Directorate General of Water Resources,
Ministry of Public Works
Republic of Indonesia

THE PROJECT
FOR
CAPACITY DEVELOPMENT
OF
JAKARTA COMPREHENSIVE FLOOD MANAGEMENT
IN
INDONESIA

TECHNICAL COOPERATION REPORT

COMPREHENSIVE FLOOD MANAGEMENT PLAN
ANNEX-1
RUNOFF ANALYSIS AND FLOOD CONTROL MEASURE

OCTOBER, 2013

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.

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Technical Cooperation Report
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Annex-1 Runoff Analysis and Flood Control Measure

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CHAPTER 1 BASIC SURVEY

1.1 Outline of River Basin

Ciliwung River originates from mountains in West Java Province and flows through Bogor and Depok before entering DKI Jakarta, diverting to the West Banjir Canal at Manggarai Gate and flowing almost from south to north into Jakarta Bay. Catchment area is approximately 553 km^2 and river channel length is approximately 145 km. The riverbed slope is approximately 1/1,000 between Bogor and Manggarai Gate and approximately 1/2,600 between Manggarai Gate and Jakarta Bay. The shape of catchment area is narrow and elongate as the maximum width of the catchment area is roughly 10 km compared to the channel length, and the area stretching from the lower reaches to the middle reaches of the river is the most vital area in Indonesia having a high concentration of important political and economic facilities. The population living in the river basin area is approximately 1.5 million. In terms of topographical conditions, flood waters in the upper reaches from Manggarai Gate are discharged into Java Sea by natural drainage (gravity drainage), however, since the lower reaches form low-lying land enclosed by river embankments and sea walls, drainage of flooding have to be relied on pumping facilities. Moreover, since large areas of the low-lying land are experiencing extensive land subsidence, the area of land situated below sea level is increasing.

Figure 1.1-1 Location of River Basin

1.1.1 Geological Feature of River Basin

The land feature and average ground level of Ciliwung river basin are shown in Figure 1.1-2 and Figure 1.1-3 respectively. The geographical features of river basin are summarized as follows.

- The elevation in upstream of the basin (from Bogor to Pangrango mountain) is approximately from 300m to 3,000m
- The elevation in middle stream of the basin (from Depok to Bogor) is approximately 80m to 300m with continuous gentle slopes
- The elevation in downstream of the basin (from Java sea to Depok) is approximately 1m to 80. Especially in the northern part of West Banjir Canal, the sea level is -1.0m to 12.0m consisting of less than 2m (half of the area), from 2m to 4m (about 40% of the area) and others (about 10%).

Figure 1.1-2 Land Feature of the Basin

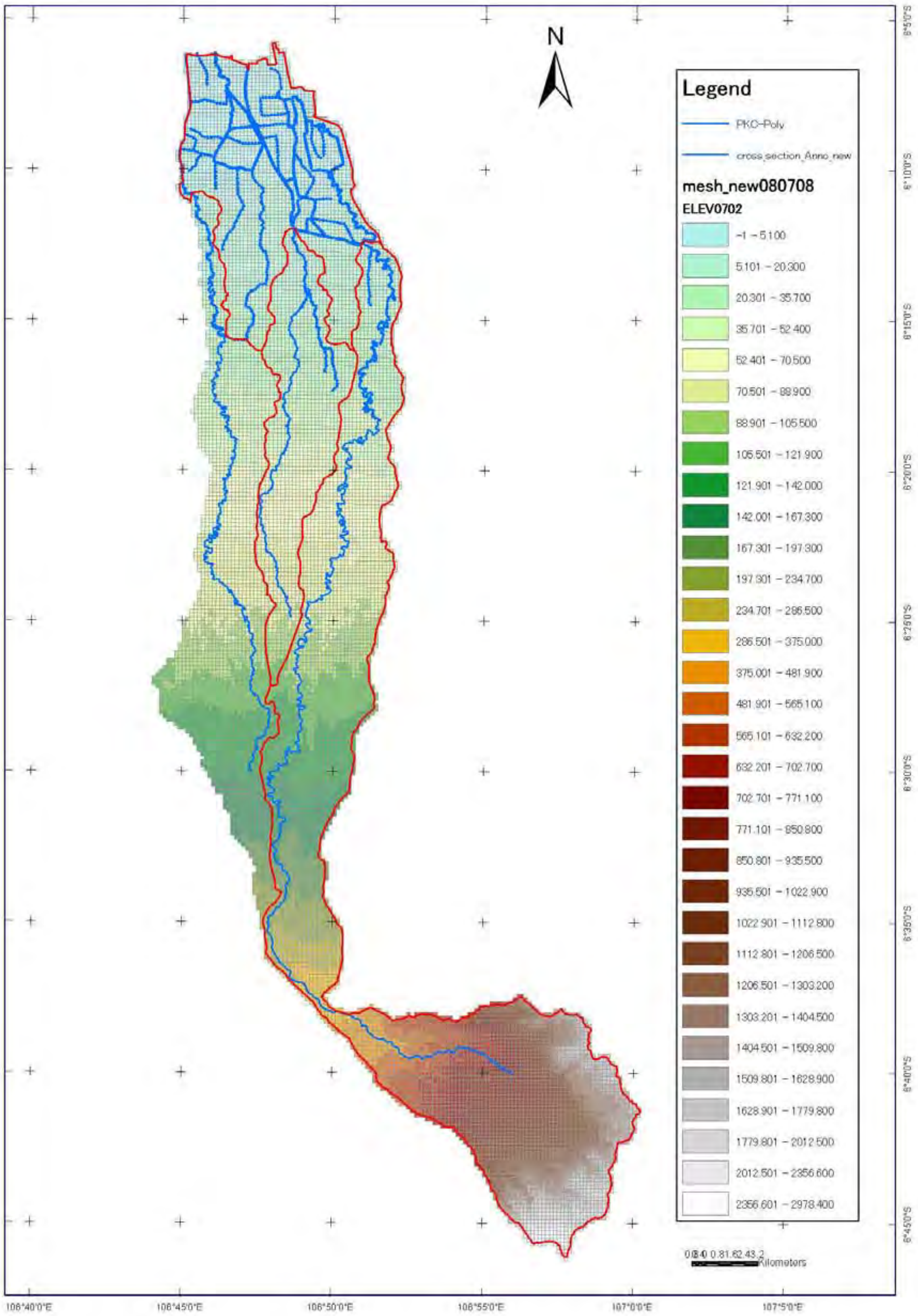


Figure 1.1-3 Average Ground Level

1.1.2 Transition of Land Use Condition

The transition of land use in the Ciliwung river basin is shown in Figure 1.1-4.

- Whereas the urbanization rate in the Ciliwung River Basin was 28.8 percent in the 1980's, it was accounted 47.6 percent in 2008 and is forecasted to increase up to 67.1 percent in the future.

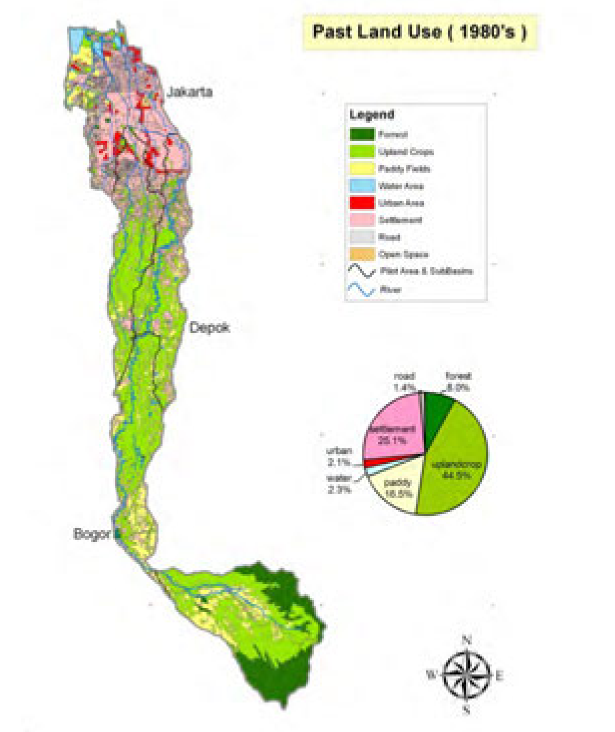
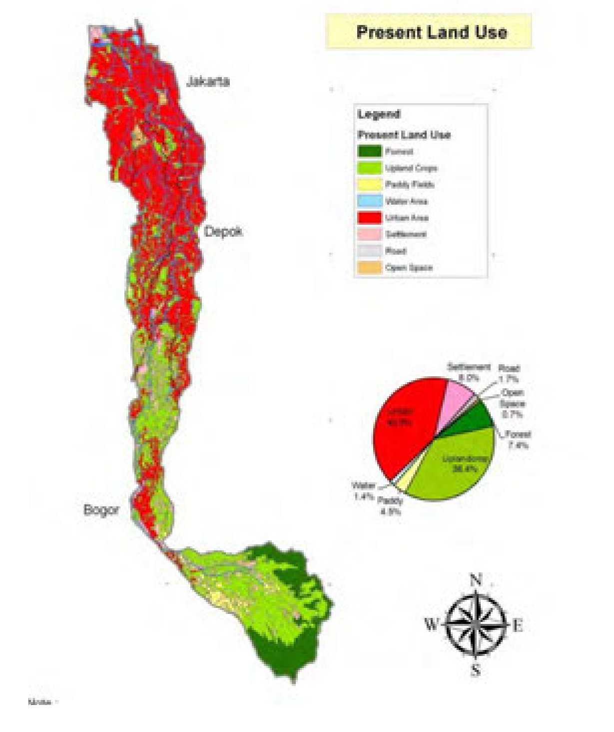
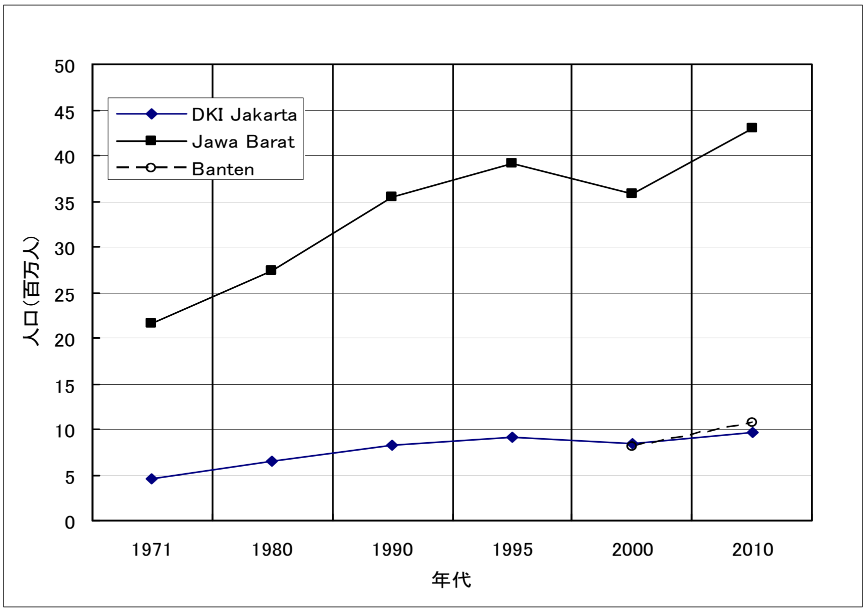
	
1980's Urbanization: 28.8%	2008 Urbanization: 47.6%

Figure 1.1-4 Transition of Land Use in the Basin

1.1.3 Population

The population of DKI Jakarta in the target basin used to be approximately 5 million in 1971, but in 2010 it increased up to about 10 million. Even though the current increase rate, compared with the rate from 1971 to 1990, tends to decrease, the current total population shows the double of that in 1971.



Source: Badan Pusat Statistik

Figure 1.1-5 Population Change in the Basin

Table 1.1-1 Population in Each Province

Provinsi	Penduduk					
	1971	1980	1990	1995	2000	2010*)
DKI Jakarta	4,579,303	6,503,449	8,259,266	9,112,652	8,389,443	9,607,787
Jawa Barat	21,623,529	27,453,525	35,384,352	39,206,787	35,729,537	43,053,732
Banten	-	-	-	-	8,098,780	10,632,166
INDONESIA	119,208,229	147,490,298	179,378,946	194,754,808	206,264,595	237,641,326

*) preliminary figures
Source: Badan Pusat Statistik

Table 1.1-2 Population Increase Ratio in Each Province

Province	1971-1980	1980-1990	1990-2000	2000-2010*
DKI Jakarta	1.42	1.27	1.02	1.15
Jawa Barat	1.27	1.29	1.01	1.20
Banten	-	-	-	1.31
INDONESIA	1.24	1.22	1.15	1.15

1.2 River System

The Ciliwung river and West Banjir Canal mainly consist of two tributaries (the Krukut river and Angke river) flowing into the Java sea. The river system map is shown in Figure 1.2-1.

