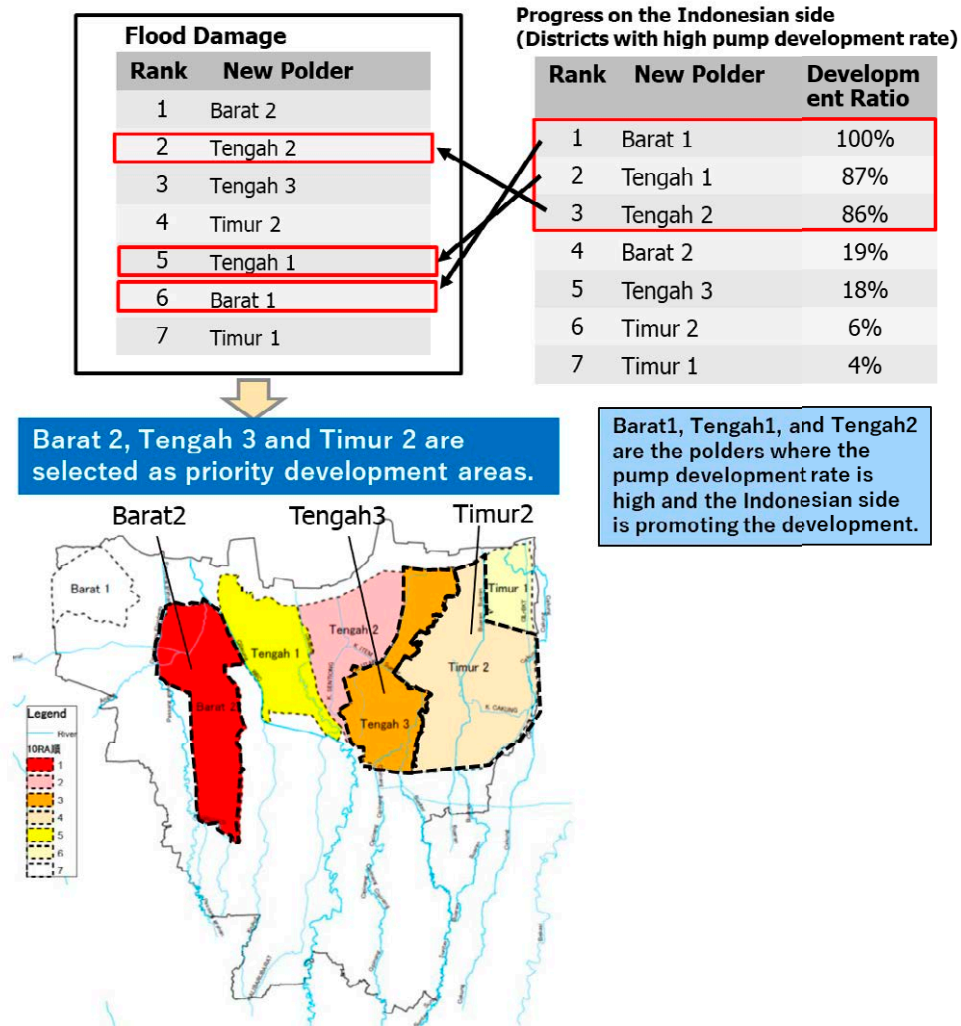


Figure 4-34 Selection of Priority Areas in the Downstream Area (New Polder)

(4) Summary of Priority Areas in the Downstream Areas (New Polder)

Based on the results of the inundation analysis and asset data from DKI, the priority polders that should be developed immediately due to the large amount of inundation damage are listed in Table 4-19.

Table 4-19 Priority Areas in the Downstream Area

	Target Polder	Remarks
1	Barat 2	<ul style="list-style-type: none"> • Highest flood damage. • The rate of pump development on the Indonesian side is low: 19%. • Ward offices, junior and senior high school facilities, etc.
2	Tengah 3	<ul style="list-style-type: none"> • Pump development rate on the Indonesian side is low: 18%. • The flood damage in Tengah 3 and Timur 2 is closely similar. • Cultural facilities, ward offices, etc.
3	Timur 2	<ul style="list-style-type: none"> • Pump development rate on the Indonesian side is particularly low: 6%. • The flood damage in Tengah 3 and Timur 2 is closely similar. • East Jakarta City Office Building

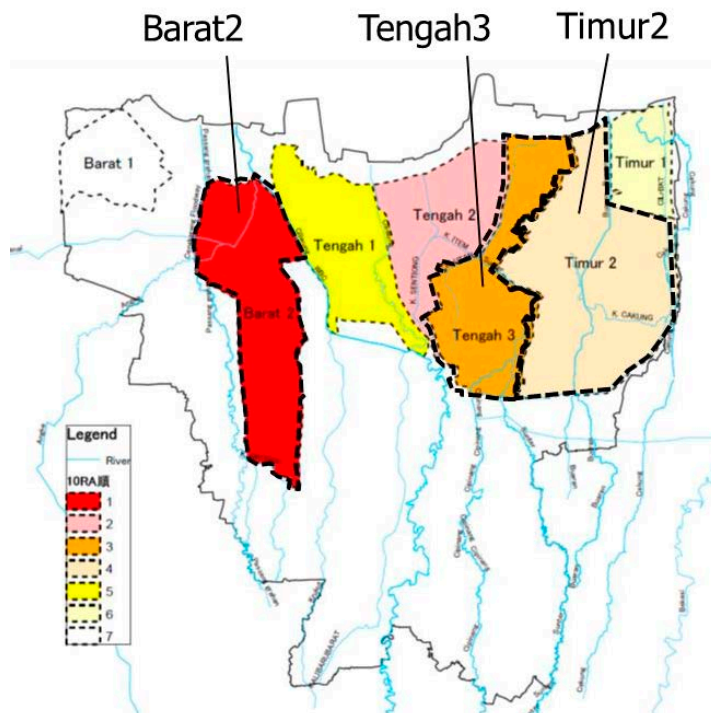


Figure 4-35 New Polder Priority Development Areas

(5) Relationship between priority areas and important facilities downstream of new polder

Important facilities (government offices, public facilities, etc.) within the priority area was identified from the land use map in 2018. Many important facilities are distributed within the new polder, but there is also a concentration of important facilities outside (south) the West Banjur Canal. Therefore, it is desirable to propose measures for the areas outside the West Banjur Canal to prevent downstream impacts from occurring.

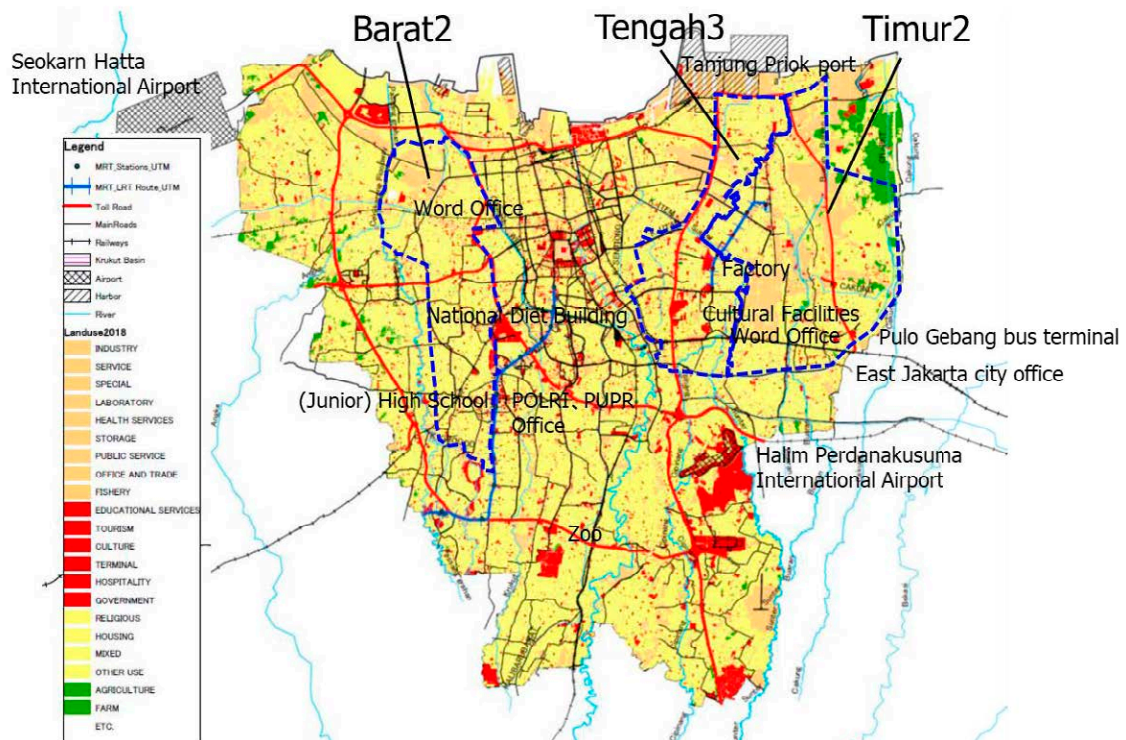


Figure 4-36 Land Use Map (2018)

4.5.7 Priority Areas Upstream

(1) Study on the Development Area Upstream for the 2020 Flood

Inundation map shown in Figure 4-37 shows an overlay of the inundation record of the February 2007 flood and the January 2020 flood, as well as a 12-hr rainfall distribution map for the January 2020 flood.

As for the floods of 2020, the spatiotemporal distribution of rainfall differs significantly from that of 2007 (partially concentrated rainfall is observed, rainfall is more pronounced upstream, etc.), and more damage occurs in areas other than the seven downstream polder areas.

Therefore, when considering countermeasures, it is necessary to consider the 2020 floods and countermeasures that will not have an adverse impact (negative impact) on the downstream side.

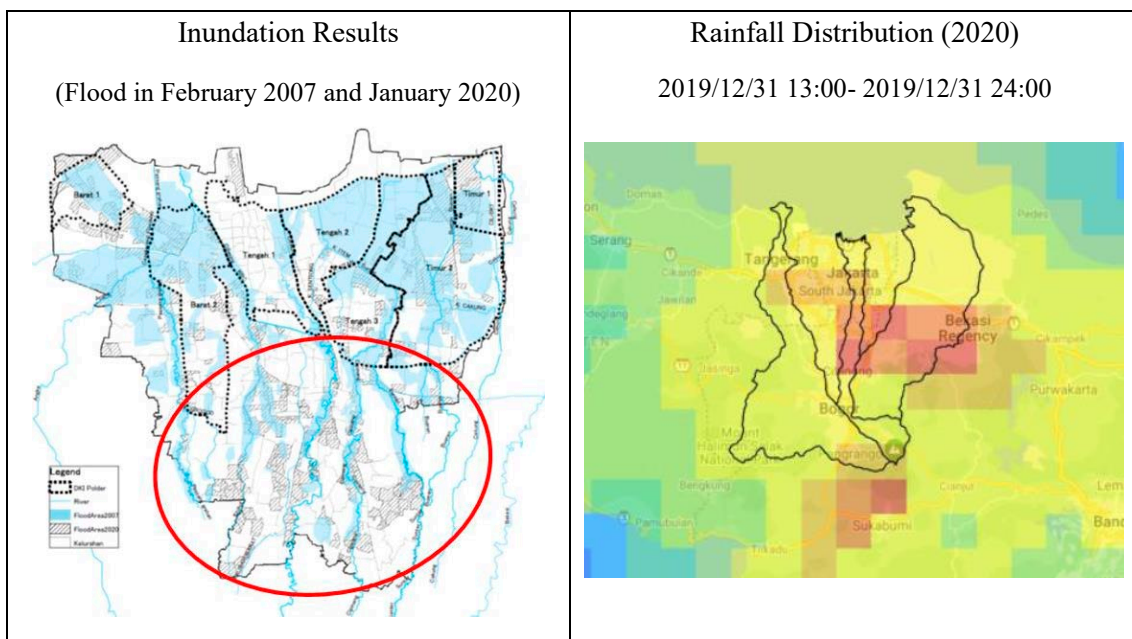


Figure 4-37 Inundation Results and Rainfall Distribution

(2) Important Areas Upstream

The distribution of assets and critical facilities in the upstream area was compared to the distribution of assets, critical facilities, and inundation results in Figure 4-38.

- The area outside of the new polder and south of the West Banjir Canal has high assets and many important facilities scattered throughout the area.
- In the January 2020 flood, inundation damage was widespread in the south of the East and West Banjir Canals.

Based on the above, the area upstream of the East and West Banjir Canals should also be considered as a priority development area.

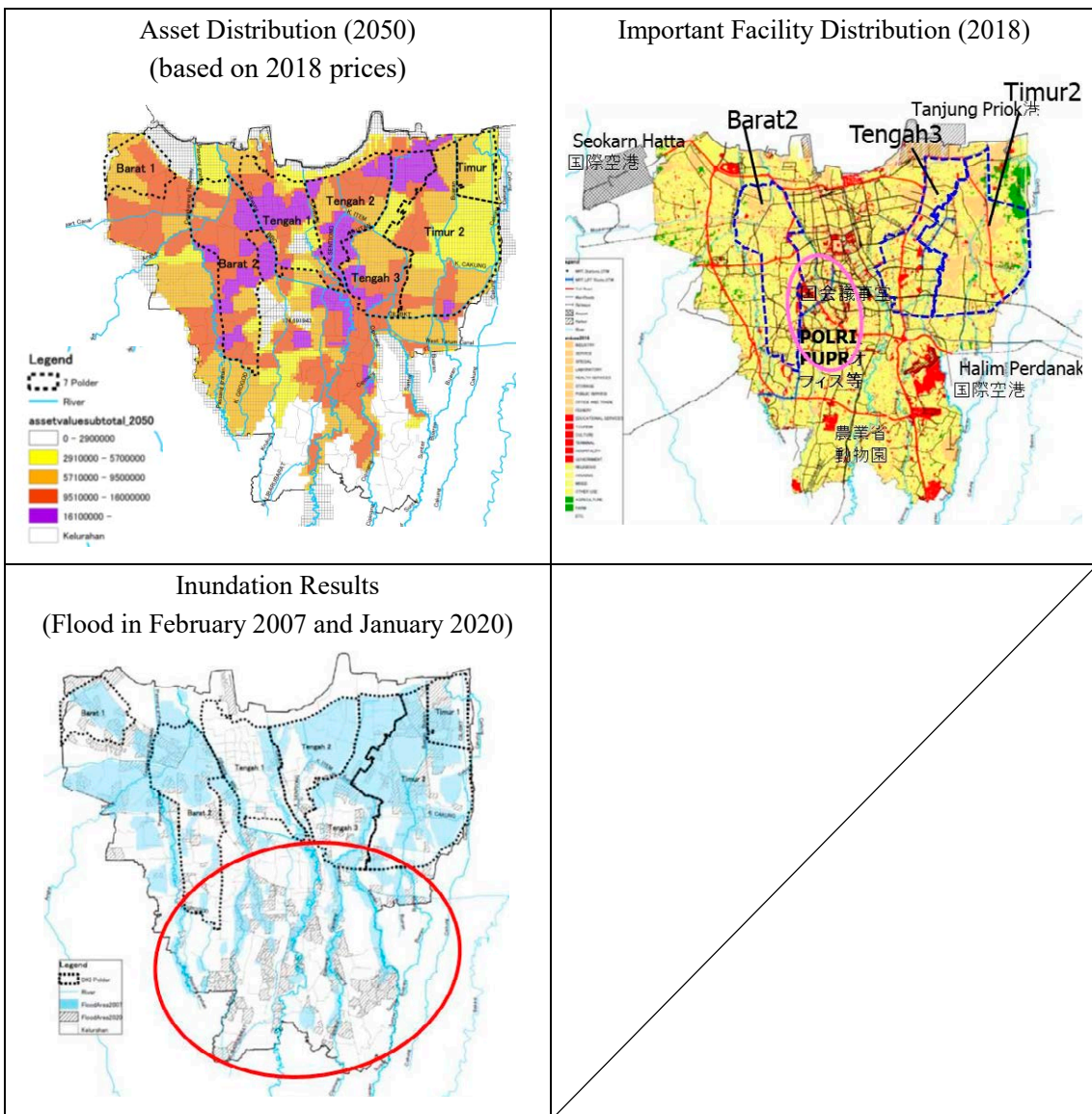
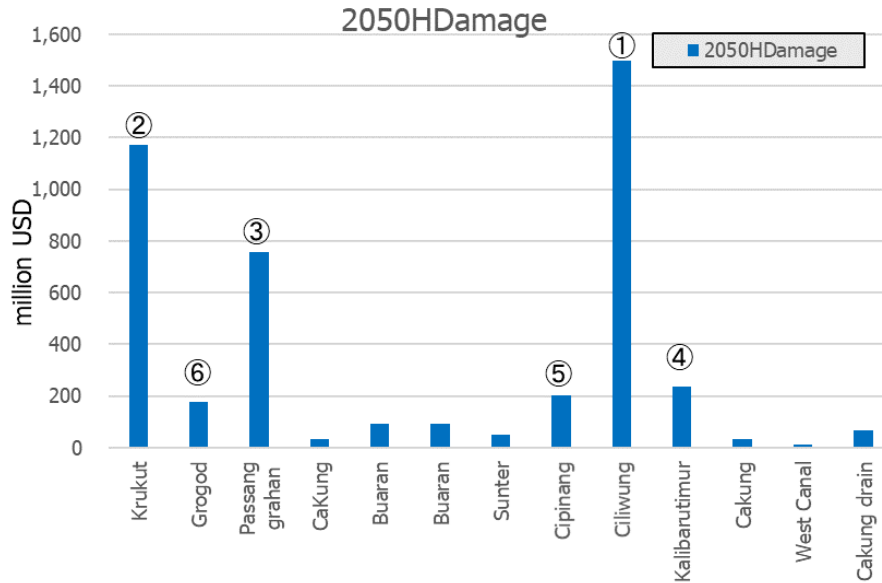


Figure 4-38 Inundation Record, Asset Distribution and Important Facility Distribution

(3) Assessment of flood damage in the upstream area (2050)

The amount of flood damage in the upstream area outside the new polder is summarized in Figure 4-39. The amount of inundation damage is calculated from the results of the inundation analysis at a 100-year scale of the 2007 flood. Comparing the inundation damage amount, Ciliwung and Krukut river basins have the highest inundation damage, followed by the Pesanggrahan river basin.



Note: Based on 2008 price

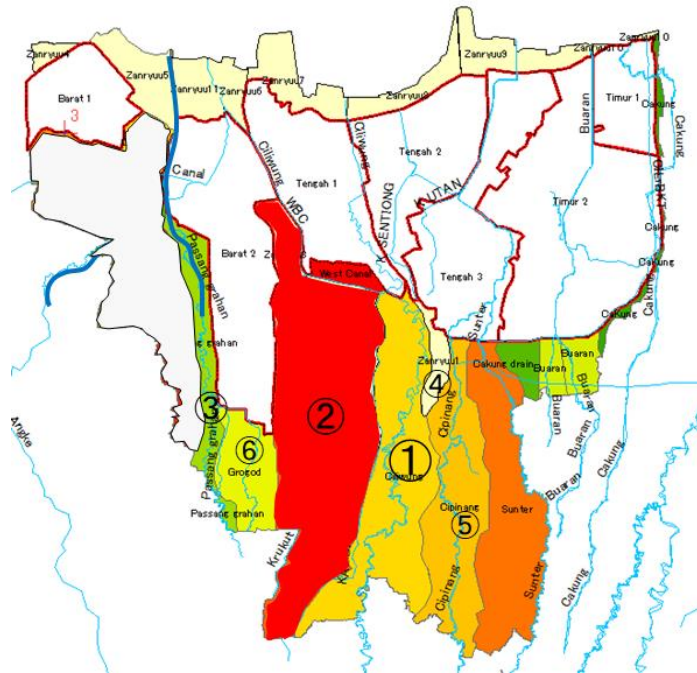


Figure 4-39 Upstream basin classification map (lower figure) and damage amount of each basin (upper figure)

(4) Results of selection of Priority Development Areas in Upstream Areas

The damage amount, maintenance status and important facilities on the Ciliwung and Krukut river basins are summarized in Table 4-21. The Ciliwung basin suffered the most damage, but because river maintenance is underway on the Indonesian side, the Krukut basin, which has the second largest amount of damage, the highest concentration of critical facilities, and the lowest rate of river maintenance, was selected as the priority development area.

Table 4-20 Priority Area in the Upstream Area

	Target Polder	Remarks
1	Krukut River	<ul style="list-style-type: none"> The river improvement rate on the Indonesian side is low. National Diet building, POLRI and PUPR offices are located. Flood damage is 1,170 million USD. (Being estimated by 2007 Flood)

Table 4-21 Damage Amount, Maintenance Status, Important Facilities on Ciliwung and Krukut Rivers

River	Total Damage (million USD)	Development Situation	Important Facilities
Ciliwung	1,496	Underway River improvement, diversion tunnel to the East Discharge Channel, two dams upstream	Station, School, Office, etc.
Krukut	1,170	Underdeveloped River improvement plan, detention pond plan	National Diet Building, POLRI, PUPR office

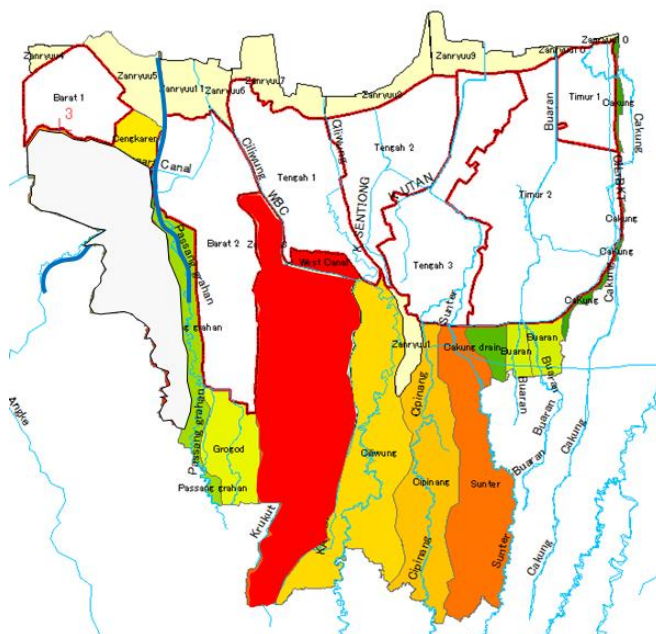


Figure 4-40 Watershed Distribution Map of the Upstream Area

4.5.8 Overall Evaluation

The process and results of the above study on the selection of priority areas have been discussed several times with the relevant Indonesian agencies (PUPR, BBWS, BAPPENAS and DKI). As a result, it was agreed that the western Jakarta area, from Barat 2 in the lower basin to Pesanggrahan, Grogol and Krukut in the upper basin, and Timur 2 in the lower basin of the eastern region would be the priority areas based on the following points:

- The eastern and western areas are relatively behind in development and vulnerable to flooding.
- It is important to maintain a balance between upstream and downstream areas, and it is commendable that both Barat 2 and Krukut have been selected as priority areas.
- The area around the Pesanggrahan River, which flows to the western end of Barat 2, is also frequently inundated, and this watershed should be considered as a priority areas as well.
- The area from Barat 2 to Pesanggrahan, Grogol, and Krukut basins is densely populated and highly urbanized, making conventional measures such as widening the river channel difficult to implement. Thus, new measures are needed.
- The eastern area used to be an agricultural area, but has recently been developed as industrial and residential area land. The drainage facilities are being developed by different development entities, but there is no uniformity among them.
- The DKI Water Resources Bureau is planning and implementing a small polder and reservoir development project in the eastern area.
- It is necessary to set the size of the facilities in consideration of maintenance and management costs.

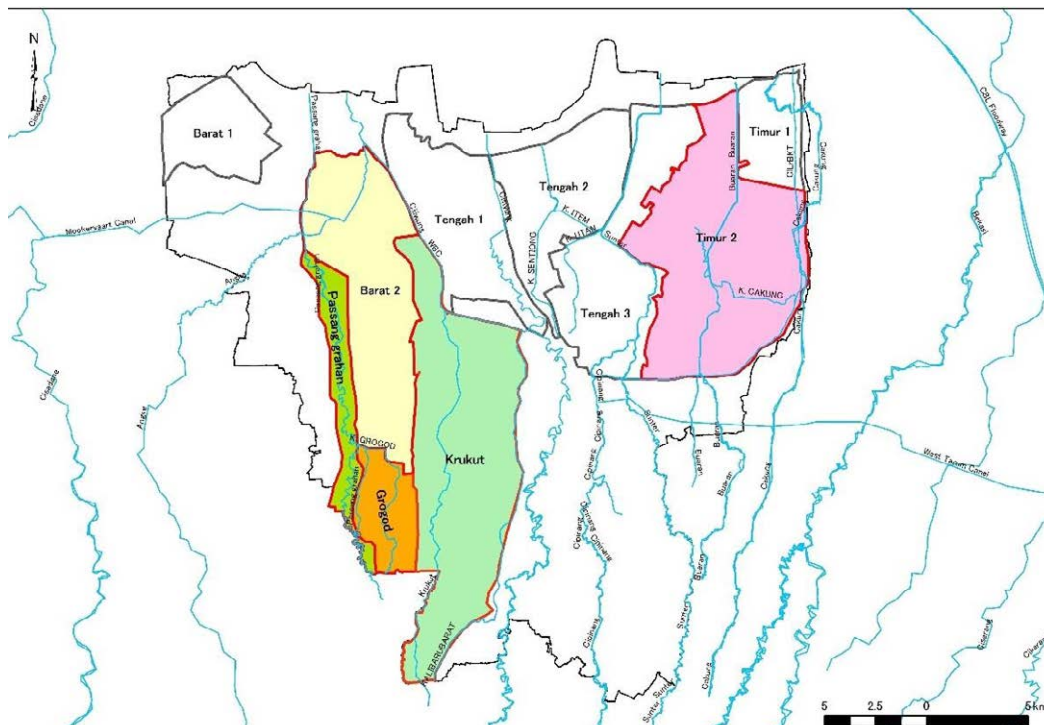


Figure 4-41 Priority Development Areas selected through Comprehensive Evaluation

4.6 Summary of the Current Situation of Priority Areas

4.6.1 Watershed Overview

(1) Overview of watersheds and rivers

West Jakarta represents the combined watershed of Barat 2 Polder, Krukut and Pesanggrahan river basins. East Jakarta represents the Timur 2 Polder.

A summary of the characteristics of rivers and river basins is shown in Table 4-22, while Figure 4-42 presents the river basin map.

Table 4-22 Watershed and River Characteristics (West Jakarta)

Priority Area	Area in DKI (km ²)	Basin Area (km ²)	Major Rivers	River Features
Barat2	53.4	53.4	Lower Angke Grogol down stream	<ul style="list-style-type: none"> • River slope of 1/7000 • Urbanization along the river • Land subsidence in progress
Krukut	80.2	84	Krukut Mampang	<ul style="list-style-type: none"> • River slope of 1/700 • Urbanization along the river
Pesanggrahan	15.6	130	Pesanggrahan	<ul style="list-style-type: none"> • River slope of 1/900 • Urbanization along the river
Timur2	77.6	77.6	Cakung Drain	<ul style="list-style-type: none"> • River slope of 1/8000 • Urbanization along the river • Land subsidence is in progress

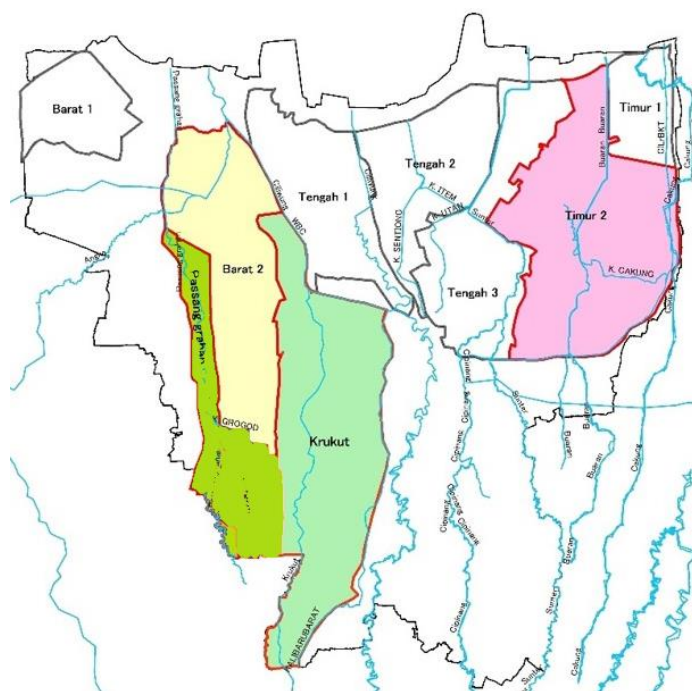


Figure 4-42 Location of Priority Areas

4.6.2 Rivers and Drainage Systems

The major rivers and major drainage system in the priority areas are shown in Figure 4-43.

Barat 2 in the West Jakarta is under the jurisdiction of DKI, while the Pesanggrahan and Krukut Rivers are under the jurisdiction of PUPR. In addition, Cakung River, the main river in Timur 2, is also under the jurisdiction of PUPR.

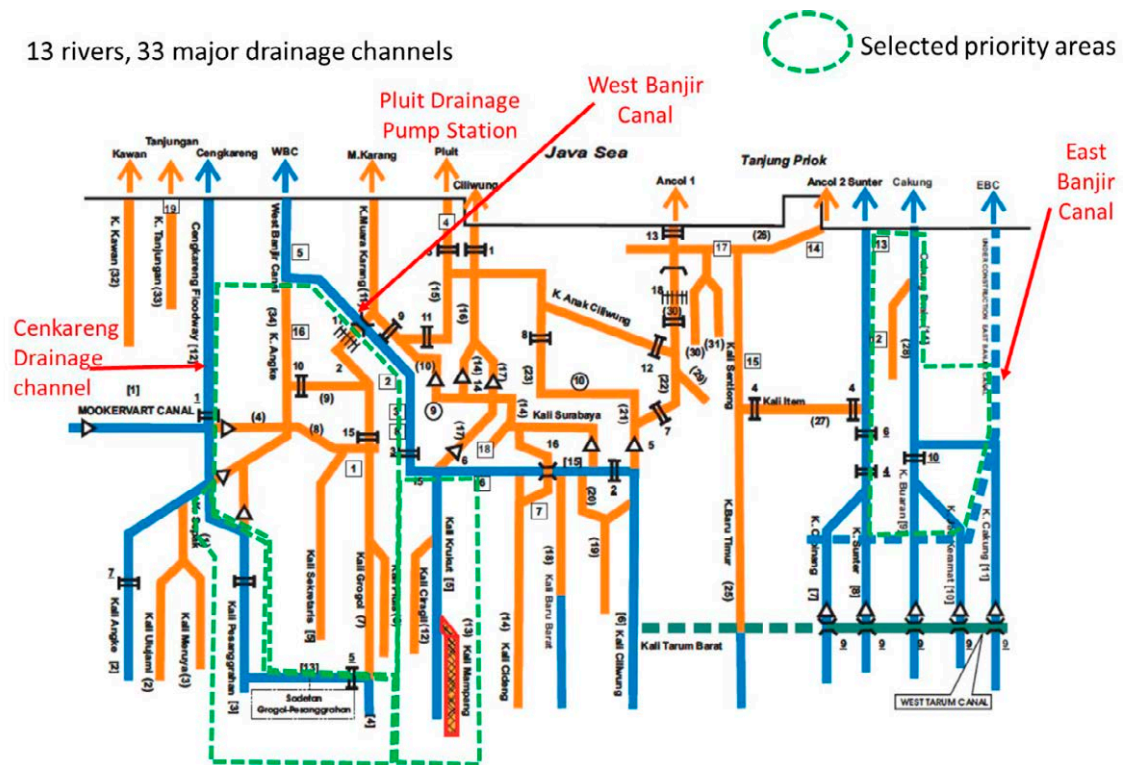


Figure 4-43 Relationship between drainage system diagram and priority development area in DKI

4.6.3 Current Flow Capacity

(1) West Jakarta

The current flow capacity of the major rivers and drainage channels in the western part of Jakarta and the past design discharges are shown in Figure 4-44. The legend in the figure indicates the following:

- Current flow capacity \geq Past Design Discharge \rightarrow Sufficient flow capacity section (light blue line)
- Current flow capacity $<$ Past Design Discharge \rightarrow Insufficient flow capacity section (red line)
- Current flow capacity / Past Design Discharge = River channel maintenance rate (purple)

In priority areas Barat 2, Pesanggrahan River, and Krukut River, most of the rivers do not retain the capacity to discharge the existing design discharge.

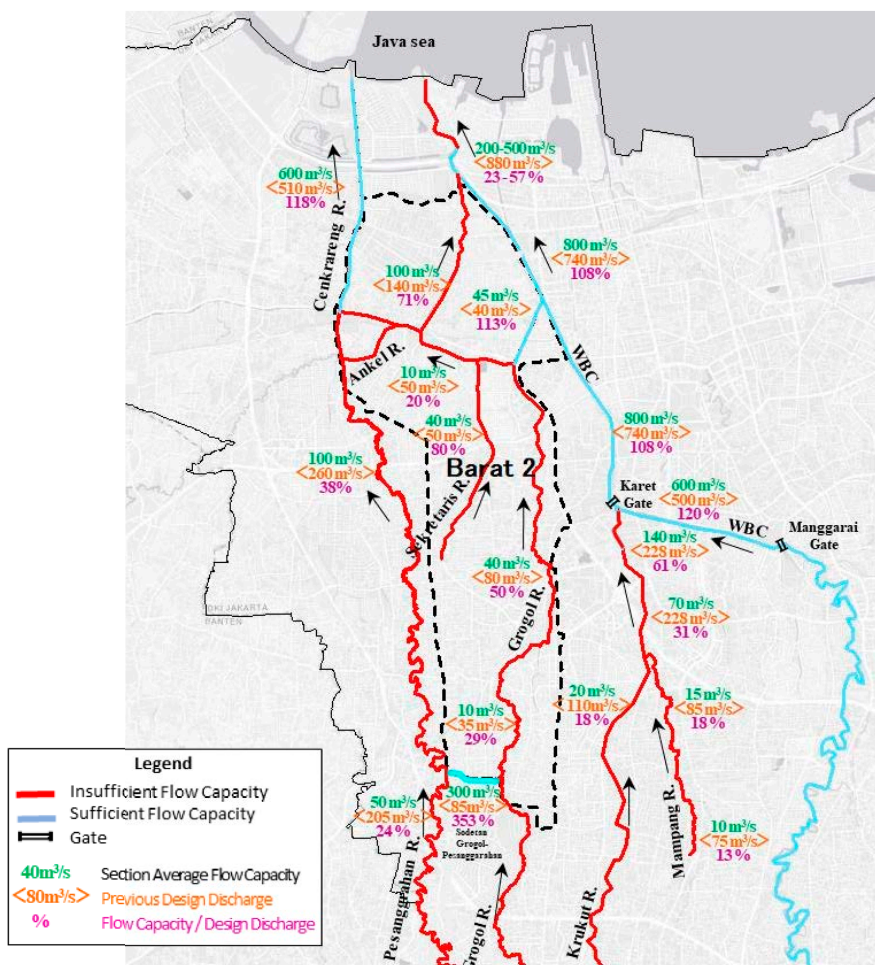


Figure 4-44 Current Flow Capacity of Major Rivers and Drainage Channels

In addition, Figure 4-45 shows the inundation damage caused by the 2007 flood, especially in Krukut, Mampang, Pesanggrahan, and Angke river basins, which have insufficient flow capacities.

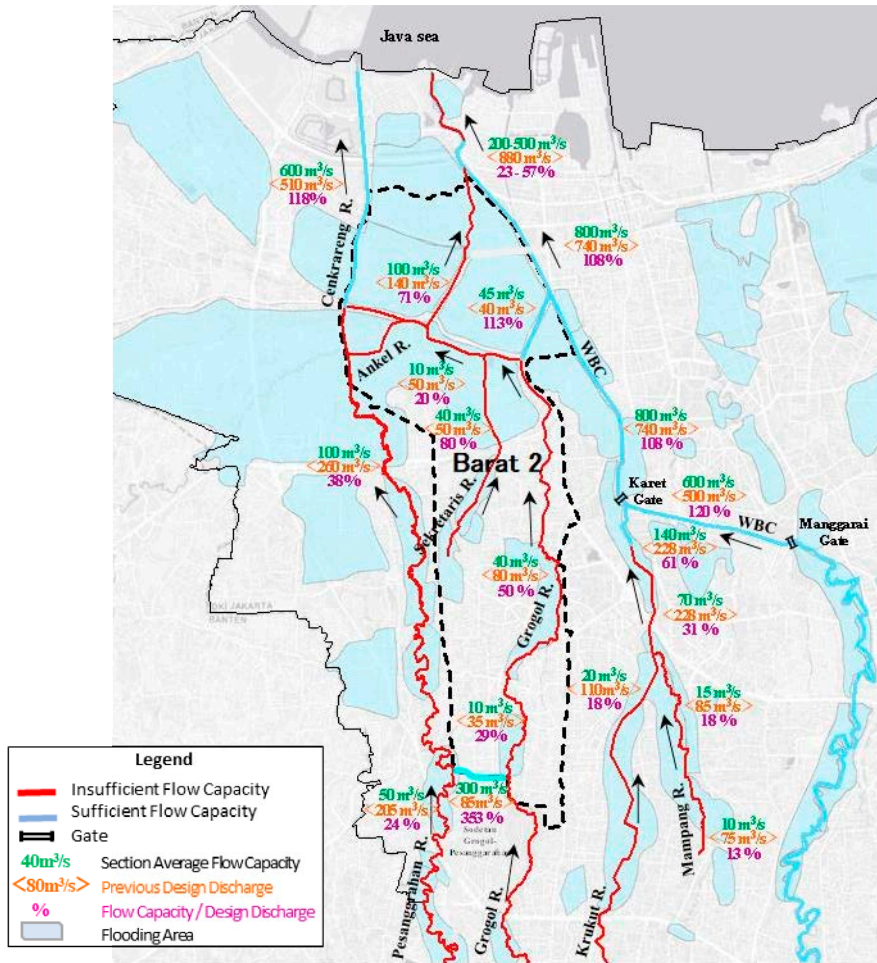


Figure 4-45 Current Flow Capacity and Inundation Area of Major Rivers and Drainage Channels

(2) Timur 2

The current flow capacity of the major rivers and drainage channels in priority area, Timur 2, and the past design discharges are shown in Figure 4-46. The Cakung River, which flows through the central part of Timur 2, currently has a flow capacity of about half of the design discharge (200 m³/s).