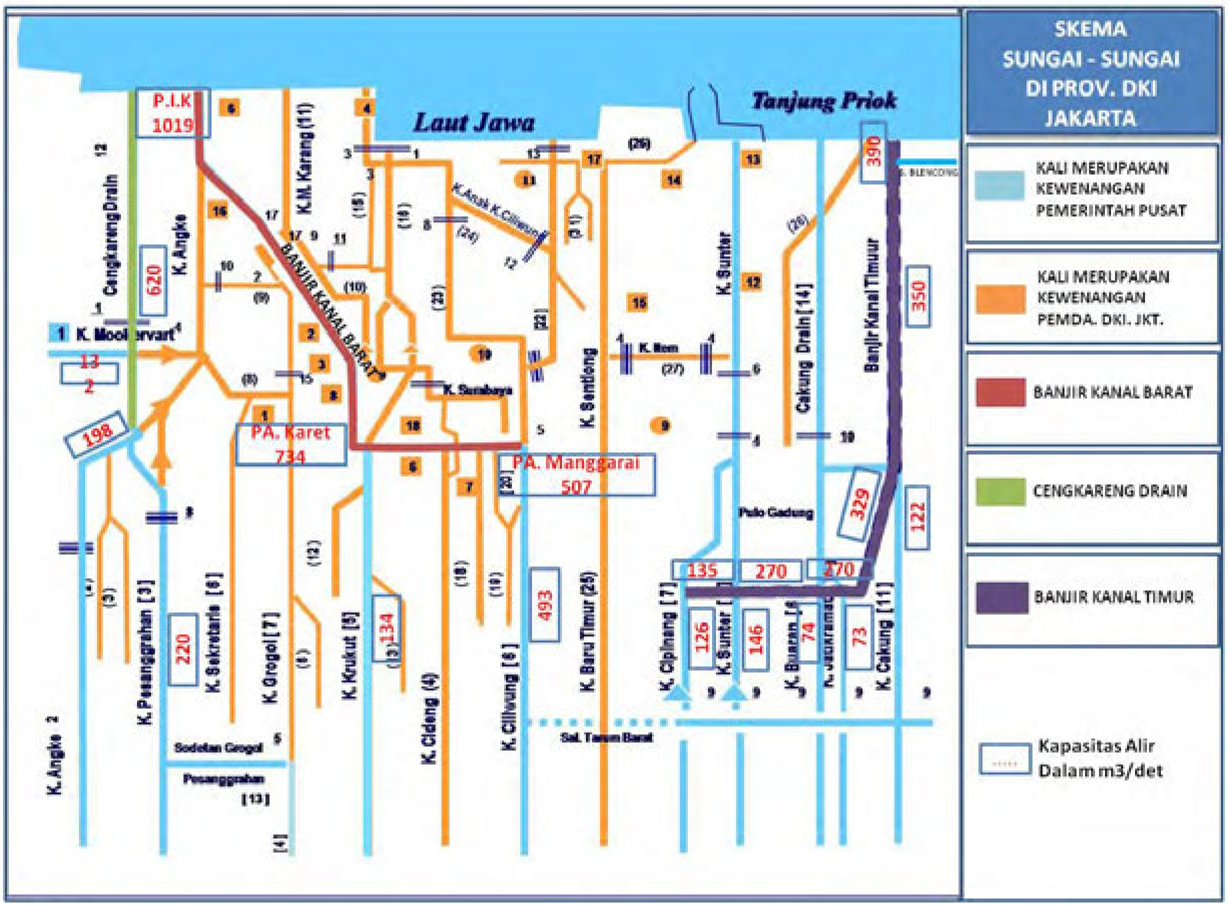


Figure 1.2-1 River System Map

Table 1.2-1 List of Major Rivers

NO.	Main stream	Primary tributary	Secndary tributary	Tertiary tributaries	River length (km)	Administrator
1	Ciliwung				100.8 km	BBWS
2	WBC				17.1 km	BBWS
3		K Angke			6.5 km	DKI
4			K Sekretaris		7.3 km	DKI
5				K Grogol	14.6 km	DKI
6		K Krukut			22.3 km	BBWS
7			Mampang		6.6 km	DKI

(1) River Conditions

The conditions of major rivers in the basin are mentioned below.

(Ciliwung River)

The total length of Ciliwung river is 100.8km with width of 30 to 60m. The Ciliwung river flows into the West Banjir Canal at Manggarai which originates from Pangrango mountain and passes through the Bogor city and Depok city.

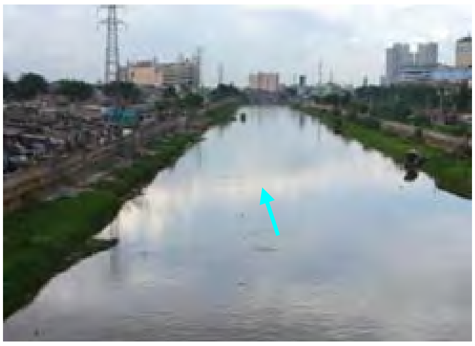
Ciliwung River (upstream of Manggarai Gate)

The current river channel condition is summarized below.

- From upstream to Katulampa gate, the river is a natural river course mainly flowing through the mountainous area.
- From Katulampa to Depok, the river is a natural river course mainly flowing through the mountainous area.
- From Depok to Manggarai gate, the river, with the width of 30m to 60m, is a natural river course mainly flowing through the urban area. The river course is partly a meandering stream and this area functions as a natural retarding basin.

(West Banjir Canal)

The length of West Banjir Canal is approximately 17.1km with the width of 50m to 70m flowing into the Java sea. The West Banjir Canal becomes branch river of Ciliwung river at the Manggarai confluent with Krukut river at the upstream of Karet gate and Angke river at the downstream. The river channel has a embanked channel with soil embankment or parapet structure. At the hinterland of the river, the urban area of DKI Jakarta expands.



West Banjir Canal (downstream of Tomang Raya)

(Krukut River)

Krukut river confluents with the West Banjir Canal at the up reach of Karet weir with the length of about 22.3km and the width of 5m to 30m. The river is a natural river with concrete embankment. There is an urban area at the hinterland of the river.

Krukut River (confluence with West Banjir Canal)

1.3 River Structure

The river structure of Ciliwung river basin is mentioned below.

1.3.1 River Course

(1) West Banjir Canal

Due to the flood occurred in February 2007, the dredging works were conducted in 14.9km from Manggarai gate to PIK bridge, and completed in 2010.

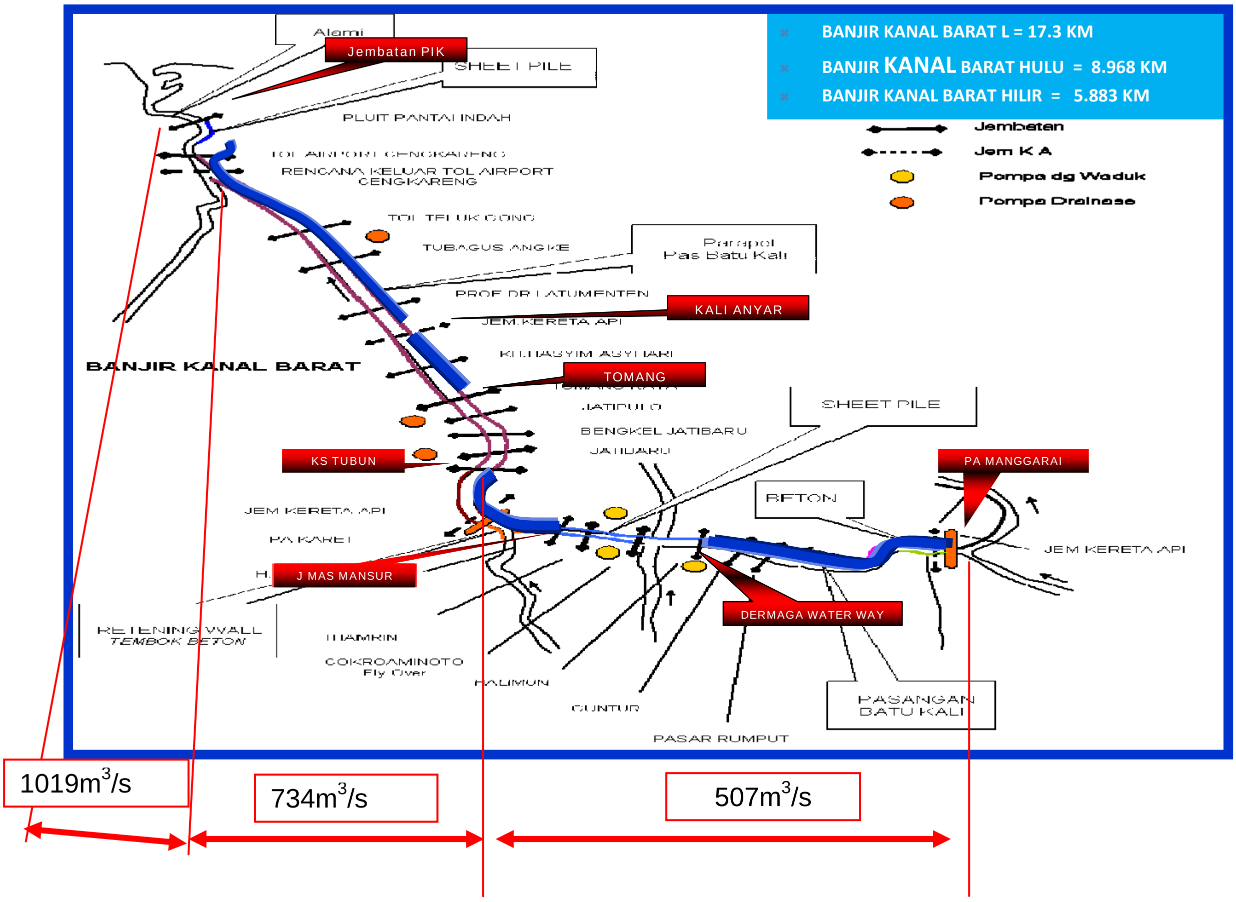
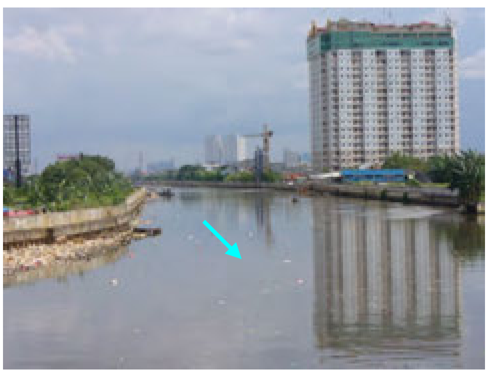


Figure 1.3-1 Improvement and Design Discharge of West Banjir Canal



West Banjir Canal (confluence with Angke River)

West Banjir Canal (upstream of Karet Gate)

Figure 1.3-2 Conditions on Improvement of West Banjir Canal

(2) East Banjir Canal

The East Banjir Canal (total length of approximately 23km) was constructed from 2004 to 2010.

The river route and design discharge of East Banjir Canal are shown in Figure 1.3-3.

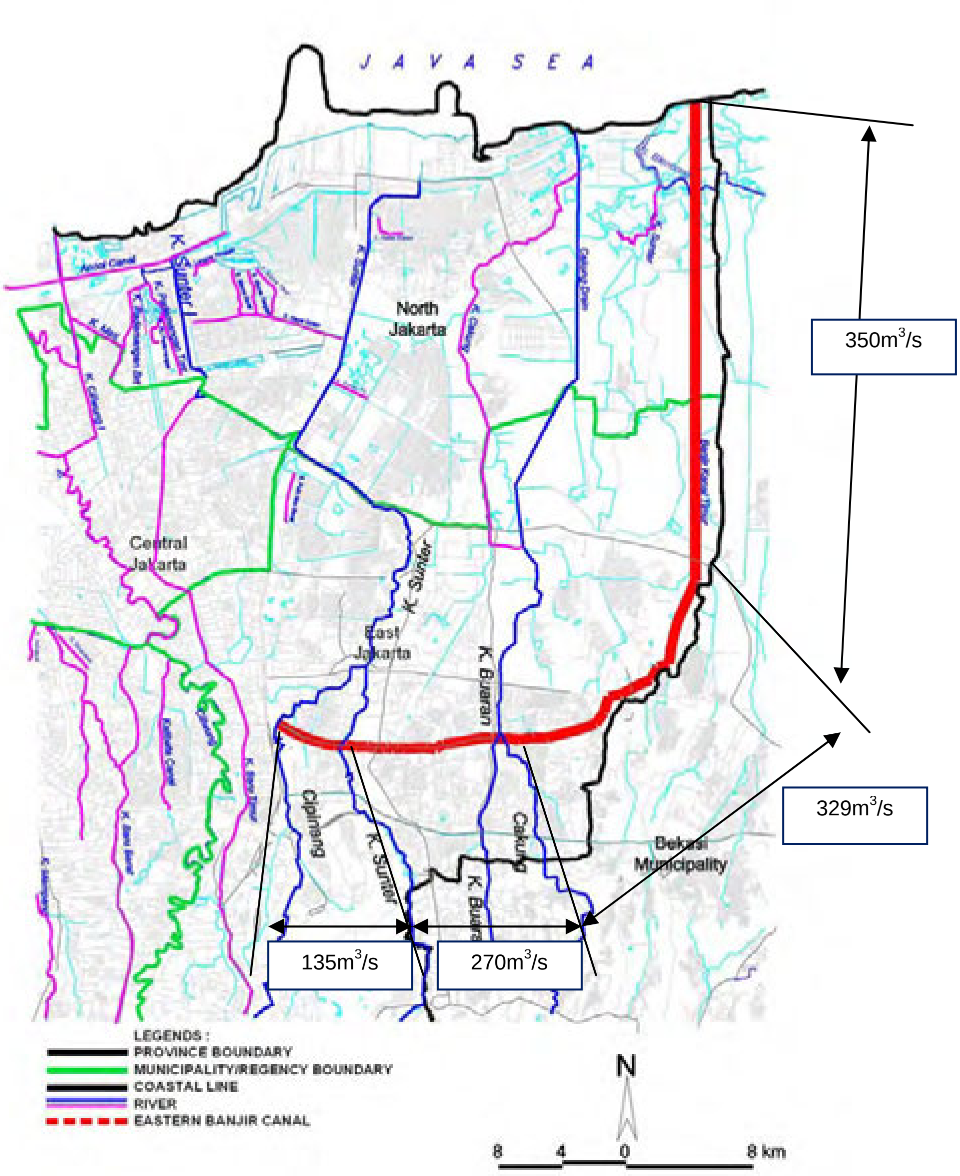


Figure 1.3-3 Improvement Route and Design Discharge Allocation of East Banjir Canal

East Banjir Canal (downstream of diversion point)

East Banjir Canal (gate near MEDAN SATRIA)

East Banjir Canal (gate near Jl.MarundaMakmur)

East Banjir Canal (estuary)

Figure 1.3-4 Improvement Condition of East Banjir Canal

1.3.2 Drainage Pump Station and Gate

The drainage plan in the area between West Banjir Canal and East Banjir Canal was formulated in 1973 as a part of Flood Management and Drainage Plan in DKI Jakarta. In accordance with this plan, the existing river channels have been improved as a main drainage channel with 25-year return period. Moreover, the targeted area was divided in to 6 drainage areas and the drainage pump stations and drainage networks have been constructed in those areas.

Currently, the stormwater drainage networks have complicated system since the major rivers including Ciliwung river flowing from Bogor area are used as main drainage channels and secondary and tertiary channels connect with those main channels. Those rivers are effects by the tide level of Java sea, thus, the inland drainage is conducted by 18 locations of drainage pump stations and 23 numbers of flood gates.

(1) Drainage Pump Station

In the lowland area of former Ciliwung river at the north of West Banjir Canal, the flood measures have been conducted by constructing the drainage pump station in order to mitigate the flood damages in the inland area. The main pump stations in this area are Pluit pump station, Cideng pump station and Melati pump station.

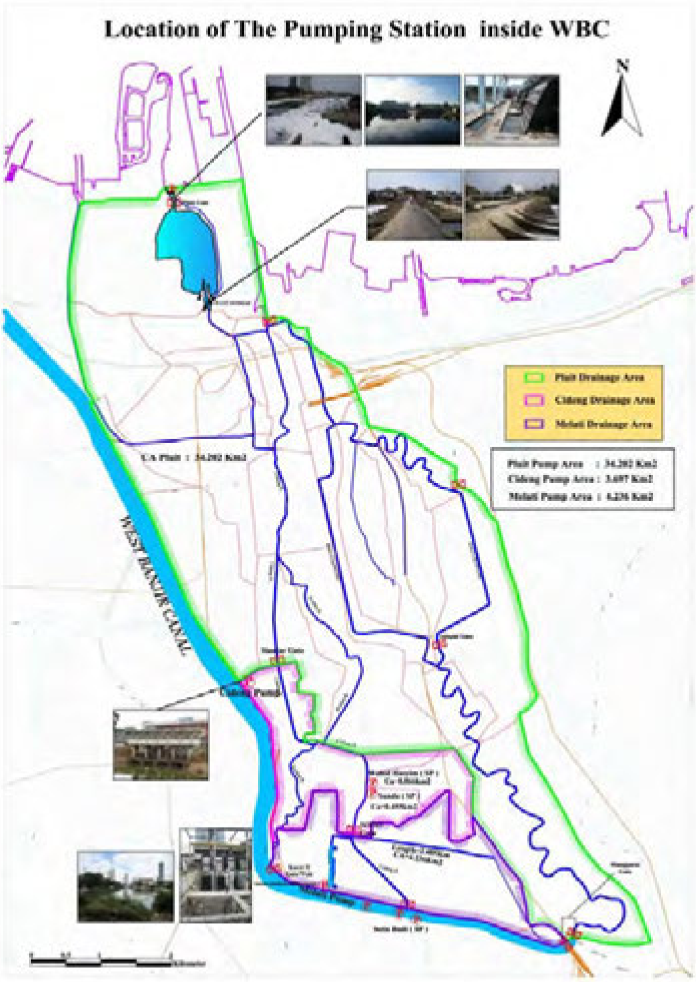


Figure 1.3-5 Location Map of Drainage Pump Station

Table 1.3-1 List of Existing Drainage Pump Station

No	Name	Pump Capacity	No. of Units	Reservoir Area (ha)	Drainage Area (ha)	River Drained	Management
1	Ancol	15	3	4	635	Ancol Canal - Java Sea	BBWS-CC
2	Sunter III	15	3	8	570	Sunter R.	BBWS-CC
3	Cideng	40.2	7	0	750	WBC	DPU
4	Istana Merdeka	1	4	0	50	Ciliwung-Gajah Mada R.	DPU
5	Kali Item	8	4	0	278	Kali Item R.	DPU
6	Melati	12.8	9	8.5	185	WBC	DPU
7	Kelapa Gading	4	2	0.5	130	Cakung R.	DPU
8	Tanjungan	12	3	0	385	Tanjungan R.	DPU
9	Yos Sudarso	0.25	1	0	1.5	Sunter R.	DPU
10	Muara Angke	2	3	0.5	50	WBC	DPU
11	Pluit	48.4	11	80	2,663.00	Java Sea	DPU
12	Sunter Selatan	15	6	25.9	586	Sunter Channel - Java Se	DPU
13	Sunter Timur I	4	3	8	200	Sunter R.	DPU
14	Sunter Utara	20	5	32	1,250.00	Japat R. - Java Sea	DPU
15	Teluk Gong	5.4	9	2.1	90	Angke .R-WBC	DPU
16	Penjaringan	4.5	3	6	150	Muara Angke R.	DPU
17	Tomang Barat	10.96	8	6	200	Sekretaris R.	DPU
18	Grogol	2.7	3	3	100	Grogol R.	DPU
19	Setiabudi Barat	8.98	7	2.85	170	WBC	DPU
20	Setiabudi Timur	8.52	6	1.7	140	WBC	DPU
21	UPP	0.25	1	0	1.5	Cipinang R.	DPU
22	Pulo Mas	7.5	3	6.8	460	Sunter R.	DPU
23	Industri	1.6	4	0	32	Pademangan R.	DPU
24	Jati Pinggir	1	2	0	50	WBC	DPU
25	Kartini	0.5	1	0	22	Pademangan R.	DPU
26	Mangga Dua Abdad	2.6	2	0	30	Ciliwung-Gunung Sahari River	DPU
27	Rajawali	0.25	1	0	2	Pademangan R.	SDPU-Center
28	Sumur Batu	0.5	2	0	25	Sunter R.	BBWS-CC
29	Terowongan Dukuh Atas	0.36	6	0	1	WBC	SDPU-Center
30	Under Pass Pasar Senen	0.8	4	0.04	1.5	Kalibaru Timur- Sentiong R	SDPU-Center
31	Under Pass Pramuka	0.8	4	0	50	Sentiong R.	SDPU-Center
32	Bimoli	1	2	0	3	Muara Angke R.	SDPU-Center
33	Gaya Motor	0.25	2	0.5	1.5	Sunter Barat R.	SDPU-North
34	Kapuk Muara	0.25	1	0	60	Angke R.	SDPU-North
35	Pinangsia	2	2	0	5	Anak Ciliwung R.	SDPU-West
36	Gang Macan	3	2	0	60	Sekretaris R.	SDPU-West
37	Pondok Bandung	1.95	4	0.06	90	WBC	SDPU-West
38	Jelambar Wijaya	8	4	1.2	50	Angke R.	SDPU-West
39	Rawa Kepa	1.5	4	0.5	223	WBC	SDPU-West
40	Sipil Hankam	0.24	6	1	50	Grogol R.	SDPU-West
41	Under Pass Tomang	0.5	4	0	1.5	Grogol R.	SDPU-West
42	IKPN Bintaro	1.1	3	0	8	Pesanggrahan R.	SDPU-South
43	Kebon Baru	0.8	4	0	32	Ciliwung R.	SDPU-South
44	Terowongan Bintaro	1.6	6	0	1	Pesanggrahan R.	SDPU-South
45	TVRI	0.36	2	0	5	Sekretaris R.	SDPU-South
46	Bidara Cina	1.65	5	0	40	Ciliwung R.	SDPU-East
47	Terowongan DI Panjaitan	1.36	5	0	40	Cipinang R.	SDPU-East
48	Under Pass Cawang	0.8	1	0	1.5	Cipinang R.	SDPU-East
49	IKIP	1	2	0	10	Sunter R.	SDPU-East
50							
51							
52							

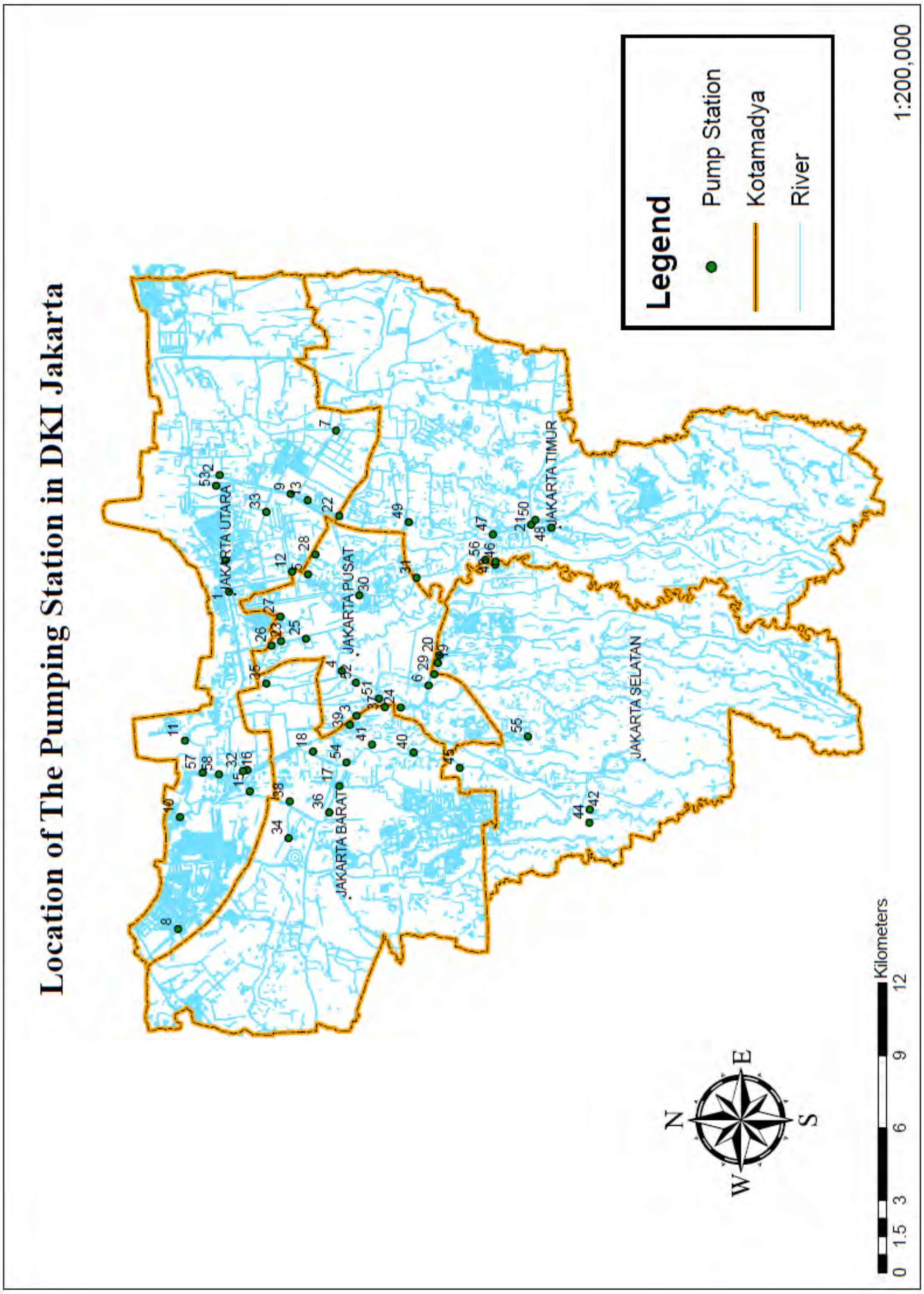


Figure 1.3-6 Location Map of Drainage Pump Station (DKI Jakarta)

(2) Gate

The location of the existing gates in the lowland area is shown in Figure 1.3-7.