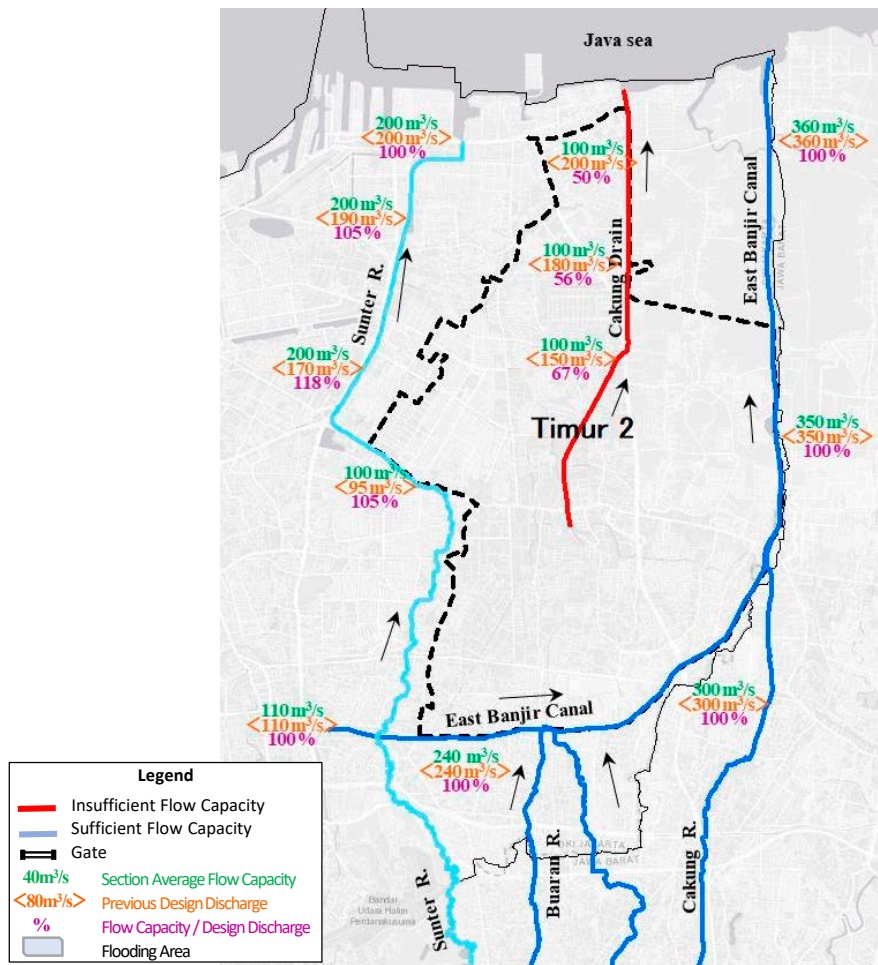


Figure 4-46 Current Flow Capacity of Major Rivers and Drainage Channels (Timur 2)

Figure 4-47 shows the flow capacity and the actual inundation area during the 2007 flood in Timur 2. The flood mostly affected the central area of Timur 2.

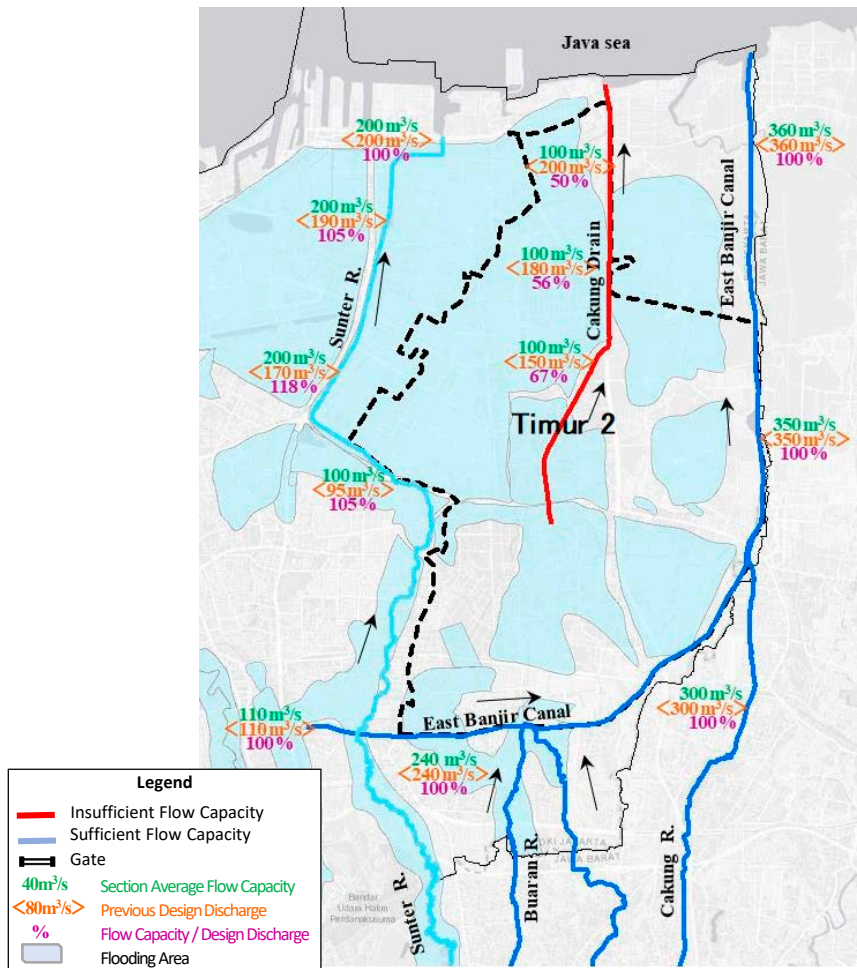


Figure 4-47 Current Flow Capacity and Inundation Area of Major Rivers and Drainage Channels (Timur 2)

4.6.4 Inundation Record

The flood situation in Krukut River (Central Jakarta) during the January 2020 flood was summarized below.

- Photo ① shows the situation of Krukut River just before the road is flooded, taken from Sudirman bridge.
- Photo ② shows the situation where the rainwater overflows from the drain at Sudirman Street.
- Photo ③ shows the flooded Sudirman Street. The flooding was caused by poor drainage of roadside ditches along Sudirman Street.

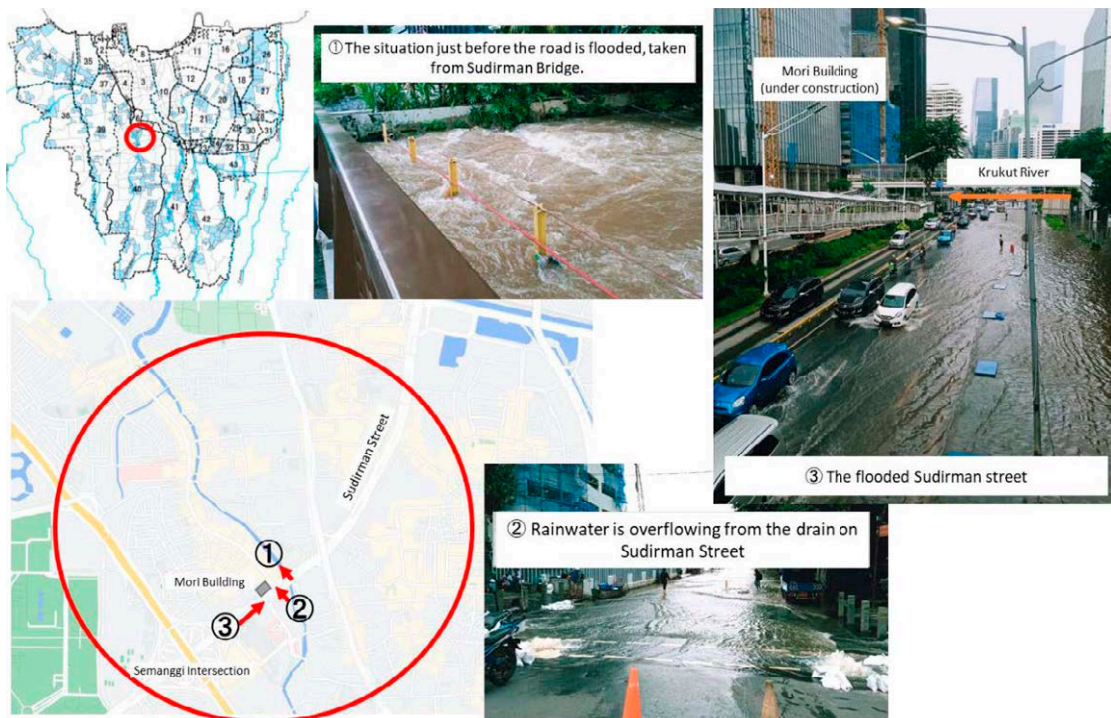


Figure 4-48 Flooding Situation in Krukut River (Central Jakarta) in 2020 Flood

The situation near the downstream of Krukut River in October 2021 is shown in Figure 4-49.

- Houses exist along the riverbanks (Photo ②)
- Riverbanks are well maintained with concrete masonry revetments and concrete sheet piles (Photo ③,④,⑥)
- The existing bridge is a bottleneck (Photo ⑤)



Figure 4-49 Current Situation in Krukut River Downstream (October 2021)

4.6.5 Pump Situation

(1) Pump Development Ratio in the New Polder

The pump development ratio of each new polder in NCICD is summarized in Figure 4-50 and Table 4-24. The pump development ratio of Barat 2 and Timur 2, which are priority areas, are 19% and 9%, respectively. These ratios are lower than those of the central area (Tengah 1 and Tengah 2).

Table 4-23 List of Pump Capacity

New Polder	Pump Station	Capacity (m ³ /s)		
		Existing	Plan	Plan
Barat 1	Tanjungan	12		12
	Kamal	—	30	20
Barat 2	Waduk Tomang Barat	11		11
	Polder Green Garden	—	15	15
	Lower Angke	—		110
Tengah 1	Pasar Ikan	31		31
	Pluit	49		49
	Muara Karang	—	4	18
Tengah 2	Ancol	13		13
	Sunter Utara	12		12
	Sunter Selatan	15		15
	Sentiong	—	50	63
Tengah 3	Sunter Timur 3 Rawa Badak	15.5		15.5
	Polder Kelapa Gading		16.5	16.5
	Polder Pulomas		12	12
	Sunter	—	—	196.5
Timur 1	Banglio	6		6
	Marunda	—		135
Timur 2	Kelapa Gading	4	16.5	20.5
	Aneka Elok	2		2
	Polder Marunda JGC		7	7
	Cakung	—	—	305

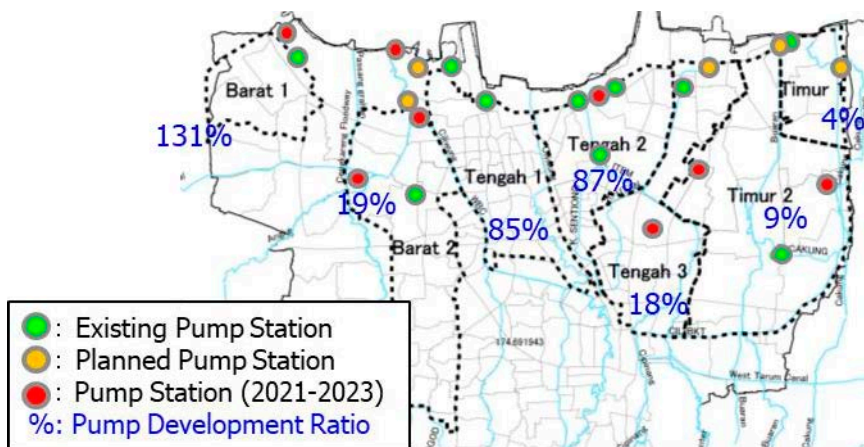


Figure 4-50 Pump Development Status of New Polder (2023)

Table 4-24 New Polder Pump Development Ratio

New Polder	Area (km ²) (A)	Necessary Pump Capacity* ² (m ³ /s) (B)	Current Pump Capacity (m ³ /s) (C)	Scale of new Pumps to be completed in 2021-2023 (m ³ /s) (D)	Pump scale in 2023 (m ³ /s) (E)=C+D	Pump Development ratio (%) (F)=E/B	Shortage (%) (G)=1.0-F	Ranking of Development rate
Barat 1	19.7	32	12	30	42	131%	0%	1
Barat 2	53.4	136	11	15	26	19%	81%	5
Tengah 1	42.3	※1 98	80	4	84	85%	15%	3
Tengah 2	37.2	103	40	50	90	87%	13%	2
Tengah 3	44.3	240	15	28.5	43.5	18%	72%	4
Timur 1	16.6	141	6	0	6	4%	96%	7
Timur 2	77.6	※3 334	6	23.5	29.5	9%	91%	6
Total	291.1	1,084	170	151	321	30%	70%	

*1: Cideng Pump St.: 50 m³/s is not included.

*2: Source: Jakarta Polder Systems - SSA- STRATEGY STAGE A POLDERS- NCICD (2020.3)

*3: Capacity of Timur2 (Cakung) is estimated based on average unit pump capacity of other New Polder.

4.6.6 Facility Maintenance Plan

(1) Under the drainage plan of DKI (Development Projects, 2021-2023)

In Krukut River basin, Waduk Briaif (retarding basin), Atmajaya and Balai Kartini (drainage channel) are currently being constructed. These facilities are mainly located in the area that was heavily inundated by the flood in January 2020.

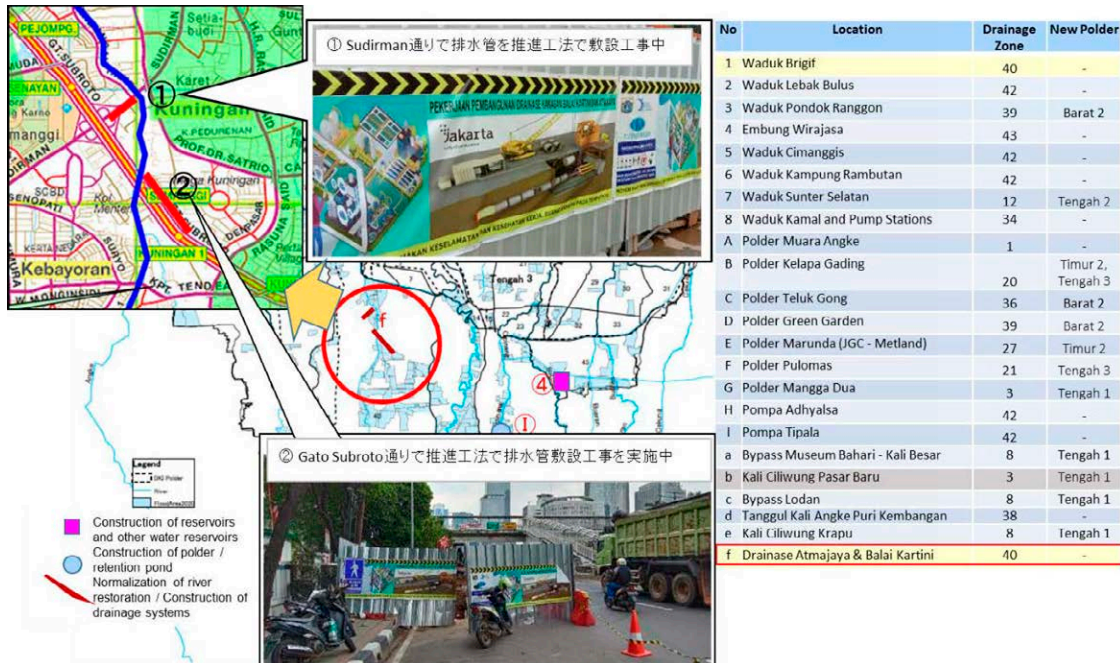


Figure 4-51 Development Projects by DKI (Krukut River Basin)

(2) Short-term development plan by DKI (Timur 2)

In DKI, three sub polders (Kelapa Gading, Pulomas and Marunda JGC) are planned to be developed from 2021 to 2023.

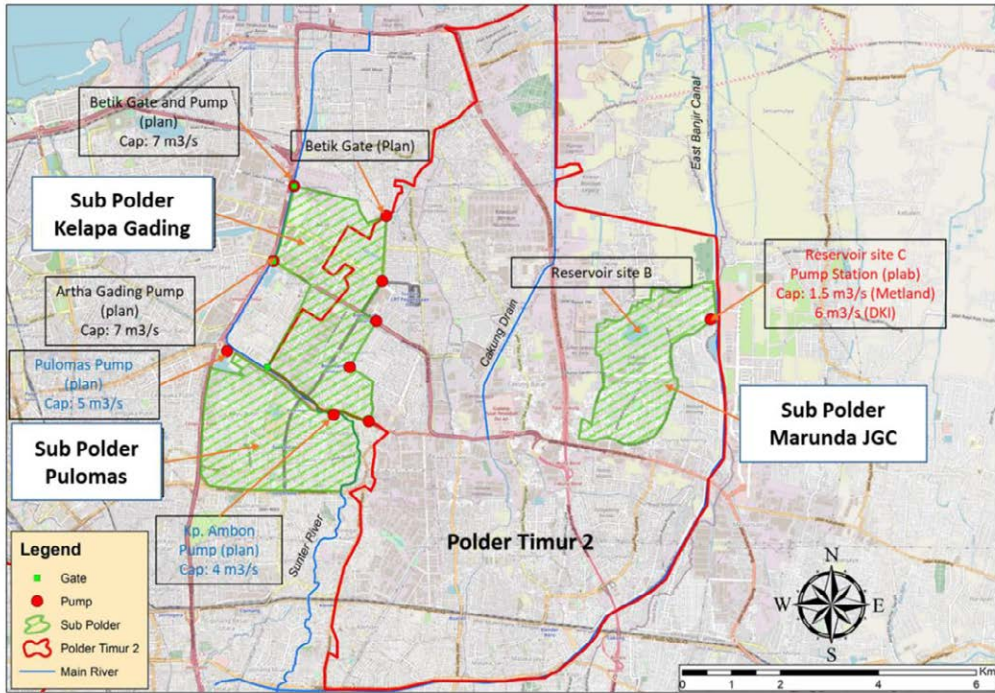


Figure 4-52 Short term development plan by DKI in Timur 2

(3) Intention of BBWS (BlueBook description, August-October 2020 Joint Survey)

In BBWS-CiCis, two sub polders (Ciligncing and Sunter Area) are planned to be constructed. In addition, Cakung drain and Marunda channel are planned to be excavated.

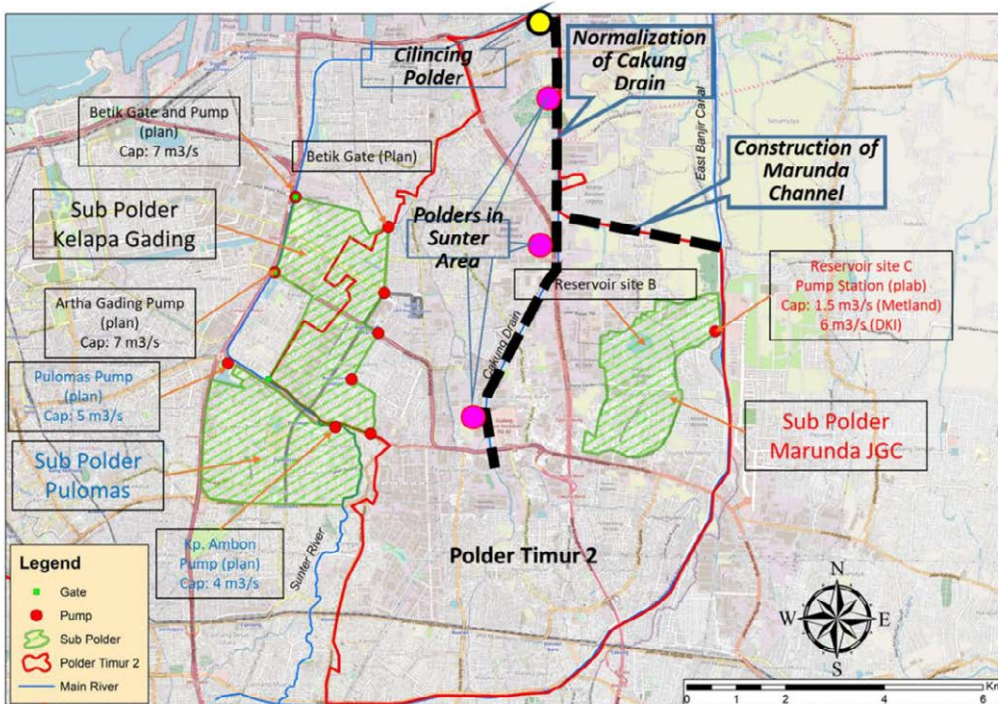


Figure 4-53 Maintenance Plan Described in Bluebook by BBWS-CiCis

4.7 Establishment of Development Policy and Goals

(1) Development Policy based on 1997 Master Plan (MP)

The development policy is shown below based on the 1997 MP.

<Planning Scale>

- In the 1997 Flood MP, major rivers have a scale of 1/100 year probability and minor rivers and tributaries have 1/25 to 50 year probability. (In priority areas, Grogol and Krukut have a 1/25 year probability).
- While Krukut and Grogol basins are highly urbanized, floods have been frequent in recent years.
- It is required to extend the 1/100 year probability section to meet the importance of Krukut and Grogol River.
- In NCICD's Plan, new polder planning scale is 1/100 year.
- In this proposal, all priority areas are set at 1/100 year.

<Design Discharge>

- Major floods have been occurring frequently since 2000 (The largest recorded flood in the 2000s was in 2007.)
- The design discharge will be set based on 2007 flood, in consideration with the recent 2020 flood.

<Countermeasures>

- The countermeasures will be proposed to accelerate the implementation of the 1997 MP considering urbanization situation, progress of the MP in the basin, and advanced flood management concept and technology.

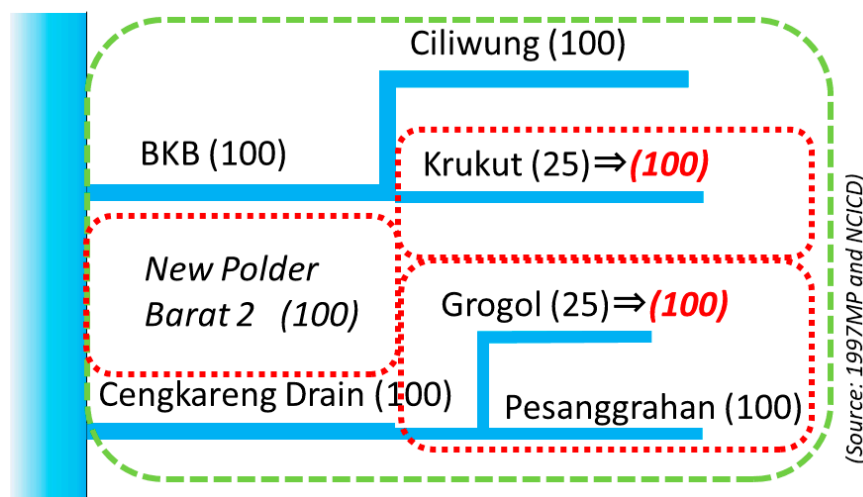


Figure 4-54 Design Scale

(2) Establishment of Development Policy and Goals

Based on the current situation, the proposed project will be divided into river flooding and inland flooding countermeasures, and the policy is to propose an ODA loan project and a project to be considered by the Indonesian government, respectively.

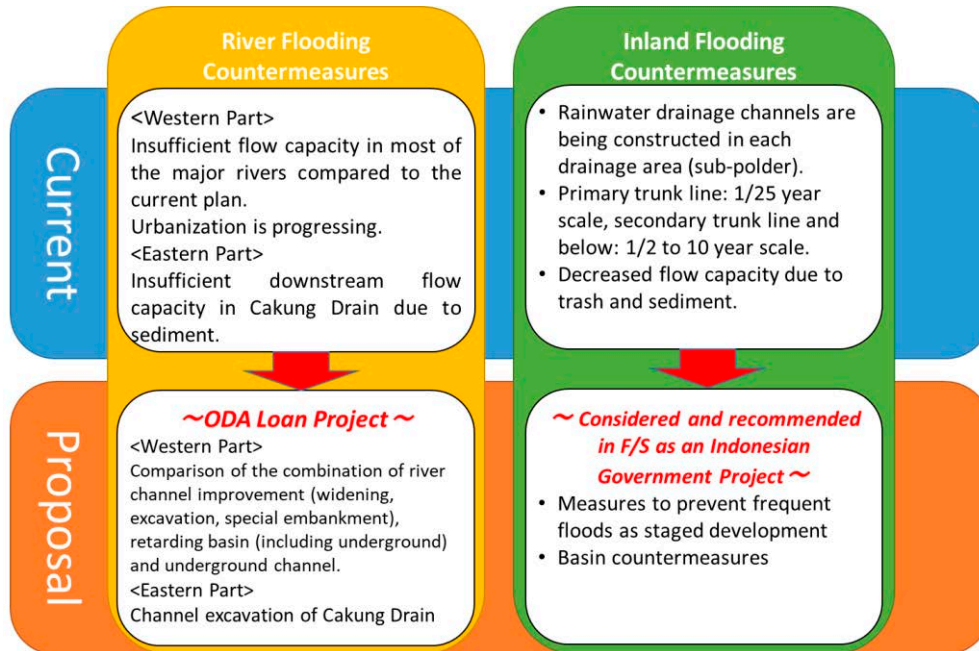


Figure 4-55 Development Policy for the Proposed Project

(3) 1/100-Year Return Period Design Discharge

(i) Study Conditions

The 1/100 year probability flow rate is based on the design rainfall duration, rainfall curve and rainfall volume in the Ciliwung River Basin surrounding DKI Jakarta, as studied in The Project for Capacity Development of Jakarta Comprehensive Flood Management in Indonesia (JICA, 2013). The details of these setting conditions are shown in Attachment 4-1.

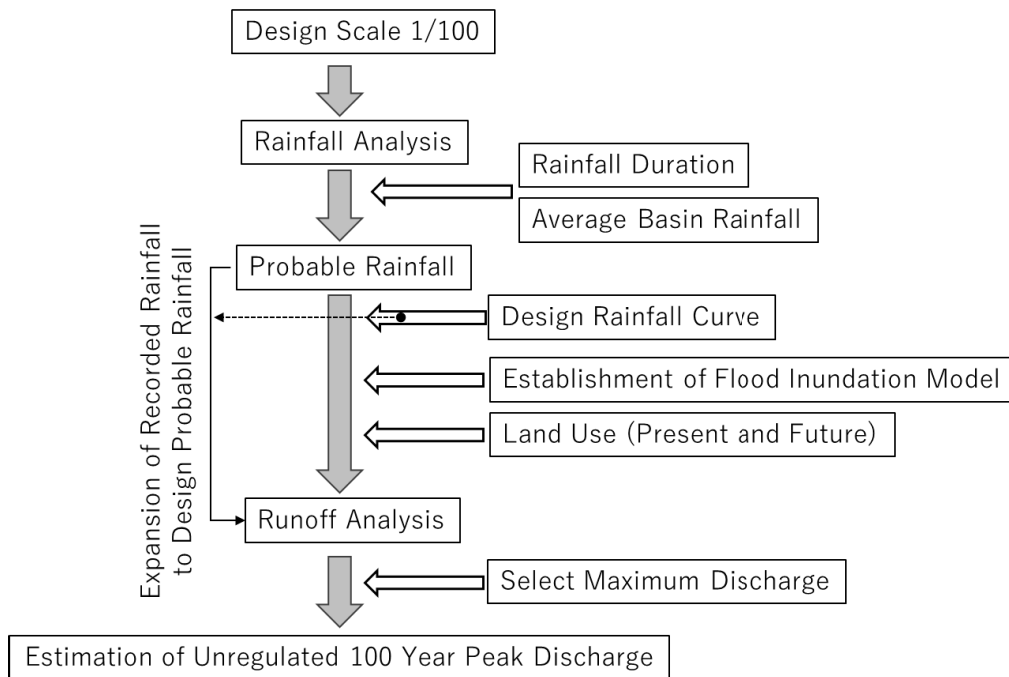


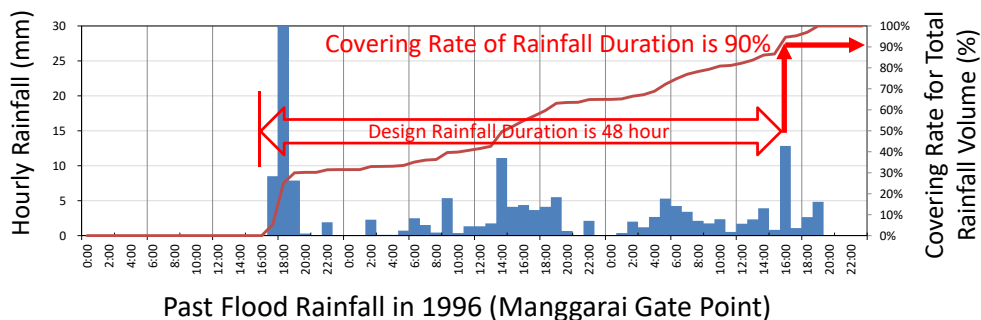
Figure 4-56 Workflow for Setting of Unregulated Peak Discharge

a) The rainfall duration is set for 48 hours.

Table 4-25 Rainfall Duration and Ratio against Total Rainfall*

Rainfall Duration	24hr	36hr	48hr	60hr	72hr
Ratio	67.4%	80.3%	88.8%	95.4%	99.3%

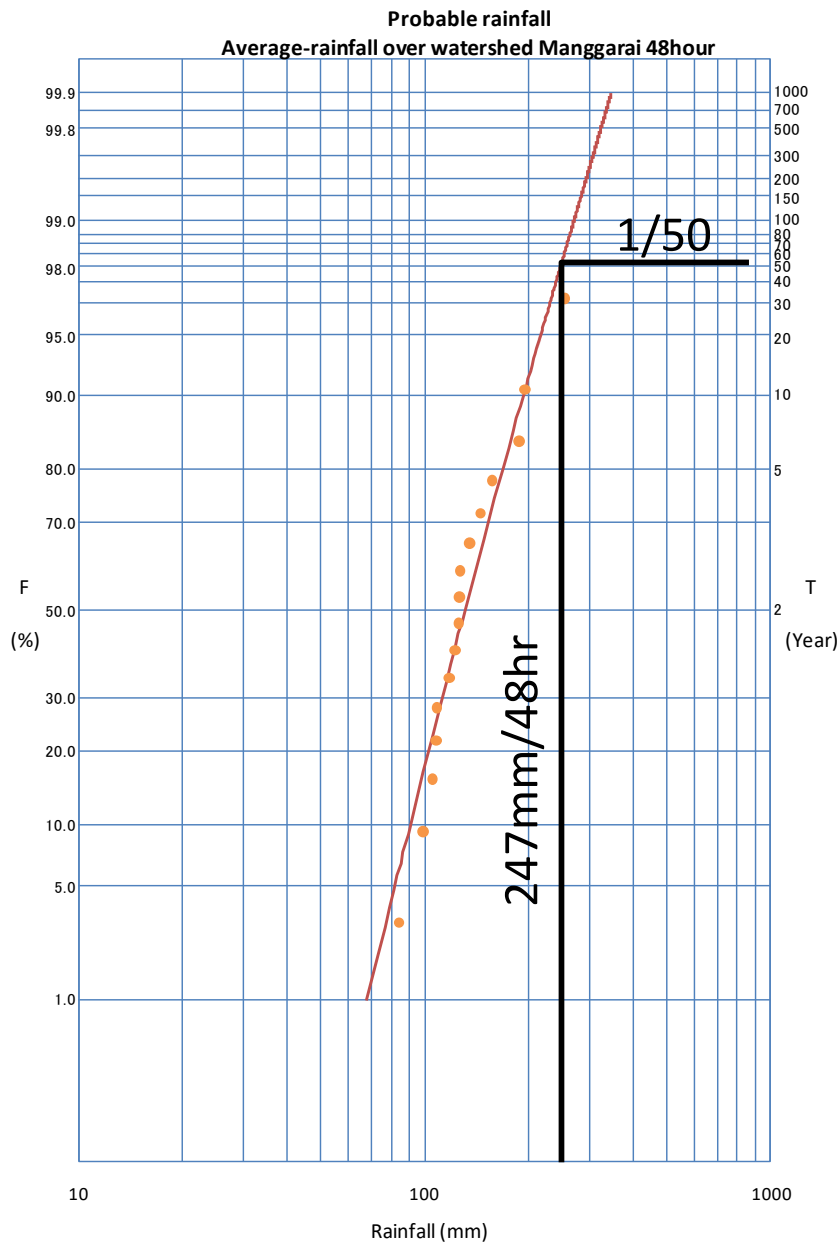
* Major Floods in 1994-2007



Source: The Project for Capacity Development of Jakarta Comprehensive Flood Management in Indonesia (JICA, 2013)

Figure 4-57 Relationship between Rainfall Duration and Covering Ratio for Total Rainfall Volume

- b) The rainfall curve of flood in February 2007 is applied.
- c) Design rainfall volume is set as 247 mm (48-hour average rainfall in the basin, Gumbel distribution)



Source: The Project for Capacity Development of Jakarta Comprehensive Flood Management in Indonesia (JICA, 2013)

Figure 4-58 Rainfall Analysis Result (Design Rainfall at Manggarai Gate Point)

- d) For the runoff analysis, the following two models were applied depending on the inundation characters in the Ciliwung River Basin: Distribution Design Flow Model (for consideration of discharge flow by topographic gradient in mountainous and hilly areas in discharge basin) and Two-Dimensional Unsteady Flow Model (describing the distribution of floodwater flow in the inundation basin).

(ii) Barat 2 and its surrounding areas

The flow distribution map in Barat 2 and its surrounding areas, designed based on a 1/100-year return period discharge, is shown below. The figure also shows the current flow capacity.

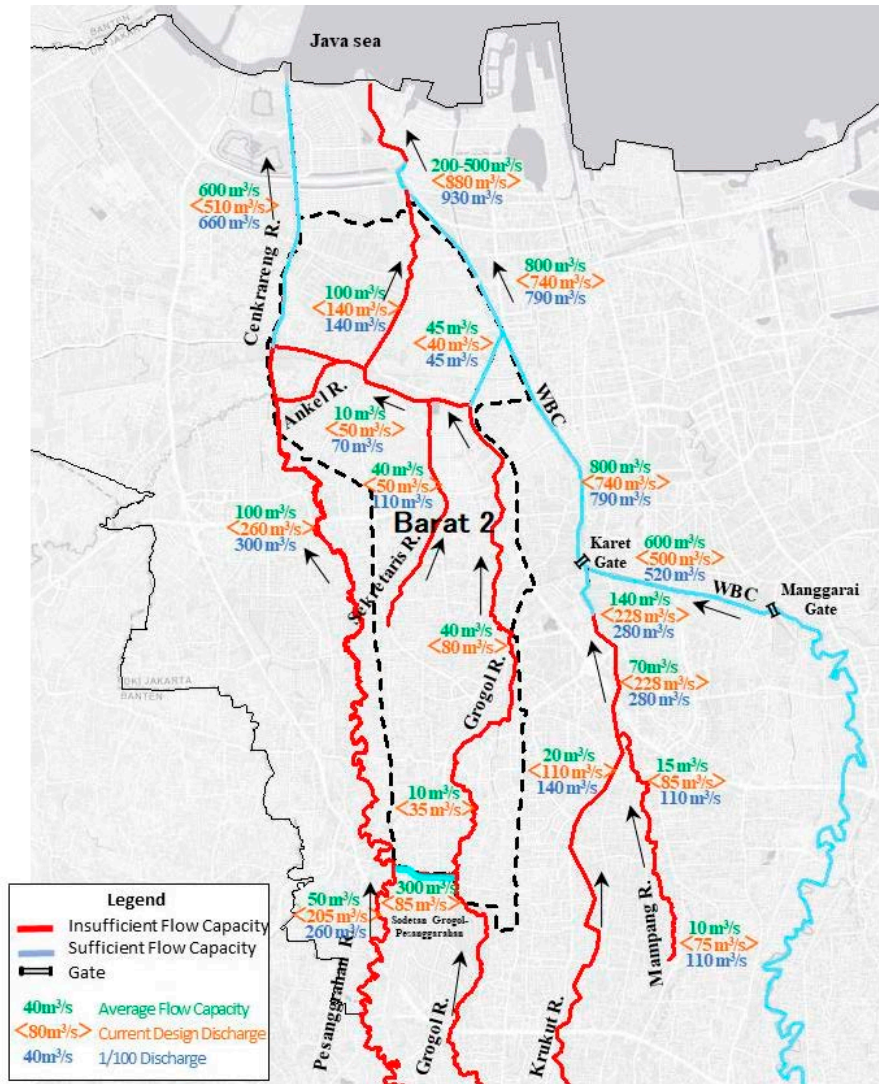


Figure 4-59 1/100-Year Return Period Design Discharge and Current Flow Capacities of Major Rivers and Drainage Channels (Barat 2 and its surrounding areas)

(iii) Timur 2

The flow distribution map in Timur 2, designed based on a 1/100-year return period discharge, is shown below. The figure also shows the current flow capacity.