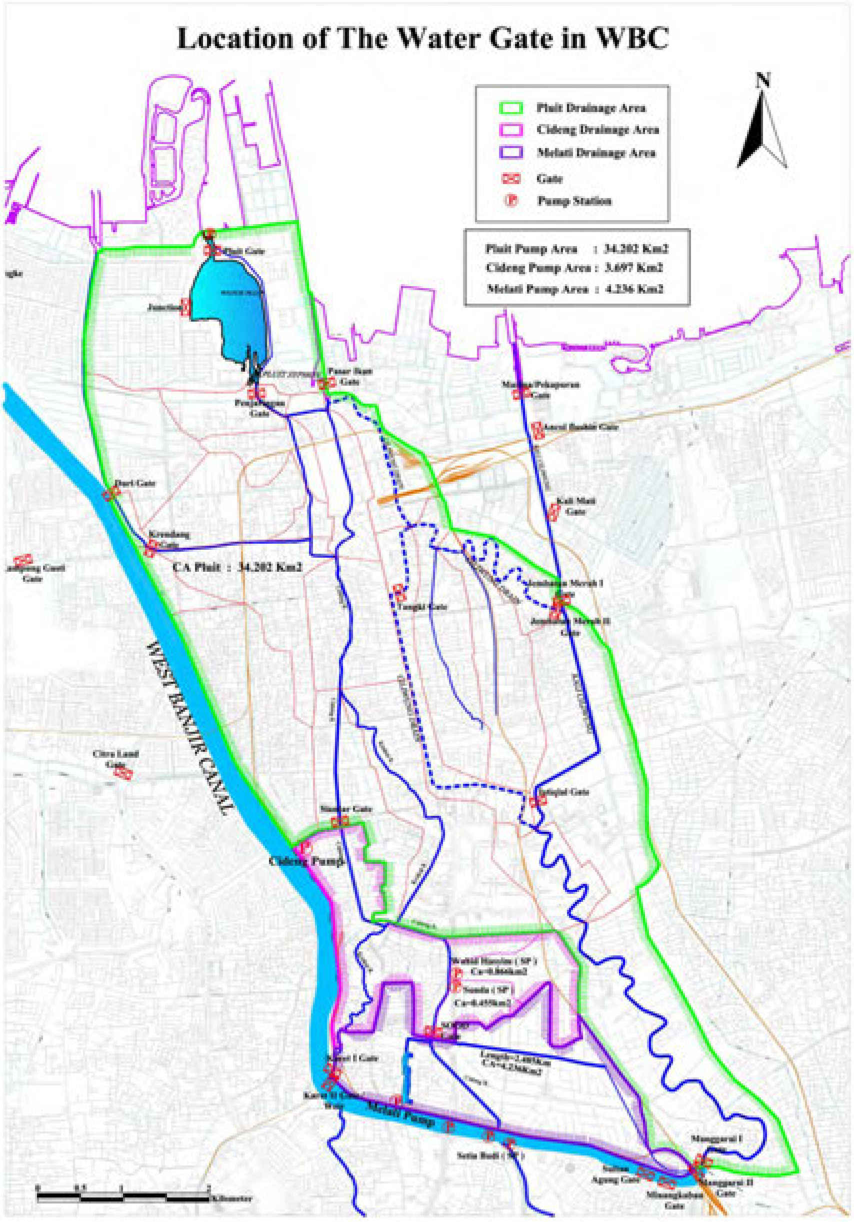


Figure 1.3-7 Location Map of Gate

Table 1.3-2 List of Existing Gate (DKI Jakarta)

No	Name	No of Gate	Width (m)	Heigh (m)	Rivers_Ins	Management	Operation
1	Karet I	4	4	6	WBC	SDPU-Center	
2	Karet II	1	3	3	WBC - Krukut	SDPU-Center	Closed
3	Manggarai I	2	5.5	8	Ciliwung - WBC	SDPU-Center	
4	Manggarai II	1	5.5	8	Ciliwung – Ciliwung Lama	SDPU-Center	Closed
5	Cideng	2	5.25	4	Cideng	SDPU-Center	Closed
6	Istiqlal	3	3.3	3	Ciliwung Lama – Ciliwung Gunung Sahari	SDPU-Center	Open
7	Jembatan Merah I	4	3	2.3	Ciliwung Gunung Sahari	SDPU-Center	Closed, but during 2007 Feb. it was opend. Tide level should be given here for 2007 flood.
8	Jembatan Merah II	2	3	2.3	Ciliwung Gunung Sahari – Ciliwung Kota	SDPU-Center	Open, but during 2007 Feb. it was closed.
9	Honda	5	0	0	Sunter	SDPU-Center	
10	Sogo	2	0	0	Cideng	SDPU-Center	Closed
11	Marina / Pekapuran	5	7.2	4.2	Ciliwung – Java Sea	SDPU-North	
12	Ancol (Flushing)	2	2.6	3.05	Ciliwung Gunung Sahari – Ancol Canal	SDPU-North	
13	Pasar Ikan	3	2.8	3.5	Besar/Pakin/Ciliwung -Java Sea	SDPU-North	Closed.
14	Koja	2	3.5	3	Lagoa / Koja – Java Sea	SDPU-North	
15	Duri	2	3.3	3.6	Duri	SDPU-North	Closed
16	Sunter C	1	0	0	Sunter	SDPU-North	
17	Sunter Utara	2	7	5	Sunter	SDPU-North	
18	Penjaringan	2	0	0	Jelakeng – Pluit Reservoir	SDPU-North	Closed.
19	Junction	2	0	0	Pluit Reservoir	SDPU-North	Closed, while WL of Pluit Reservoir is higher than that of drain.
20	Kali mati	2	2.8	3.7	Kali Mati	SDPU-North	
21	Ancol (Pumping Station)	2	2.6	3.3	Ancol Canal – Java Sea	BBWS CC	
22	Muara Angke	2	0	0	Muara	SDPU-North	
23	Kampung Gusti	2	1.7	3.5	Angke Drain- Jelambar - Grogol	SDPU-North	
24	Poglar	2	4.5	5	Angke	SDPU-North	
25	Citra Land	2	2.2	4.2	Grogol	SDPU-North	
26	Cengkareng Drain	4	4	3.5	Cengkareng Floodway	BBWS-CC	
27	Koneng	2	0	0	Pesanggrahan – Cengkareng Floodway	SDPU-North	
28	Tangki	3	0	0	Anak Ciliwung	SDPU-North	Open
29	Minangkabau	2	2.5	3	Kalibaru Barat - WBC	SDPU-South	
30	Warung Pedok	2	1.6	1.8	Kalibaru Barat - WBC	SDPU-South	
31	Bali Matraman	2	2.75	3	WBC	SDPU-South	
32	Sultan Agung	1	2.6	2.8	WBC	SDPU-South	
33	Kebon Baru	6	1	3	Ciliwung	SDPU-South	
34	Cakung Drain	3	0	0	Cakung – Cakung Floodway	SDPU-East	
35	Pulo Gadung	4	4.4	4.8	Sunter	SDPU-East	
36	HEK	2	1.5	2	Kalibaru Timur	SDPU-East	
37	Bidara Cina	5	1	3	Ciliwung	SDPU-East	

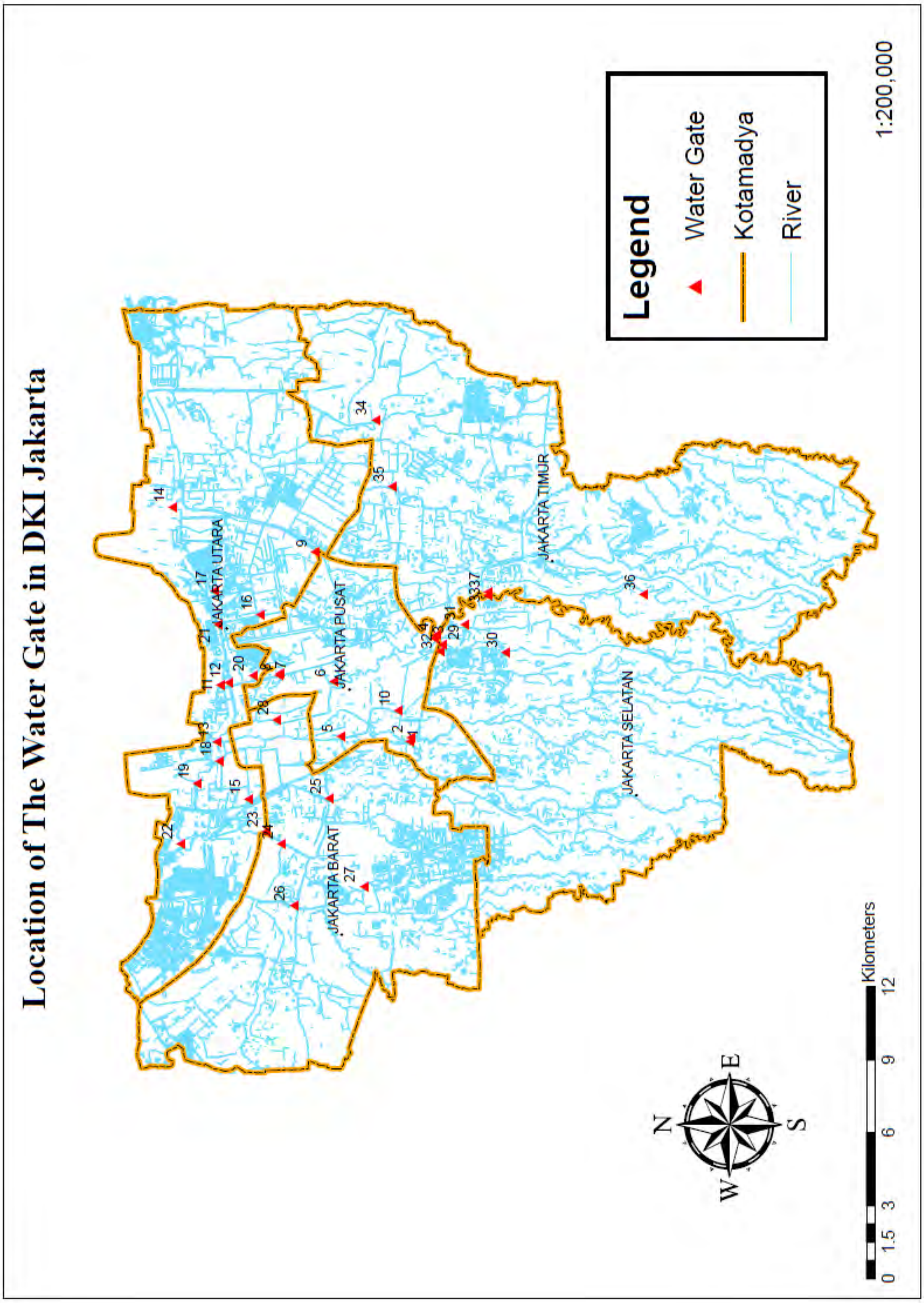
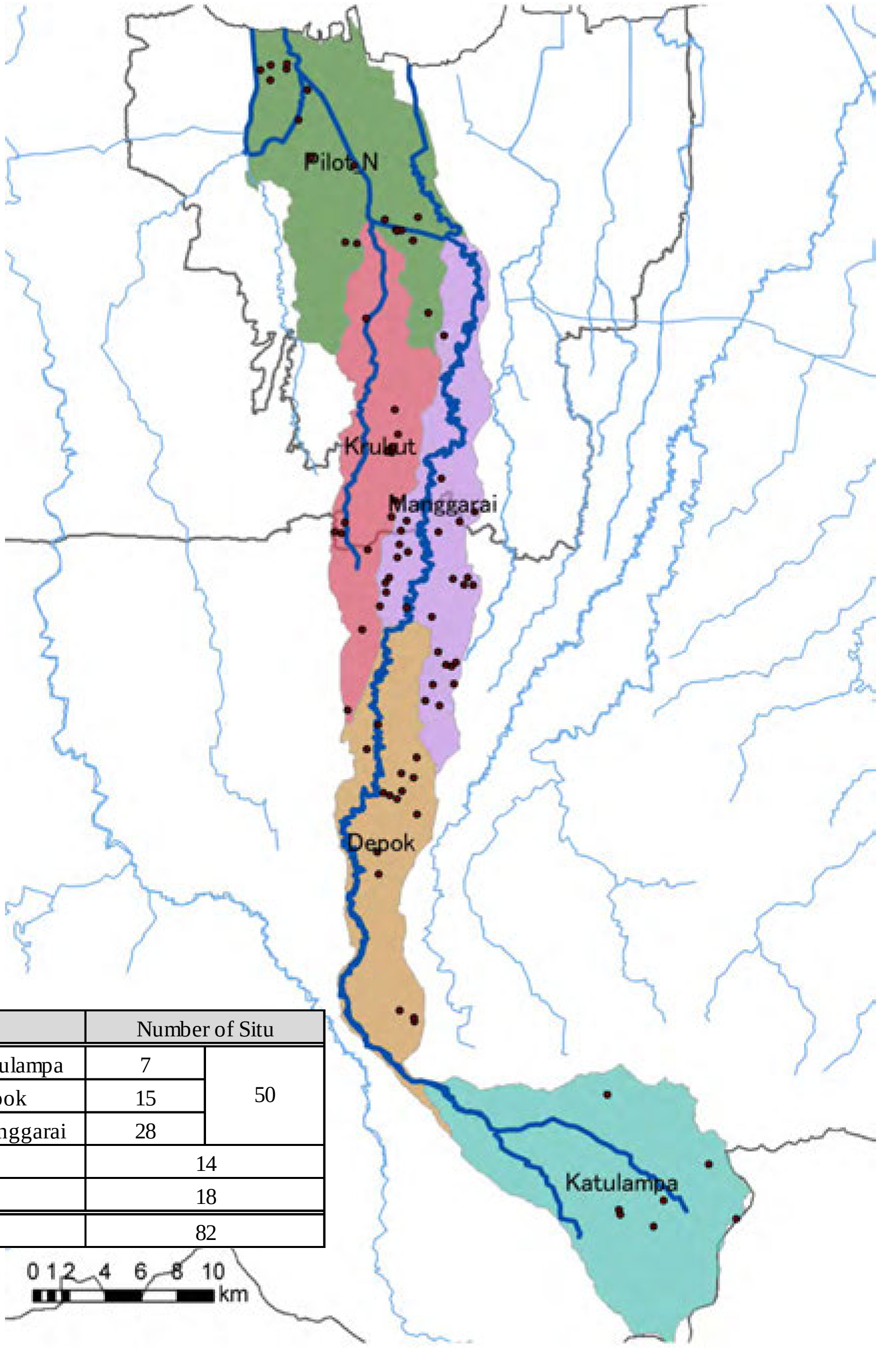


Figure 1.3-8 Location Map of Gate (DKI Jakarta)

1.3.3 Situ-Situ

The conditions of existing Situ-Situ in Ciliwung river basin are shown in Figure 1.3-9 and Table 1.3-3.

The total number of existing Situ-Situ is estimated at 82 locations consisting of 50 locations in Ciliwung river, 14 locations in Krukut river, 18 locations in West Banjir Canal.



Basin		Number of Situ	
Ciliwung	Katulampa	7	50
	Depok	15	
	Manggarai	28	
Krukut		14	
WBC		18	
Total		82	

Figure 1.3-9 Location Map of Situ-Situ

Table 1.3-3 List of Existing Situ-Situ

KODE	NAMA	STATUS	KONDISI	DPS	Lintang	Bujur	Luas (Ha)	Keliling (m)	DESA	KECAMATAN	KABUPATEN/KOTA
31	Babakan 6	Existing	Berair	WBC	-6.341157	106.823932	9.74	2,030	JAGAKARSA	JAGAKARSA	DKI JAKARTA
95	Beji Timur 1	Existing	Dangkal	WBC	-6.382495	106.818909	1.32	839	BEJI TIMUR	BEJI	KOTA DEPOK
96	Beji Timur 2	Existing	Dangkal	WBC	-6.379871	106.820723	1.12	446	BEJI TIMUR	BEJI	KOTA DEPOK
136	Bogor Raya	Existing	Berair	WBC	-6.598077	106.826804	1.04	443	SUKARAJA	SUKARAJA	KOTA BOGOR
137	Bogor Raya Golf 1	Existing	Berair	WBC	-6.603774	106.834174	0.60	302	SUKATANI	SUKARAJA	KABUPATEN BOGOR
138	Bogor Raya Golf 2	Existing	Berair	WBC	-6.601702	106.833903	0.99	512	SUKATANI	SUKARAJA	KABUPATEN BOGOR
144	BOJONG BARU	Potential	Kering	WBC	-6.488189	106.818155	1.24	542	BOJONG BARU	BOJONGGEDE	KABUPATEN BOGOR
243	Cibeureum 1	Existing	Kering	WBC	-6.466222	106.809713	2.89	1,133	RAWA PANJANG	BOJONGGEDE	KABUPATEN BOGOR
245	Cibeureum 3	Existing	Kering	WBC	-6.453827	106.815592	1.81	964	PONDOK JAYA	PANCORAN MAS	KABUPATEN BOGOR
247	CIBEUREUM 5	Potential	Kering	WBC	-6.706574	106.954865	0.50	337	CIBEUREUM	CISARUA	KABUPATEN BOGOR
263	Ciburiat	Potential	Kering	WBC	-6.675198	106.982712	1.81	767	TUGU UTARA	CISARUA	KABUPATEN BOGOR
296	Cikareat	Existing	Dangkal	WBC	-6.470328	106.834785	18.91	3,325	HARAPAN JAYA	CIBINONG	KABUPATEN BOGOR
316	Cilodong 1	Existing	Dangkal	WBC	-6.441582	106.838970	8.11	1,270	KALIBARU	SUKMA JAYA	KOTA DEPOK
317	Cilodong 2	Potential	Kering	WBC	-6.422487	106.854460	3.69	1,058	CILANGKAP	CIMANGGIS	KOTA DEPOK
318	Cilodong 3	Potential	Kering	WBC	-6.433129	106.853396	3.98	1,137	CILANGKAP	CIMANGGIS	KOTA DEPOK
319	Cilodong 4	Potential	Kering	WBC	-6.424498	106.852274	2.33	839	CILANGKAP	CIMANGGIS	KOTA DEPOK
324	Ciming	Existing	Kering	WBC	-6.380432	106.852690	1.53	496	TUGU	CIMANGGIS	KOTA DEPOK
348	CIPEDAK	Existing	Dangkal	WBC	-6.357488	106.796643	0.54	436	CIPEDAK	JAGAKARSA	DKI JAKARTA
362	Cisarua Ragunan	Existing	Kering	WBC	-6.307411	106.824957	1.49	604	RAGUNAN	PASAR MINGGU	DKI JAKARTA
378	Citayam 1	Existing	Berair	WBC	-6.446542	106.800086	6.73	1,835	BOJONG PONDOK TERON	PANCORAN MAS	KOTA DEPOK
380	Citeko 1	Existing	Berair	WBC	-6.698260	106.937432	0.89	430	CITEKO	CISARUA	KABUPATEN BOGOR
381	Citeko 2	Existing	Dangkal	WBC	-6.700678	106.938086	0.31	228	CITEKO	CISARUA	KABUPATEN BOGOR
386	Cjantung/Kibing	Existing	Berair	WBC	-6.444085	106.846100	0.41	259	CILANGKAP	CIMANGGIS	KABUPATEN BOGOR
437	Dep Pertanian	Existing	Berair	WBC	-6.295092	106.823201	0.54	320	RAGUNAN	PASAR MINGGU	DKI JAKARTA
438	Div Infantri Cilodong	Existing	Berair	WBC	-6.433493	106.842781	0.98	533	KALIBARU	SUKMA JAYA	KOTA DEPOK
440	Dongkelan/Aman	Existing	Dangkal	WBC	-6.351288	106.856007	12.41	2,467	TUGU	CIMANGGIS	KOTA DEPOK
441	DPR / MPR	Existing	Berair	WBC	-6.210610	106.798167	0.52	267	GELORA	TANAH ABANG	DKI JAKARTA
645	Karet	Existing	Berair	WBC	-6.209588	106.832020	1.97	852	GUNTUR	SETIA BUDI	DKI JAKARTA
656	Kebantenan	Existing	Kering	WBC	-6.480411	106.833397	3.06	1,166	PAKANSARI	CIBINONG	KABUPATEN BOGOR
736	Lembang	Existing	Kering	WBC	-6.197881	106.834548	0.52	293	GONDANGDIA	MENTENG	DKI JAKARTA
754	Mangga Bolong	Existing	Dangkal	WBC	-6.349090	106.821814	2.02	1,008	SRENGSENG SAWAH	JAGAKARSA	DKI JAKARTA
755	Manggal Belong	Existing	Kering	WBC	-6.329680	106.846787	1.46	569	BARU	PASAR REBO	DKI JAKARTA
762	Matoa Golf	Existing	Berair	WBC	-6.356887	106.793291	0.25	199	KRUKUT	LIMO	DKI JAKARTA
764	Megamendung	Existing		WBC	-6.640197	106.931311	18.00	3,149	MEGAMENDUNG	MEGAMENDUNG	KABUPATEN BOGOR
806	Nanggewer mekar	Existing	Berair	WBC	-6.499130	106.835056	0.52	265	NANGGEWER MEKAR	CIBINONG	KABUPATEN BOGOR
854	PAKANSARI	Potential	Kering	WBC	-6.491306	106.825191	2.32	953	PAKANSARI	CIBINONG	KABUPATEN BOGOR
867	Paladen 1	Existing	Kering	WBC	-6.365830	106.809834	0.91	575	KUKUSAN	BEJI	KOTA DEPOK
868	Paladen 2	Existing	Berair	WBC	-6.387333	106.819267	1.32	532	BEJI TIMUR	BEJI	KOTA DEPOK
872	Pancoran 3	Existing	Dangkal	WBC	-6.246041	106.839799	0.88	524	MENTENG DALAM	TEBET	DKI JAKARTA
874	Pangarengan 1	Existing	Kering	WBC	-6.383350	106.858387	9.57	2,617	CISALAK PASAR	CIMANGGIS	KOTA DEPOK
875	Pangarengan 2	Existing	Kering	WBC	-6.383527	106.862944	2.59	1,173	CISALAK PASAR	CIMANGGIS	KOTA DEPOK
876	Pangarengan 3	Existing	Kering	WBC	-6.379666	106.860150	2.00	755	CISALAK PASAR	CIMANGGIS	KOTA DEPOK
895	Pasir Gunung Selatan	Potential	Dangkal	WBC	-6.356698	106.845333	0.33	226	PASIR GUNUNG SELATAN	CIMANGGIS	KOTA DEPOK
909	Pekayon 1	Potential	Kering	WBC	-6.346325	106.863559	0.82	356	PEKAYON	PASAR REBO	DKI JAKARTA
911	Pemda	Existing	Dangkal	WBC	-6.478317	106.827174	5.65	1,331	TENGAH	CIBINONG	KABUPATEN BOGOR
939	Pitara/Pancoranmas	Existing	Kering	WBC	-6.406132	106.807219	1.28	702	PANCORAN MAS	PANCORAN MAS	KOTA DEPOK
941	Pondok Cina/Pondok Dua	Existing	Berair	WBC	-6.366809	106.830134	4.46	840	PONDOK CINA	BEJI	KOTA DEPOK
985	Ragunan 1	Existing	Berair	WBC	-6.316735	106.821778	0.97	364	RAGUNAN	PASAR MINGGU	DKI JAKARTA
986	Ragunan 2	Existing	Berair	WBC	-6.316237	106.819389	1.96	646	RAGUNAN	PASAR MINGGU	DKI JAKARTA
987	Ragunan 3	Existing	Berair	WBC	-6.313846	106.822499	3.74	1,002	RAGUNAN	PASAR MINGGU	DKI JAKARTA
1014	Rawa Ciganjur	Existing	Berair	WBC	-6.352070	106.798493	0.47	261	CIPEDAK	JAGAKARSA	DKI JAKARTA
1024	Rawa Kepa	Existing	Berair	WBC	-6.171683	106.802336	0.69	582	TOMANG	GROGOL PETAMBURA	DKI JAKARTA
1058	Rawabesar 1	Existing	Kering	WBC	-6.394876	106.829591	2.56	723	DEPOK	PANCORAN MAS	KOTA DEPOK
1059	Rawabesar 2	Existing	Berair	WBC	-6.394299	106.816145	13.49	2,132	DEPOK JAYA	PANCORAN MAS	KOTA DEPOK
1068	Salam	Existing	Dangkal	WBC	-6.529288	106.815921	0.77	464	PASIR JAMBU	SUKARAJA	KABUPATEN BOGOR
1079	Sela/Seta	Existing	Kering	WBC	-6.518173	106.815180	1.48	710	PASIR JAMBU	SUKARAJA	KABUPATEN BOGOR
1097	Sidomukti/Baru 1	Existing	Kering	WBC	-6.399424	106.842152	5.85	1,135	TIRTAJAYA	SUKMA JAYA	KOTA DEPOK
1098	Sidomukti/Baru 2	Existing	Kering	WBC	-6.417207	106.845443	4.38	1,472	CILODONG	SUKMA JAYA	KOTA DEPOK
1108	situ Mandara Permai 1	Existing	Berair	WBC	-6.123225	106.768350	2.45	1,037	KAPUK MUARA	PENJARINGAN	DKI JAKARTA
1109	situ Mandara Permai 2	Existing	Berair	WBC	-6.123801	106.755159	7.02	2,730	KAPUK MUARA	PENJARINGAN	DKI JAKARTA
1110	situ Mandara Permai 3	Existing	Berair	WBC	-6.121220	106.760360	4.79	2,260	KAPUK MUARA	PENJARINGAN	DKI JAKARTA
1111	situ Mandara Permai 4	Existing	Berair	WBC	-6.120595	106.768439	3.05	1,205	KAPUK MUARA	PENJARINGAN	DKI JAKARTA
1138	SUKAHATI	Potential	Kering	WBC	-6.489525	106.821516	10.45	1,624	SUKAHATI	CIBINONG	KABUPATEN BOGOR
1147	SUKAMAJU 4	Potential	Kering	WBC	-6.423707	106.849390	1.86	747	SUKAMAJU	SUKMA JAYA	KOTA DEPOK
1215	Taman Ria Remaja	Existing	Berair	WBC	-6.211146	106.803865	4.84	1,827	GELORA	TANAH ABANG	DKI JAKARTA
1272	TENGAH	Potential	Kering	WBC	-6.487370	106.827556	1.40	830	TENGAH	CIBINONG	KABUPATEN BOGOR
1285	TMP Kalibata	Existing	Berair	WBC	-6.257390	106.847773	4.00	1,187	PENGADEGAN	PANCORAN	DKI JAKARTA
1289	Tugu Selatan	Potential	Kering	WBC	-6.693454	106.960013	1.37	528	TUGU SELATAN	CISARUA	KABUPATEN BOGOR
1291	UI 1	Existing	Berair	WBC	-6.351154	106.829422	5.89	1,658	SRENGSENG SAWAH	JAGAKARSA	DKI JAKARTA
1292	UI 2	Existing	Berair	WBC	-6.356122	106.826699	9.45	2,865	KUKUSAN	BEJI	DKI JAKARTA
1293	UI 3	Existing	Berair	WBC	-6.363019	106.825744	4.84	1,405	KUKUSAN	BEJI	KOTA DEPOK
1294	UI 4	Existing	Berair	WBC	-6.369705	106.824813	1.81	761	KUKUSAN	BEJI	KOTA DEPOK
1299	Vikamas Barat 11	Existing	Berair	WBC	-6.128916	106.760118	0.45	262	KAPUK MUARA	PENJARINGAN	DKI JAKARTA
1305	W. Jalembar	Existing	Berair	WBC	-6.148884	106.774545	0.87	398	WIJAYA KESUMA	GROGOL PETAMBURA	DKI JAKARTA
1306	W. Kebon Melati	Existing	Berair	WBC	-6.198965	106.817964	2.06	1,001	KEBON MELATI	TANAH ABANG	DKI JAKARTA
1317	W. Teluk Gong	Existing	Dangkal	WBC	-6.133740	106.778741	2.74	769	PEJAGALAN	PENJARINGAN	DKI JAKARTA
1318	W. Tomang	Existing	Berair	WBC	-6.167775	106.780696	6.33	1,003	TANJUNG DUREN UTARA	GROGOL PETAMBURA	DKI JAKARTA
1319	W. Setiabudi 1	Existing	Berair	WBC	-6.204469	106.826425	2.68	1,037	MENTENG	MENTENG	DKI JAKARTA
1320	W. Setiabudi 2	Existing	Berair	WBC	-6.204060	106.823399	0.72	521	KARET TENGSIN	TANAH ABANG	DKI JAKARTA
1321	W. Setiabudi 3	Existing	Berair	WBC	-6.204794	106.824103	2.23	1,044	KARET TENGSIN	TANAH ABANG	DKI JAKARTA
1322	Walikota Jaksel	Existing	Dangkal	WBC	-6.249001	106.808666	0.28	211	MELAWAI	KEBAYORAN BARU	DKI JAKARTA
1326	Telaga Warna	Existing	Berair	WBC	-6.702658	106.996653	1.02	396	Tugu Utara	Cisarua	KABUPATEN BOGOR

1.4 Flood Inundation Record

The major flood records currently occurred is listed in Table 1.4-1.