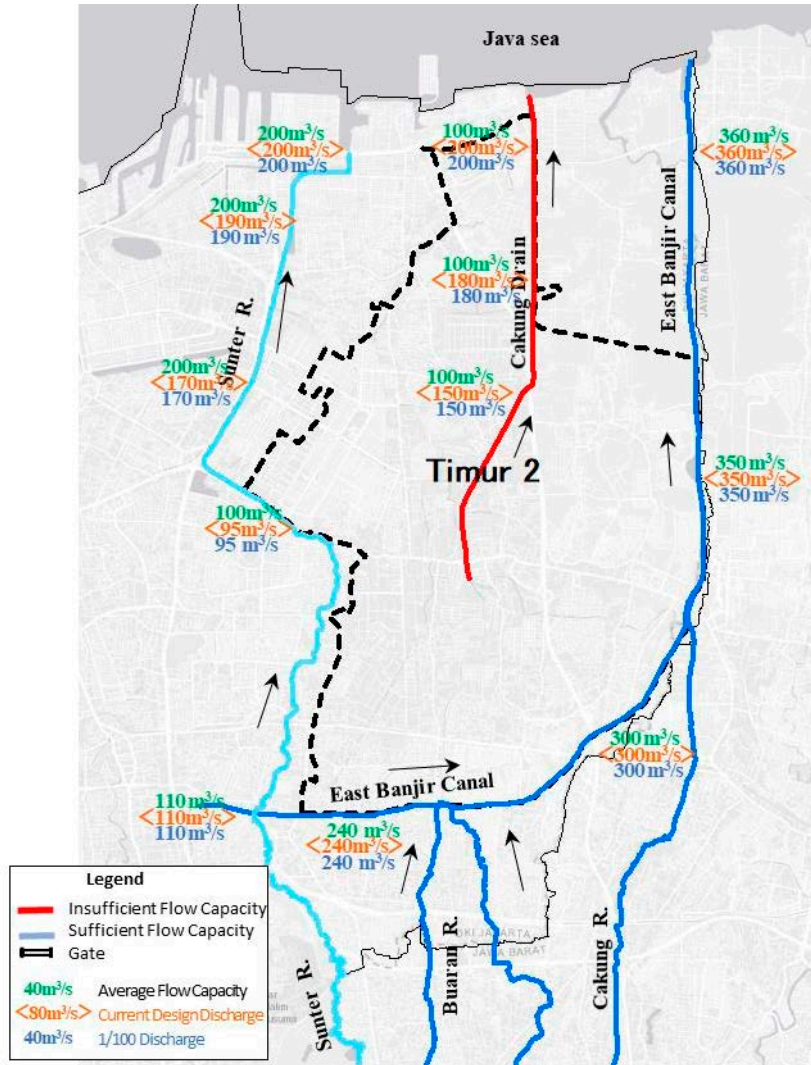


Figure 4-60 1/100-Year Return Period Design Discharge and Current Flow Capacities of Major Rivers and Drainage Channels (Timur 2)

4.8 Flood Countermeasures in West Jakarta

4.8.1 Study on Flood Countermeasures for Barat 2 Area

(1) Comparative Case Study on the Flood Countermeasures

A comparative case study were conducted by combining flood countermeasures in the three groups shown below to determine the feasibility of the flood countermeasures in the West Jakarta area. The comparative study is conducted for the Pesanggrahan River.

All rivers in the Barat 2 area (Pesanggrahan, Sekretaris, Grogol, Lower Angke, Krukut, Mampang) have narrow river channels, insufficient flow capacity and houses are densely packed on the left and right banks, making channel widening very difficult. The conditions of the rivers and basins are similar. Therefore, it was judged that the results of the comparative study could be applied to other rivers if the study was conducted on a representative river. Thus, a comparative study was conducted only for Pesanggrahan.

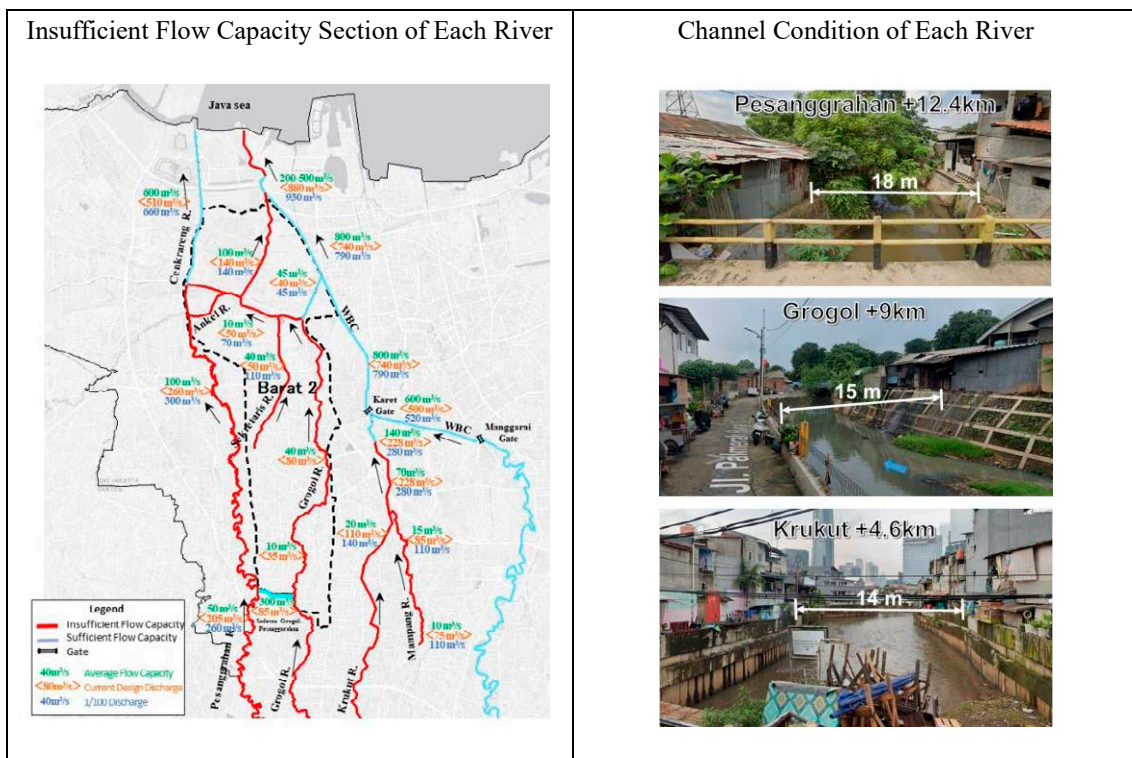


Figure 4-61 Channel Conditions of Each River

The possible combinations of proposed flood countermeasures are shown in Table 4-26. The combinations are divided into three groups, which are classified according to the river channel improvement methods (river channel widening, embankment raising, channel excavation and underground channel).

- Group 1: River improvement and underground channel
- Group 2: Combination of retarding basin and Group 1
- Group 3: Combination of river improvement, retarding basin and underground channel

Table 4-26 Case Study on the Flood Countermeasures for Barat 2 Area

Case No.	Countermeasures	River Improvement			Retarding basin	Underground Channel
		River Widening	Embankment Raising	River Excavation		
1-1	• River Widening only	○	—	—	—	—
2-1	• Embankment Raising only	—	○	—	—	—
3-1	• River Excavation only	—	—	○	—	—
4-1	• Underground channel only	—	—	—	—	○
1-2	• River Widening + • Retarding Basin	○	—	—	○	—
2-2	• Embankment Raising + • Retarding Basin	—	○	—	○	—
3-2	• River Excavation + • Retarding Basin	—	—	○	○	—
4-2	• Retarding Basin + • Underground channel	—	—	—	○	○
4-2 (1)	• Existing River + • Retarding Basin + • Underground channel	—	—	—	○	○
4-2 (2)	• River Excavation + • Retarding Basin + • Underground channel	—	—	○	○	○

Group 1: Case Study on the Individual Effect of Each River Improvement and Underground Channel

Group 2: Case Study on the Effect of the Combination of Group 1 + Retarding basin

Group 3: Case Study on the Effect of the Combination of River Improvement + Retarding Basin + Underground Channel

(i) Group 1: River improvement and underground channel

A comparative case study of different river improvement methods was conducted to evaluate the feasibility of the project. The criteria for evaluation were technical and social aspects, safety, and project costs.

Case Study Plan

- Case 1-1: River Widening only
- Case 2-1: Embankment Raising only
- Case 3-1: River Excavation only
- Case 4-1: Underground Channel only

The results of the comparative case study are shown in Table 4-27. As a result, Case 4-1: Underground Channel only was determined to be applicable because it is technically and socially feasible and can ensure safety compared to other plans. However, the project cost is high.

Table 4-27 Comparative Case Study on River Improvement and Underground Channel (Group 1)

Case	Evaluation				Rough cost Estimate	Judgment
	Technical Aspect	Social & Environment Aspect	Safety			
1-1 River Widening only	<ul style="list-style-type: none"> Feasible Requires coordination with the river/facilities managers 	<ul style="list-style-type: none"> Not feasible Requires a large-scale land acquisition and relocation 	<ul style="list-style-type: none"> Can lower flood water level (improve flow capacity) 	<ul style="list-style-type: none"> Too High Cost Total Cost : 3,600 MIL USD (51,305 Bil. IDR) Construction Cost: 70 MIL USD (995 Bil. IDR) Land Acquisition Area: 72 ha Land Cost : 2,337 MIL USD (33,300 Bil. IDR) Compensation Fee: 1,194 MIL USD (17,010 Bil. IDR) 	<ul style="list-style-type: none"> X Not applicable 	
2-1 Embankment Raising only	<ul style="list-style-type: none"> Not feasible Requires coordination with the river/facilities managers 	<ul style="list-style-type: none"> Not feasible Requires a reconstruction of ancillary facilities, such as bridges and gutters, land acquisition and relocation 	<ul style="list-style-type: none"> It will increase flood water level that is against the basic principle of flood control 	<ul style="list-style-type: none"> High Cost Total Cost : 2,081 MIL USD (29,654 Bil. IDR) Construction Cost : 1,140 MIL USD (16,238 Bil. IDR) Land Acquisition Area: 19.2 ha Land Cost : 623 MIL USD (8,880 Bil. IDR) Compensation Fee : 318 MIL USD (4,536 Bil. IDR) 	<ul style="list-style-type: none"> X Not applicable 	
3-1 River Excavation only	<ul style="list-style-type: none"> Feasible Difficult to maintain the riverbed height 	<ul style="list-style-type: none"> Not feasible Requires a large-scale riverbed excavation 	<ul style="list-style-type: none"> Can lower flood water level (improve flow capacity) Even doing excavation, flood cannot flow into the tidal areas as expected. 	<ul style="list-style-type: none"> High Cost Total Cost : 2,116 MIL USD (30,156 Bil. IDR) Construction Cost : 1,175 MIL USD (16,740 Bil. IDR) Land Acquisition Area: 19.2 ha Land Cost : 623 MIL USD (8,880 Bil. IDR) Compensation Fee : 318 MIL USD (4,536 Bil. IDR) 	<ul style="list-style-type: none"> X Not applicable 	
4-1 Underground Channel only	<ul style="list-style-type: none"> Feasible 	<ul style="list-style-type: none"> Feasible 	<ul style="list-style-type: none"> Can lower flood water level toward downstream of the river (reduce the discharge) 	<ul style="list-style-type: none"> High Cost Total Cost : 2,209 MIL USD (31,494 Bil. IDR) Construction Cost : 1,268 MIL USD (18,068 Bil. IDR) Land Acquisition Area: 19.2 ha Land Cost : 623 MIL USD (8,880 Bil. IDR) Compensation Fee : 318 MIL USD (4,536 Bil. IDR) 	<ul style="list-style-type: none"> △ Applicable 	

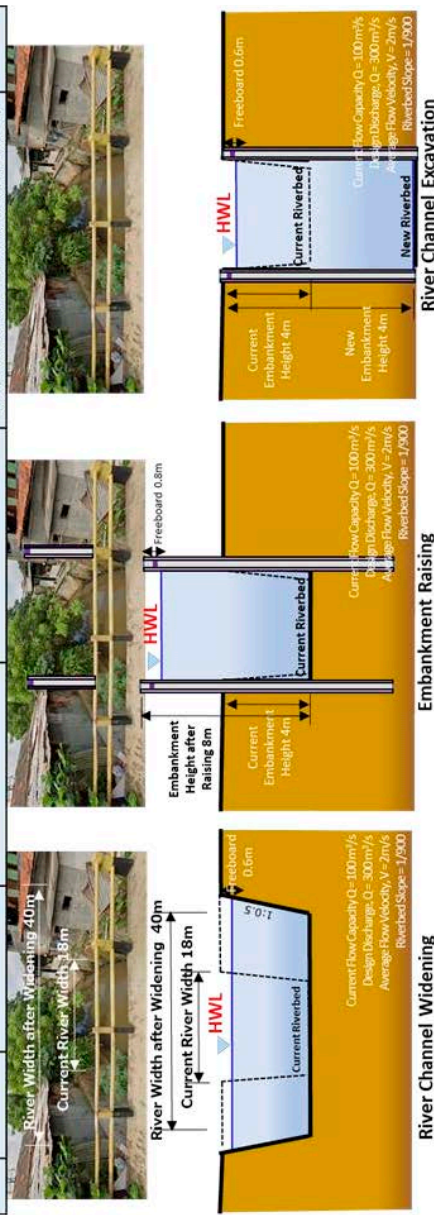


Figure 4-62 Cross-sectional Image of the River Improvement

(ii) Group 2: River Improvement + Retarding Basin

A comparative case study of different river improvement methods with retarding basin was conducted to evaluate the feasibility of each plan. The criteria for evaluation were technical and social aspects, safety, and project costs.

Case Study Plan

- Case 1-2: River channel widening + Retarding Basin
- Case 2-2: Embankment Raising + Retarding Basin
- Case 3-2: River Excavation + Retarding Basin
- Case 4-2: Underground Channel + Retarding Basin

The results of the comparative study are shown in Table 4-28. As a result, Case 4-2: Underground Channel + Retarding Basin was determined to be applicable because it is technically and socially feasible and can ensure safety compared to other plans. However, the project cost is high.

Figure 4-64 shows the flood countermeasure effect of the retarding basins.

Table 4-28 Comparative Case Study on River Improvement + Retarding Basin (Group 2)

Case	Evaluation			Judgment	
	Technical Aspect	Social & Environment Aspect	Safety		
1-2 River Widening + Retarding Basin	<ul style="list-style-type: none"> Feasible Potential sites for retarding basins are limited 	<ul style="list-style-type: none"> Not feasible It requires a large-scale land acquisition and relocation 	<ul style="list-style-type: none"> Can lower flood water level (improve flow capacity) Can lower flood water level toward downstream of the river (reduce the discharge) 	Rough cost Estimate Too High Cost • Total Cost : 3,273 Mil.USD (46,635 Bil.IDR) • Construction Cost : 133 Mil.USD (1,895 Bil.IDR) • Land Acquisition Area : 62.4 ha • Land Cost : 2,025 Mil.USD (28,860 Bil.IDR) • Compensation Fee : 1,114 Mil.USD (15,880 Bil.IDR)	X Not applicable
2-2 Embankment Raising + Retarding Basin	<ul style="list-style-type: none"> Not feasible Requires coordination with the river/facilities managers Potential sites for retarding basins are limited 	<ul style="list-style-type: none"> Not feasible Requires a reconstruction of ancillary facilities such as bridges and gutters, land acquisition and relocation 	<ul style="list-style-type: none"> It will increase flood water level that is against the basic principle of flood control 	High Cost • Total Cost : 2,432 Mil.USD (34,649 Bil.IDR) • Construction Cost : 1,410 Mil.USD (20,096 Bil.IDR) • Land Acquisition Area : 19.2 ha • Land Cost : 623 Mil.USD (8,880 Bil.IDR) • Compensation Fee : 398 Mil.USD (5,674 Bil.IDR)	X Not applicable
3-2 River Excavation + Retarding Basin	<ul style="list-style-type: none"> Feasible Difficult to maintain the riverbed height 	<ul style="list-style-type: none"> Not feasible Requires a large-scale riverbed excavation 	<ul style="list-style-type: none"> Can lower flood water level (improve flow capacity) Even doing excavation, flood cannot flow into the tidal areas as expected. 	High Cost • Total Cost : 2,357 Mil.USD (33,590 Bil.IDR) • Construction Cost : 1,336 Mil.USD (19,036 Bil.IDR) • Land Acquisition Area : 19.2 ha • Land Cost : 623 Mil.USD (8,880 Bil.IDR) • Compensation Fee : 398 Mil.USD (5,674 Bil.IDR)	X Not applicable
4-2 Underground Channel + Retarding Basin	<ul style="list-style-type: none"> Feasible 	<ul style="list-style-type: none"> Does not require land acquisition and relocation 	<ul style="list-style-type: none"> Can lower flood water level toward downstream of the river (reduce the discharge) 	High Cost • Total Cost : 2,109 Mil.USD (30,053 Bil.IDR) • Construction Cost : 1,088 M USD (15,499 Bil.IDR) • Land Acquisition Area : 19.2 ha • Land Cost : 623 Mil.USD (8,880 Bil.IDR) • Compensation Fee : 398 Mil.USD (5,674 Bil.IDR)	△ Applicable

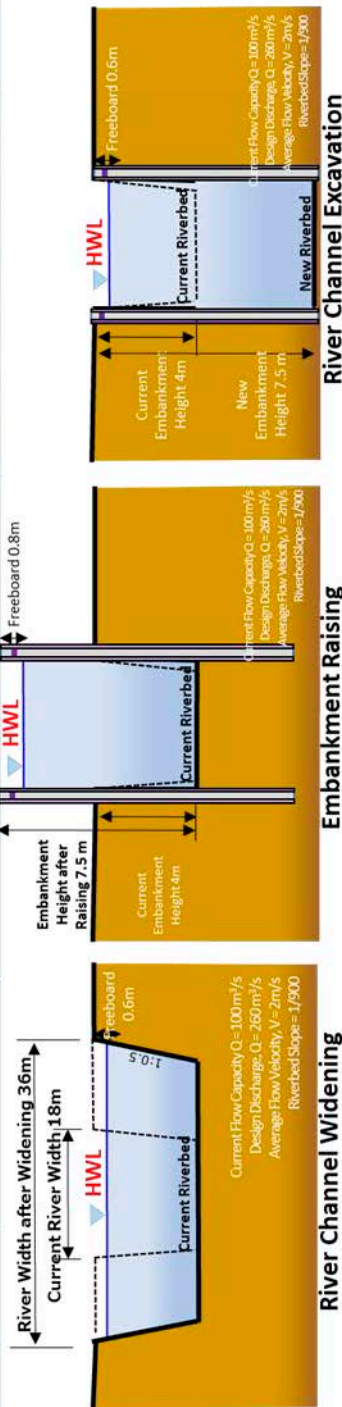


Figure 4-63 Cross-sectional Image of the River Improvement + Retarding Basin

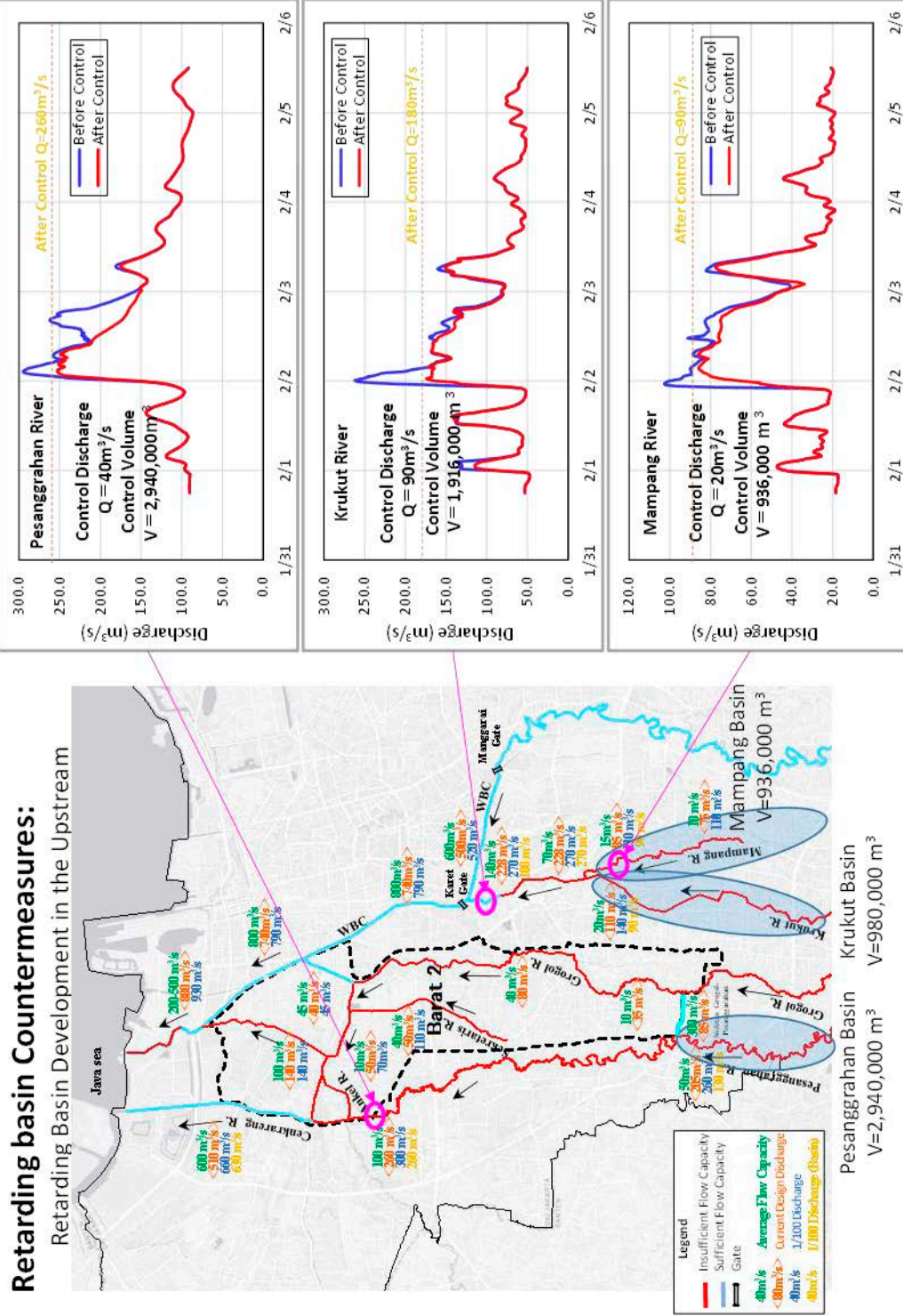


Figure 4-64 Flood Countermeasure Effect of Retarding Basins at Major Points of Each River (100-year scale)

(iii) Group 3: River Improvement + Retarding Basin + Underground Channel

A comparative case study of different river improvement methods (existing river and river excavation) with retarding basin and underground channel was conducted to evaluate the feasibility of each combination. The criteria for evaluation were technical and social aspects, safety, and project costs.

Case Study Plan

- Case 4-2 (1): Existing River + Retarding Basin + Underground Channel
- Case 4-2 (2): River Excavation + Retarding Basin + Underground Channel

The results of the comparative study are shown in Table 4-29. As a result, Case 4-2 (2): River Excavation + Retarding Basin + Underground Channel was considered to have the highest applicability compared to Case 4-2 (1): Existing River + Retarding Basin + Underground Channel, because the technical and social feasibility and safety assurance are comparable but the project cost is relatively low.

As a result of the studies from (i) to (iii) above, the combination of flood control measures in Group 3: "River Improvement + Retarding Basin + Underground Channel" is the most feasible combination of flood control measures for the Jakarta West District.

In (2) to (4), which will be described later, a comparative study of Group 3: "River Improvement + Retarding Basin + Underground Channel" will be conducted for each river.

Table 4-29 Comparative Case Study on River Improvement + Retarding Basin + Underground Channel (Group 3)

Case	Evaluation			Judgment	
	Technical Aspect	Social & Environment Aspect	Safety		
4-2(1) Existing River + Retarding Basin + Underground Channel	<ul style="list-style-type: none"> Feasible Underground channel will be larger in scale, more costly and time-consuming than 4-2(2) 	<ul style="list-style-type: none"> Feasible Does not require land acquisition and relocation 	<ul style="list-style-type: none"> Can lower flood water level toward downstream of the river (reduce the discharge) 	<p>High Cost</p> <ul style="list-style-type: none"> Total Cost : 2,109 M USD (30,053 Bil. IDR) Construction Cost : 1,088 M USD (15,499 Bil. IDR) Land Acquisition Area: 19.2 ha Land Cost : 623 Mil USD (8,880 Bil. IDR) Compensation Fee : 398 Mil USD (5,674 Bil. IDR) 	<p>△ Applicable</p>
4-2(2) River Excavation + Retarding Basin + Underground Channel	<ul style="list-style-type: none"> Feasible Underground channel will be smaller in scale, costly and time-consuming than 4-2(1) 	<ul style="list-style-type: none"> Feasible Does not require land acquisition and relocation 	<ul style="list-style-type: none"> Can lower flood water level toward downstream of the river (reduce the discharge) 	<p>Quite High Cost</p> <ul style="list-style-type: none"> Total Cost : 1,740 Mil USD (24,788 Bil. IDR) Construction Cost : 718 Mil USD (10,235 Bil. IDR) Land Acquisition Area: 19.2 ha Land Cost : 623 Mil USD (8,880 Bil. IDR) Compensation Fee : 398 Mil USD (5,674 Bil. IDR) 	<p>○ Most Applicable</p>

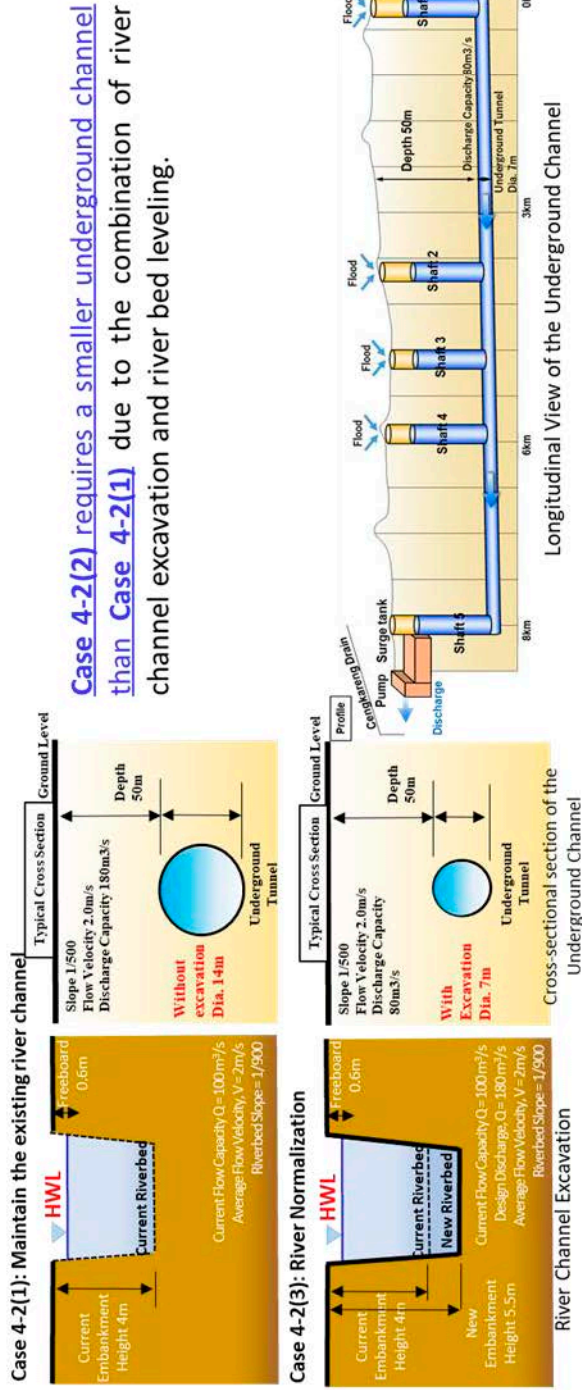


Figure 4-65 Cross-sectional Profile of River Channel Improvement + Retarding Basin + Underground Channel

(2) Study on Flood Countermeasures in Pesanggrahan River

Due to the difference in the river improvement methods (existing river and river excavation) in the River Improvement + Retarding Basin + Underground Channel plan, the discharge distribution of the underground channel case, Case 4-2 (2): River Excavation + Retarding Basin + Underground Channel, was confirmed.

(i) Design Flow Rate

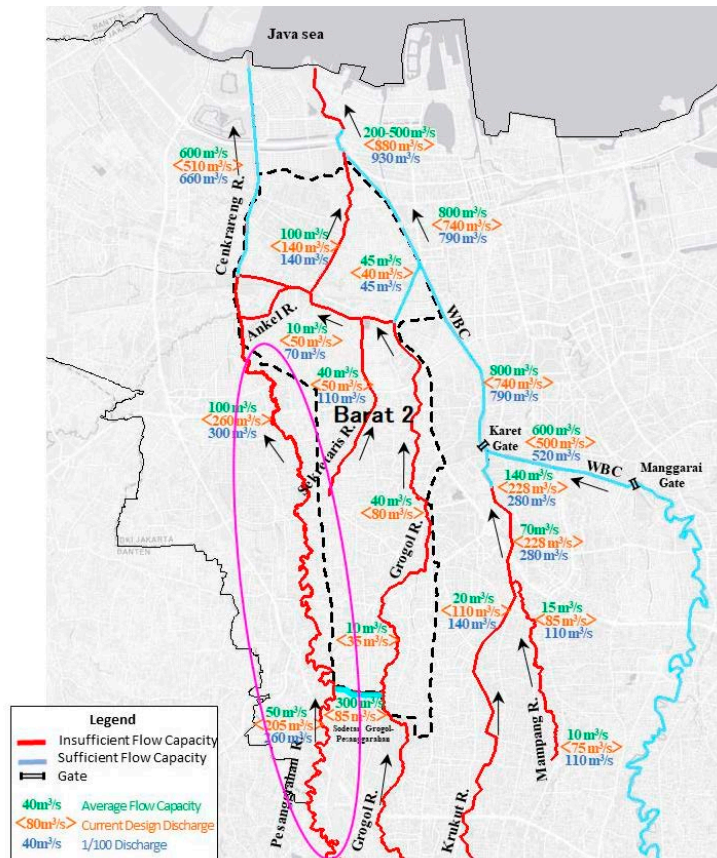


Figure 4-66 1/100 Year Return Period Flood and Current Flow Capacity (Pesanggrahan)

(i) Countermeasures Menu and Discharge Distribution

Table 4-30 shows the countermeasures and the discharge distribution of each menu in the following two cases:

- Case 4-2 (1): Existing River + Retarding Basin + Underground Channel
- Case 4-2 (2): River Excavation + Retarding Basin + Underground Channel

Table 4-30 Countermeasure Menu and Discharge Distribution (Pesanggrahan)

Case	Countermeasure Menu			Discharge Distribution (m ³ /s)			Total Discharge (m ³ /s)
	River Channel Excavation	Retarding Basin	Underground Channel	River Channel	Retarding Basin	Underground Channel	
Pesanggrahan River							
Case 4-2(1)	-	○	○	100	50	150	300
Case 4-2(2)	○	○	○	170	50	80	300

(Effect of River Channel Excavation = 70m³/s)

(Maximizing the use of the retarding basin)

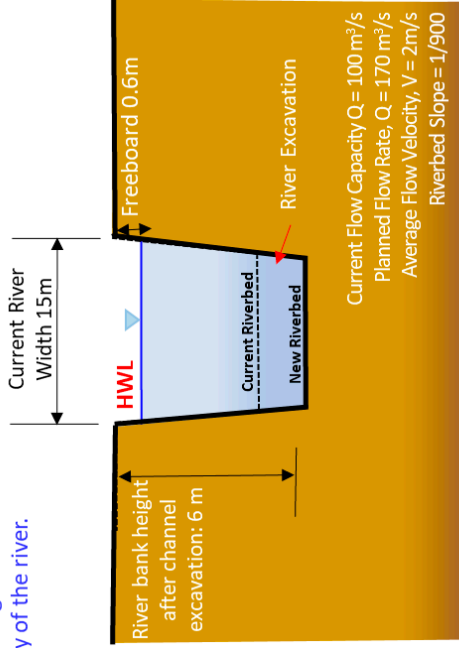
In Case 4-2 (1), discharge distribution in underground channel is larger and it would require a large amount of labor and cost for the underground channel so Case 4-2 (2), which includes river channel excavation, would result to a smaller discharge in underground channel. Therefore, Case 4-2 (2) was determined to be the best solution.

Figure 4-67 shows a draft countermeasure menu for Case 4-2 (2).

Case 4-2(2): River Excavation + Retarding Basin + Underground Channel

Highly Feasible

- Adjustment of discharge by the development of retarding basin in the upstream and construction of the underground channel.
- The existing river width is narrow but it can be normalized the river to increase flow capacity of the river.



Pesanggrahan Discharge Distribution
 River Improvement: River Channel Excavation ($Q_{cut} = 170 \text{ m}^3/\text{s}$)
 Underground Channel: $Q_{cut} = 80 \text{ m}^3/\text{s}$
 Retarding Basin: $Q_{cut} = 50 \text{ m}^3/\text{s}$

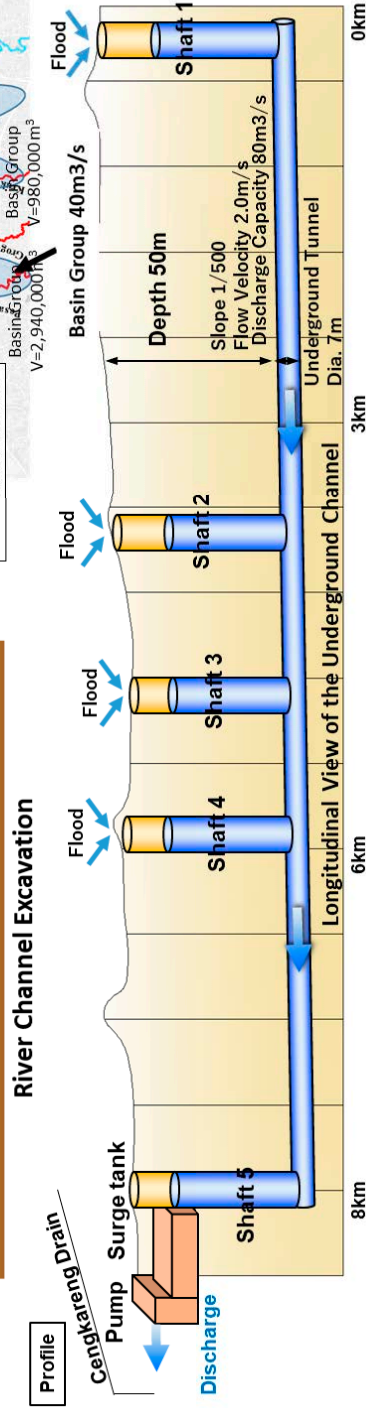
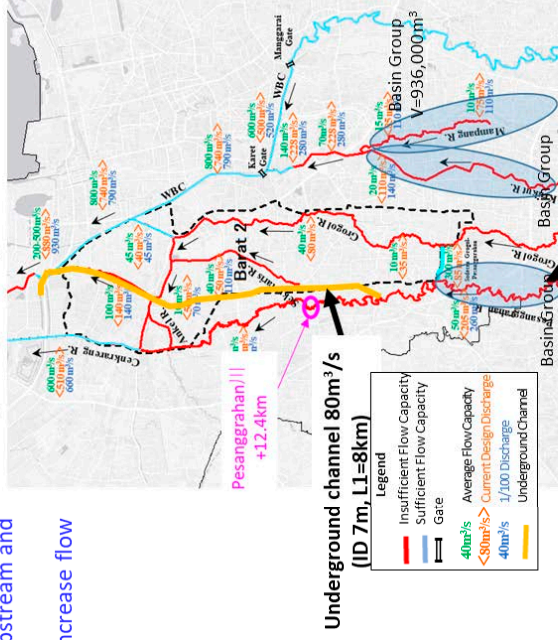


Figure 4-67 Case 4-2 (2): River Excavation + Retarding Basin + Underground Channel (Pesanggrahan River)

(3) Study on Flood Countermeasures in Barat 2 (Lower Angke, Grogol)

Due to the difference in the river improvement methods (existing river and river excavation) in the River Improvement + Retarding Basin + Underground Channel case, the discharge distribution of the underground channel case, Case 4-2 (2): River Excavation + Retarding Basin + Underground Channel, was confirmed.