Table 1.4-1 List of Current Major Flood

Occurrence Days	Peak Water Level at Manggarai (m)	Basin average rainfall (Manggarai)					Type of Disaster	Damage
		1hour (mm)	6hour (mm)	24hour (mm)	48hour (mm)	168hour (mm)	Dike Break/ Overflow/ Inundation	Inundation Area (km2)
1996.1. 5	9.70	31.8	64.6	130.5	156.9	296.7	Overflow/ Inundation	
2002.1.26～2.20	10.50	16.6	59.9	132.4	194.9	398.0	Overflow/ Inundation	87.1
2007.01.30～02.07	10.61	21.5	86.6	179.5	254.6	482.7	Overflow/ Inundation	300.0

(1) Flood Event (January 1996)

The flood was occurred on 6 and 7 January 1996 in DKI Jakarta and Bogor. This flood mainly caused by the heavy rain in the mountainous area in the upstream of Ciliwung river.

- The peak water level at Katulampa weir was 2.5m from the top of weir (more than 700m3/s discharge).
- At Depok point, the water level reached to 4.35m which exceeded 3.5m of standard water level. The average water level in the rainy season from November to March ranges from 1.2m to 1.5m.
- The surrounding areas along the Ciliwung river suffered from the severe flood disaster. The flood water overtopped at the lower Ciliwung located at the downstream of Manggarai gate.
- The water level of West Banjir Canal reached to the warning level and flood water overtopped at some points. The recorded water level at Setia Budi pump station showed the level more than the design water level led by the back water of West Banjir Canal.

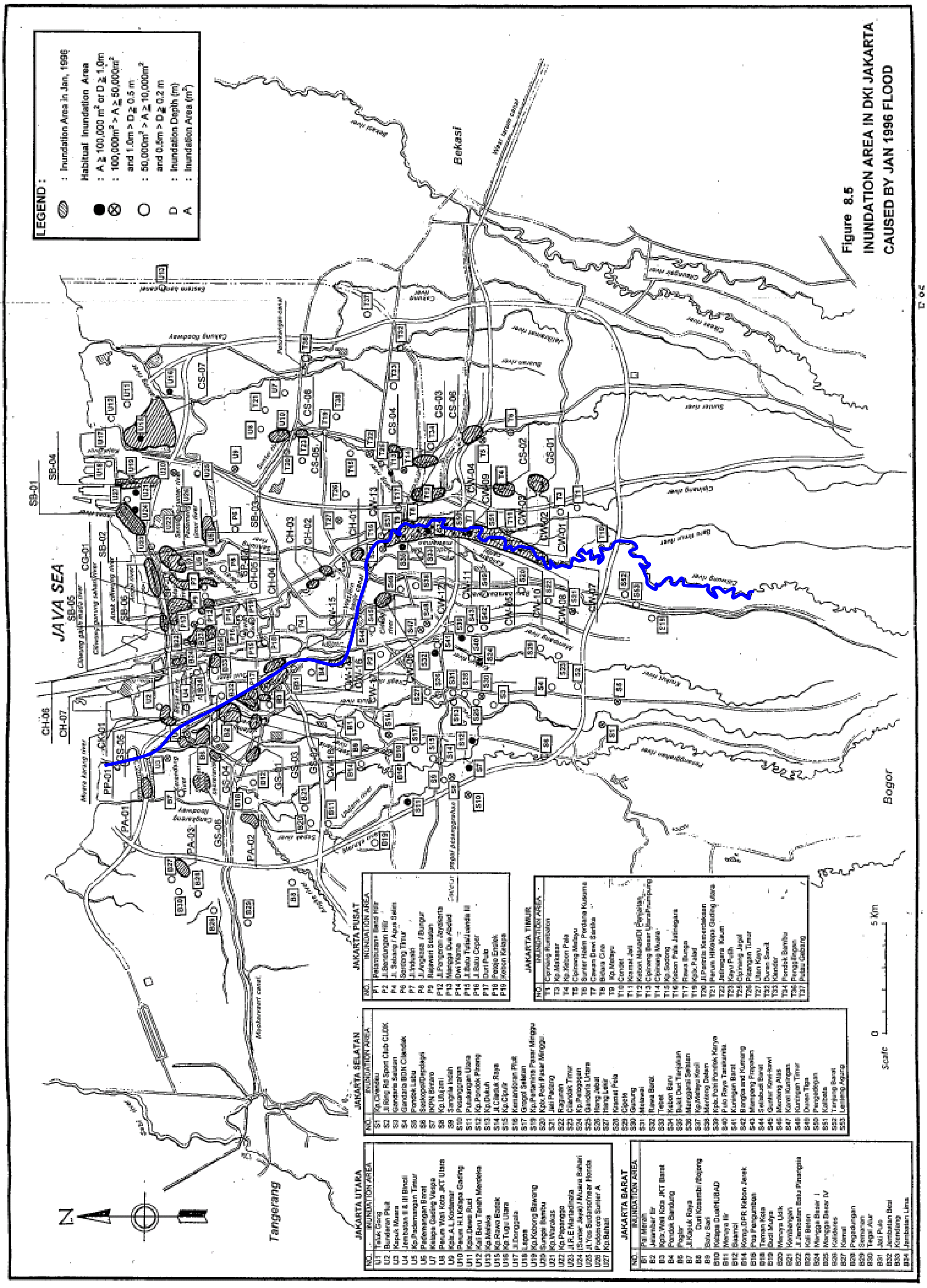
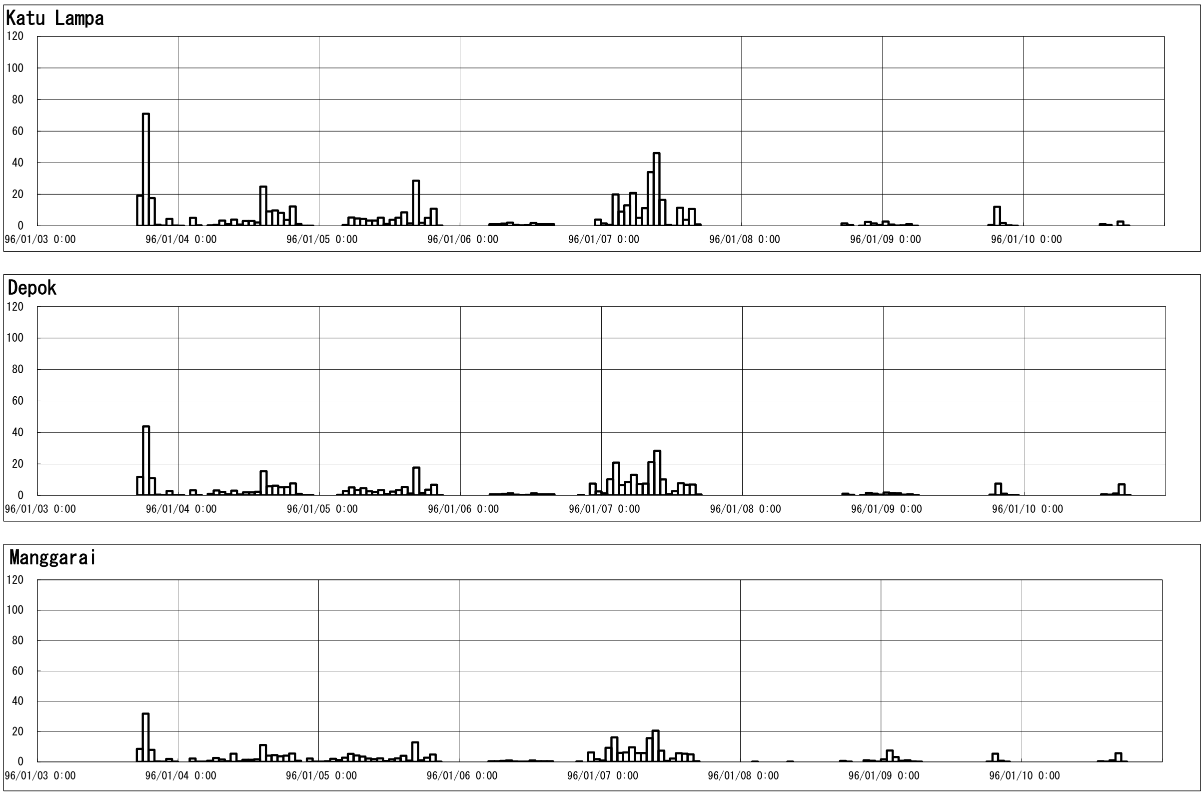


Figure 1.4-1 Inundation Area Map (January 1996)

Rainfall depth



Water level

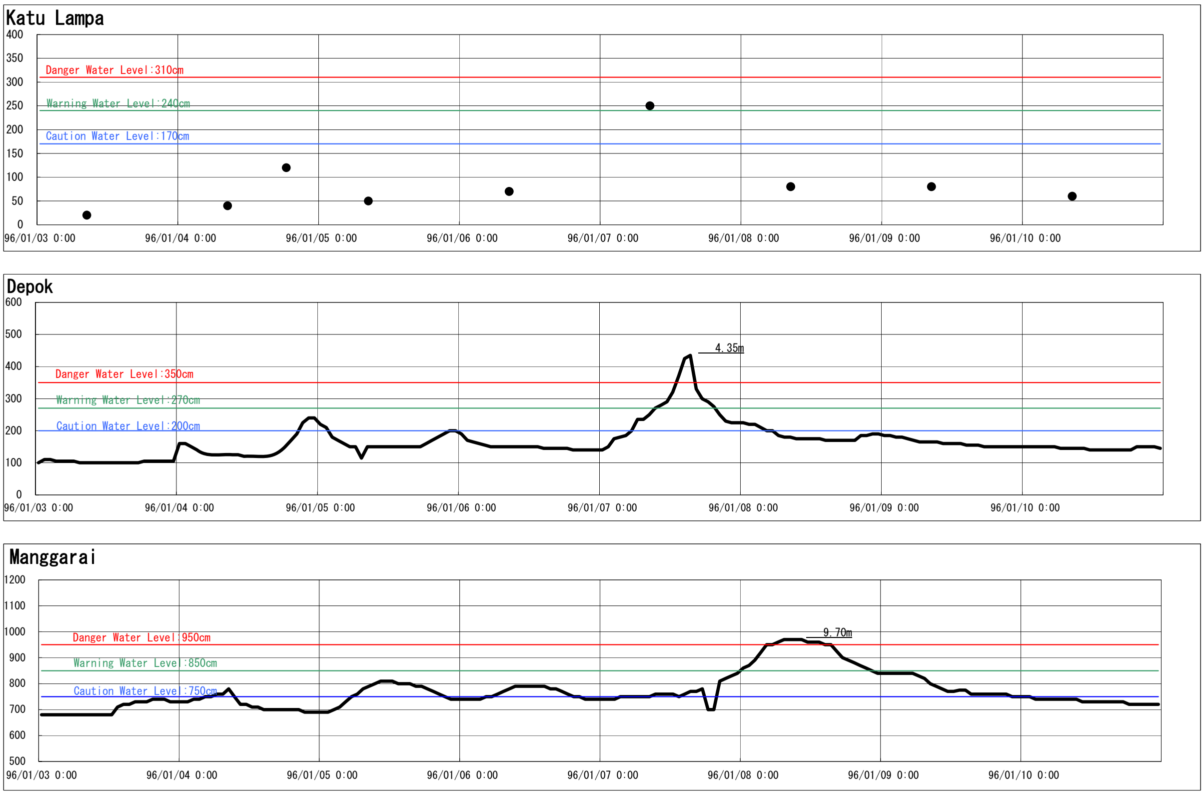


Figure 1.4-2 Hyetograph and Hydrograph (Flood in January 1996)

(2) Flood Event (January to February 2002)

The flood occurred from 26 January to 20 February 2002 causing the serious damages in the urban area of Jakarta Metropolitan Area (JABODETABEK). According to the emergency flood survey in 2002, the inundation area was estimated as 526km^2 which is approximately 8.6% of JABODETABEK. The inundation depth was more than 0.5m, and 52km^2 area had flood duration for more than 1 week

Due to this flood, the inundation areas counted as 87km^2 in DKI Jakarta and 15.2km^2 in Tangerang city, Bekasi city and Depok city. The inundation area in DKI Jakarta is shown in Figure 1.4-4.