(i) Design Flow Rate

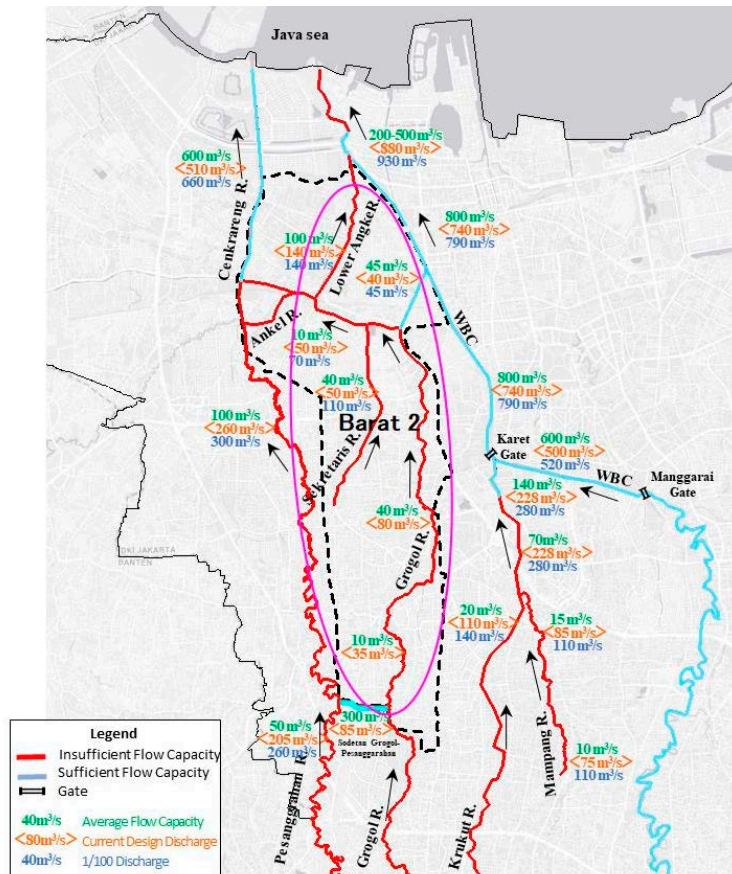


Figure 4-68 1/100 Year Return Period Flood Discharge and Current Flow Capacity (Lower Angke, Grogol River)

(ii) Countermeasure Menu and Discharge Distribution

Table 4-31 shows the countermeasures and the discharge distribution of each menu in the following two cases:

- Case 4-2 (1): Existing River + Retarding Basin + Underground Channel
- Case 4-2 (2): River Excavation + Retarding Basin + Underground Channel

Table 4-31 Countermeasures Menu and Discharge Distribution (Lower Angke, Grogol)

Case	Countermeasure Menu			Discharge Distribution (m ³ /s)			Total Discharge (m ³ /s)
	River Channel Excavation	Retarding Basin	Underground Channel	River Channel	Retarding Basin	Underground Channel	
Lower Angke River							
Case 4-2(1)	-	-	○	70	-	70	140
Case 4-2(2)	○	-	○	90	-	50	140
Grogol River							
Case 4-2(1)	-	-	○	40	-	70	110
Case 4-2(2)	○	-	○	60	-	50	110

※) The river channel excavation effect is 20m³/s

In Case 4-2 (1), discharge distribution in underground channel is larger and it would require a large amount of labor and cost for the underground channel so Case 4-2 (2), which includes river normalization, would result to a smaller discharge in underground channel. Therefore, Case 4-2 (2) was determined to be the best solution. Figure 4-69 shows a draft countermeasure menu for Case 4-2 (2).

Case 4-2(2): River Excavation + Retarding Basin + Underground Channel River Measures: River Channel Excavation ($Q_{cut}=60m^3/s$)

Highly Feasible

- Adjustment of discharge by the development of retarding basin in the upstream and construction of the underground channel.
- The existing river width is narrow but it can be normalized the river to increase flow capacity of the river.

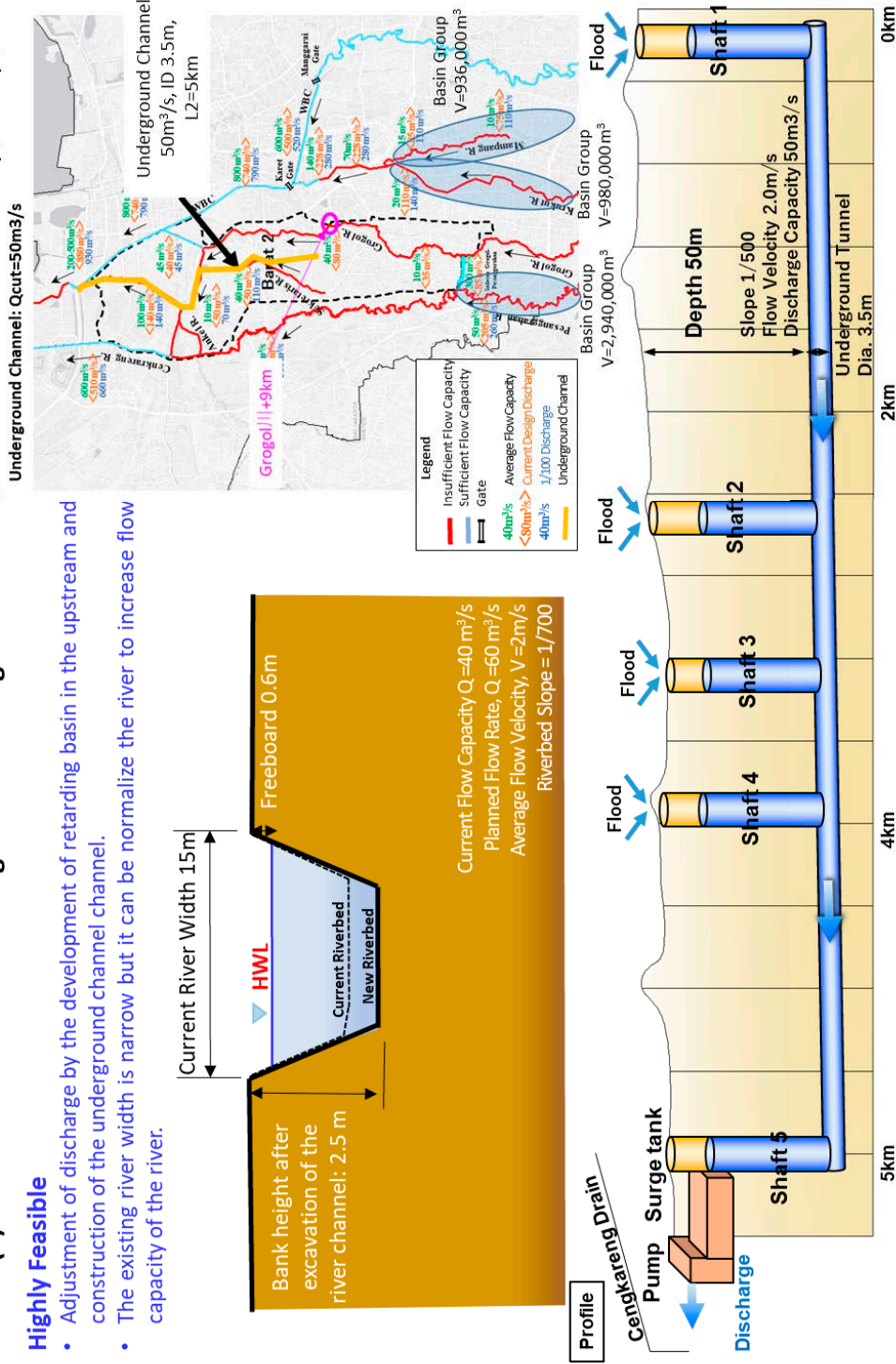
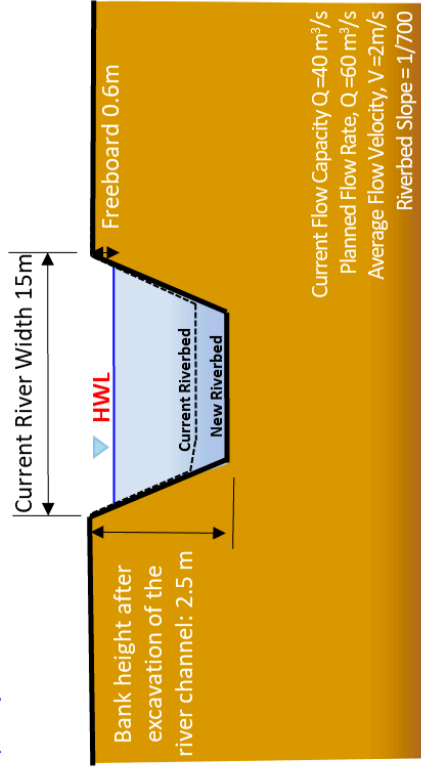


Figure 4-69 Case 4-2 (2): River Excavation + Retarding Basin + Underground Channel (Barat 2)

(4) Study on Flood Countermeasures in Krukut and Mampang Rivers

Due to the difference in the river improvement methods (existing river and river excavation) in the River Improvement + Retarding Basin + Underground Channel case, the discharge distribution of the underground channel case, Case 4-2 (2): River Excavation + Retarding Basin + Underground Channel, was confirmed.

(i) Design Flow Rate

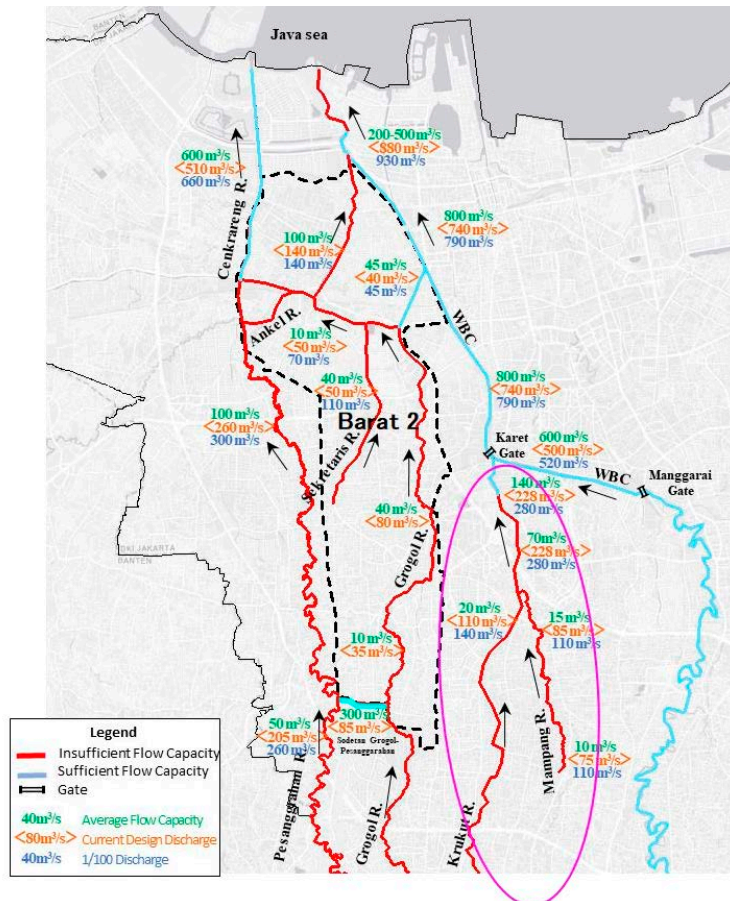


Figure 4-70 1/100 Year Return Period Flood Discharge and Current Flow Capacity (Krukut River, Mampang River)

(ii) Countermeasure Menu and Discharge Distribution

Table 4-32 shows the countermeasures and the discharge distribution of each menu in the following two cases:

- Case 4-2 (1): Existing River + Retarding Basin + Underground Channel
- Case 4-2 (2): River Excavation + Retarding Basin + Underground Channel

Table 4-32 Countermeasures Menu and Discharge Distribution (Krukut and Mampang Rivers)

Case	Countermeasure menu			Discharge Distribution (m ³ /s)			Total Discharge (m ³ /s)
	River Channel Excavation	Retarding Basin	Underground Channel	River Channel	Retarding Basin	Underground Channel	
Krukut Upstream							
Case 4-2(1)	-	○	○	20	50	70	140
Case 4-2(2)	○	○	○	40	50	50	140
Mampang River							
Case 4-2(1)	-	○	○	10	20	80	110
Case 4-2(2)	○	○	○	40	20	50	110
Krukut after confluence							
Case 4-2(1)	-	○	○	70	90	110	280
Case 4-2(2)	○	○	○	120	90	70	280

※) Krukut upstream channel excavation effect is 20m³/s
Mampang rivel channel excavation effect is 30m³/s
Krukut (after confluence) channel excavation effect is 50m³/s

In Case 4-2(1), discharge distribution in underground channel is larger and it would require a large amount of work and money for the underground channel so Case 4-2(2), which includes river normalization, would result to a smaller discharge in underground channel. Therefore, Case 4-2(2) was determined to be the best solution.

Figure 4-71 shows a draft countermeasure menu for Case 4-2 (2)

(5) Summary of the Optimal Plan

The results of the comparative study of the flood control menus (two cases below) for each of the above-mentioned rivers (2) to (4) showed that the following flood control menus: Case 4-2 (2): "River Excavation + Retarding Basin + Underground Channel" was highly applicable to all of the rivers.

Case 4-2 (1): Existing River + Retarding Basin + Underground Channel

- The design discharge will be regulated by retarding basin in the upstream area and underground channel
- However, number of potential sites for retarding basin is limited due to urbanization so the design discharge distribution of the underground channel is larger than Case 4-2(2).
- Therefore, the scale of the underground channel will be larger, more costly and time-consuming than Case 4-2(2).

Case 4-2 (2): River Excavation + Retarding Basin + Underground Channel

- The design discharge will be regulated by retarding basin in the upstream area and underground channel.
- The existing river width is narrow but the river can be normalized to increase the flow capacity to accommodate the design discharge. This reduces the design discharge distribution allocated to the underground channel.
- Therefore, the scale, cost and construction time of the underground channel will be much lower and smaller than Case 4-2(1).

(i) Flood Control Menu

Based on the above, the most effective and efficient flood control measures to control the 1/100 year return period flood is the combination of the following countermeasures below. In addition, the Figure 4-72 shows the overall image of the countermeasures and the actual inundation in the February 2007 flood.

- River channel normalization for major rivers
- Retarding basin construction in the upstream area
- Underground channel construction

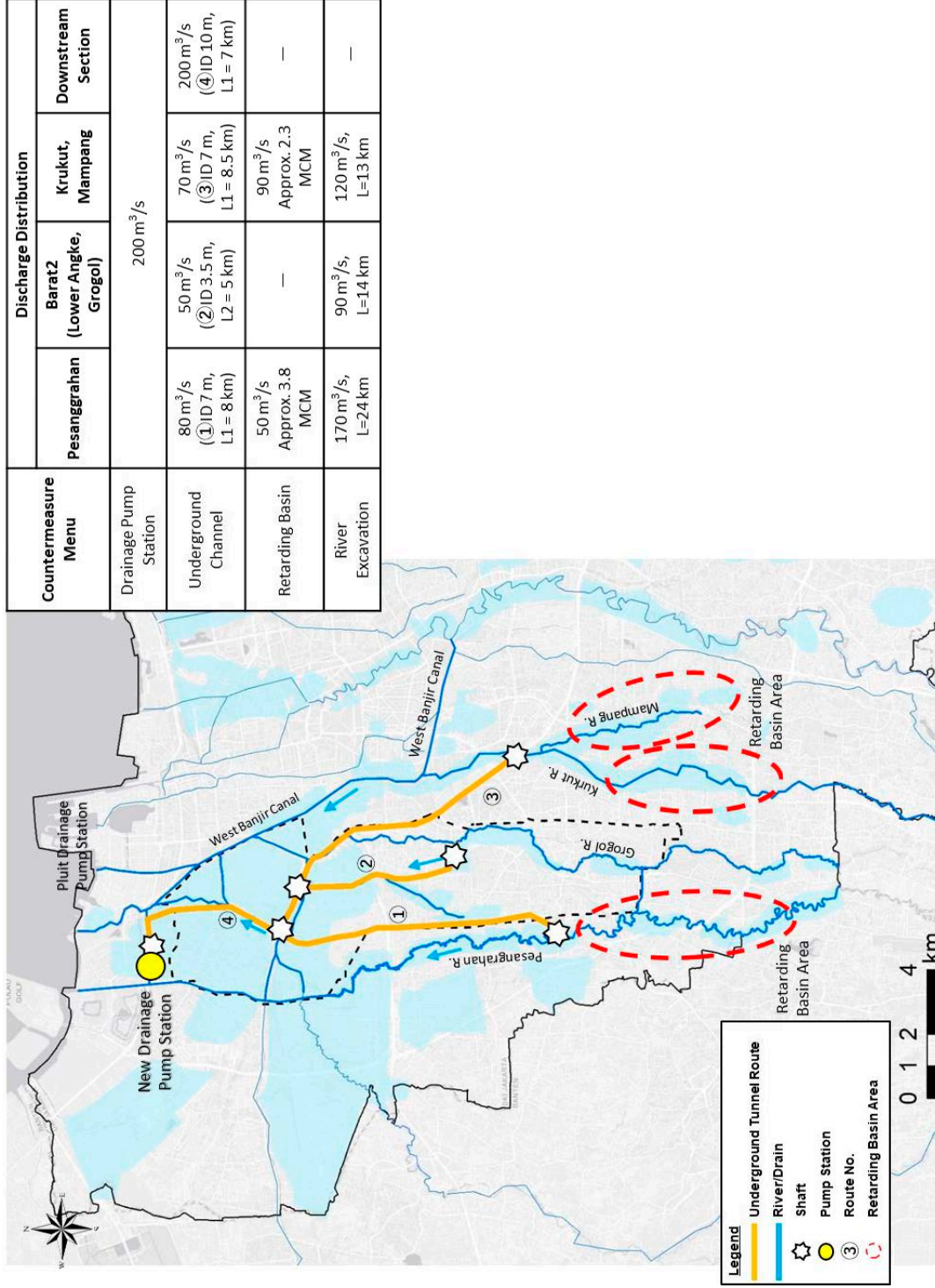


Figure 4-72 Overall Countermeasures in Barat 2, Krukut, Pesanggrahan (Draft)

(ii) Construction Cost Estimation

The rough construction cost estimation of the flood countermeasures, including the underground channel, retarding basin and river normalization in Barat 2, Krukut and Pesanggrahan, is estimated as 1,536 Mil. USD (21,894 Bil. IDR).

Table 4-33 Rough Construction Cost Estimation of the Flood Countermeasures in Barat 2, Krukut, Pesanggrahan

Countermeasure Menu	Discharge Distribution				Total Cost (Mil.USD)
	Pesanggrahan	Barat2 (Lower Angke, Grogol)	Krukut,Mampang	Lowermost section	
Drainage Pump (Construction Cost)	200m ³ /s (378 Mil.USD)				378
Underground Channel (Construction Cost)	80 m ³ /s (①ID 7m,L1=8km) 207 Mil.USD	50 m ³ /s (②ID3.5m, 2=5km) 62Mil.USD	70m ³ /s (③ID 7m,L1=8.5km) 258Mil.USD	200m ³ /s (④ID 10m, L1=7km) 414Mil.USD	941
Retarding Basin (Construction Cost)	40m ³ /s Approx. 3.5MCM 83Mil.USD	—	90m ³ /s Approx. 2.3MCM 50Mil.USD	—	133
River Excavation (Construction Cost)	170m ³ /s、L=24km Depth 2m、 Volume 843,000m ³ 43Mil.USD	90m ³ /s、L=14km Depth 1m、 Volume 241,000m ³ 17Mil.USD	110m ³ /s、L=13km Depth 1.5~1m、 Volume 337,000m ³ 24Mil.USD	—	84
Total					1,536

(iii) Staged Construction Plan

In order to ensure the flood control safety level in the western Jakarta, the following staged construction plan is proposed.

Table 4-34 Staged Construction Plan (Draft)

Step-by-step construction	Contents	Cost of construction	Accrued construction costs
STEP-1	<ul style="list-style-type: none"> Construction of the downstream section (4) However, only 100m³/s of drainage pumping station is advanced. 	<ul style="list-style-type: none"> Drainage pump stations: 202 million USD Underground channel (4) 412 million USD Subtotal 614 million USD 	614 million USD
STEP-2	<ul style="list-style-type: none"> Construction of (2), the center of the western region of Jakarta (Barat2) 	<ul style="list-style-type: none"> Underground channel (2) 62 million USD River channel excavation 17.5 million USD Subtotal 79.5 million USD 	693.5 million USD
STEP-3	<ul style="list-style-type: none"> Construction of the shortage of drainage pump stations (100m³/s) Construction of a drainage basin in the (3) Krukut River basin, a densely populated area 	<ul style="list-style-type: none"> Drainage pump stations: 175.4 million USD Underground channel (3) 258 million USD Retarding Basin 50 million USD River channel excavation 24 million USD Subtotal 507.4 million USD 	1,200.9 million USD
STEP-4	<ul style="list-style-type: none"> Develop a retarding basin (4) for the Pesanggrahan River, which has a large watershed upstream. 	<ul style="list-style-type: none"> Underground channel (1) 206.1 million USD Retarding Basin 83.3 million yen River channel excavation 47.4 million USD Subtotal: 336.8 million USD 	1,537.7 million USD

※This does not include the maintenance of facilities for the underground channel.

The above staged construction plan was set based on the following ideas. This stage construction plan needs to make a comprehensive judgment including the environmental aspects after calculating the individual project effects while confirming the intention of the Indonesian side during the F/S survey.

- ✓ It is clear that the downstream area should be constructed first, but the river to be carried out next was selected as the river that flows through the center of the Barat 2 area (Grogol River). This river is the small river that flows through the center of the area, least developed and low-lying area so it was considered important to first improve the level of safety of the area where the inundation time is the longest.
- ✓ In addition, the estimated cost-effectiveness results of Barat 2, Krukut, and Pesanggrahan was found to be in order of Barat 2 ($B/C=2.9$) > Krukut ($B/C=1.2$) > Pesanggrahan ($B/C=1.0$), which is considered to be the most effective maintenance in terms of cost-effectiveness.

(6) Retarding Basin

(i) Pesanggrahan River

Satellite images from Google Earth were analyzed and 16 sites were selected as potential sites for the construction of retarding basin. These sites do not have existing buildings near the river and the location range was from the confluence of the Cengkareng Floodway of the Pesanggrahan River to the boundary of DKI. The area of each site was measured on the image, and the depth of the regulating pond was set to 5 m to calculate the capacity. The total capacity of the 16 sites would be 6,200,000 m³.

Furthermore, out of the 16 sites, 11 sites with a capacity of approximately 4,400,000 m³, which are open and green spaces near the river, were identified as highly feasible candidate sites.

(ii) Krukut and Mampang River

Krukut River

Satellite images from Google Earth were analyzed and 20 sites were selected as potential sites for the construction of retarding basin. These sites do not have existing buildings near the river and the location range was from the confluence of the West Banjir Canal with Krukut River to the boundary of DKI. The area of each site was measured, and the depth of the regulating pond was set to 5 m to calculate the capacity. The total capacity of the 20 sites would be 4,950,000 m³.

Furthermore, out of the 20 sites, 8 sites with a capacity of approximately 2,375,000 m³, which are open and green spaces located near the river, were identified as highly feasible candidate sites.

Mampang River

Satellite images from Google Earth were analyzed and 8 sites were selected as potential sites for construction of retarding basin. These sites do not have existing buildings near the river and the location range was from the confluence of the Krukut River with Mampang River to the boundary of DKI. The area of each site was measured on the image, and the depth of the regulating pond was set to 5 m to calculate the capacity. The total capacity of the 8 sites would be 3,025,000 m³.

Furthermore, out of the eight sites, three sites with a capacity of approximately 1,300,000 m³, which are open and green spaces located near the river, were identified as highly feasible candidate sites.

(iii) Regulatory effects of the playground groups on each river

The flood control effects of the Pesanggrahan, Krukut, and Mampang River retarding basin groups are shown in Figure 4-76.

Pesanggrahan River retarding basin group:	$Q_{cut} = 40 \text{ m}^3/\text{s}$ (flood capacity $2.940 \times 10^6 \text{ m}^3$)
Krukut River retarding basin group:	$Q_{cut} = 90 \text{ m}^3/\text{s}$ (flood capacity: $1.916 \times 10^6 \text{ m}^3$)
Mampang River retarding basin group:	$Q_{cut} = 20 \text{ m}^3/\text{s}$ (flood capacity: $0.936 \times 10^6 \text{ m}^3$)

Retarding Basin	Present Condition	Area (m2)	Depth (m)	Capacity (m ³)	Preferred Candidate
Retarding Basin ①	Commercial Lot	60,000	5	300,000	×
Retarding Basin ②	Vacant Lot, Vacant Lot in the old building, Plaza in the building	20,000		175,000	×
Retarding Basin ③	Vacant Lot	5,000		200,000	△
Retarding Basin ④	Restaurant, Vacant Lot	10,000			
Retarding Basin ⑤	Vacant Lot	40,000		125,000	×
Retarding Basin ⑥	Park, Vacant Lot	10,000			
Retarding Basin ⑦	Vacant Lot, Sacred Tomb of Wan Sharifa Fatma	15,000		300,000	○
Retarding Basin ⑧	Vacant Lot	60,000		300,000	○
Retarding Basin ⑨	Vacant Lot, Park	60,000		125,000	×
Retarding Basin ⑩	Commercial Lot	25,000		350,000	×
Retarding Basin ⑪	Vacant Lot	70,000		350,000	○
Retarding Basin ⑫	Vacant Lot	70,000		150,000	○
Retarding Basin ⑬	Vacant Lot	30,000		300,000	○
Retarding Basin ⑭	Vacant Lot	60,000		300,000	△
Retarding Basin ⑮	Vacant Lot	60,000		750,000	△
Retarding Basin ⑯	Cemetery	150,000		600,000	○
Retarding Basin ⑰	Vacant Lot	120,000		225,000	○
Retarding Basin ⑱	Vacant Lot	45,000		150,000	○
Retarding Basin ⑳	Cemetery, Insulation Distributor	30,000		250,000	△
Total				4,950,000	
Item	Preferred Candidate Condition	Capacity (10 ³ m ³)	Preferred Candidate	Capacity (m ³)	
○	Vacant lots and green areas near the river	1,176	○	2,375,000	
△	Vacant lots and cemeteries near the river		△	1,500,000	
×	Areas under construction and private property far from river		×	1,075,000	
Total				4,950,000	

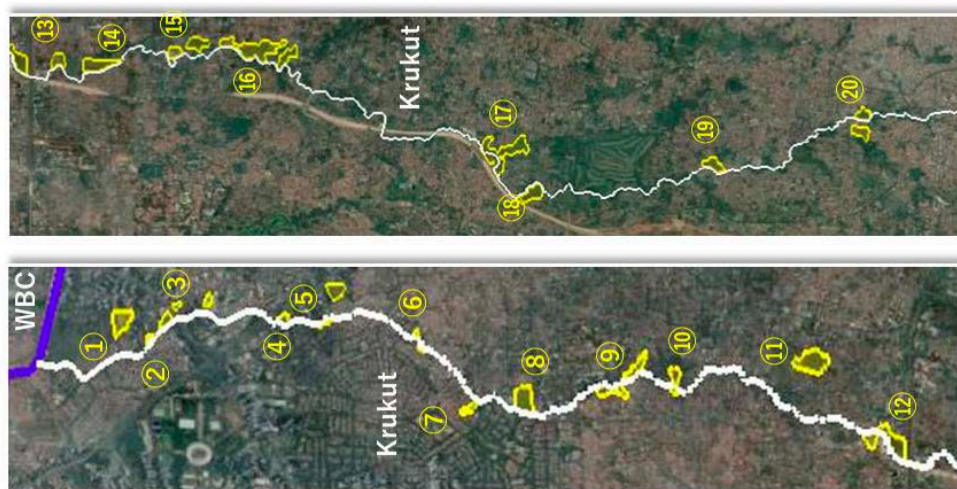
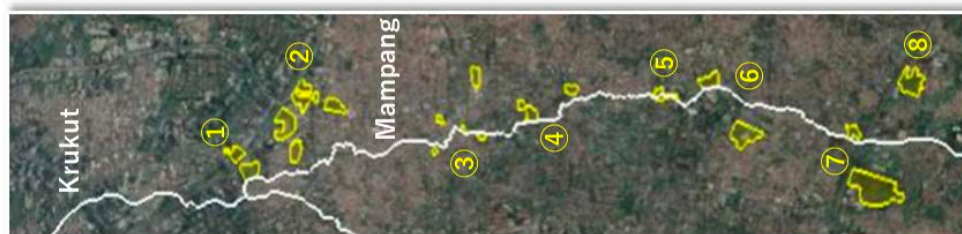


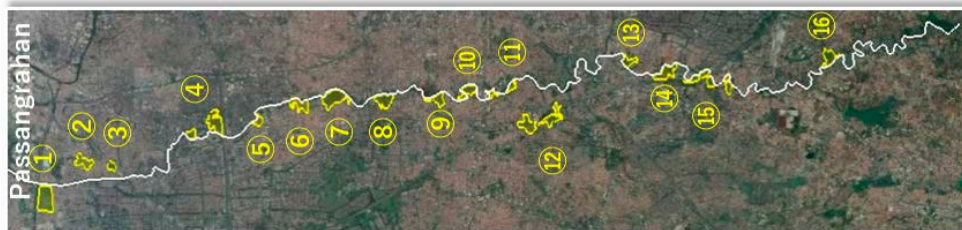
Figure 4-73 Proposed Retarding Basin Sites (Krukut River)



Retarding Basin	Present Condition	Area (m ²)	Depth (m)	Capacity (m ³)	Preferred Candidate
Retarding Basin ①	Vacant Lot	60,000	5	300,000	△
Retarding Basin ②	Vacant Lot, Building Sites, Soccer Fields	150,000		750,000	x
Retarding Basin ③	Vacant Lot	40,000		200,000	△
Retarding Basin ④	Vacant Lot	45,000		225,000	△
Retarding Basin ⑤	Vacant Lot, Company and Office Building	40,000		100,000	○
Retarding Basin ⑥	Vacant Lot, Park, Fish Pond	45,000		450,000	○
Retarding Basin ⑦	Vacant Lot, Campground	150,000		750,000	○
Retarding Basin ⑧	Offices, Restaurants	50,000		250,000	x
Total			Total	3,025,000	

Item	Preferred Candidate Condition	Capacity (10 ³ m ³)	Preferred Candidate	Capacity (m ³)
○	Vacant lots and green areas near the river	1,123	○	1,300,000
△	Vacant lots and cemeteries near the river		△	725,000
x	Areas under construction and private property far from river		x	1,000,000
Total			Total	3,025,000

Figure 4-74 Proposed Retarding Basin Sites (Mampang River)



Retarding Basin	Present Condition	Area (m ²)	Depth (m)	Capacity (m ³)	Preferred Candidate
Retarding Basin ①	Vacant Lot, Green Areas	150,000	5	750,000	○
Retarding Basin ②	Vacant Lot	70,000		△	
Retarding Basin ③	Municipal Park	30,000		△	
Retarding Basin ④	Vacant Lot, Commercial, Restaurants, Cemetery, Swamp Pond	130,000		○	
Retarding Basin ⑤	Vacant Lot	30,000		○	
Retarding Basin ⑥	Vacant Lot, Restaurants, Residential Areas	65,000		○	
Retarding Basin ⑦	Park	120,000		○	
Retarding Basin ⑧	Government Agency, Swamp Pond	75,000		○	
Retarding Basin ⑨	Shopping Mall (to be constructed)	50,000		×	
Retarding Basin ⑩	Vacant Lot	60,000		○	
Retarding Basin ⑪	Vacant Lot	40,000		○	
Retarding Basin ⑫	Vacant Lot, Cemetery, Restaurants, Residential Areas	140,000		×	
Retarding Basin ⑬	Vacant Lot, Cemetery, Restaurants	40,000		△	
Retarding Basin ⑭	Vacant Lot, Residential Areas	80,000		○	
Retarding Basin ⑮	Vacant Lot, Residential Areas	100,000		○	
Retarding Basin ⑯	Vacant Lot, Residential Areas	60,000		○	
Total			Total	6,200,000	

Item	Preferred Candidate Condition	Capacity (10 ³ m ³)	Preferred Candidate	Capacity (m ³)
○	Vacant lots and green areas near the river	3780	○	4,400,000
△	Vacant lots and cemeteries near the river		△	1,100,000
×	Areas under construction and private property far from river		×	700,000
Total			Total	6,200,000

Figure 4-75 Proposed Retarding Basin Sites (Pesanggrahan River)

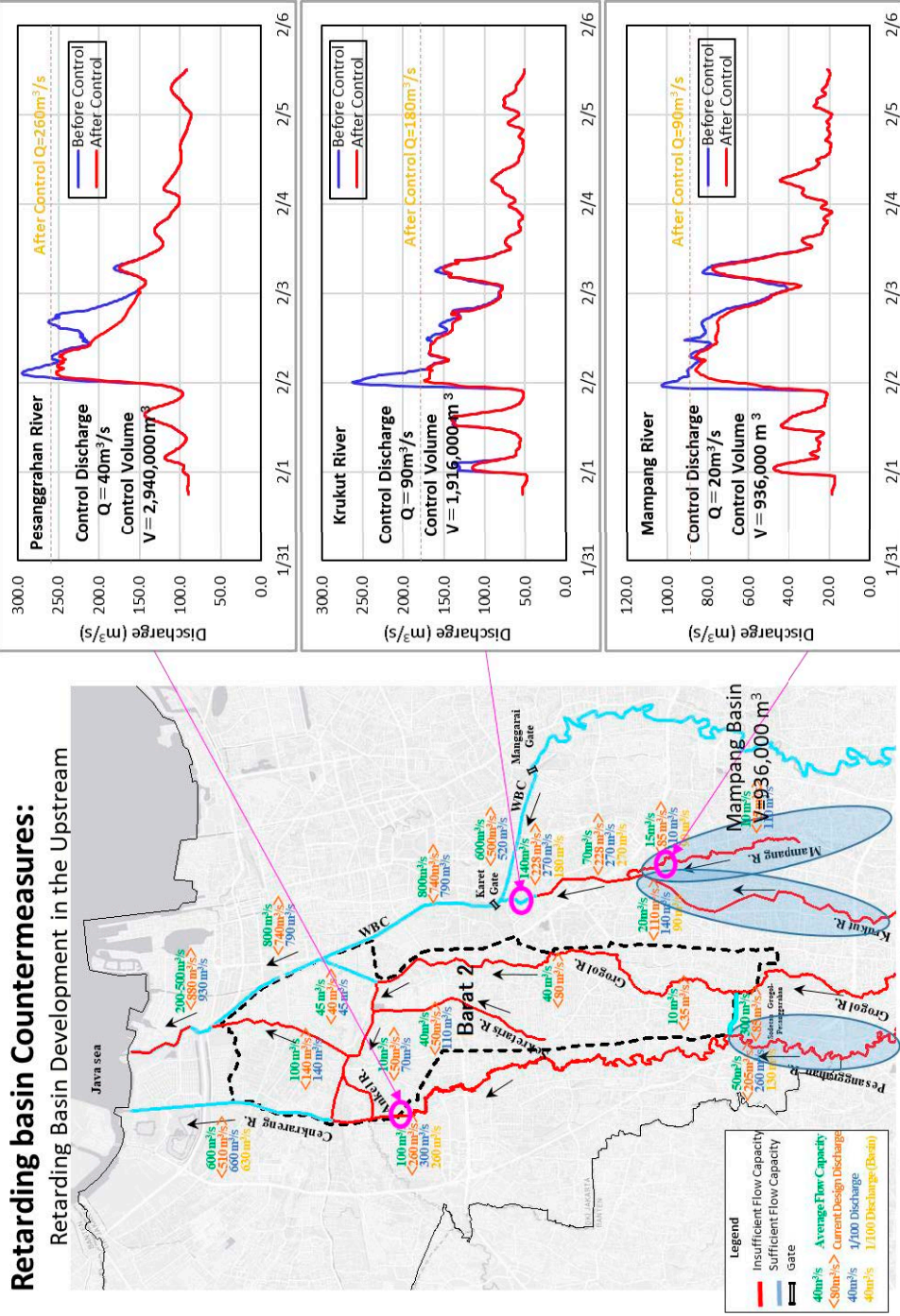


Figure 4-76 Flood Countermeasure Effect of Retarding Basins at Major Points of Each River (100-year scale)

(7) Underground Channel

(i) Route Selection

As for the routes of the underground channel, the following routes under the major roads and major rivers were considered:

- Route (1): Flow along the main road in the western part of the area along the Pesanggrahan River and joins Route 4.
- Route (2): The flow is parallel to Grogol River, which flows through the center of Barat 2, and joins Route 4.
- Route (3): Flow along the highway from the city center to the airport and joins Route 4.
- Route (4): The flow is parallel to lower Angke River, which flows through the center of Barat 2, and drains near Cenkareng Drain.



Figure 4-77 Underground Channel Route

(ii) Longitudinal Section

For the longitudinal section plan, the representative routes (4) + (3) are shown below.

Route (4) + (3) is to take flood water from the Krukut River near the intersection of the Krukut River and the central highway, channel it along the highway, take in surrounding inland water at two intermediate shafts, temporarily store it in a regulating reservoir near the Cengkareng Drain, and then pump it out. Since the expressway is elevated, an underground channel with a depth of about 50 m will be used.

If the inner diameter of the shield in the most downstream section (4) is 10 m and the longitudinal gradient is 1/500, a flow capacity of about 200 m³/s can be expected at a flow velocity of 2.0 m/s.

If the inner diameter of the shield in section (3) is 7 m and the longitudinal gradient is 1/500, a flow capacity of about 70 m³/s at a flow velocity of 2.0 m/s can be expected.

The end of the underground channel will be located near the Cengkareng Drain, where a 300,000 m³ regulating reservoir and a drainage pump station with a capacity of 200 m³/s will be located. From the viewpoint of land acquisition, the area near the mouth of the West Banjir Canal may be advantageous. The drainage facility will be studied in the next study from the viewpoint of the detailed flow capacity of the Cengkareng Drain and the mouth of the West Banjir Canal and the degree of difficulty of land acquisition.

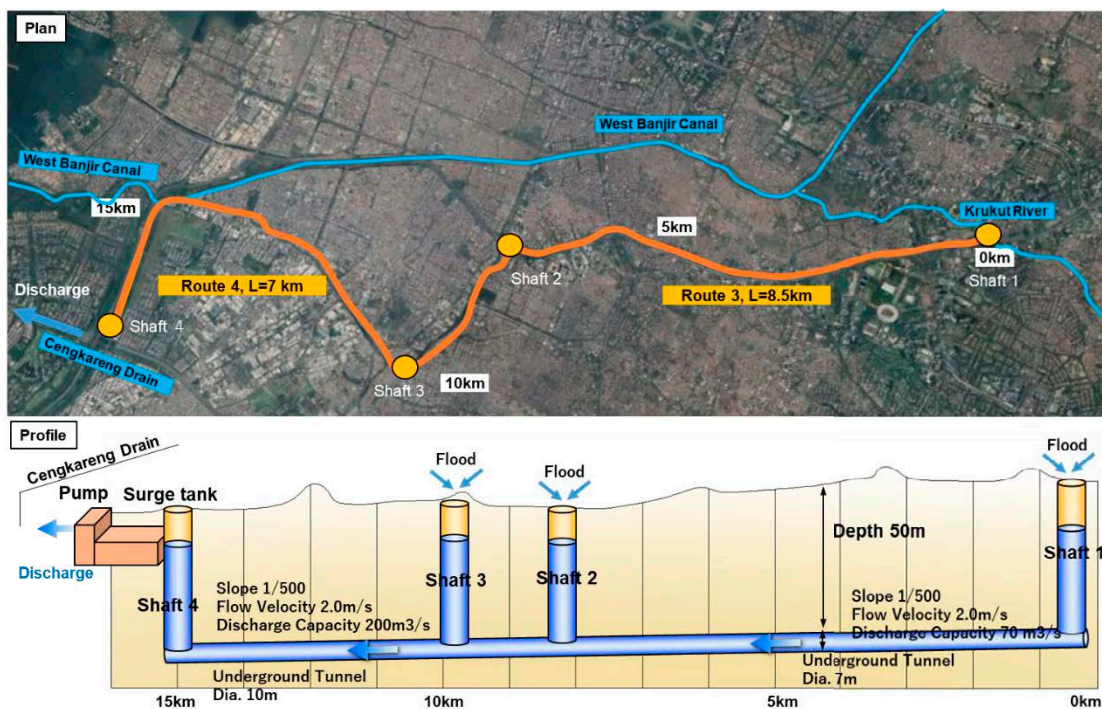


Figure 4-78 Schematic Plan and Longitudinal Section of the Underground Channel Route (4) + (3)



Figure 4-79 Proposed Site for Retarding Basin and Drainage Pump Station

(iii) Estimated Construction Cost and Schedule

The estimated construction cost of the underground drainage system was calculated with reference to the construction cost of similar projects in Japan and other Asian countries. For each route, various parameters were assumed and construction costs were calculated for each.

- Route (1): Length 8.0 km, Diameter 7 m, 1 shaft (starting point)
- Route (2): Length 5.0 km, Diameter 3.5 m, 1 shaft (starting point)
- Route (3): Length 8.5 km, Diameter 7 m, 2 shafts (starting point, confluence (2)(3))
- Route (4): Length 7.0 km, Diameter 10 m, 2 shafts (confluence(1)(3), endpoint)

As a result, the construction cost was 23.5 billion yen for route (1), 7 billion yen for route (2), 29.3 billion yen for route (3), and 47.2 billion yen for route (4).

As for the construction period, it is estimated to take about 10 years from F/S to completion because the construction of the starting port and the tunnel excavation will be the critical path.

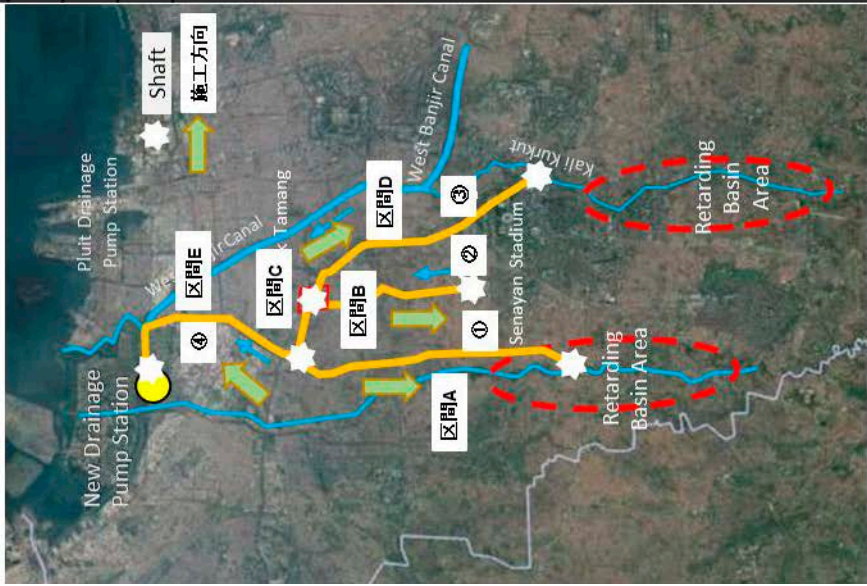
It is considered that the underground channel plan does not require large-scale resettlement of residents and land acquisition, but it is expected that a large amount of residual soil will be generated during the tunnel excavation, so it is necessary to pay attention to environmental and social considerations.

Table 4-35 Estimated Construction Cost of Underground Channel

Route (1): Length 8.0 km, Diameter 7 m, 1 shaft (starting point)					
Item	Unit	Quantity	Unit Price (USD)	Amount (USD)	Remarks
Inflow Facility	No.	2	1,842,105	3,684,211	Actual Unit Price (Metropolitan Area Outer Underground Discharge Channel) * 0.7
Shaft (Dia 30 m, H 60 m)	No.	1	24,561,404	24,561,404	Same as above
Underground Tunnel (Dia 7 m, Depth 50 m)	m	7000	25,538	178,764,035	Actual Value of Jakarta MRT Project (2013), Kolkata East-West Metro Project (2013), Metro Manila Paranaque Spillway (2017)
Total				207,009,649	
Route (2): Length 5.0 km, Diameter 3.5 m, 1 shaft (starting point)					
Item	Unit	Quantity	Unit Price (USD)	Amount (USD)	Remarks
Inflow Facility	No.	1	1,842,105	1,842,105	Actual Unit Price (Metropolitan Area Outer Underground Discharge Channel) * 0.7
Shaft (Dia 30 m, H 60 m)	No.	1	24,561,404	24,561,404	Same as above
Underground Tunnel (Dia 3.5 m, Depth 50 m)	m	5000	7,104	35,517,544	Actual Value of Jakarta MRT Project (2013), Kolkata East-West Metro Project (2013), Metro Manila Paranaque Spillway (2017)
Total				61,921,053	
Route (3): Length 8.5 km, Diameter 7 m, 2 shafts (starting point, confluence (2)(3))					
Item	Unit	Quantity	Unit Price (USD)	Amount (USD)	Remarks
Inflow Facility	No.	2	1,842,105	3,684,211	Actual Unit Price (Metropolitan Area Outer Underground Discharge Channel) * 0.7
Shaft (Dia 30 m, H 60 m)	No.	1	24,561,404	24,561,404	Same as above
Shaft (Dia 15 m, H 60 m)	No.	1	12,280,702	12,280,702	Same as above
Underground Tunnel (Dia 7 m, Depth 50 m)	m	8500	25,538	217,070,614	Actual Value of Jakarta MRT Project (2013), Kolkata East-West Metro Project (2013), Metro Manila Paranaque Spillway (2017)
Total				257,596,930	
Route (4): Length 7.0 km, Diameter 10 m, 2 shafts (confluence(1)(3), endpoint)					
Item	Unit	Quantity	Unit Price (USD)	Amount (USD)	Remarks
Inflow Facility	No.	2	1,842,105	3,684,211	Actual Unit Price (Metropolitan Area Outer Underground Discharge Channel) * 0.7
Shaft (Dia 30 m, H 60 m)	No.	2	24,561,404	49,122,807	Same as above
Underground Tunnel (Dia 10 m, Depth 50 m)	m	7000	51,640	361,482,456	Actual Value of Jakarta MRT Project (2013), Kolkata East-West Metro Project (2013), Metro Manila Paranaque Spillway (2017)
Surge Tank (W180 x L180 x H10 m)	No.	1	23,105,263	23,105,263	Japanese construction package unit price (box) * 0.7
Pump (including Pump 50 m ³ /s x 4)	No.	1	263,157,895	263,157,895	Actual Unit Price (Metropolitan Area Outer Underground Discharge Channel) * Imported from Japan
Pump Station	No.	1	92,105,263	92,105,263	Actual Unit Price (Metropolitan Area Outer Underground Discharge Channel) * 0.7
Total				792,657,895	
Grand Total				1,319,185,526	USD

Implementation Schedule (Route ① + ② + ③ + ④)		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Item	Feasibility Study, E/N, L/A										
	Basic Design										
	Contractor Bidding (Design Build)										
	Shaft (Route ①③④ 合流部)										
	Shaft (Route ②③合流部)										
	Shaft (Route ①起点)										
	Shaft (Route ②起点)										
	Shaft (Route ③起点)										
	Shaft (Route ④終点)										
	区間A Tunnel (L=7000m, 8m/day each)										
	区間B Tunnel (L=5000m, 8m/day each)										
	区間C Tunnel (L=1500m, 8m/day each)										
	区間D Tunnel (L=7000m, 8m/day each)										
	区間E Tunnel (L=8000m, 8m/day each)										
	Surge tank										
	Pump Station										

It takes at least 3 years from the start of shaft construction to the start of shield excavation.



* The above process was based on the case of the Metropolitan Area Outer Floodway.

Figure 4-80 Draft Construction Schedule for Underground Channel

4.8.2 Estimated Project Cost and Economic Benefits

(1) Estimated Project Cost

The estimated project cost for flood countermeasures including underground channel, retarding basins and river improvement in Barat 2, Krukut River, and Pesanggrahan River is 1,986 Mil. USD (28,305 Bil. IDR).

Table 4-36 Estimated Overall Project Cost for Barat 2, Krukut, Pesanggrahan

Countermeasure Menu	Discharge Distribution				Total Cost (Mil.USD)
	Pesanggrahan	Barat2 (Lower Angke, Grogol)	Krukut,Mampang	Lowermost section	
(1)Construction Cost					
Drainage Pump	200m ³ /s				378
Underground Channel	80 m ³ /s (①ID 7m,L1=8km)	50 m ³ /s (②ID3.5m, 2=5km)	70m ³ /s (③ID 7m,L1=8.5km)	200m ³ /s (④ID 10m, L1=7km)	941
Retarding Basin	40m ³ /s Approx. 3.5MCM	—	90m ³ /s Approx. 2.3MCM	—	133
River Excavation	170m ³ /s、L=24km Depth 2m、 Volume 843,000m ³	90m ³ /s、L=14km Depth 1m、 Volume 241,000m ³	110m ³ /s、L=13km Depth 1.5~1m、 Volume 337,000m ³	—	84
Sub Total					1,536
(2) Incidental construction cost					
Bridge replacement	—	—	—	—	
Sub-Total					0
(3) Land compensation costs					
Land Compensation for Retarding Basin	91ha	—	25ha for Krukut 19.5ha for Mamg pang	—	119
Sub-Total					119
(4)Overhead costs (Σ[(1)to(3)]×20%)					331
(5)Total Cost					1,986

As for the ancillary works, it is assumed that the project will include outlet and bridge replacements, but the estimated construction cost of this study is not taken into account because it is only a rough estimate of the cost of the project. Therefore, a more detailed examination will be required in the next survey.

(2) Damage Reduction Effects for Different Return Periods

Inundation simulations were conducted with and without the overall countermeasures to investigate the damage reduction effects. Six simulation cases with different return period floods (100-year, 50-year, 30-year, 20-year, 10-year and 5-year) were carried out.

The damage reduction effects were organized by inundated area, inundated volume, number of inundated houses and damage costs. The damage reduction effects for each indicator are shown in Table 4-37 to Table 4-42 and Figure 4-81 to Figure 4-86.

Table 4-37 Damage Reduction of the Overall Countermeasures for Barat 2, Krukut and Pesanggrahan (100-Year Return Period)

Basin	Without countermeasures					With countermeasures					Damage Reduction				
	Inundation Area	Inundation Volume	Flooded Houses	Damage Cost		Inundation Area	Inundation Volume	Flooded Houses	Damage Cost		Inundation Area	Inundation Volume	Flooded Houses	Damage Cost	
Unit	km ²	MCM	No.	Mil.USD	Bil.IDR	km ²	MCM	No.	Mil.USD	Bil.IDR	km ²	MCM	No.	Mil.USD	Bil.IDR
Barat2	24	18	446,000	2,435	34,963	12	6	225,000	882	12,672	-12	-11	-221,000	-1,552	-22,291
Krukut	19	21	361,000	1,932	27,750	9	7	171,000	652	9,358	-10	-14	-190,000	-1,281	-18,393
Pesanggrahan	14	18	257,000	1,669	23,967	4	4	79,000	267	3,841	-9	-14	-178,000	-1,402	-20,127
Total	56	56	1,064,000	6,036	86,680	25	17	475,000	1,802	25,870	-31	-39	-589,000	-4,235	-60,810

※ 2050H unit was used.
 ※ Exchange Rate 1 USD = 14,360 IDR
 ※ Mil.USD = Million US Dollar, Bil.IDR = Billion Indonesian Rupiah
 ※ For the number of flooded houses, the average number of houses (1,000 units) per 230m x 230m grid was used.
 ※ GDP growth rate is assumed to be 1.6 times.

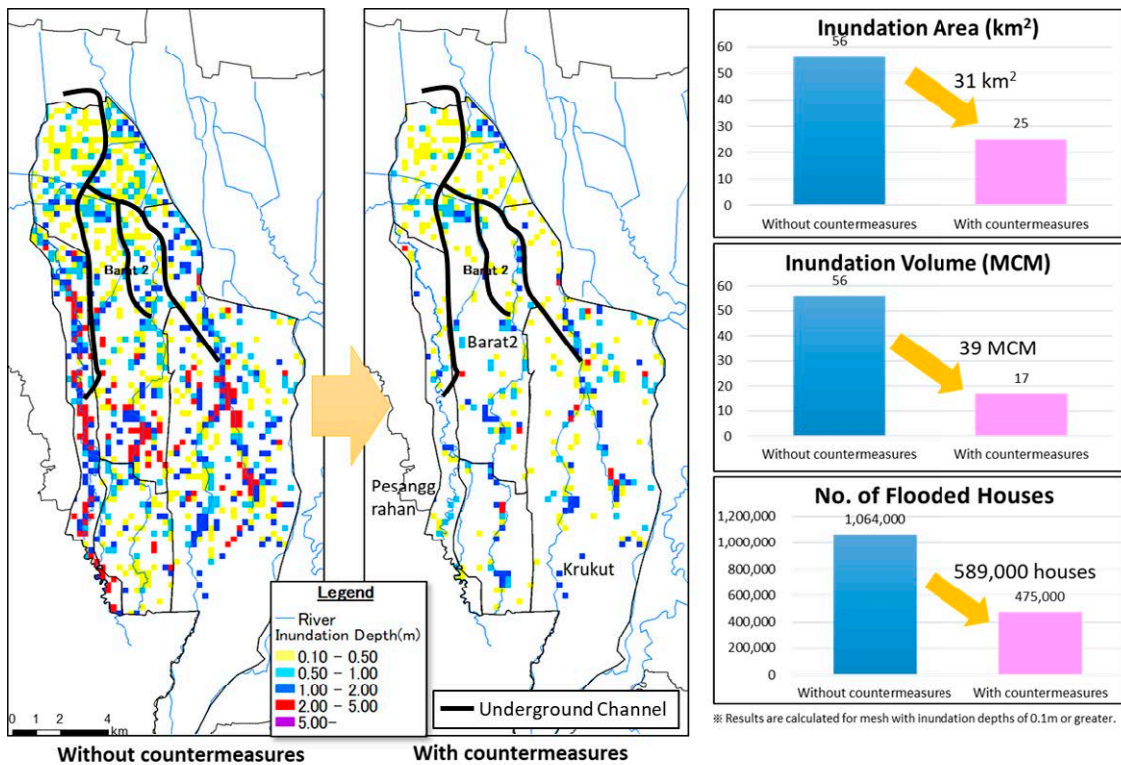
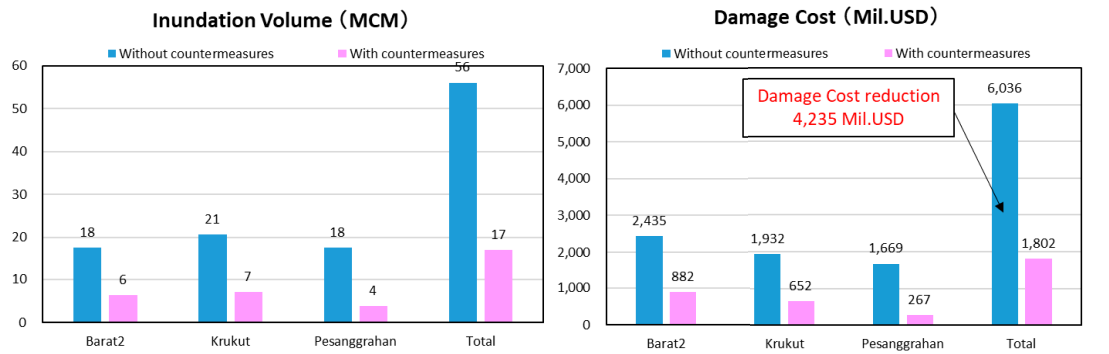


Figure 4-81 Damage Reduction of the Overall Countermeasures for Barat 2, Krukut and Pesanggrahan (100-Year Return Period)

Table 4-38 Damage Reduction of the Overall Countermeasures for Barat 2, Krukut and Pesanggrahan (50-Year Return Period)

Basin	Without countermeasures					With countermeasures					Damage Reduction				
	Inundation Area	Inundation Volume	Flooded Houses	Damage Cost		Inundation Area	Inundation Volume	Flooded Houses	Damage Cost		Inundation Area	Inundation Volume	Flooded Houses	Damage Cost	
Unit	km ²	MCM	No.	Mil.USD	Bil.IDR	km ²	MCM	No.	Mil.USD	Bil.IDR	km ²	MCM	No.	Mil.USD	Bil.IDR
Barat2	22	15	407,000	2,140	30,732	11	5	207,000	762	10,944	-11	-10	-200,000	-1,378	-19,789
Krukut	18	19	346,000	1,823	26,179	9	6	162,000	569	8,177	-10	-13	-184,000	-1,254	-18,002
Pesanggrahan	13	16	251,000	1,408	20,219	4	3	71,000	102	1,461	-10	-12	-180,000	-1,306	-18,757
Total	53	50	1,004,000	5,371	77,130	23	15	440,000	1,433	20,562	-30	-35	-564,000	-3,938	-56,548

※ 2050H unit was used.
 ※ Exchange Rate 1 USD = 14,360 IDR
 ※ Mil.USD = Million US Dollar, Bil.IDR = Billion Indonesian Rupiah
 ※ For the number of flooded houses, the average number of houses (1,000 units) per 230m x 230m grid was used.
 ※ GDP growth rate is assumed to be 1.6 times.

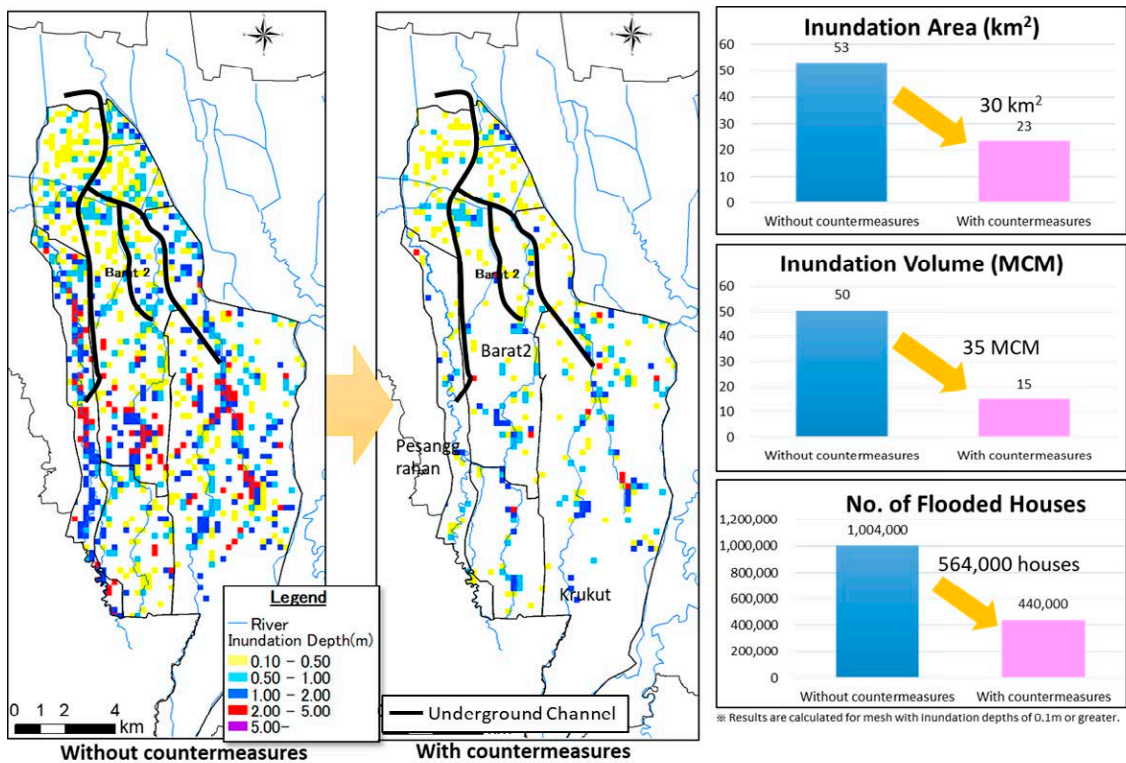
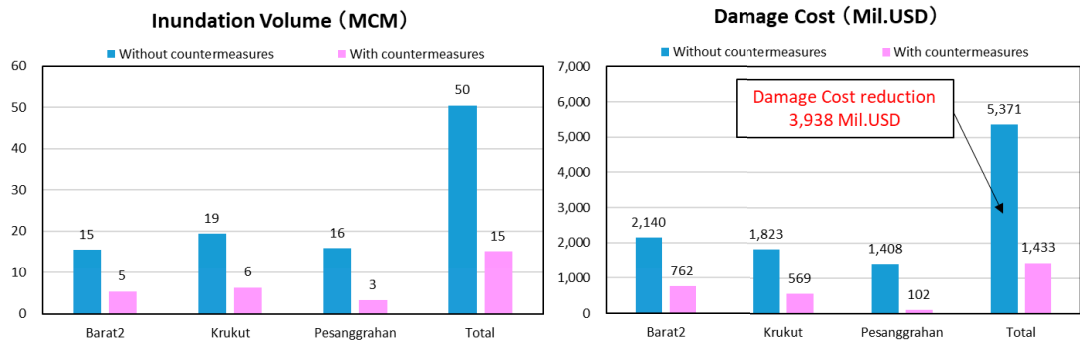


Figure 4-82 Damage Reduction of the Overall Countermeasures for Barat 2, Krukut and Pesanggrahan (50-Year Return Period)

Table 4-39 Damage Reduction of the Overall Countermeasures for Barat 2, Krukut and Pesanggrahan (30-Year Return Period)

Basin	Without countermeasures					With countermeasures					Damage Reduction				
	Inundation Area	Inundation Volume	Flooded Houses	Damage Cost		Inundation Area	Inundation Volume	Flooded Houses	Damage Cost		Inundation Area	Inundation Volume	Flooded Houses	Damage Cost	
Unit	km ²	MCM	No.	Mil.USD	Bil.IDR	km ²	MCM	No.	Mil.USD	Bil.IDR	km ²	MCM	No.	Mil.USD	Bil.IDR
Barat2	20	14	381,000	1,900	27,278	10	5	187,000	675	9,691	-10	-9	-194,000	-1,225	-17,588
Krukut	18	18	335,000	1,677	24,086	8	6	158,000	536	7,691	-9	-12	-177,000	-1,142	-16,394
Pesanggrahan	13	14	241,000	1,329	19,091	4	3	68,000	210	3,016	-9	-11	-173,000	-1,119	-16,076
Total	51	46	957,000	4,906	70,455	22	14	413,000	1,420	20,398	-29	-32	-544,000	-3,486	-50,057

※ 2050H unit was used.
 ※ Exchange Rate 1 USD =14,360 IDR
 ※ Mil.USD = Million US Dollar, Bil.IDR = Billion Indonesian Rupiah
 ※ For the number of flooded houses, the average number of houses (1,000 units) per 230m x 230m grid was used.
 ※ GDP growth rate is assumed to be 1.6 times.

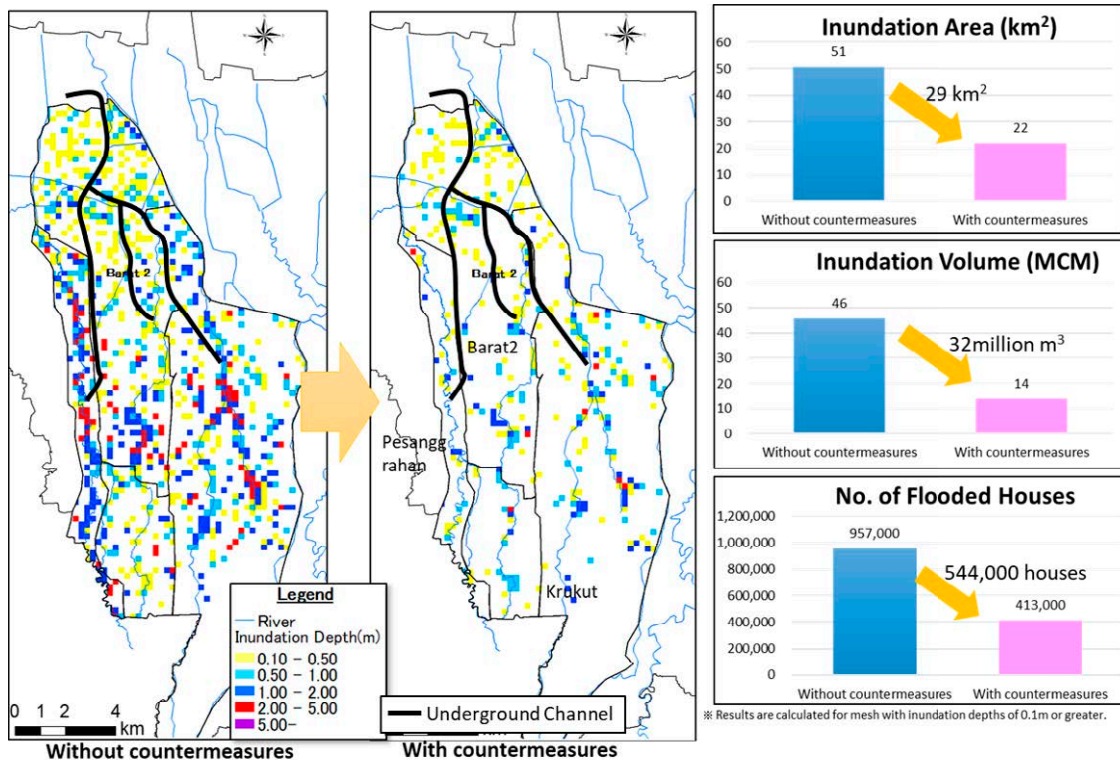
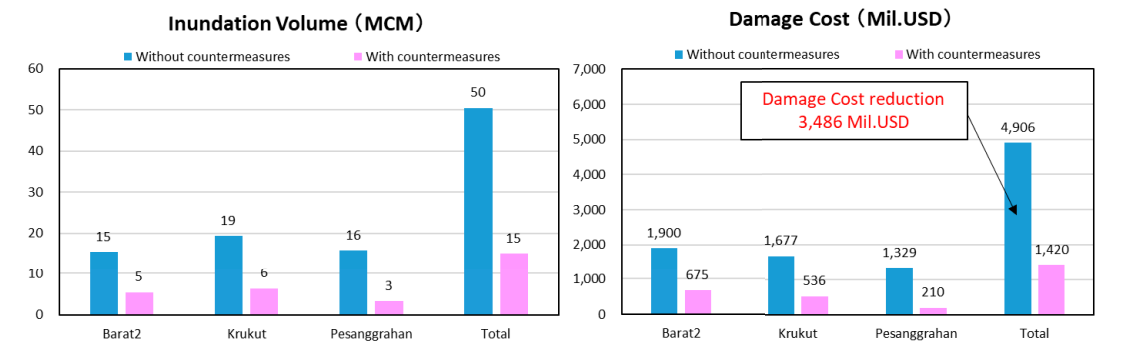


Figure 4-83 Damage Reduction of the Overall Countermeasures for Barat 2, Krukut and Pesanggrahan (30-Year Return Period)

Table 4-40 Damage Reduction of the Overall Countermeasures for Barat 2, Krukut and Pesanggrahan (20-Year Return Period)

Basin	Without countermeasures				With countermeasures				Damage Reduction			
	Inundation Area	Inundation Volume	Flooded Houses	Damage Cost	Inundation Area	Inundation Volume	Flooded Houses	Damage Cost	Inundation Area	Inundation Volume	Flooded Houses	Damage Cost
Unit	km ²	MCM	No.	Mil.USD Bil.IDR	km ²	MCM	No.	Mil.USD Bil.IDR	km ²	MCM	No.	Mil.USD Bil.IDR
Barat2	20	13	371,000	1,777 25,514	9	4	174,000	610 8,762	-10	-8	-197,000	-1,167 -16,752
Krukut	17	17	328,000	1,646 23,639	8	6	151,000	504 7,244	-9	-12	-177,000	-1,142 -16,395
Pesanggrahan	13	14	237,000	1,308 18,787	3	3	62,000	190 2,751	-9	-11	-175,000	-1,118 -16,057
Total	50	44	936,000	4,731 67,940	20	13	387,000	1,305 18,736	-29	-32	-549,000	-3,426 -49,205

※ 2050H unit was used.
 ※ Exchange Rate 1 USD =14,360 IDR
 ※ Mil.USD = Million US Dollar, Bil.IDR = Billion Indonesian Rupiah
 ※ For the number of flooded houses, the average number of houses (1,000 units) per 230m x 230m grid was used.
 ※ GDP growth rate is assumed to be 1.6 times.

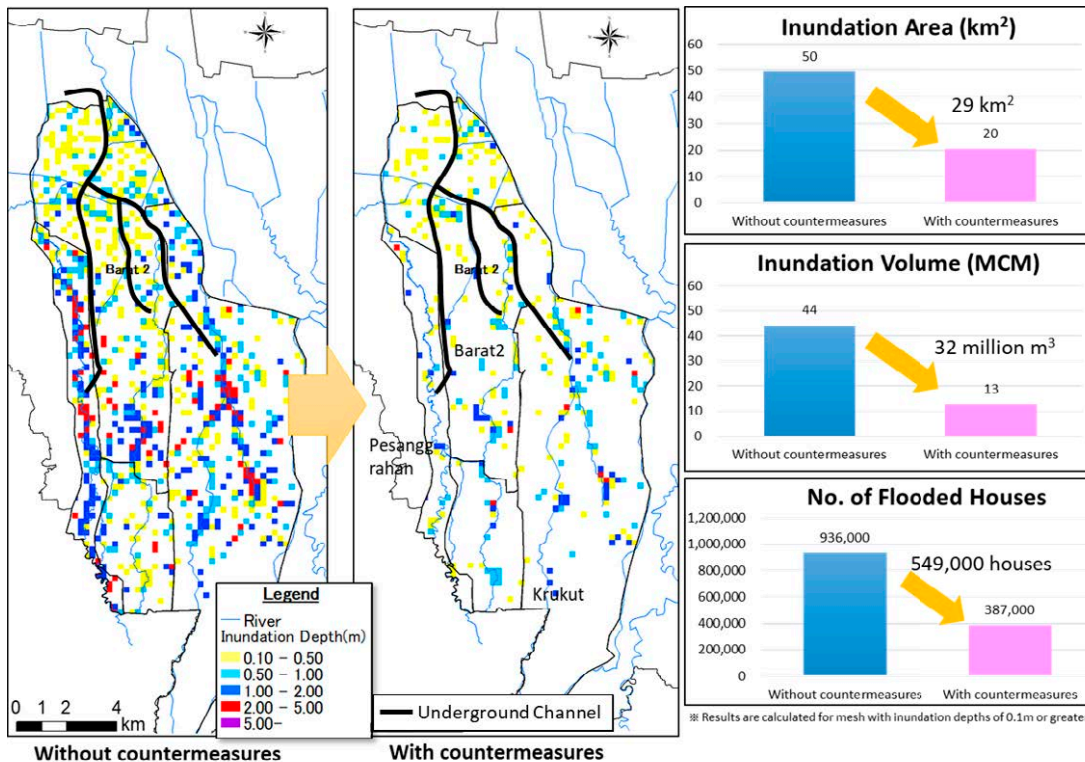
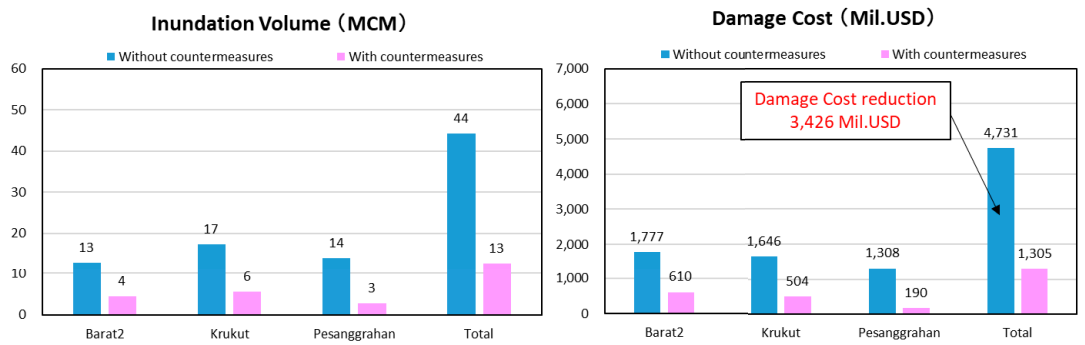


Figure 4-84 Damage Reduction of the Overall Countermeasures for Barat 2, Krukut and Pesanggrahan (20-Year Return Period)

Table 4-41 Damage Reduction of the Overall Countermeasures for Barat 2, Krukut and Pesanggrahan (10-Year Return Period)

Basin	Without countermeasures					With countermeasures					Damage Reduction				
	Inundation Area	Inundation Volume	Flooded Houses	Damage Cost		Inundation Area	Inundation Volume	Flooded Houses	Damage Cost		Inundation Area	Inundation Volume	Flooded Houses	Damage Cost	
Unit	km ²	MCM	No.	Mil.USD	Bil.IDR	km ²	MCM	No.	Mil.USD	Bil.IDR	km ²	MCM	No.	Mil.USD	Bil.IDR
Barat2	18	11	347,000	1,552	22,289	8	4	154,000	488	7,011	-10	-7	-193,000	-1,064	-15,277
Krukut	17	16	312,000	1,521	21,847	8	5	143,000	444	6,371	-9	-11	-169,000	-1,078	-15,476
Pesanggrahan	12	12	221,000	1,126	16,171	3	2	52,000	167	2,403	-9	-10	-169,000	-959	-13,768
Total	47	39	880,000	4,200	60,306	18	11	349,000	1,099	15,785	-28	-28	-531,000	-3,100	-44,521

※ 2050H unit was used.
 ※ Exchange Rate 1 USD =14,360 IDR
 ※ Mil.USD = Million US Dollar, Bil.IDR = Billion Indonesian Rupiah
 ※ For the number of flooded houses, the average number of houses (1,000 units) per 230m x 230m grid was used.
 ※ GDP growth rate is assumed to be 1.6 times.