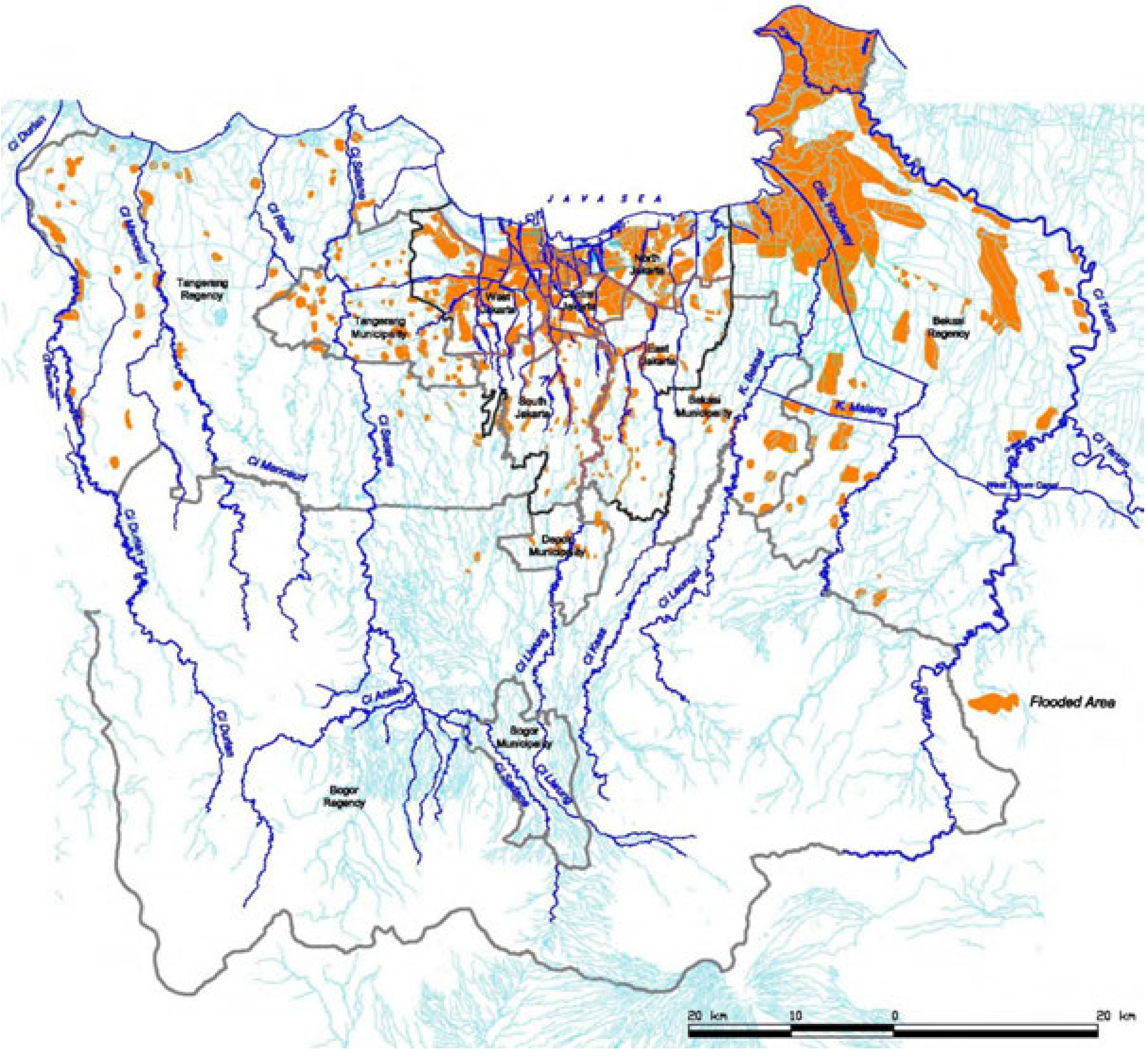


Figure 1.4-3 Inundation Area Map (2002)

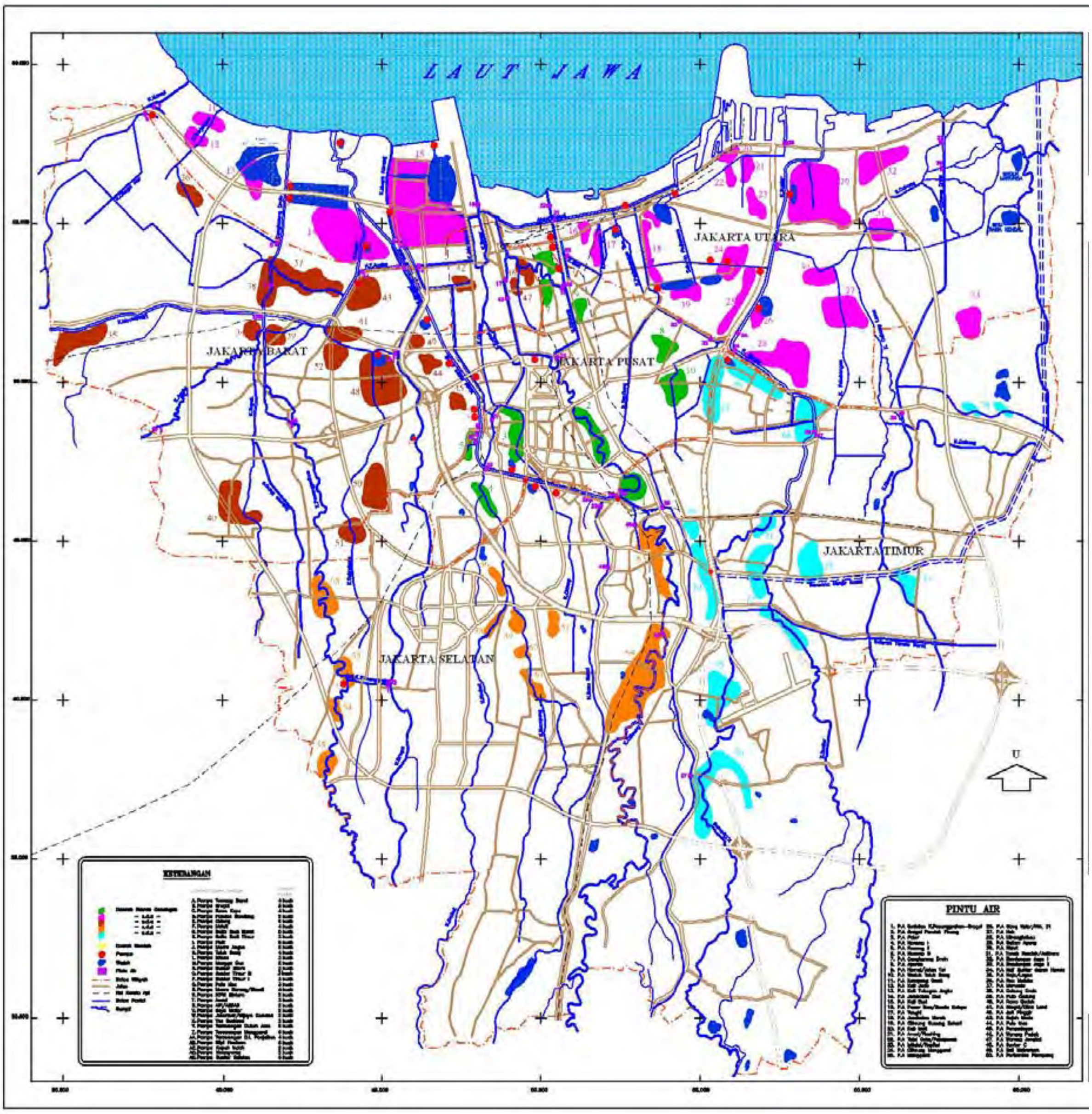
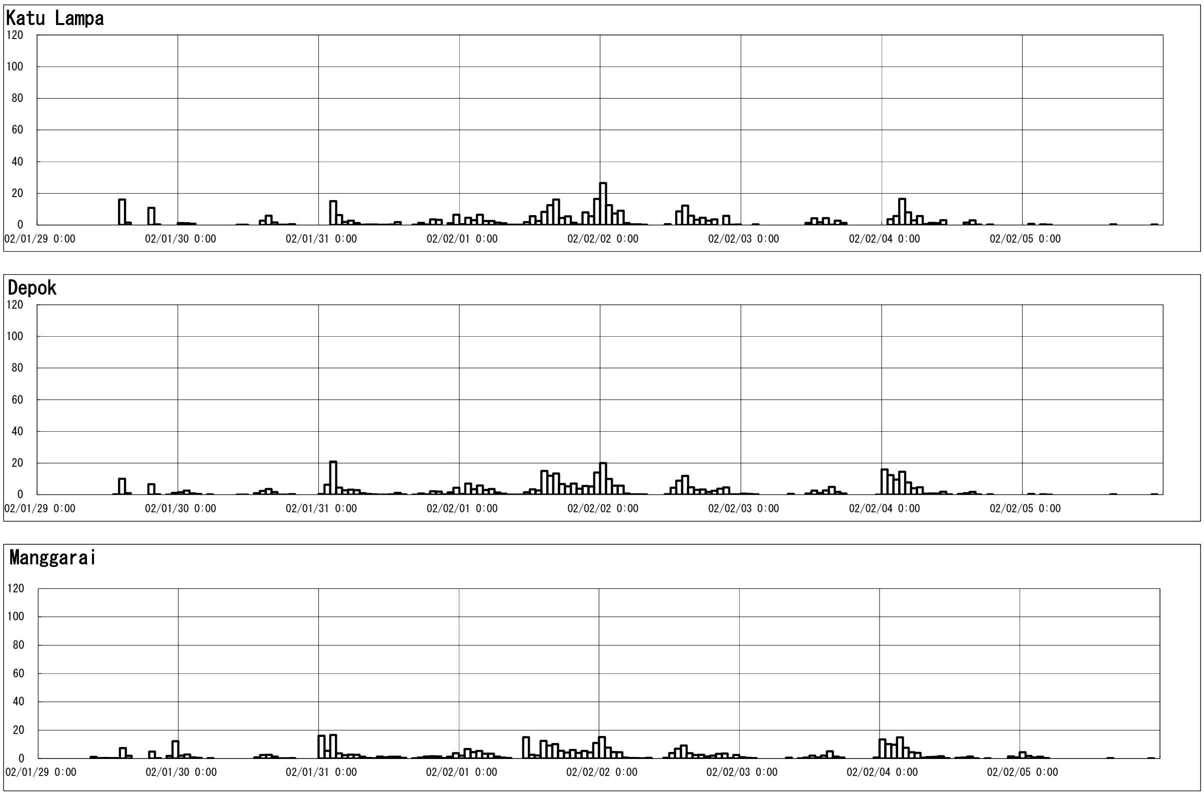


Figure 1.4-4 Inundation Area Map (DKI Jakarta in February 2002)

Rainfall depth



Water level

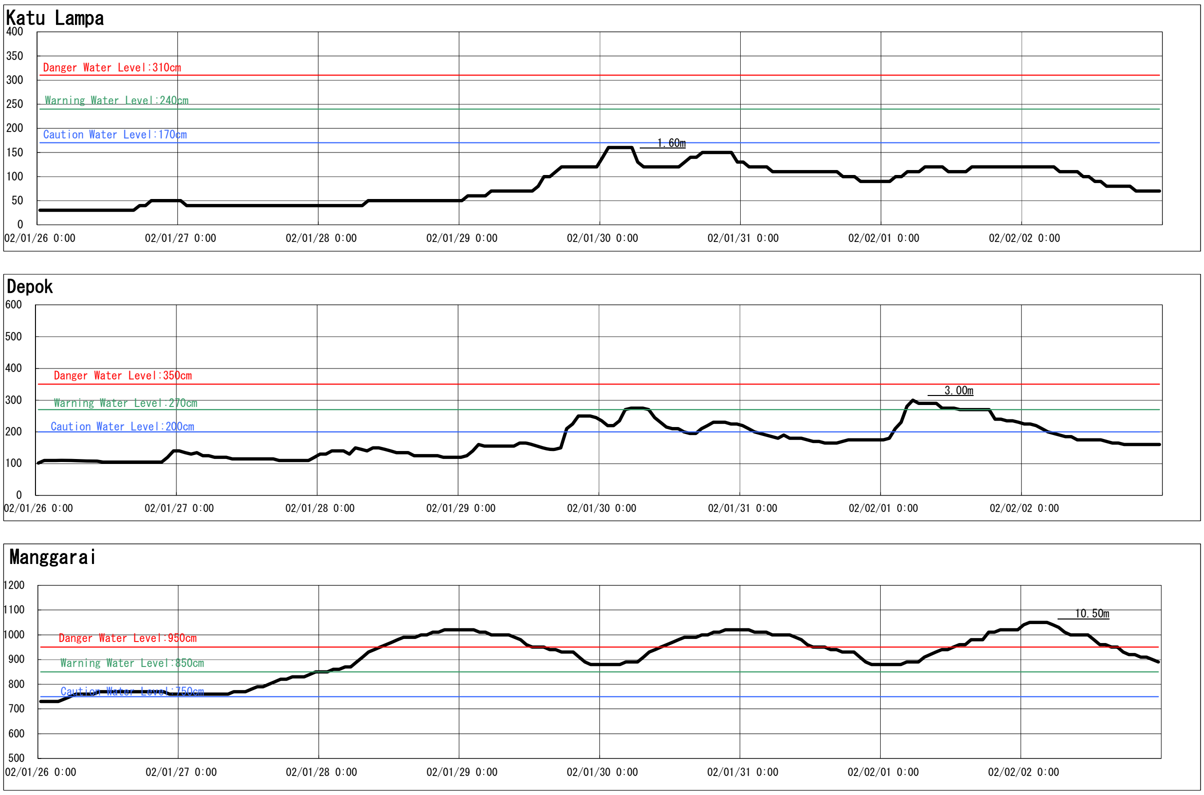


Figure 1.4-5 Hyetograph and Hydrograph (Flood in February 2002)

(3) Flood Event (February 2007)

The JABODETABEK area suffered from the tremendous flood damages due to the flood in February2007. The inundation area by this flood reached to 300km^2 which is about 45% of JABODETABEK area.

The peak water level at Manggarai point reached to 10.61m as a maximum level so far, and the water level exceeded warning level for 1.5 days.