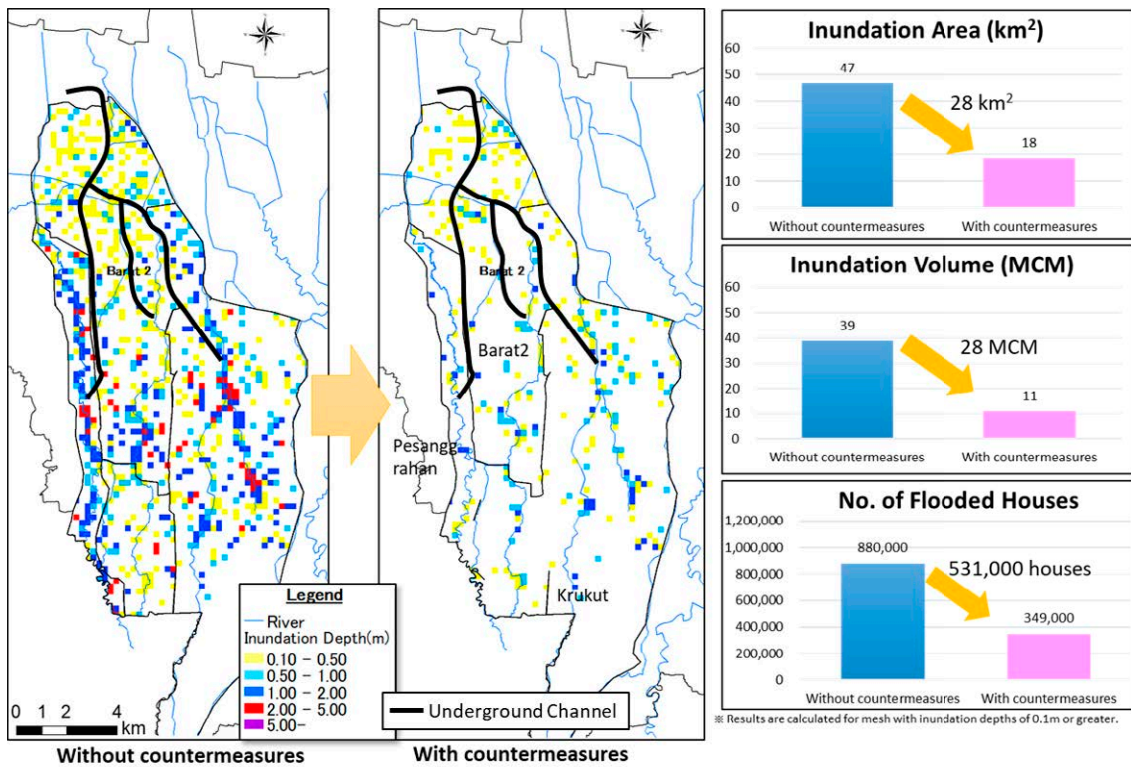
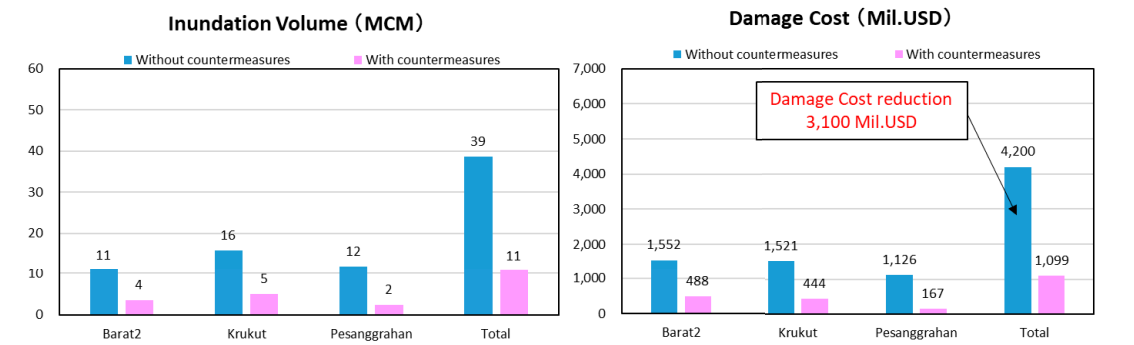


Figure 4-85 Damage Reduction of the Overall Countermeasures for Barat 2, Krukut and Pesanggrahan (10-Year Return Period)

Table 4-42 Damage Reduction of the Overall Countermeasures for Barat 2, Krukut and Pesanggrahan (5-Year Return Period)

Basin	Without countermeasures					With countermeasures					Damage Reduction				
	Inundation Area	Inundation Volume	Flooded Houses	Damage Cost		Inundation Area	Inundation Volume	Flooded Houses	Damage Cost		Inundation Area	Inundation Volume	Flooded Houses	Damage Cost	
Unit	km ²	MCM	No.	Mil.USD	Bil.IDR	km ²	MCM	No.	Mil.USD	Bil.IDR	km ²	MCM	No.	Mil.USD	Bil.IDR
Barat2	17	10	321,000	1,353	19,429	7	3	126,000	386	5,539	-10	-7	-195,000	-967	-13,890
Krukut	16	14	303,000	1,321	18,967	7	4	130,000	404	5,795	-9	-10	-173,000	-917	-13,172
Pesanggrahan	11	10	205,000	925	13,284	2	2	39,000	144	2,070	-9	-8	-166,000	-781	-11,214
Total	44	34	829,000	3,599	51,680	16	9	295,000	933	13,404	-28	-25	-534,000	-2,666	-38,277

※ 2050H unit was used.
 ※ Exchange Rate 1 USD = 14,360 IDR
 ※ Mil.USD = Million US Dollar, Bil.IDR = Billion Indonesian Rupiah
 ※ For the number of flooded houses, the average number of houses (1,000 units) per 230m x 230m grid was used.
 ※ GDP growth rate is assumed to be 1.6 times.

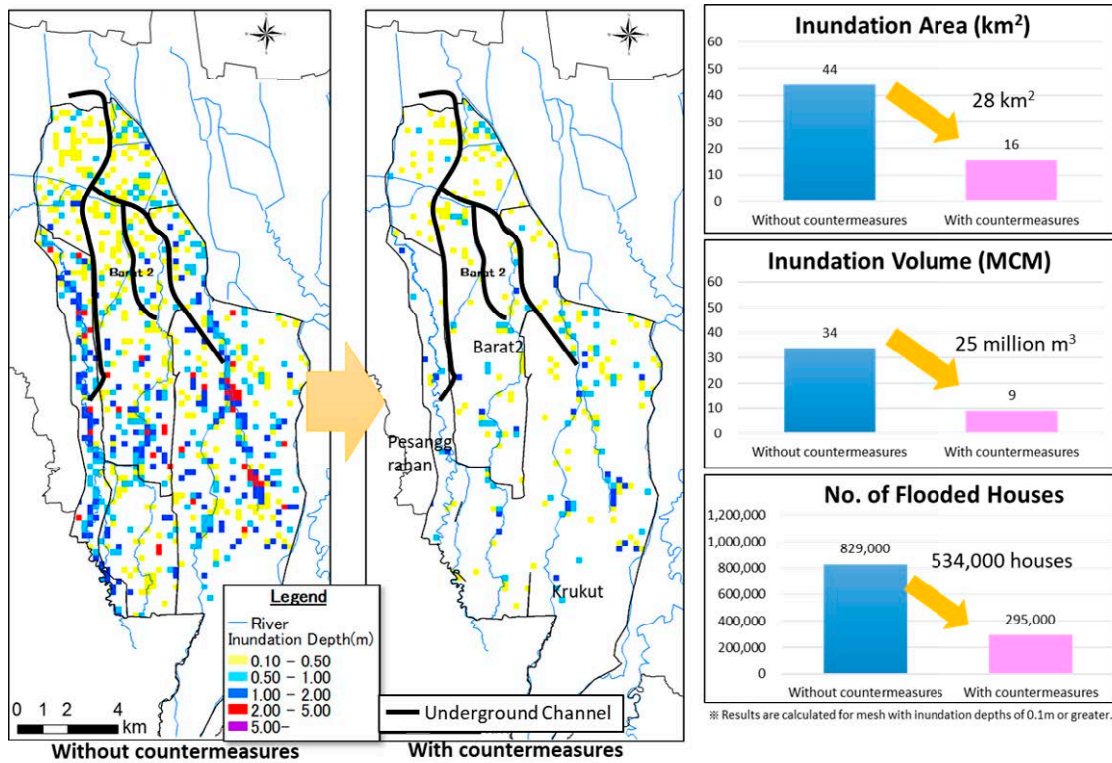
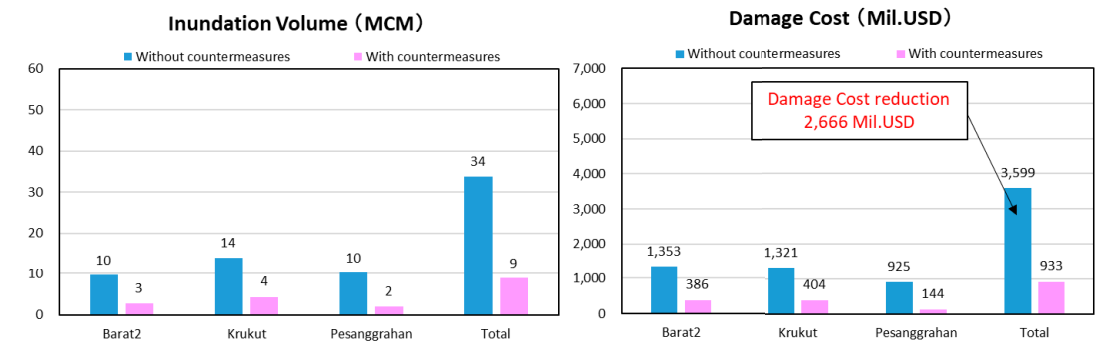


Figure 4-86 Damage Reduction of the Overall Countermeasures for Barat 2, Krukut and Pesanggrahan (5-Year Return Period)

(3) Expected Annual Average Damage Reduction

The damage reduction effect was confirmed by comparing each damage cost for different return periods flood, with and without countermeasures.

The expected annual average damage reduction cost was estimated to be approximately 599 Mil.USD (8,602 Bil.IDR).

Table 4-43 Expected Annual Average Damage Reduction Cost
(Barat 2, Krukut, Pesanggrahan)

Design Flood Frequency (1/Return Period)	Probability	Damage Cost		③=①-② Damage Reduction Cost (Mil.USD)	④ Section Average Damage Reduction Cost (Mil.USD)	⑤ Section Probability	④x⑤ Annual Average Damage Reduction Cost (Mil.USD)	Cumulative Annual Average Damage Reduction Cost = Expected Annual Average Damage Reduction Cost (Mil.USD)
		① Without Countermeasures (Mil.USD)	② With Countermeasures (Mil.USD)					
		1/5	0.2					
1/10	0.1	4,200	1,099	3100.34	2882.92	0.10	288	288
1/20	0.05	4,731	1,305	3426.50	3263.42	0.05	163	451
1/30	0.03	4,906	1,420	3485.87	3456.19	0.02	58	509
1/50	0.02	5,371	1,433	3937.91	3711.89	0.01	49	559
1/100	0.01	6,036	1,802	4234.70	4086.30	0.01	41	599

※ Mil.USD = Million US Dollar

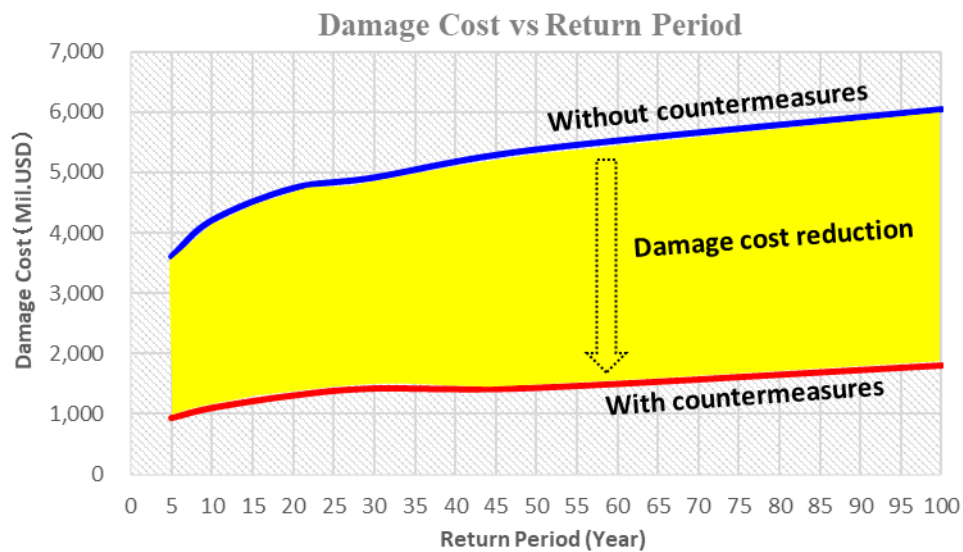


Figure 4-87 Damage cost for different return periods flood, with and without countermeasures (Barat 2, Krukut, Pesanggrahan)

(4) Economic Evaluation

(i) Evaluation Conditions

a Evaluation Period

The project implementation period will be 10 years from 2022, and the project evaluation period will be 50 years after the project completion.

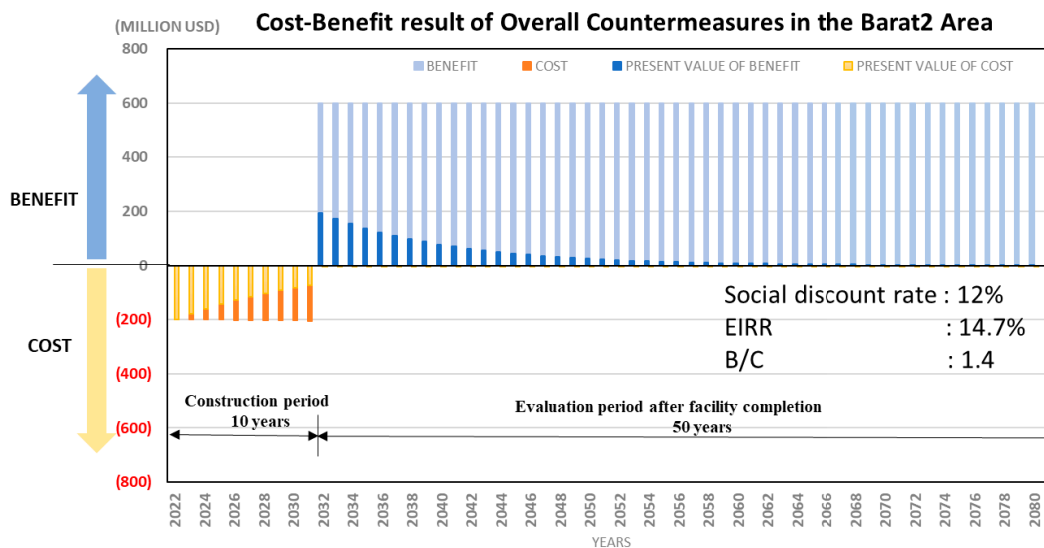
b Social Discount Rate

The social discount rate was set to 12% from the standard value of 10-12%, which is generally adopted for Japanese Yen loan projects, with reference to the standards of the World Bank, Asian Development Bank, JICA and others.

(ii) Evaluation Result

The results of the economic evaluation using costs and benefits are as follows, confirming the high cost-effectiveness and economic benefits of the project.

- The equity internal rate of return (EIRR) is 14.7%, which exceeded 12%, confirming the high cost-effectiveness of the project.
- Cost-benefit ratio (B/C) is 1.4, which exceeded 1, also indicating that the project was highly cost-effective.



※) This is calculated by rough project cost estimation.

Figure 4-88 Cost-Benefit (Barat 2, Krukut, Pesanggrahan)

4.9 Flood Countermeasure in Timur 2

4.9.1 Study on Flood Countermeasures for Timur 2

(1) Combinations of Flood Countermeasures

Considering the normalization plan of the Cakung Drain of BBWS and the current flow capacity of the Cakung Drain, widening the channel, raising the embankment, and excavating the channel will be studied to improve the flow capacity of the Cakung Drain.

- Case 1: River Widening only
- Case 2: Embankment Raising only
- Case 3: River Excavation only

Table 4-44 Case Study on the Flood Countermeasures for Timur 2

Case No.	Countermeasures	River Improvement		
		River Widening	Embankment Raising	River Excavation
1	• River Widening only	○	—	—
2	• Embankment Raising only	—	○	—
3	• River Excavation only	—	—	○

(2) Comparative Case Study on the Flood Countermeasures

A comparative case study of different river improvement methods was conducted to evaluate the feasibility of the project. The criteria for evaluation were technical, social, safety, and project costs.

Compared to other cases, Case 3: River Excavation only was determined to be the most applicable countermeasure because it is technically and socially feasible, ensures safety, and has the lowest project cost.

Table 4-45 Comparative Case Study on River Improvement

Case	Evaluation		Judgment
	Technical Aspect	Social & Environment Aspect	
1 River Widening only	<ul style="list-style-type: none"> Feasible Requires coordination with the river/facilities managers 	<ul style="list-style-type: none"> Not feasible Requires a large-scale land acquisition and relocation 	<p>Too High Cost</p> <p>-Total Cost : 762 MILUSD (10,853 BILIDR)</p> <ul style="list-style-type: none"> Construction Cost : 134 MILUSD (1,903 BILIDR) Land Acquisition Area: 7.8 ha Land Cost : 478 MILUSD (6,809 BILIDR) Compensation Fee: 150 MILUSD (2,141 BILIDR)
	<ul style="list-style-type: none"> Not feasible Requires coordination with the river/facilities managers 	<ul style="list-style-type: none"> Not feasible Requires a reconstruction of ancillary facilities such as bridges and gutters, land acquisition and relocation 	
2 Embankment Raising only	<ul style="list-style-type: none"> Feasible Requires coordination with the river/facilities managers 	<ul style="list-style-type: none"> Small effect on Social & Environment. 	<p>High Cost</p> <p>-Total Cost : 775 MILUSD (11,038 BILIDR)</p> <ul style="list-style-type: none"> Construction Cost : 339 MILUSD (4,825 BILIDR) Land Acquisition Area: 7.8 ha Land Cost : 384 MILUSD (5,467 BILIDR) Compensation Fee : 52 MILUSD (745 BILIDR)
	<ul style="list-style-type: none"> Feasible Requires coordination with the river/facilities managers 	<ul style="list-style-type: none"> Can lower flood water level (improve flow capacity) 	
3 River Excavation only	<ul style="list-style-type: none"> Feasible Requires coordination with the river/facilities managers 	<ul style="list-style-type: none"> Can lower flood water level (improve flow capacity) 	<p>High Cost</p> <p>-Total Cost : 623 MILUSD (8,881 BILIDR)</p> <ul style="list-style-type: none"> Construction Cost : 187 MILUSD (2,669 BILIDR) Land Acquisition Area: 7.8 ha Land Cost : 384 MILUSD (5,467 BILIDR) Compensation Fee : 52 MILUSD (745 BILIDR)
	<ul style="list-style-type: none"> Can lower flood water level (improve flow capacity) 	<ul style="list-style-type: none"> It will increase flood water level that is against the basic principle of flood control 	

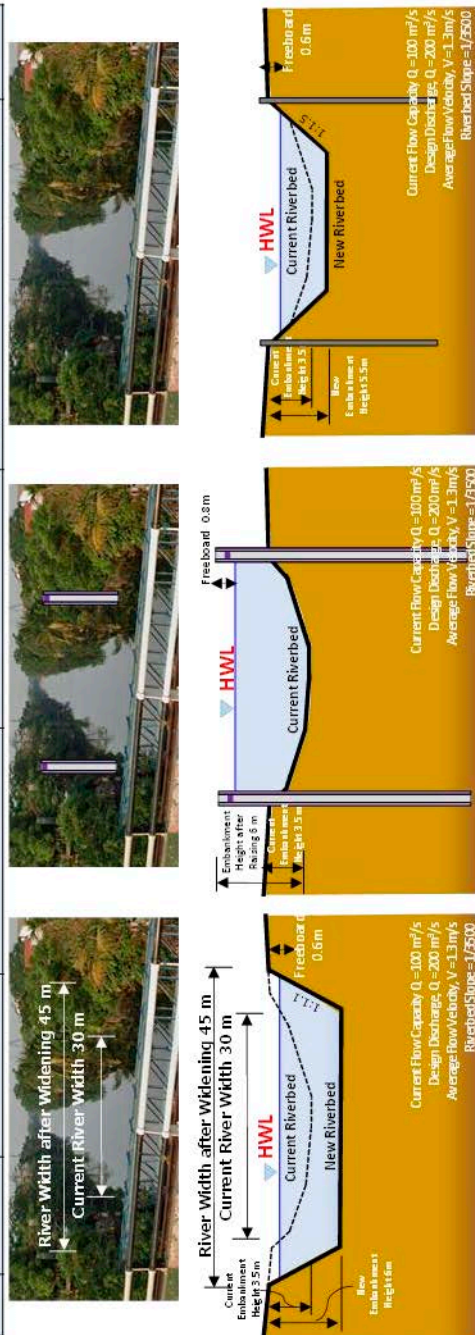


Figure 4-89 Cross-sectional Profile of River Channel Improvement

(3) Review of the Excavation Plan of BBWS Cilicis

(i) Excavation Plan

The river excavation plan by BBWS Cilicis is shown in Figure 4-90. The excavation plan includes the construction of a channel on both sides of the river, which will cover the shortage of embankment height on the right bank of the section 6 km-9 km.

The sheet pile revetment is adopted to secure the height of the embankment and provide a passageway for management. In order to secure the river volume, in-channel excavation is performed. In the section where the river is wide enough, the riverbed width is 15 m and the slope is 1:1.5. This design is considered to be based on the experience of the BBWS.

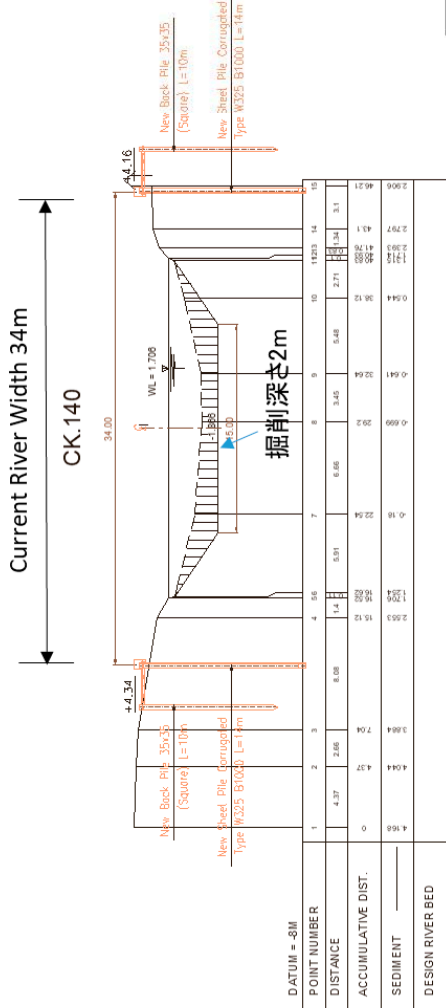
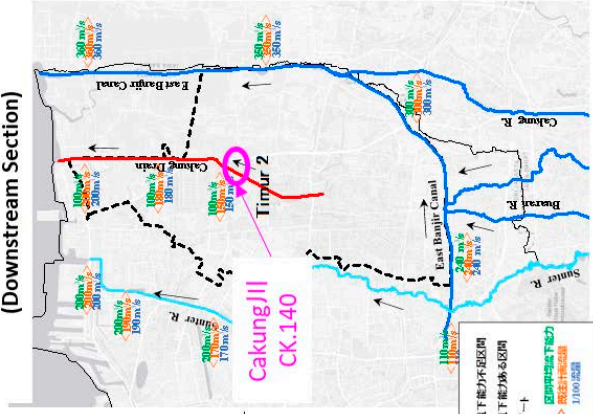
Excavation Plan Specifications

Planned dredging section	: from the river mouth up to approx. 9.8 km
Planned dredging depth	: approx. 2 m
Planned dredging gradient	: 1/3,290
Sheet pile	: revetment
Width of management corridor	: approx. 4 m

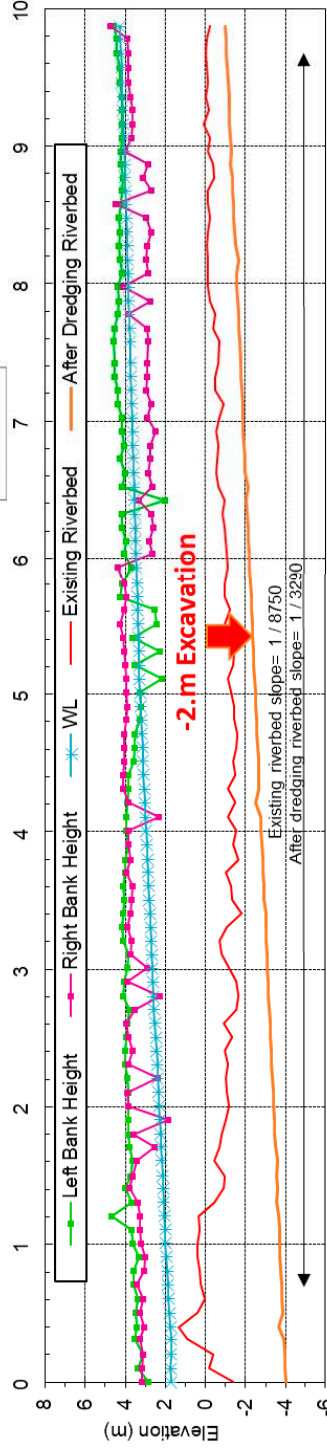
(ii) Review of Excavation Plan

Based on the excavation plan by BBWS Cilicis, the flow capacity of the excavated river channel was evaluated. The results are shown in Figure 4-91, and it was confirmed that the planned flow rate was planned to flow below HWL.

Planned Flow Rate $Q = 200 \text{ m}^3/\text{s}$
 (Downstream Section)



Cross section of river by BBWS Cilicis



Cakung Drain Longitudinal Profile

Figure 4-90 River Channel Excavation Plan by BBWS Cilicis in Timur 2

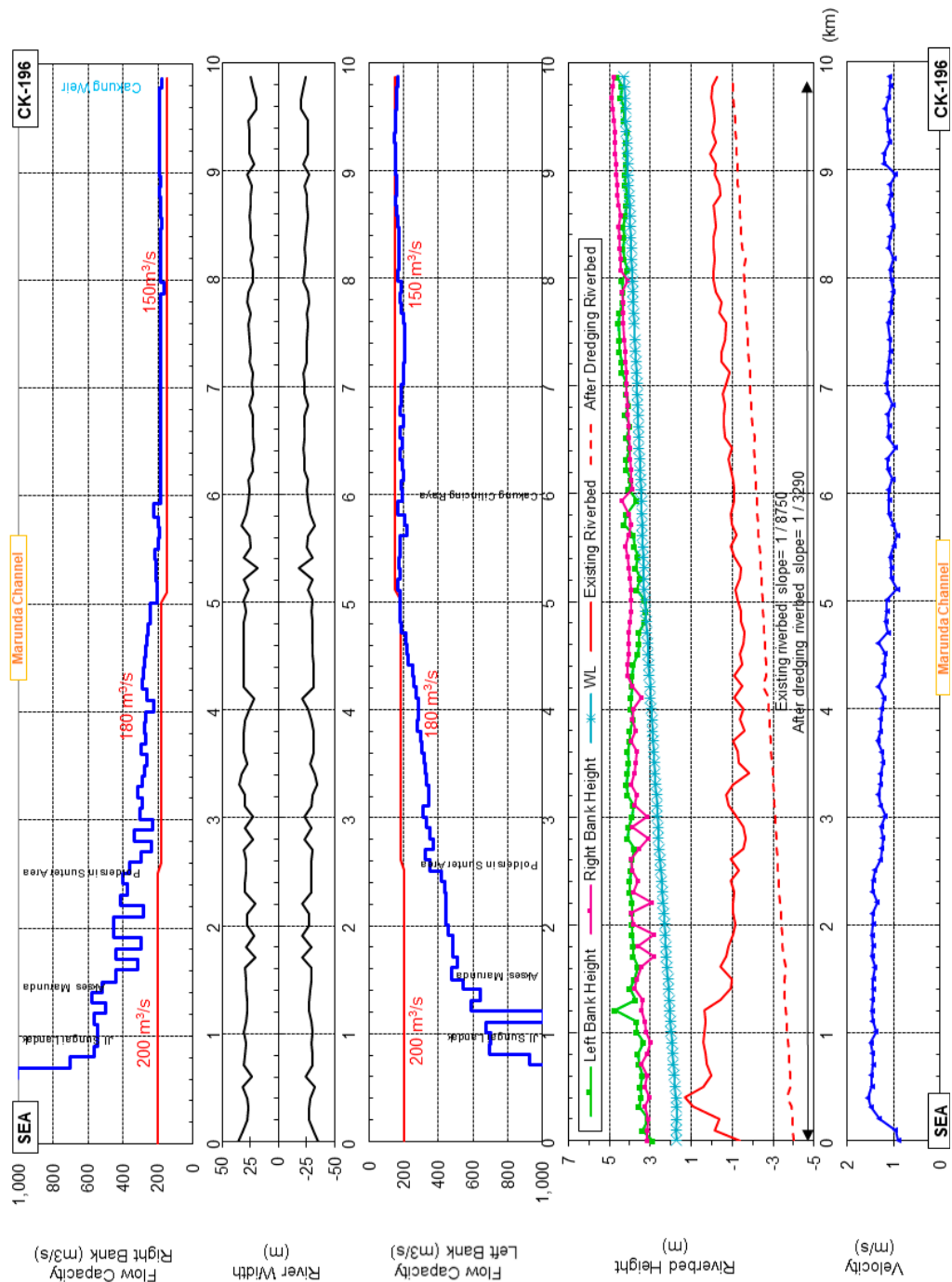


Figure 4-91 Cakung Drain Flow Capacity Diagram (After excavation of river channel)

(4) Summary of the Optimal Plan

(i) Flood Control Menu

In Cakung Drain, it was confirmed that a 100-year return period flood could be controlled by in-channel excavating and partial sheet pile raising. On the other hand, the catchment area is low-lying and it is necessary to increase the drainage capacity to the main river. BBW Cil-Cis has proposed the construction of the three drainage pump stations and retarding basins along the Cakung Drain, which will be adopted.

Figure 4-92 shows an overall image of countermeasures for Timur 2.

- Excavation of Cakung River
- Construction of drainage pump station and retarding basin

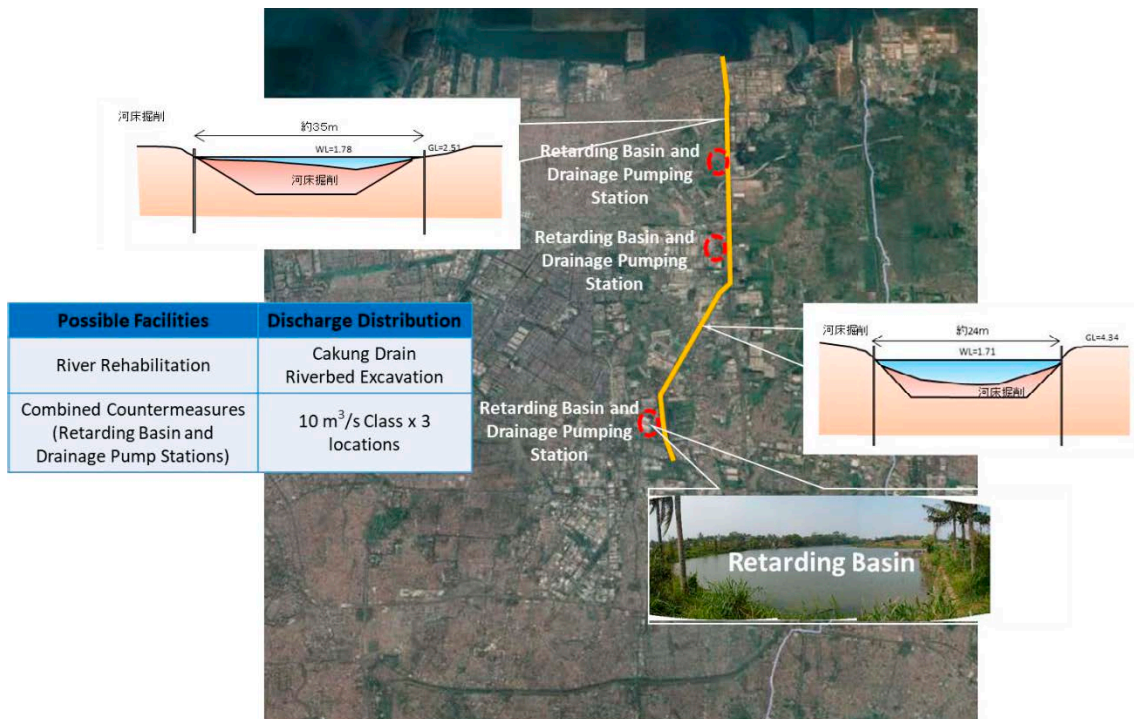


Figure 4-92 Overall image of countermeasures for Timur 2 (Draft)

(ii) Construction Cost Estimation

The estimated construction cost of the flood countermeasures including excavation of Cakung Drain and combined countermeasures (retarding basin, drainage pump station) is 188 Mil. USD (2,669 Bil. IDR).

Table 4-46 Estimated Construction Cost of Overall Countermeasures for Timur 2

Countermeasure Menu	Discharge Distribution	Total Cost (Mil.USD)
	Cakung Drain	
River Excavation (Construction Cost)	200m ³ /s、L=9.8 km Depth 2m、 Volume 317,000m ³ 74 Mil.USD	74
Drainage Pump (Construction Cost)	30m ³ /s (57 Mil.USD)	57
Retarding Basin (Construction Cost)	Approx. 2.6MCM 57Mil.USD	57
Total		188

4.9.2 Estimated Project Cost and Economic Benefits

(1) Estimated Project Cost

The estimated project cost for flood countermeasures including the excavation of Cakung Drain and combined countermeasures (retarding basin, drainage pump station), is 625 Mil. USD (8,905 Bil. IDR), which is the estimated construction cost plus land compensation and overhead costs.

Table 4-47 Estimated Overall Project Cost for Timur 2

Countermeasure Menu	Discharge Distribution	Total Cost (Mil.USD)
	Cakung Drain	
(1) Construction Cost		
River Excavation	Qd=200m ³ /s、L=9.8 km、Depth 2m Volume 317,000m ³	74
Sub Total		74
(2) Incidental construction cost		
Drainage Pump	30m ³ /s	57
Retarding Basin	Approx. 2.6MCM	57
Sub-Total		114
(3) Land compensation costs		
Land Acquisition	86ha for Retarding Basin	333
Sub-Total		333
(4) Overhead costs (Σ[(1)to(3)]×20%)		104
(5) Total Cost		625

(2) Damage Reduction Effects for Different Return Periods

Inundation simulations were conducted with and without the overall countermeasures to investigate the damage reduction effects. Six simulation cases with different return period floods (100-year, 50-year, 30-year, 20-year, 10-year and 5-year) were carried out.

The damage reduction effects were organized by inundated area, inundated volume, number of inundated houses and damage costs. The damage reduction effects for each indicator are shown in Table 4-48 to Table 4-53 and Figure 4-93 to Figure 4-98.

Table 4-48 Damage Reduction of the Overall Countermeasures in Timur 2
(100-Year Return Period)

Basin	Without countermeasures					With countermeasures					Damage Reduction				
	Inundation Area	Inundation volume	Flooded Houses	Damage cost		Inundation Area	Inundation volume	Flooded Houses	Damage cost		Inundation Area	Inundation volume	Flooded Houses	Damage cost	
Unit	km ²	MCM	No.	Mil. USD	Bil. IDR	km ²	MCM	No.	Mil. USD	Bil. IDR	km ²	MCM	No.	Mil. USD	Bil. IDR
Timur 2	38	18	718,000	1,091	15,672	32	11	600,000	733	10,532	-6	-7	-118,000	-358	-5,141
Total	38	18	718,000	1,091	156,723	32	11	600,000	733	105,318	-6	-7	-118,000	-358	-51,405

※ 2050H unit was used.
 ※ Exchange Rate 1 USD =14,360 IDR
 ※ Mil.USD = Million US Dollar, Bil.IDR = Billion Indonesian Rupiah
 ※ For the number of flooded houses, the average number of houses (1,000 units) per 230mx230m grid was used.
 ※ GDP growth rate is assumed to be 1.6 times.

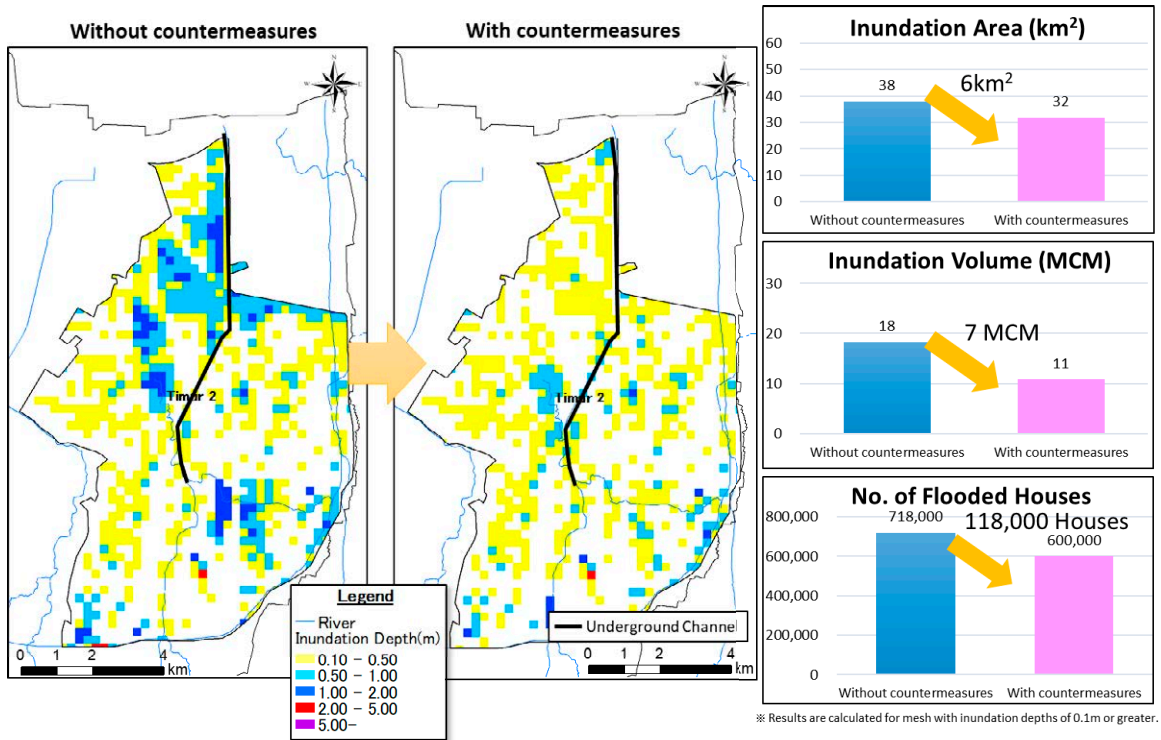


Figure 4-93 Damage Reduction of the Overall Countermeasures in Timur 2
(100-Year Return Period)

Table 4-49 Damage Reduction of the Overall Countermeasures in Timur 2
(50-Year Return Period)

Basin	Without countermeasures					With countermeasures					Damage Reduction				
	Inundation Area	Inundation volume	Flooded Houses	Damage cost		Inundation Area	Inundation volume	Flooded Houses	Damage cost		Inundation Area	Inundation volume	Flooded Houses	Damage cost	
Unit	km ²	MCM	No.	Mil. USD	Bil.IDR	km ²	MCM	No.	Mil. USD	Bil.IDR	km ²	MCM	No.	Mil. USD	Bil.IDR
Timur 2	36	17	674,000	1,073	15,408	29	10	557,000	701	10,069	-6	-7	-117,000	-372	-5,339
全体	36	17	674,000	1,073	154,082	29	10	557,000	701	100,688	-6	-7	-117,000	-372	-53,394

※ 2050H unit was used.
 ※ Exchange Rate 1 USD =14,360 IDR
 ※ Mil.USD = Million US Dollar, Bil.IDR = Billion Indonesian Rupiah
 ※ For the number of flooded houses, the average number of houses (1,000 units) per 230mx230m grid was used.
 ※ GDP growth rate is assumed to be 1.6 times.

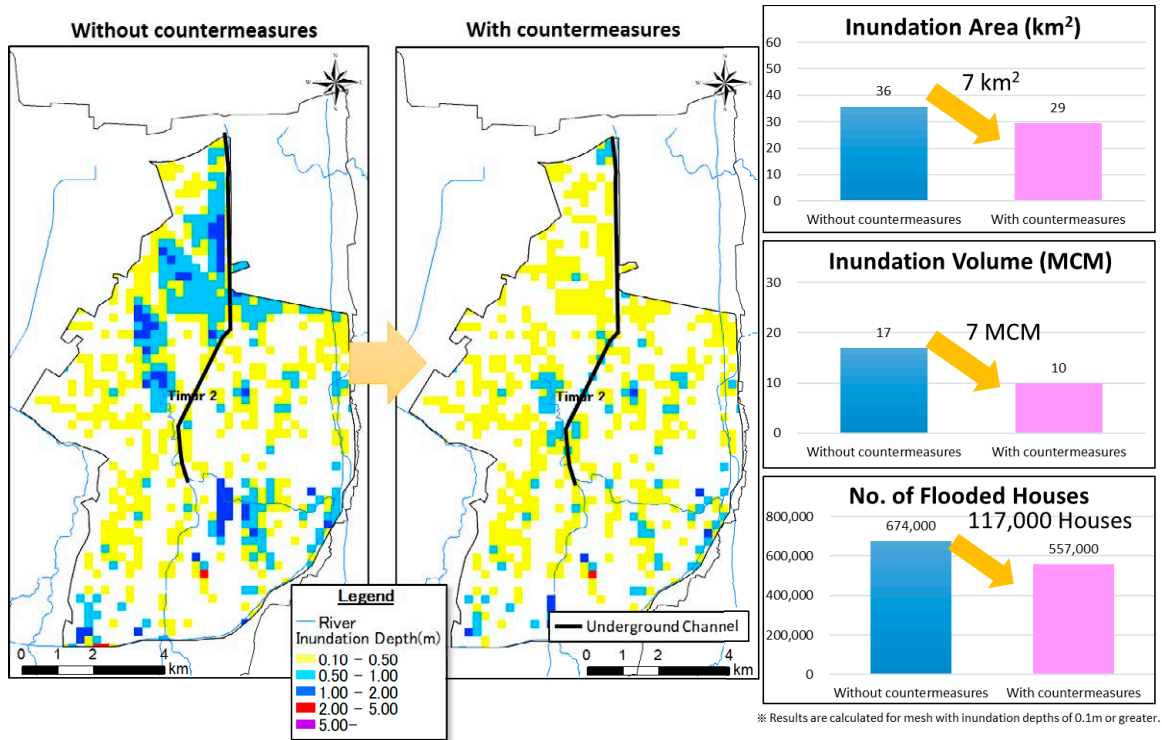


Figure 4-94 Damage Reduction of the Overall Countermeasures in Timur 2
(50-Year Return Period)

Table 4-50 Damage Reduction of the Overall Countermeasures in Timur 2
(30-Year Return Period)

Basin	Without countermeasures					With countermeasures					Damage Reduction				
	Inundation Area	Inundation volume	Flooded Houses	Damage cost		Inundation Area	Inundation volume	Flooded Houses	Damage cost		Inundation Area	Inundation volume	Flooded Houses	Damage cost	
Unit	km ²	MCM	No.	Mil. USD	Bil. IDR	km ²	MCM	No.	Mil. USD	Bil. IDR	km ²	MCM	No.	Mil. USD	Bil. IDR
Timur 2	34	16	645,000	1,019	14,628	29	9	541,000	638	9,158	-6	-7	-104,000	-381	-5,470
全体	34	16	645,000	1,019	146,282	29	9	541,000	638	91,581	-6	-7	-104,000	-381	-54,700

※ 2050H unit was used.
 ※ Exchange Rate 1 USD =14,360 IDR
 ※ Mil.USD = Million US Dollar, Bil.IDR = Billion Indonesian Rupiah
 ※ For the number of flooded houses, the average number of houses (1,000 units) per 230mx230m grid was used.
 ※ GDP growth rate is assumed to be 1.6 times.

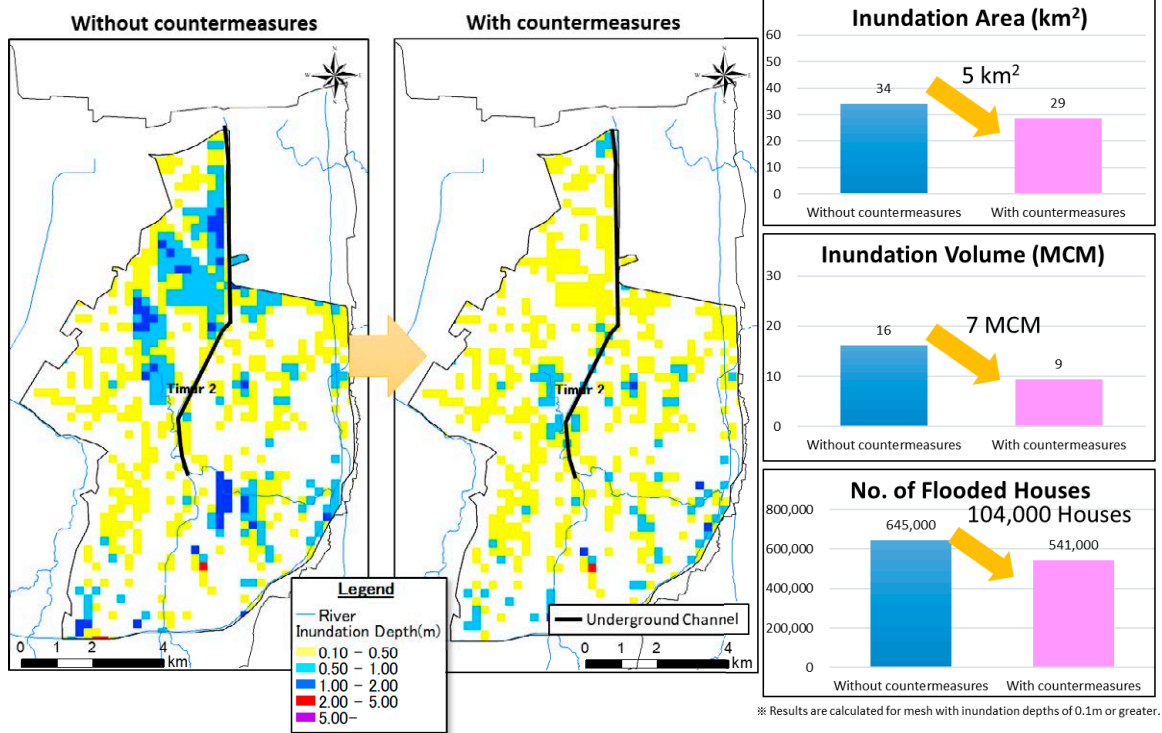


Figure 4-95 Damage Reduction of the Overall Countermeasures in Timur 2
(30-Year Return Period)

Table 4-51 Damage Reduction of the Overall Countermeasures in Timur 2
(20-Year Return Period)

Basin	Without countermeasures					With countermeasures					Damage Reduction				
	Inundation Area	Inundation volume	Flooded Houses	Damage cost		Inundation Area	Inundation volume	Flooded Houses	Damage cost		Inundation Area	Inundation volume	Flooded Houses	Damage cost	
Unit	km ²	MCM	No.	Mil. USD	Bil. IDR	km ²	MCM	No.	Mil. USD	Bil. IDR	km ²	MCM	No.	Mil. USD	Bil. IDR
Timur 2	33	15	632,000	954	13,706	27	9	515,000	594	8,526	-6	-7	-117,000	-361	-5,180
全体	33	15	632,000	954	137,060	27	9	515,000	594	85,257	-6	-7	-117,000	-361	-51,803

※ 2050H unit was used.
 ※ Exchange Rate 1 USD =14,360 IDR
 ※ Mil.USD = Million US Dollar, Bil.IDR = Billion Indonesian Rupiah
 ※ For the number of flooded houses, the average number of houses (1,000 units) per 230mx230m grid was used.
 ※ GDP growth rate is assumed to be 1.6 times.

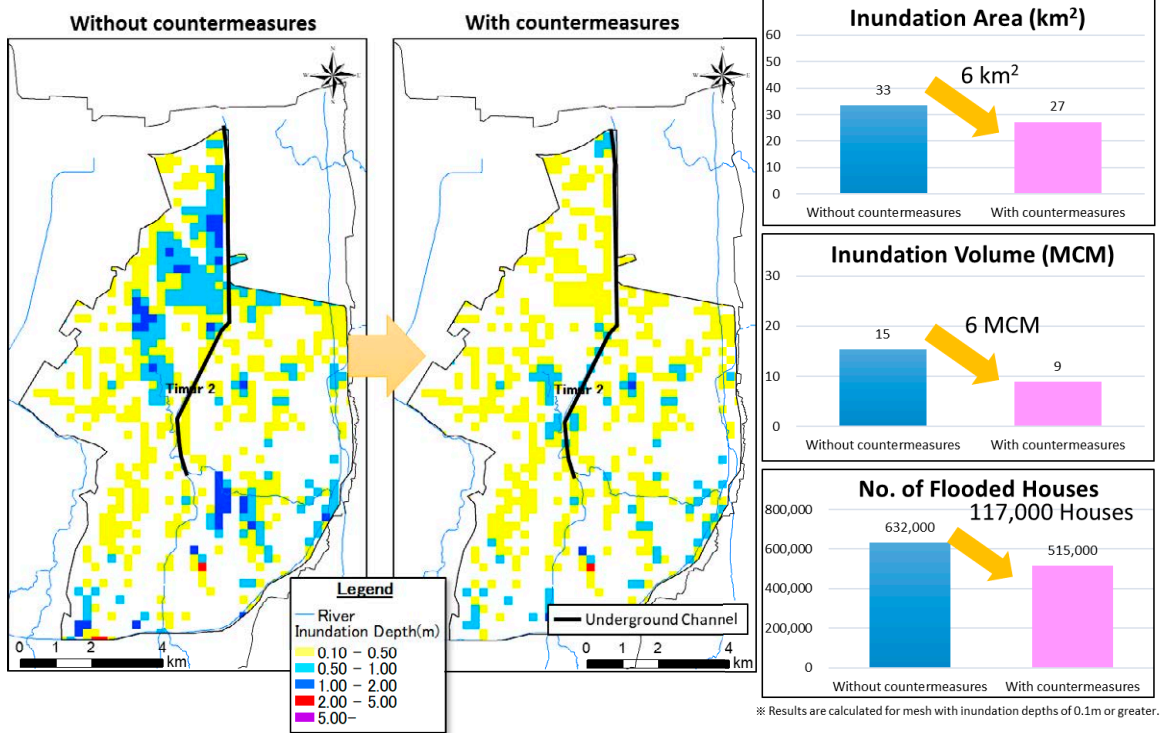


Figure 4-96 Damage Reduction of the Overall Countermeasures in Timur 2
(20-Year Return Period)

Table 4-52 Damage Reduction of the Overall Countermeasures in Timur 2
(10-Year Return Period)

Basin	Without countermeasures					With countermeasures					Damage Reduction				
	Inundation Area	Inundation volume	Flooded Houses	Damage cost		Inundation Area	Inundation volume	Flooded Houses	Damage cost		Inundation Area	Inundation volume	Flooded Houses	Damage cost	
Unit	km ²	MCM	No.	Mil. USD	Bil.IDR	km ²	MCM	No.	Mil. USD	Bil.IDR	km ²	MCM	No.	Mil. USD	Bil.IDR
Timur 2	32	14	596,000	908	13,038	26	8	484,000	565	8,120	-6	-6	-112,000	-342	-4,918
全体	32	14	596,000	908	130,380	26	8	484,000	565	81,202	-6	-6	-112,000	-342	-49,178

※ 2050H unit was used.
 ※ Exchange Rate 1 USD =14,360 IDR
 ※ Mil.USD = Million US Dollar, Bil.IDR = Billion Indonesian Rupiah
 ※ For the number of flooded houses, the average number of houses (1,000 units) per 230mx230m grid was used.
 ※ GDP growth rate is assumed to be 1.6 times.

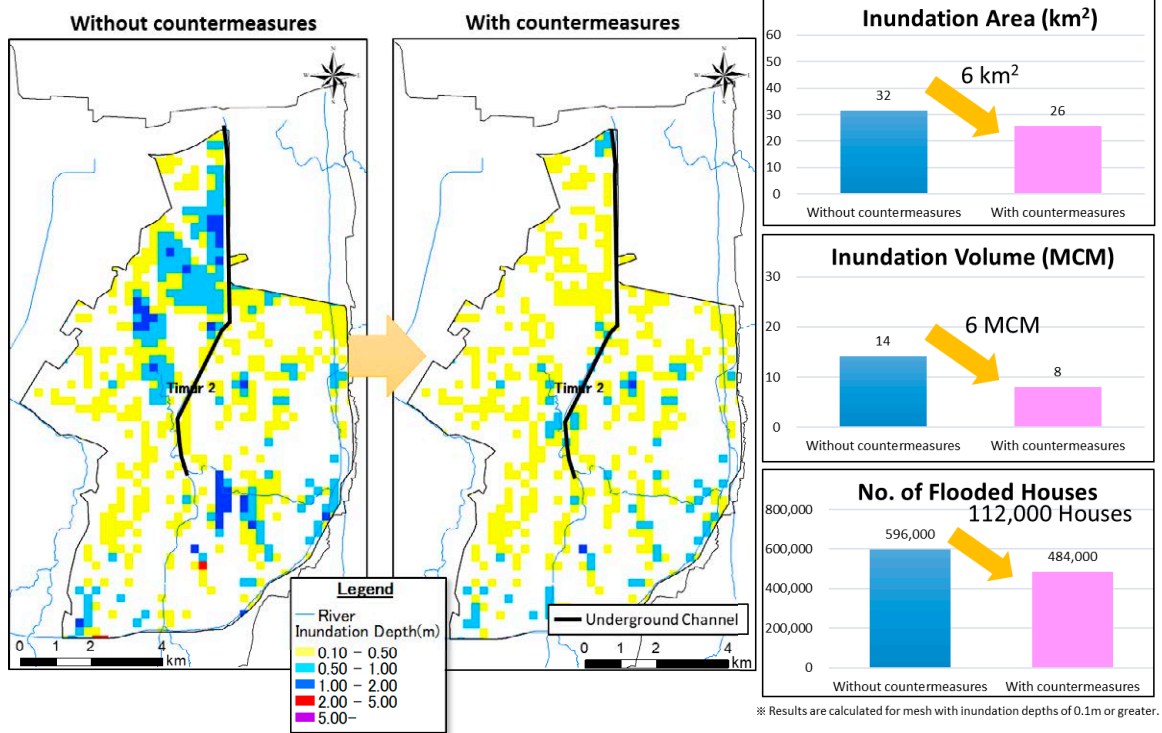


Figure 4-97 Damage Reduction of the Overall Countermeasures in Timur 2
(10-Year Return Period)

Table 4-53 Damage Reduction of the Overall Countermeasures in Timur 2
(5-Year Return Period)

Basin	Without countermeasures					With countermeasures					Damage Reduction				
	Inundation Area	Inundation volume	Flooded Houses	Damage cost		Inundation Area	Inundation volume	Flooded Houses	Damage cost		Inundation Area	Inundation volume	Flooded Houses	Damage cost	
Unit	km ²	MCM	No.	Mil. USD	Bil.IDR	km ²	MCM	No.	Mil. USD	Bil.IDR	km ²	MCM	No.	Mil. USD	Bil.IDR
Timur 2	29	13	552,000	826	11,865	23	7	438,000	493	7,075	-6	-6	-114,000	-334	-4,790
全体	29	13	552,000	826	118,655	23	7	438,000	493	70,750	-6	-6	-114,000	-334	-47,905

※ 2050H unit was used.

※ Exchange Rate 1 USD =14,360 IDR

※ Mil.USD = Million US Dollar, Bil.IDR = Billion Indonesian Rupiah

※ For the number of flooded houses, the average number of houses (1,000 units) per 230mx230m grid was used.

※ GDP growth rate is assumed to be 1.6 times.

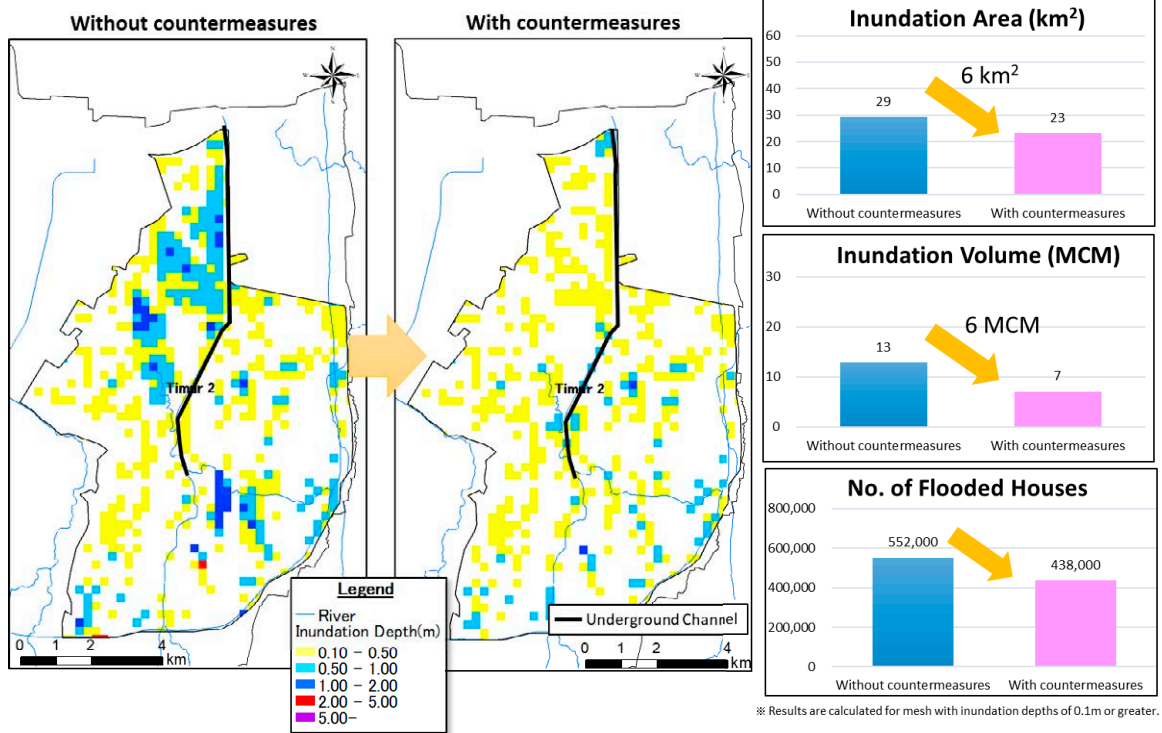


Figure 4-98 Damage Reduction of the Overall Countermeasures in Timur 2
(5-Year Return Period)

(3) Expected Annual Average Damage Reduction

The damage reduction effect was confirmed by comparing each damage cost for different return periods flood, with and without countermeasures. The expected annual average damage reduction cost was estimated to be approximately 185 Mil.USD (2,657 Bil.IDR) as shown in Table 4-54.

Table 4-54 Expected Annual Average Damage Reduction Cost (Timur 2)

Design Flood Frequency (1/Return Period)	Probability	Damage Cost		③=①-② Damage Reduction Cost (Mil.USD)	④ Section Average Damage Reduction Cost (Mil.USD)	⑤ Section Probability	④x⑤ Annual Average Damage Reduction Cost (Mil.USD)	Cumulative Annual Average Damage Reduction Cost = Expected Annual Average Damage Reduction Cost (Mil.USD)
		① Without Countermeasures (Mil.USD)	② With Countermeasures (Mil.USD)					
		1/1.1	0.909					
1/5	0.2	826	493	333.60	166.80	0.71	118	118
1/10	0.1	908	565	342.46	338.03	0.10	34	152
1/20	0.05	954	594	360.75	351.61	0.05	18	170
1/30	0.03	1,019	638	380.92	370.83	0.02	6	176
1/50	0.02	1,073	701	371.82	376.37	0.01	5	181
1/100	0.01	1,091	733	357.97	364.90	0.01	4	185

※ Mil.USD = Million US Dollar

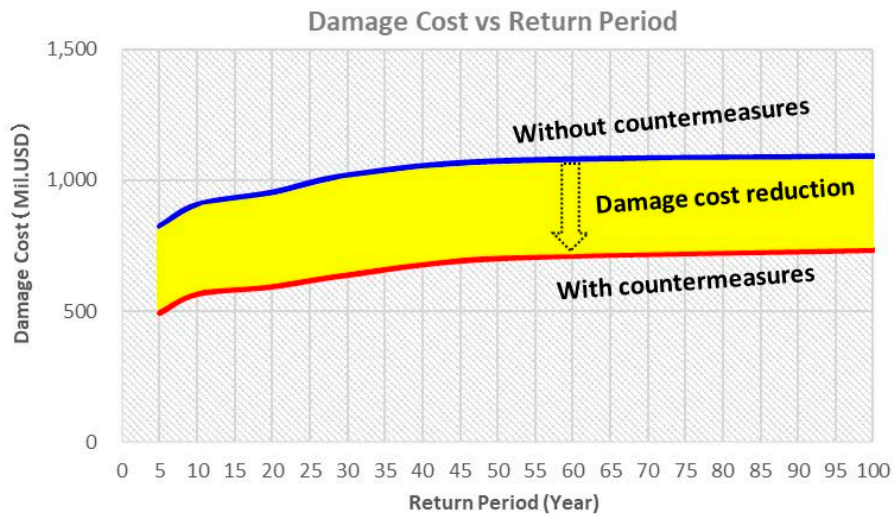


Figure 4-99 Damage cost for different return periods flood, with and without countermeasures (Timur 2)

(4) Economic Evaluation

(i) Evaluation Conditions

a Evaluation Period

The project implementation period will be 10 years from 2022, and the project evaluation period will be 50 years after the project completion.

b Social Discount Rate

The social discount rate was set to 12% from the standard value of 10-12%, which is generally adopted for Japanese Yen loan projects, in reference to the standards of the World Bank, Asian Development Bank, JICA and others.

(ii) Evaluation Result

The results of the economic evaluation using costs and benefits are as follows, confirming the high cost-effectiveness and economic benefits of the project.

- The equity internal rate of return (EIRR) is 14.6%, which exceeded 12%, confirming the high cost-effectiveness of the project.
- Cost-benefit ratio (B/C) is 1.36, which exceeded 1, also indicating that the project was highly cost-effective.

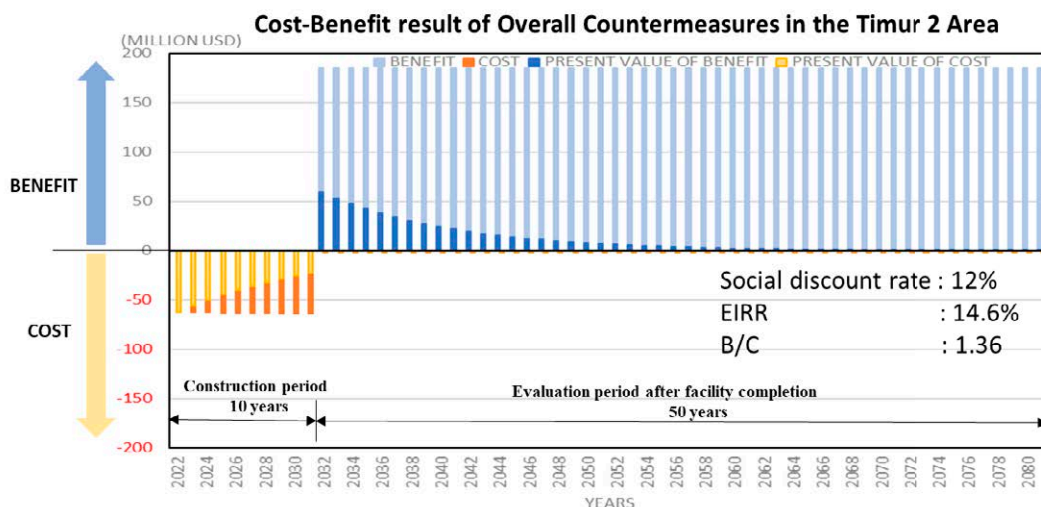


Figure 4-100 Cost-Benefit (Timur 2)

Attachment 4-1 Existing Rainfall Analysis Document

Designed rainfall duration, hyetograph and rainfall volume for the Ciliwung River Basin, as studied in the Project for Capacity Development of Jakarta Comprehensive Flood Management in Indonesia (JICA, 2013), are summarized as below.

1 Rainfall Observation Station and Rainfall Data Arrangement Status

The status of rainfall data arrangement of object rainfall observation station is shown in Table 1. The collected data during the rainy season from January and March which are available and when the major flood occurred will be used for the rainfall analysis.

Table 1 Rainfall Observation Station and Status of Rainfall Data Arrangement

Agency	BMG	BMG	BMG	BMG
Station	Pondok Betung Ciledug	Damaga Bogor	Citeko	Jakarta OBS
Instrument	Hilman	Hilman	Hilman	Hilman
Observation	Sep/1981 -	Jan/1985 -	Jan/1992 -	Jan/2000 -
1981	*:*:*:*			
1982	*:*:*:*:*:*:*:*			
1983	*:*:*:*:*:*:*:*			
1984	*:*:*:*:*:*:*:*			
1985	*:*:*:*:*:*:*:*	*:*:*:*:*:*:*:*		
1986	*:*:*:*:*:*:*:*	N:N:N:N:N:N:N:N		
1987	*:*:*:*:*:*:*:*	*:*:*N:*:*:*:*:*		
1988	*:*:*:*:*:*:*:*	*:*:*:*:*:*:*:*		
1989	*:*:*:*:*:*:*:*	*:*:*:*:*:*:*:*		
1990	*:*:*:*:*:*:*:*	N:N:*N:*:*:*:*		
1991	*:*:*:*:*:*:*:*	N:*:*:*:*:*:*		
1992	*:*:*:*:*:*:*:*	*:*:*:*:*:*:*:*	*:*:*:*:*:*:*:*	
1993	*:*:*:*:*:*:*:*	*:*:N:N:*:*:*	*:*:*:*:*:*:*:*	
1994	*:*:*:*:*:*:*:*	*:*:*:*:*:*:*:	*:*:*:*:*:*:*:	
1995	*:*:*:*:*:*:*:	*:*:*:*:*:*:*:	*:*:*:*:*:*:	
1996	*:*:*:*:*:*:*:	*:*:*:*:*:*:*:	*:*:*:*:*:*:	
1997	*:*:*:*:*:*:*:	*:*:*:*:*:*:*:	*:*:*:*:*:*:	
1998	*:*:*:*:*:*:*:	*:*:*:*:*:*:*:	*:*:*:*:*:*:	
1999	*:*:*:*:*:*:*:	*:*:*:*:*:*:*:	*:*:*:*:*:*:	
2000	*:*:*:*:*:*:*:	*:*:*:*:*:*:*:	*:*:*:*:*:*:	*:*:*:*:*:*:
2001	*:*:*:*:*:*:*:	*:*:*:*:*:*:*:	*:*:*:*:*:*:	*:*:*:*:*:*:
2002	*:*:*:*:*:*:*:	*:*:*:*:*:*:*:	*:*:*:*:*:*:	*:*:*:*:*:*:
2003	*:*:*:*:*:*:*:	*:*:*:*:*:*:*:	*:*:*:*:*:*:	*:*:*:*:*:*:
2004	*:*:*:*:*:*:*:	N:*:*:*:*:*:*:	*:*:*:*:*:*:	*:*:*:*:*:*:
2005	*:*:*:*:*:*:*:	*:*:*:*:*:*:*:	*:*:*:*:*:*:	*:*:*:*:*:*:
2006	*:*:*:*:*:*:*:	*:*:*:*:*:*:*:	*:*:*:*:*:*:	*:*:*:*:*:*:
2007	*:*:*:*:*:*:*:	*:*:*:*:*:*:*:	*:*:*:*:*:*:	*:*:*:*:*:*:
2008	*:*:*:*:*:*:*:	*:*:*:*:*:*:*:	*:*:*:*:*:*:	*:*:*:*:*:*:
Agency	BBWS	BBWS	BBWS	BBWS
Station	Sawangan	Manggarai	Cibinong	Cilember
Instrument	Telemeter	Telemeter	Telemeter	Telemeter
Observation	Mar/2004 -	Feb/2002 -	Feb/2003 -	Feb/2003 -
2002		-:*:*:*:*:*:*:		
2003		*:*:*:*:*:*:*:	-0:*:*:*0:-:0:0:*0	-0:*:*:*:*:*:*:
2004	-:0:*:*0:-:0:0:*	*:*:*:*0:-:0:0:*	*:*:*:*0:*:*:*:	*:*:*:*0:-:0:0:*
2005	*:*0*0:0:*:*:*	*:*:*:*0:0:0*0	*:*:*0:0:0*0	*:*:*:*:*:*:
2006	*:*:*:*:*:*:	*:*:*:*0*:*:*	*:*:*:*:*:*:	*0:0:0:0*0
2007	*:*:*0:0:0:0*0	*:*:*0:0:0*0	*:*:*0:-:0*:*:*0	*:*:*:*:*:*:
2008	*:*:*:*:*:*:	*:*:*:*:*:*:	*:*:*:*:*:*:	*:*:*:*:*:*:

*:Received(data available) N:Not received yet
-:Missing observation 0:Partly missing observation
Data can be applied.

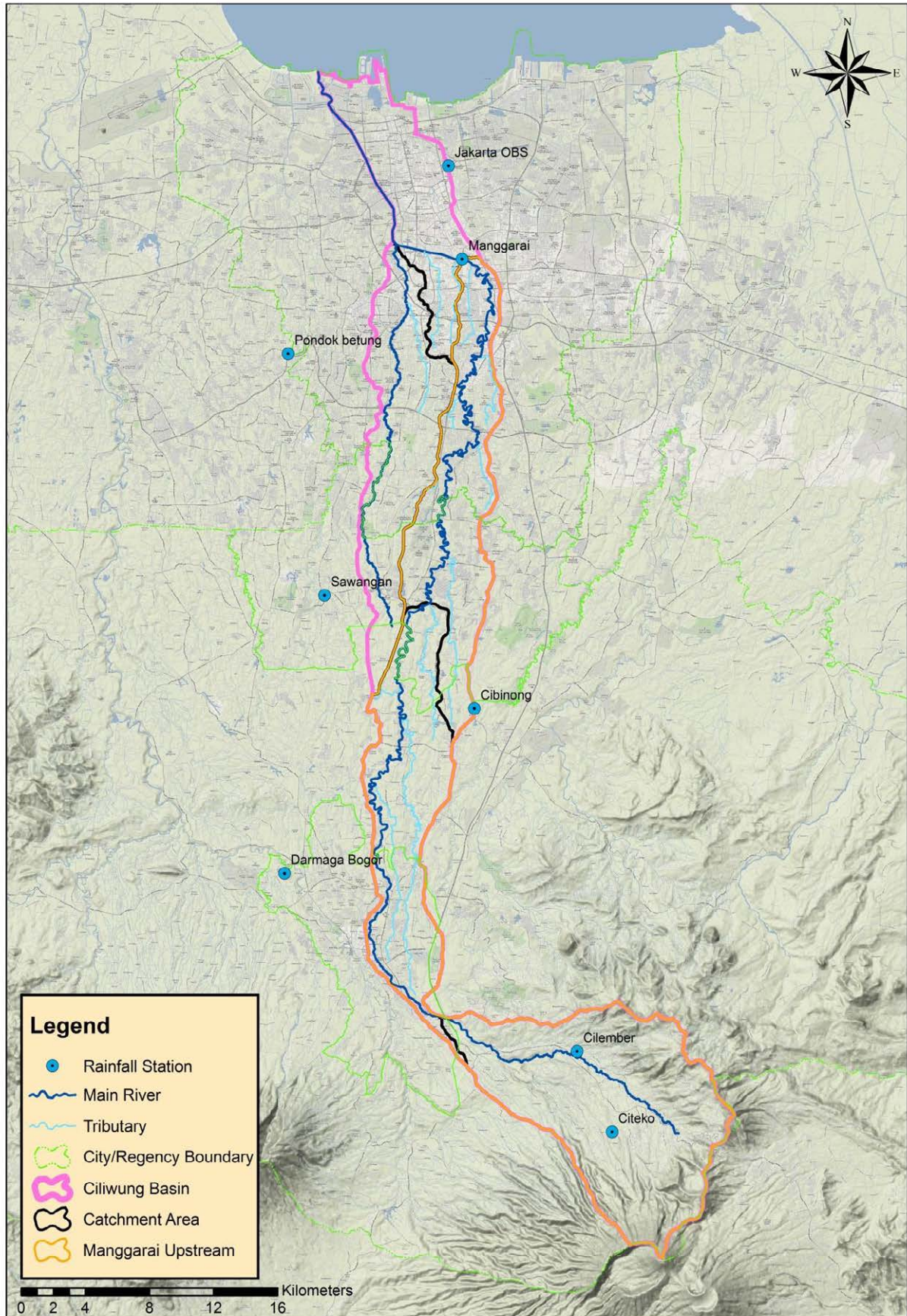


Figure 1 Location Map of Rainfall Observation Station

2 Basin Average Probable Rainfall

The basin average rainfall at the major locations is estimated by Thiessen Polygon, and the annual maximum 6, 12, 24, 48, 96, 144, and 168 hourly rainfalls are extracted. The probable rainfall analysis is conducted by using those extracted maximum hourly rainfall data.

- Location of basin average rainfall: Manggarai, Depok, and Katu Lampa

2.1 Thiessen Polygon

To work out the basin average rainfall at the above major locations, the Thiessen Polygon is conducted. Due to the difference of data arrangement by each year in each observation station, 6 patterns of

Thiessen Polygon are applied as shown in the following tables.

Table 2 Pattern of Thiessen Polygon

Agency	BM G	BM G	BM G	BM G	BBW S	BBW S	BBW S	BBW S	Pattern
Station	Pondok Betung Ciledug	Damag a Bogor	Citeko	Jakarta OBS	Sawanga n	Manggara i	Cibinon g	Cilembe r	
1992	●	●	●						1
1993									
1994	●	●	●						1
1995	●	●	●						1
1996	●	●	●						1
1997	●	●	●						1
1998	●	●	●						1
1999	●	●	●						1
2000	●	●	●	●					2
2001	●	●	●	●					2
2002	●	●	●	●					2
2003	●	●	●	●		●			3
2004	●		●	●		●	●	●	4
2005	●	●	●	●	●	●	●	●	5
2006	●	●	●	●	●	●	●	●	6
2007	●	●	●	●	●	●	●	●	5
2008	●	●	●	●	●	●	●	●	5

Table 3 Thiessen Coefficient (Pattern 1)

Basin Name	Basin Area (km ²)	Station	Accumulative Area (km ²)	Proportion (%)
Katulampa	149.79	Citeko	149.79	100.00
Depok	95.72	Pondok betung	1.43	1.49
		Darmaga Bogor	92.94	97.09
		Citeko	1.35	1.41
Manggarai	91.58	Pondok betung	77.44	84.56
		Darmaga Bogor	14.14	15.44
Krukut	84.96	Pondok betung	78.12	91.94
		Darmaga Bogor	6.85	8.06
Pesanggrahan	111.25	Pondok betung	69.05	62.07
		Darmaga Bogor	42.20	37.93
Sawangan	30.10	Pondok betung	1.40	4.66
		Darmaga Bogor	28.70	95.34

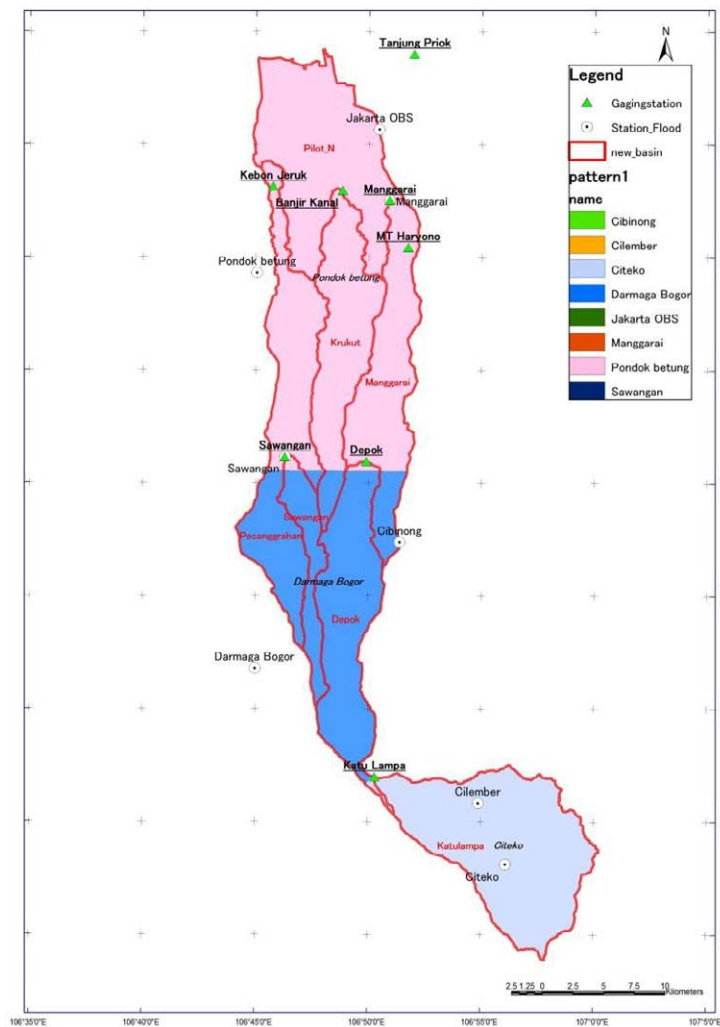


Figure 2 Thiessen Polygon (Pattern 1)

Table 4 Thiessen Coefficient (Pattern 2)

Basin Name	Basin Area (km ²)	Station	Accumulative Area (km ²)	Proportion (%)
Katulampa	149.79	Citeko	149.79	100.00
Depok	95.72	Pondok betung	1.43	1.49
		Darmaga Bogor	92.94	97.09
		Citeko	1.35	1.41
Manggarai	91.58	Pondok betung	64.17	70.07
		Darmaga Bogor	14.14	15.44
		Jakarta OBS	13.26	14.48
Krukut	84.96	Pondok betung	73.26	86.22
		Darmaga Bogor	6.85	8.06
		Jakarta OBS	4.86	5.72
Pesanggrahan	111.25	Pondok betung	69.00	62.02
		Darmaga Bogor	42.20	37.93
		Jakarta OBS	0.06	0.05
Sawangan	30.10	Pondok betung	1.40	4.66
		Darmaga Bogor	28.70	95.34

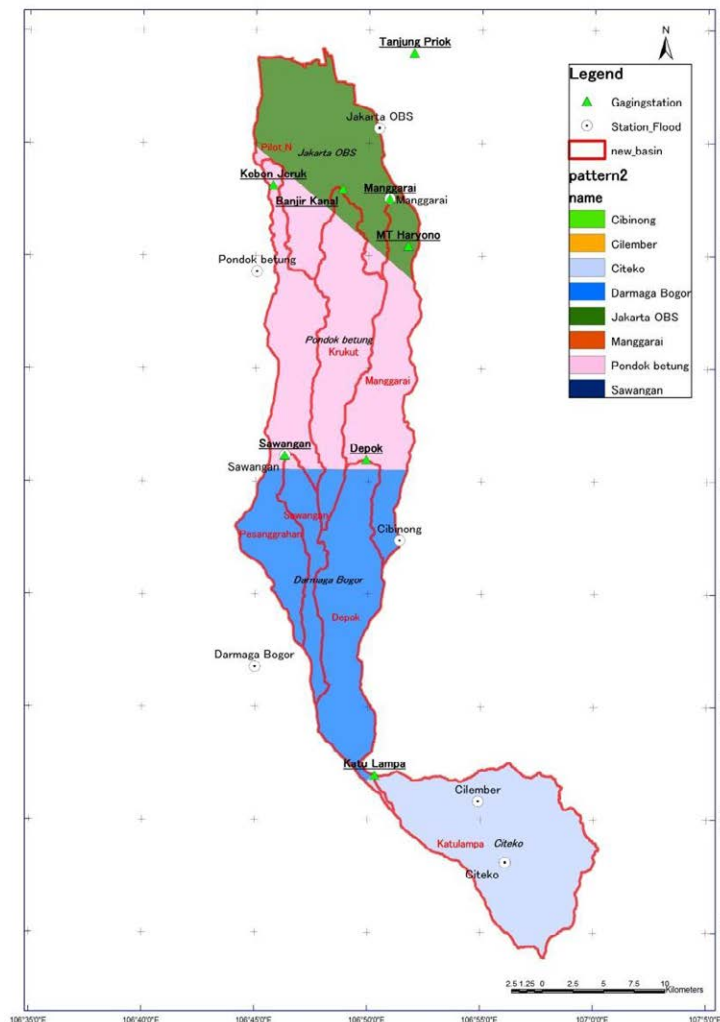


Figure 3 Thiessen Polygon (Pattern 2)

Table 5 Thiessen Coefficient (Pattern 3)

Basin Name	Basin Area (km ²)	Station	Accumulative Area (km ²)	Proportion (%)
Katulampa	149.79	Citeko	149.79	100.00
Depok	95.72	Pondok betung	1.43	1.49
		Darmaga Bogor	92.94	97.09
		Citeko	1.35	1.41
Manggara i	91.58	Manggara i	36.37	39.71
		Pondok betung	41.07	44.84
		Darmaga Bogor	14.14	15.44
Krukut	84.96	Manggara i	23.52	27.68
		Pondok betung	54.60	64.26
		Darmaga Bogor	6.85	8.06
Pesanggrahan	111.25	Pondok betung	69.00	62.02
		Darmaga Bogor	42.20	37.93
		Jakarta OBS	0.06	0.05
Sawangan	30.10	Pondok betung	1.40	4.66
		Darmaga Bogor	28.70	95.34

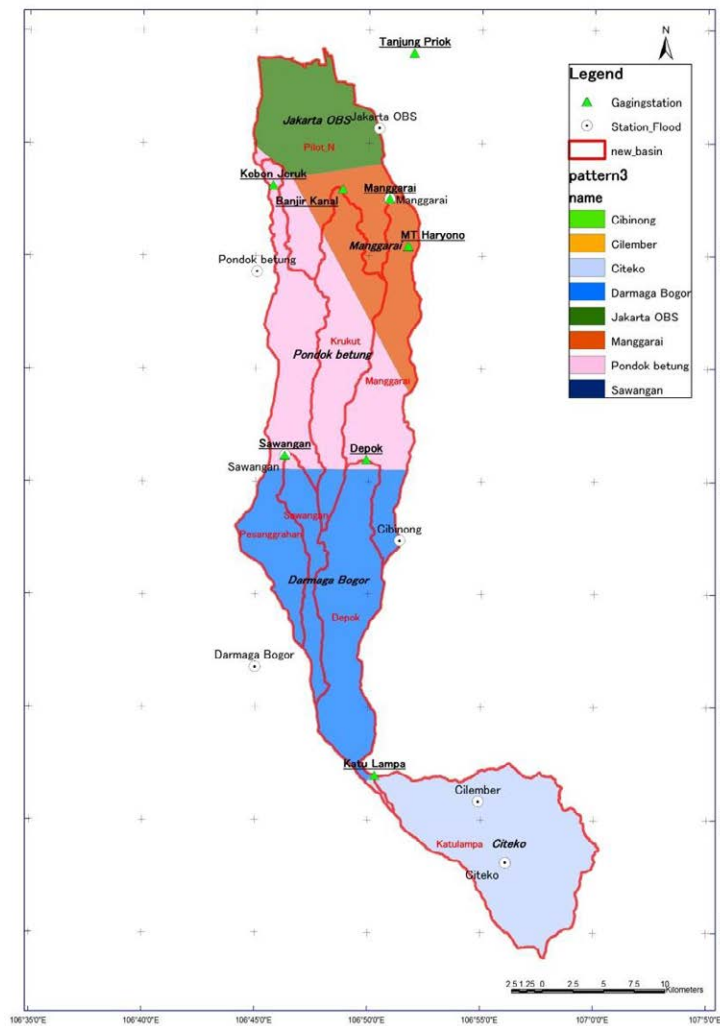


Figure 4 Thiessen Polygon (Pattern 3)

Table 6 Thiessen Coefficient (Pattern 4)

Basin Name	Basin Area (km ²)	Station	Accumulative Area (km ²)	Proportion (%)
Katulampa	149.79	Cilember	64.35	42.96
		Citeko	85.43	57.04
Depok	95.72	Cibinong	73.70	76.99
		Cilember	22.03	23.01
Manggarai	91.58	Manggarai	34.52	37.70
		Cibinong	50.83	55.51
		Pondok betung	6.22	6.80
Krukut	84.96	Manggarai	23.52	27.68
		Cibinong	19.99	23.53
		Pondok betung	41.45	48.78
Pesanggrahan	111.25	Cibinong	54.05	48.58
		Pondok betung	57.14	51.36
		Jakarta OBS	0.06	0.05
Sawangan	30.10	Cibinong	30.10	100.00

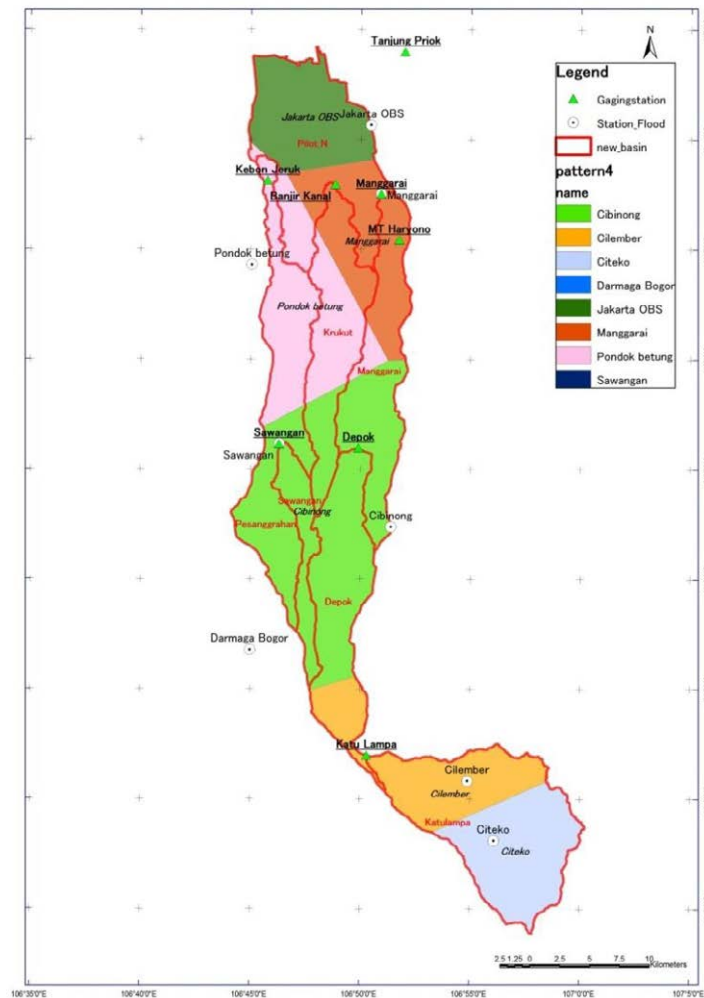


Figure 5 Thiessen Polygon (Pattern 4)

Table 7 Thiessen Coefficient (Pattern 5)

Basin Name	Basin Area (km ²)	Station	Accumulative Area (km ²)	Proportion (%)
Katulampa	149.79	Cilember	64.35	42.96
		Citeko	85.43	57.04
Depok	95.72	Cibinong	49.26	51.46
		Cilember	5.47	5.72
		Sawangan	3.08	3.22
Manggarai	91.58	Darmaga Bogor	37.90	39.60
		Manggarai	32.14	35.10
		Cibinong	22.96	25.07
		Sawangan	35.75	39.04
Krukut	84.96	Pondok betung	0.72	0.79
		Manggarai	23.52	27.68
		Cibinong	0.39	0.46
		Sawangan	35.81	42.15
Pesanggrahan	111.25	Pondok betung	25.24	29.71
		Cibinong	1.95	1.76
		Sawangan	57.60	51.78
		Pondok betung	39.38	35.40
		Darmaga Bogor	12.26	11.02
Sawangan	30.10	Jakarta OBS	0.06	0.05
		Cibinong	4.72	15.69
		Sawangan	14.14	46.96
		Darmaga Bogor	11.24	37.35

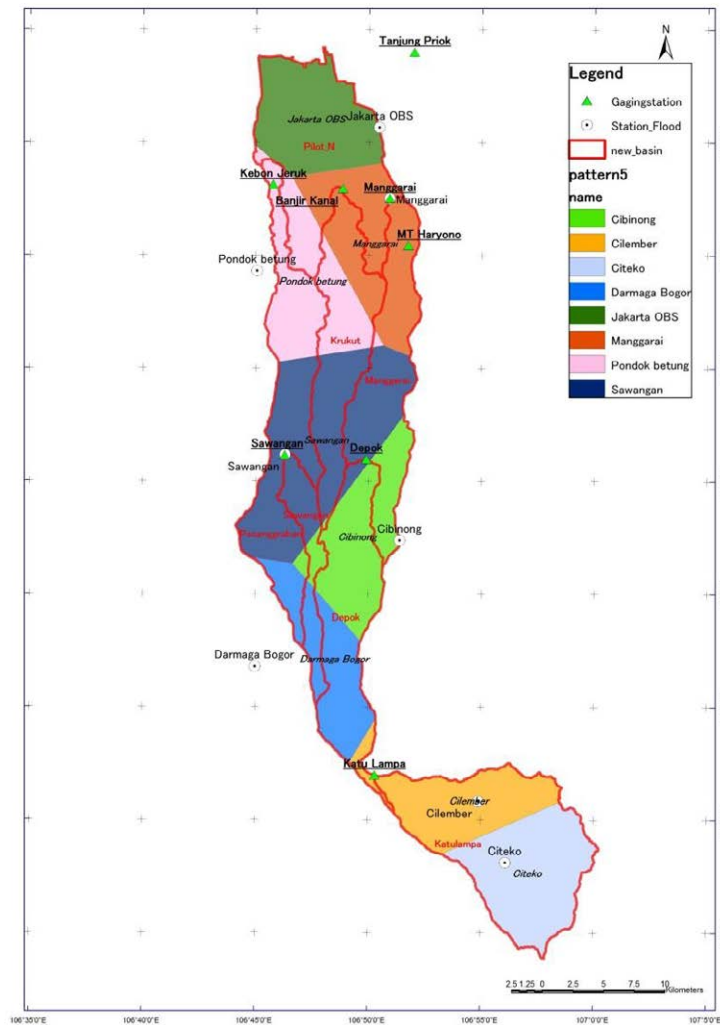


Figure 6 Thiessen Polygon (Pattern 5)

Table 8 Thiessen Coefficient (Pattern 6)

Basin Name	Basin Area (km ²)	Station	Accumulative Area (km ²)	Proportion (%)
Katulampa	149.79	Citeko	149.79	100.00
Depok	95.72	Cibinong	49.26	51.46
		Sawangan	3.08	3.22
		Darmaga Bogor	42.02	43.90
		Citeko	1.35	1.41
Manggarai	91.58	Manggarai	32.14	35.10
		Cibinong	22.96	25.07
		Sawangan	35.75	39.04
		Pondok betung	0.72	0.79
Krukut	84.96	Manggarai	23.52	27.68
		Cibinong	0.39	0.46
		Sawangan	35.81	42.15
Pesangrahan	111.25	Pondok betung	25.24	29.71
		Cibinong	1.95	1.76
		Sawangan	57.60	51.78
		Pondok betung	39.38	35.40
		Darmaga Bogor	12.26	11.02
Sawangan	30.10	Jakarta OBS	0.06	0.05
		Darmaga Bogor	0.00	0.00
		Cibinong	4.72	15.69
		Sawangan	14.14	46.96
		Darmaga Bogor	11.24	37.35

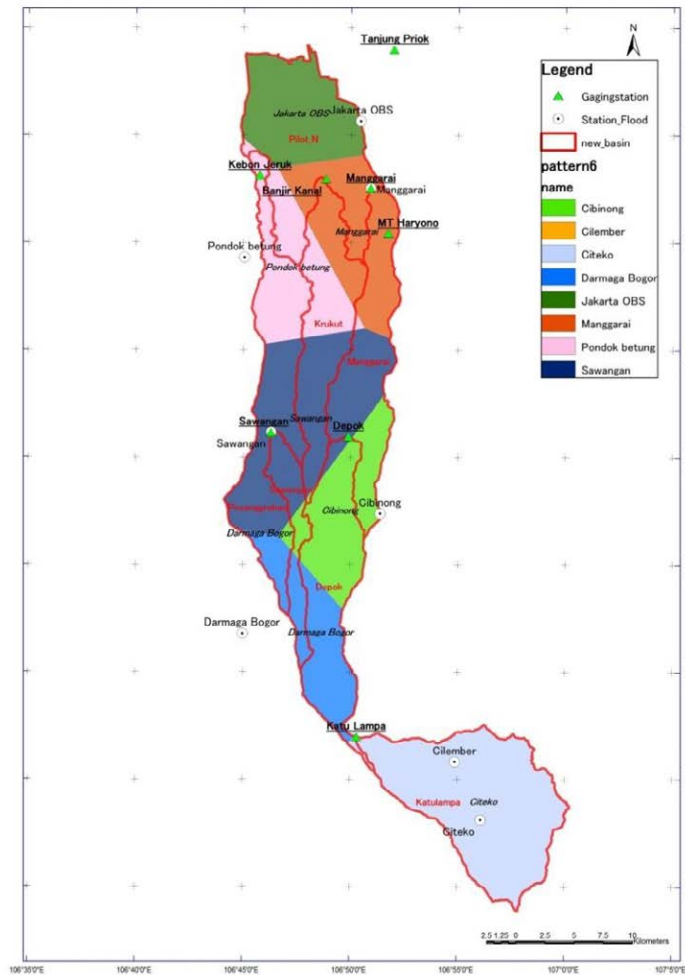


Figure 7 Thiessen Polygon (Pattern 6)

2.2 Annual Maximum Basin Average Rainfall

The annual maximum 6, 12, 24, 48, 96, 144, and 168 hourly rainfall data are extracted.

Table 9 Maximum Annual Rainfall (Manggarai)

Year	Annual maximum rainfall													
	6hour		12hour		24hour		48hour		96hour		144hour		168hour	
	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date
1992	59.82	26-Sep	60.16	26-Sep	69.57	25-Feb	105.38	25-Feb	183.70	23-Feb	237.71	23-Feb	257.72	22-Feb
1994	46.46	03-Apr	67.02	21-Jan	99.96	21-Jan	134.77	20-Jan	172.71	18-Jan	241.07	21-Jan	288.23	20-Jan
1995	79.03	30-Dec	86.20	08-Dec	93.27	30-Dec	108.56	29-Dec	139.59	06-Feb	186.85	07-Dec	205.22	05-Nov
1996	82.62	10-Feb	104.95	06-Jan	132.78	10-Feb	156.91	04-Jan	296.66	02-Jan	314.29	02-Jan	328.09	02-Jan
1997	44.56	19-May	46.06	19-May	78.51	19-May	84.45	19-May	105.48	10-May	144.10	01-Jan	167.10	01-Jan
1998	56.28	11-May	59.46	11-May	73.60	22-Mar	125.40	02-Mar	158.72	22-Mar	217.24	21-Mar	240.03	21-Mar
1999	68.17	30-Jun	73.18	30-Jun	86.96	13-Jan	99.16	12-Jan	128.48	12-Jan	151.37	16-Oct	173.09	14-Oct
2000	51.05	02-Jul	53.93	26-Jan	77.49	25-Jan	117.59	25-Jan	156.58	23-Jan	171.46	01-Feb	190.80	01-Feb
2001	54.75	01-Oct	71.25	22-Jan	91.64	07-Feb	145.19	07-Feb	193.80	05-Feb	250.19	06-Feb	274.14	05-Feb
2002	59.90	31-Jan	94.13	29-Jan	132.40	29-Jan	194.91	28-Jan	288.71	28-Jan	383.18	26-Jan	398.01	26-Jan
2003	70.04	04-Feb	80.80	13-Feb	90.08	12-Feb	125.72	11-Feb	153.21	11-Feb	193.89	07-Feb	210.46	07-Feb
2004	60.05	12-Dec	72.42	12-Dec	85.70	11-Dec	122.39	11-Dec	168.33	25-Dec	200.73	23-Dec	220.77	12-Feb
2005	59.17	18-Jan	85.87	18-Jan	136.25	18-Jan	187.04	17-Jan	266.91	15-Jan	300.12	15-Jan	312.22	13-Jan
2006	58.68	23-Jan	67.45	23-Jan	83.56	23-Jan	126.70	23-Jan	189.90	23-Jan	248.04	23-Jan	259.15	22-Jan
2007	86.62	03-Feb	146.03	03-Feb	179.46	03-Feb	254.62	03-Feb	364.57	31-Jan	432.18	29-Jan	482.75	29-Jan
2008	50.55	14-Mar	51.30	14-Mar	68.73	01-Feb	108.19	01-Feb	143.55	11-Mar	185.59	11-Mar	205.92	07-Mar

2.3 Basin Average Probable Rainfall

The probable rainfall is estimated based on the extracted annual maximum 6, 12, 24, 48, 96, 144, and 168 hourly rainfall data. The results are summarized in the following tables.

For the calculation of probable rainfall, the Gunbel Probability Distribution Model is applied, which is commonly used in Indonesia.

Table 10 Probable Rainfall (Manggari)

Unit: mm

Return period	Rainfall duration						
	6hour	12hour	24hour	48hour	96hour	144hour	168hour
2	59.6	72.3	93.8	130.4	182.6	227.5	249.2
3	65.1	82.4	106.4	148.1	212.7	262.2	285.2
4	68.6	88.9	114.4	159.4	232.0	284.5	308.2
5	71.2	93.7	120.3	167.8	246.3	301.0	325.3
6	73.2	97.5	125.1	174.4	257.7	314.1	338.8
7	75.0	100.7	129.0	180.0	267.1	325.0	350.1
8	76.4	103.4	132.4	184.7	275.2	334.3	359.7
9	77.7	105.8	135.3	188.9	282.2	342.4	368.1
10	78.9	107.9	137.9	192.5	288.5	349.7	375.6
15	83.2	115.9	147.8	206.5	312.3	377.1	404.0
20	86.2	121.5	154.7	216.3	329.0	396.4	423.9
25	88.6	125.9	160.1	223.8	341.8	411.2	439.2
30	90.5	129.4	164.4	229.9	352.3	423.2	451.7
35	92.1	132.3	168.1	235.1	361.1	433.4	462.2
40	93.5	134.9	171.3	239.6	368.7	442.2	471.2
45	94.7	137.2	174.1	243.5	375.4	449.9	479.2
50	95.8	139.2	176.5	247.0	381.4	456.8	486.4
60	97.6	142.6	180.9	253.1	391.7	468.8	498.7
70	99.2	145.6	184.5	258.2	400.5	478.8	509.2
80	100.6	148.1	187.6	262.7	408.0	487.6	518.2
90	101.8	150.4	190.4	266.6	414.7	495.2	526.1
100	102.9	152.4	192.9	270.1	420.6	502.1	533.2
150	107.1	160.1	202.4	283.5	443.5	528.5	560.5
200	110.0	165.5	209.2	293.0	459.7	547.2	579.9
250	112.3	169.8	214.4	300.4	472.3	561.8	594.9
300	114.2	173.2	218.7	306.4	482.6	573.6	607.1
350	115.8	176.1	222.3	311.5	491.3	583.6	617.5
400	117.1	178.7	225.4	315.9	498.8	592.3	626.5
500	119.4	182.9	230.6	323.3	511.3	606.8	641.5
1000	126.5	196.0	246.9	346.2	550.3	651.8	688.0

3 Examination of Rainfall Features

3.1 Examination of Major Rainfall

In Ciliwung river basin, the hourly intensity of rainfall will exceed more than 100mm. However, it is assumed that those intensive rainfall do not cause the inundation in the basin, and the long time rainfall results in raising the water level when the remarkable flood occurred in 1996, 2002 and 2007.

Therefore, the major floods with the water level exceeding the certain point are extracted.

The warning level (Siaga III) designated by BBWS Ciliwung-Cisadane is applied as a extraction criteria by using the rainfall data arranged by Depok rainfall observation station in the middle-stream and Manggarai rainfall observation station in the down-stream.

The water level in Depok rainfall observation station exceeds 235 m and that in Manggarai rainfall observation station is more than 800 m.

The 10 floods are selected based on the above criteria from 1992 to 2008. The dry hours for less than 6 hours are counted in the rainfall duration.

The major floods and observed data (observed rainfall, basin average rainfall, and observed water level) are summarized below.

Table 11 List of Major Flood

No.	Occurrence date	Actual rainfall Basin			rainfall duration (hr)
		KatuLampa	Depok	Manggarai	
1	1994/01/20	190.80	157.03	141.69	67
2	1995/02/07	216.00	165.67	149.22	105
3	1996/01/05	520.20	377.37	296.70	102
4	2001/02/06	240.00	210.92	179.40	85
5	2002/01/26	375.70	397.65	397.79	164
6	2003/02/13	74.70	73.24	80.88	17
7	2004/02/16	167.43	144.55	138.76	89
8	2005/01/16	294.26	252.69	242.54	76
9	2006/01/23	339.60	286.24	255.57	154
10	2007/01/30	602.88	465.69	445.64	153

3.2 Design Rainfall Duration

The design rainfall duration is defined as a rainfall duration affecting the peak discharge.

The flood arrival time is estimated as double of difference between peak rainfall and peak discharge in accordance with the assumption of rational formula.

Regarding the flood with more than 750cm water level (Siaga IV) at Manggarai observation station, the differences between peak rainfall and peak discharge are summarized in Table 12.

Table 12 Difference between Peak Rainfall and Peak Water Level

Occurrence date	Depok			Manggarai		
	Peak Rainfall	Peak Water level	Gap	Peak Rainfall	Peak Water level	Gap
1992/1/15	1992/1/15 18:00	1992/1/15 21:00	3	No clear relation of water level to rainfall		
1992/1/29	1992/1/29 16:00	1992/1/30 0:00	8	1992/1/29 16:00	1992/1/30 11:00	19
1992/2/26	1992/2/26 13:00	1992/2/26 19:00	6	No clear relation of water level to rainfall		
1992/2/26	1992/2/26 13:00	1992/2/26 19:00	6	No clear relation of water level to rainfall		
1994/1/21	1994/1/21 4:00	1994/1/21 18:00	14	1994/1/21 4:00	1994/1/22 8:00	28
1994/1/21	1994/1/21 4:00	1994/1/21 9:00	5	1994/1/21 16:00	1994/1/22 8:00	16
1994/1/26	1994/1/26 17:00	1994/1/26 22:00	5	1994/1/26 17:00	1994/1/27 9:00	16
1994/1/29	1994/1/29 14:00	1994/1/29 19:00	5	No clear relation of water level to rainfall		
1995/2/9	1995/2/9 16:00	1995/2/9 21:00	5	1995/2/9 16:00	1995/2/10 12:00	20
1995/2/17	1995/2/17 18:00	1995/2/17 23:00	5	1995/2/17 18:00	1995/2/18 10:00	16
1995/3/29	1995/3/29 19:00	1995/3/30 1:00	6	1995/3/29 19:00	1995/3/30 11:00	16
1996/1/6	1996/1/6 9:00	1996/1/6 15:00	6	1996/1/6 9:00	1996/1/7 7:00	22
1996/2/10	1996/2/10 9:00	1996/2/10 14:00	5	1996/2/10 9:00	1996/2/11 7:00	22
1996/3/9	1996/3/9 19:00	1996/3/10 0:00	5	No clear relation of water level to rainfall		
1997/1/7	1997/1/7 18:00	1997/1/7 23:00	5	No clear relation of water level to rainfall		
1997/2/19	No clear relation of water level to rainfall			No clear relation of water level to rainfall		
1997/2/28	1997/2/28 17:00	1997/2/28 21:00	4	No clear relation of water level to rainfall		
1998/2/26	1998/2/26 17:00	1998/2/26 21:00	4	1998/2/26 17:00	1998/2/27 11:00	18
1998/3/4	1998/3/4 15:00	1998/3/4 22:00	7	1998/3/4 15:00	1998/3/5 10:00	19
1998/3/20	1998/3/20 16:00	1998/3/20 22:00	6	1998/3/20 16:00	1998/3/21 5:00	13
1998/3/25	1998/3/25 15:00	1998/3/25 21:00	6	1998/3/25 15:00	1998/3/26 7:00	16
1999/2/17	1999/2/17 18:00	1999/2/17 22:00	4	1999/2/17 18:00	1999/2/18 9:00	15
1999/2/25	1999/2/25 17:00	1999/2/25 22:00	5	1999/2/25 17:00	1999/2/26 7:00	14
1999/3/12	1999/3/12 14:00	1999/3/12 21:00	7	1999/3/12 14:00	1999/3/13 9:00	19
2000/1/27	2000/1/27 18:00	2000/1/27 23:00	5	2000/1/27 18:00	2000/1/28 10:00	16
2000/2/4	2000/2/4 21:00	2000/2/4 22:00	1	2000/2/4 21:00	2000/2/5 7:00	10
2000/2/24	2000/2/24 13:00	2000/2/24 22:00	9	2000/2/24 13:00	2000/2/25 12:00	23
2001/1/8	2001/1/8 18:00	2001/1/8 23:00	5	2001/1/8 18:00	2001/1/9 9:00	15
2001/2/8	2001/2/8 12:00	2001/2/8 20:00	8	2001/2/8 11:00	2001/2/9 9:00	22
2001/2/28	2001/2/28 14:00	2001/2/28 19:00	5	2001/2/28 14:00	2001/3/1 4:00	14
2001/3/28	2001/3/28 17:00	2001/3/28 20:00	3	2001/3/28 17:00	2001/3/29 7:00	14
2002/1/31	2002/2/1 0:00	2002/2/1 5:00	5	2002/2/1 3:00	2002/2/2 1:00	22
2002/2/13	2002/2/13 2:00	2002/2/13 7:00	5	2002/2/13 2:00	2002/2/13 23:00	21
2002/2/20	2002/2/20 12:00	2002/2/20 18:00	6	2002/2/20 12:00	2002/2/21 5:00	17
2003/2/4	2003/2/4 22:00	2003/2/5 5:00	7	2003/2/4 22:00	2003/2/5 16:00	18
2003/2/7	2003/2/8 0:00	2003/2/8 5:00	5	2003/2/8 0:00	2003/2/8 17:00	17
2003/2/13	2003/2/13 8:00	2003/2/13 13:00	5	2003/2/13 8:00	2003/2/14 1:00	17
2003/3/12	2003/3/12 18:00	2003/3/13 2:00	8	2003/3/12 18:00	2003/3/13 14:00	20
2004/1/18	2004/1/18 14:00	2004/1/18 19:00	5	2004/1/18 14:00	2004/1/19 6:00	16
2004/2/9	2004/2/9 20:00	2004/2/10 1:00	5	2004/2/9 20:00	2004/2/10 12:00	16
2004/2/13	2004/2/13 13:00	2004/2/13 19:00	6	2004/2/13 13:00	2004/2/14 5:00	16
2004/2/19	2004/2/19 12:00	2004/2/19 17:00	5	2004/2/19 12:00	2004/2/20 3:00	15
2005/1/18	2005/1/18 14:00	2005/1/18 22:00	8	2005/1/19 3:00	2005/1/19 20:00	17
2005/2/20	2005/2/20 17:00	2005/2/20 22:00	5	2005/2/20 17:00	2005/2/21 11:00	18
2005/3/5	2005/3/5 20:00	2005/3/5 22:00	2	2005/3/5 23:00	2005/3/6 13:00	14
2005/12/10	2005/12/10 15:00	2005/12/10 22:00	7	2005/12/10 15:00	2005/12/11 9:00	18
2006/1/12	2006/1/12 20:00	2006/1/13 0:00	4	2006/1/12 20:00	2006/1/13 11:00	15
2006/1/23	2006/1/23 17:00	2006/1/23 21:00	4	2006/1/23 17:00	2006/1/24 10:00	17
2006/2/26	2006/2/26 17:00	2006/2/26 19:00	2	2006/2/26 17:00	2006/2/27 8:00	15
2007/1/29	2007/1/29 18:00	2007/1/30 0:00	6	2007/1/29 18:00	2007/1/30 14:00	20
2007/2/3	2007/2/3 10:00	2007/2/3 18:00	8	2007/2/3 10:00	2007/2/4 6:00	20
2007/12/19	2007/12/19 13:00	2007/12/19 21:00	8	2007/12/19 13:00	2007/12/20 7:00	18

Table 13 Distribution of Flood Arrival Time

Depok			Manggarai		
Gsp	Time of flood concentration	Number of times	Gsp	Time of flood concentration	Number of times
2	4	2	13	26	1
3	6	2	14	28	4
4	8	5	15	30	5
5	10	20	16	32	9
6	12	9	17	34	5
7	14	4	18	36	5
8	16	6	19	38	3
9	18	1	20	40	4
			21	42	1
			22	44	4
			23	46	1

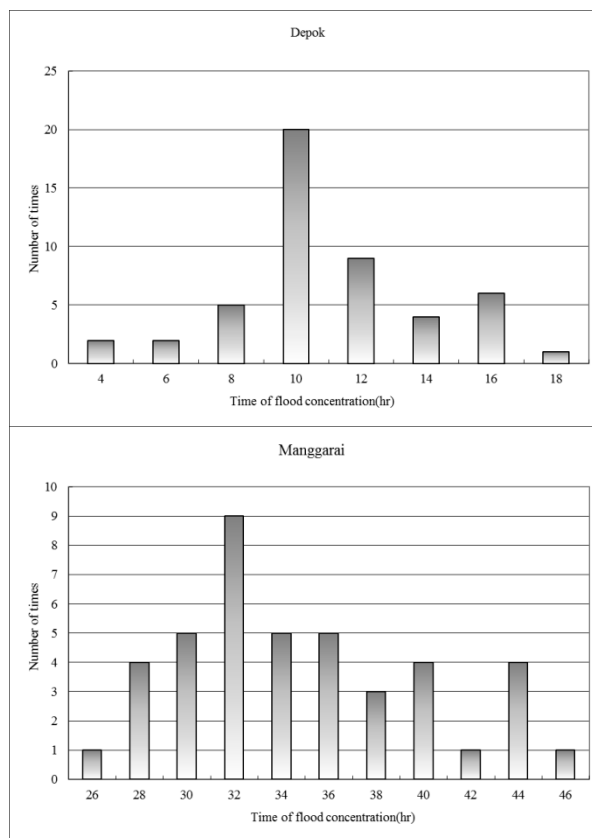


Figure 8 Distribution of Flood Arrival Time at Depok/Manggarai Benchmark

The flood arrival time at Manggarai Benchmark is estimated for 26 to 46 hours.

The median value is 36 hours, and the average is 35 hours. Thus, the design rainfall duration for the analysis is defined as 48 hours, which involve both median and average values.

3.3 Design Rainfall Curve

The rainfall applied for basin high water discharge volume will be selected by evaluating the extension rate. In order to avoid overestimate, the rainfall is selected with less than twice of extension rate.

In accordance with the scale of West Banjir Canal, the 50-year return period is applied as discharge volume is evaluated by extension rate at Manggarai point as design benchmark.

The evaluation results of extension rate of major floods are summarized in Table 14.

Table 14 Evaluation of Major Flood (Manggarai Benchmark)

No.	Occurrence date	Actual rainfall (mm/48hr)	50-year rainfall (mm/48hr)	Extension Rate
1	1994/01/20	134.77	247.00	1.83 ○
2	1995/02/07	88.03		2.81 ×
3	1996/01/05	156.91		1.57 ○
4	2001/02/06	145.19		1.70 ○
5	2002/01/26	194.91		1.27 ○
6	2003/02/13	80.88		3.05 ×
7	2004/02/16	93.67		2.64 ×
8	2005/01/16	187.04		1.32 ○
9	2006/01/23	126.70		1.95 ○
10	2007/01/30	254.62		0.97 ○

Regarding the 7 curves with less than 2.0 of extension rate above, the probability of rainfalls after extension is evaluated at up-stream (Katu Lampa) and middle-stream (Depok) to confirm the balance of basin rainfall, and the overestimated and underestimated rainfall curves in each area are dismissed.

The criteria for dismissal are the evaluated probability of rainfall after extension is other than 1/20 to 1/150 and rainfall curves in 1994, 2001, 2006 and 2007

Table 15 Evaluation of Major Flood (Up-stream, Middle-stream)

No.	Occurrence date	Actual rainfall (mm/48hr)		Extension Rate	50-year rainfall (mm/48hr)	
		KatuLampa	Depok		KatuLampa	Depok
1	1994/01/20	184.50	149.49	1.830	337.64 (1/27)	273.57 (1/30)
2	1996/01/05	281.90	205.42	1.570	442.58 (1/172)	322.51 (1/96)
3	2001/02/06	187.60	167.24	1.700	318.92 (1/21)	284.31 (1/39)
4	2002/01/26	222.60	219.14	1.270	282.70 (1/10)	278.31 (1/34)
5	2005/01/16	221.93	194.20	1.320	292.95 (1/12)	256.34 (1/19)
6	2006/01/23	198.30	150.11	1.950	386.69 (1/63)	292.71 (1/47)
7	2007/01/30	409.01	304.58	0.970	396.74 (1/75)	295.44 (1/51)