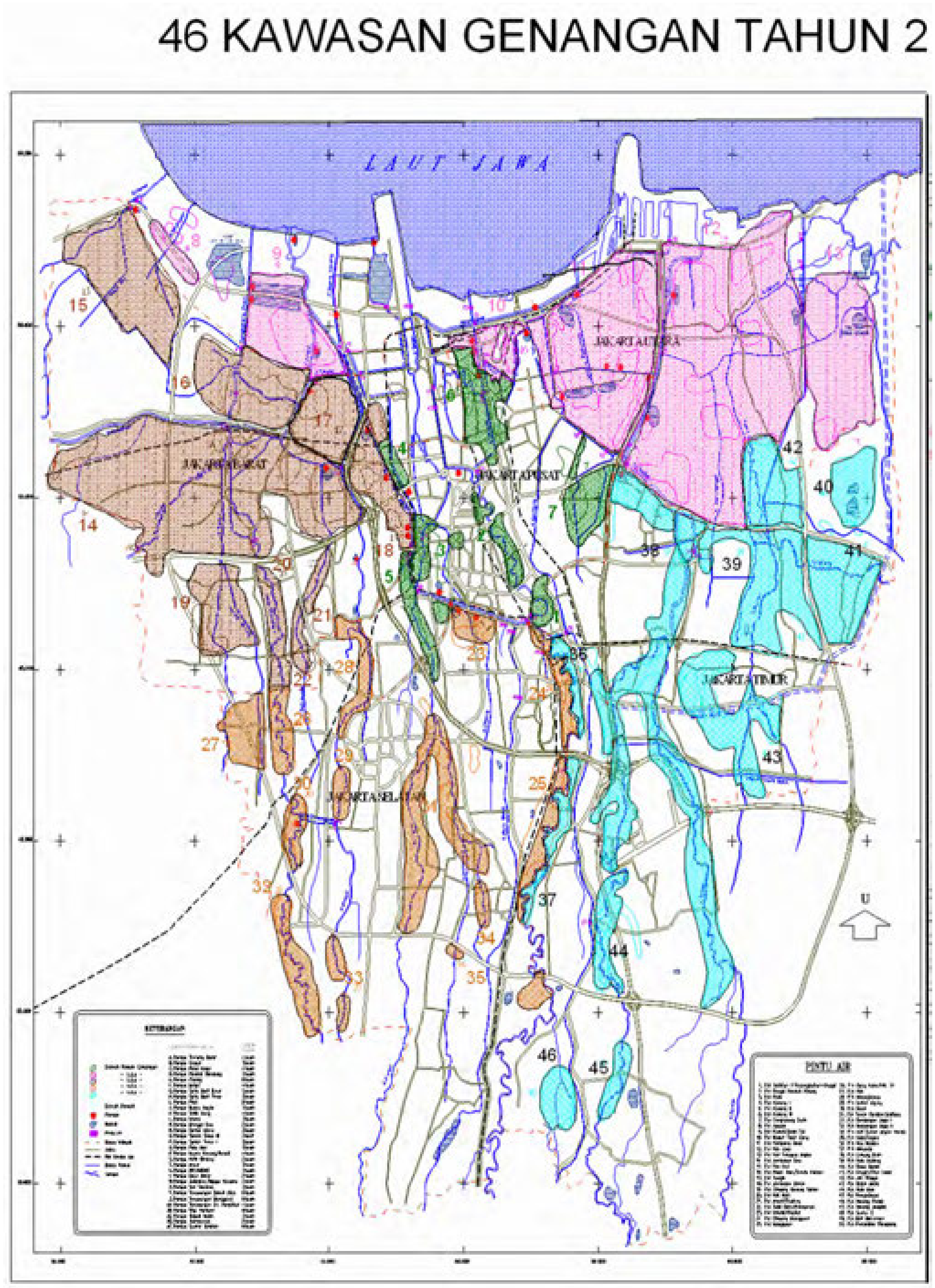


Figure 1.4-6 Inundation Area Map (DKI Jakarta in February 2007)

Banjir Kanal Barat (04.02.07)

Banjir Kanal Barat Undepas Duku Atas ke Hilir (04.02.07)

Figure 1.4-7 Flood Damage Condition (Flood in February 2007)

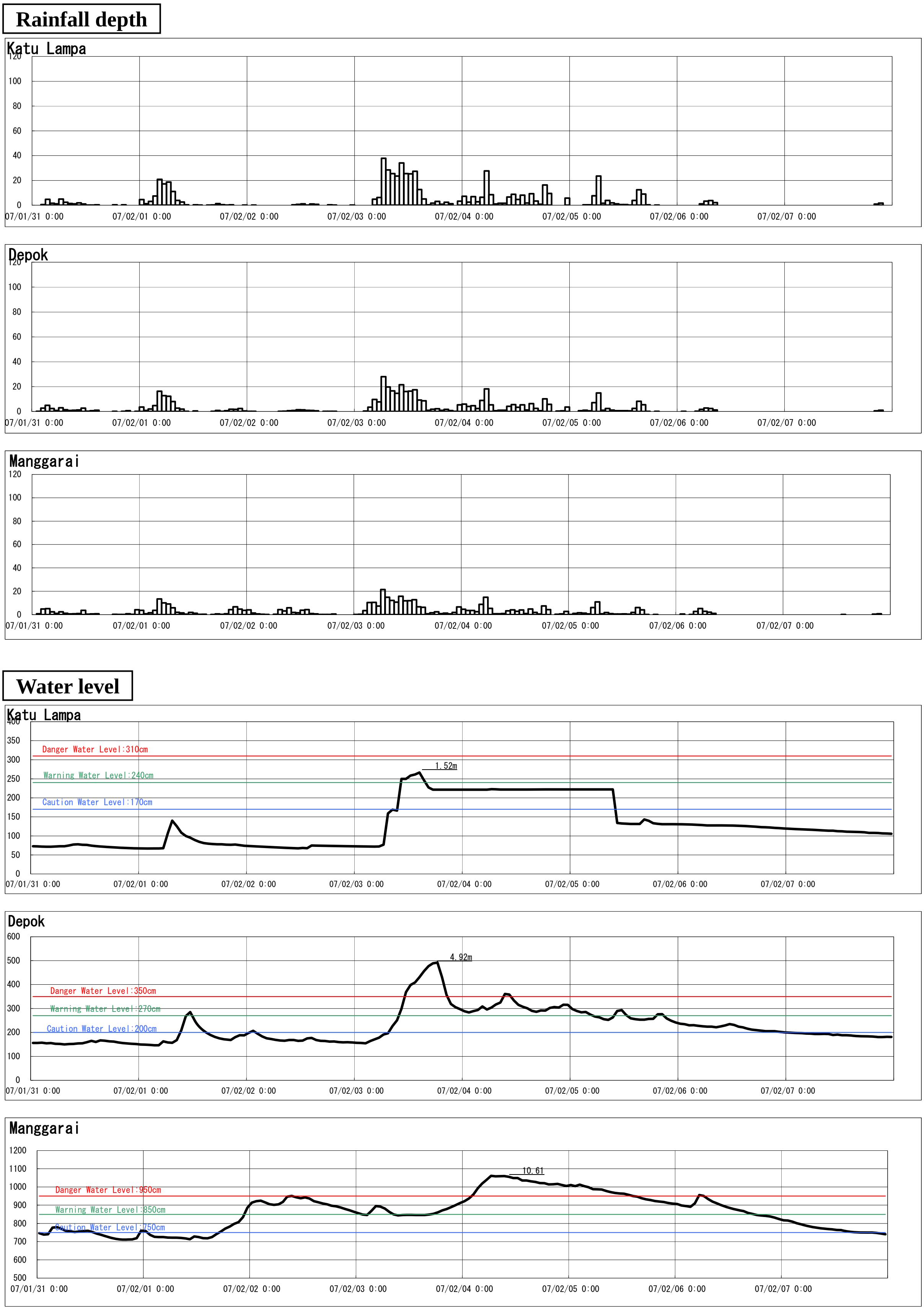


Figure 1.4-8 Hyetograph and Hydrograph (Flood in February 2007)

1.5 Examination of Related Plans

1.5.1 Existing Flood Management Plans

The Flood control plan of Jakarta is based on “Master plan for drainage and flood control of Jakarta” formulated in 1973 with the support from the Netherlands and “The Study on Comprehensive River Water Management Plan in JABOTABEK (1995–1997)” conducted by JICA. Brief summaries and implementation status of both plans are represented in Table 1.5-1.

Table 1.5-1 Existing Flood Management Plans

Plan	Flood Management Plan and Progress
Master Plan for drainage and flood control of Jakarta, PU, 1973	■ Expansion of West Banjir Canal (WBC) (constructed in 1924) intercepting Ciliwung and Krukut rivers and East Banjir Canal (EBC) intercepting rivers in eastern Jakarta area with a 100-year return period ■ Construction of Cengkareng Banjir Canal in downstream of WBC with a 100-year return period, and expansion of WBC based on M/P was completed. Construction of EBC is almost completed in January 2010 and started to be operated. ■ Plan of drainage areas between WBC and EBC was formulated. In accordance with this plan, existing river was improved to be used for main drainage with a 25-year return period, and pump stations and drainages were constructed in the areas divided into 6 areas. ■ In the plan, improvement of existing river and construction of pump stations have been achieved. Currently, since these facilities are suffered from the sea level, the water discharge has been conducted at 18 of pump stations and 23 flood gates.
The Study on Comprehensive River Water Management Plan in JABOTABEK, JICA, 1995-1997	■ To formulate the M/P on flood management in JABOTABEK area and to conduct F/S study on the proposed priority projects ■ M/P aims to improve the return period from 25-year to 100-year through the river improvement, canal reconstruction and new dredging in the main eight river basins

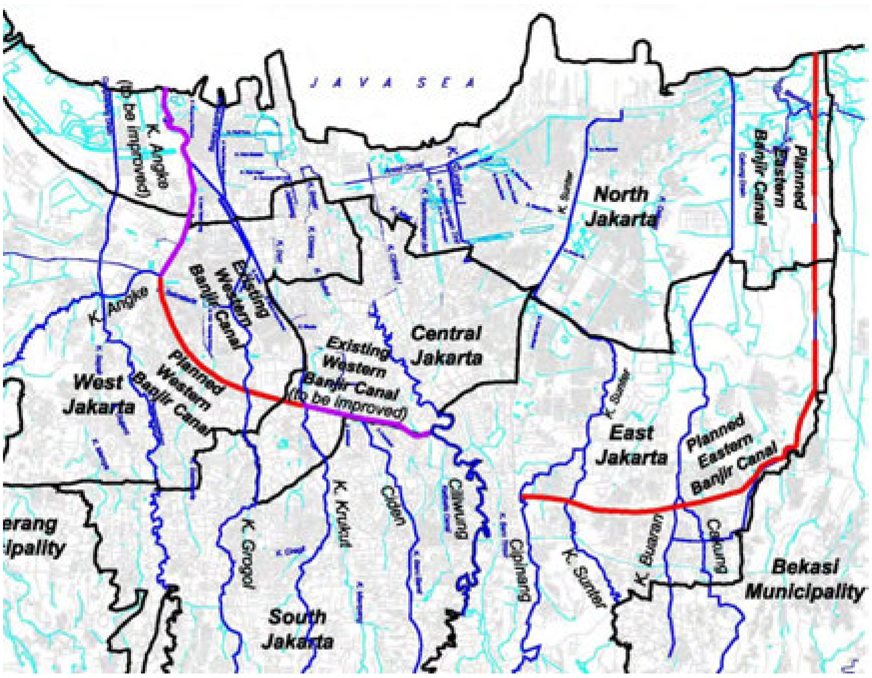


Figure 1.5-1 Master Plan in 1973

a. Target Year: Target year was 2025, and the masterplan was established on the assumption that most of the basin would be developed.

b. Design Discharge: The masterplan was established to improve the safety level of each river in DKI Jakarta against the return period of 25-year, 50-year, and 100-year flood depending on the degree of relative priority of improvement of the rivers.

c. Flood Management Measure: The masterplan consisted of river improvements, drainage channel improvements, and building new canals.

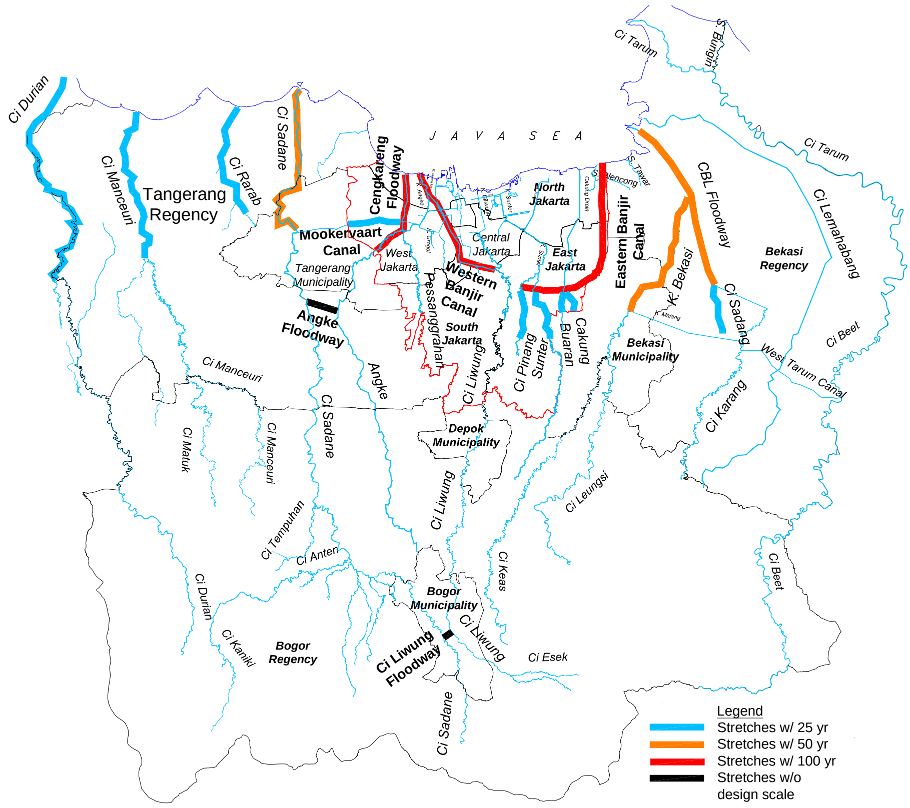


Figure 1.5-2 Master Plan in 1997

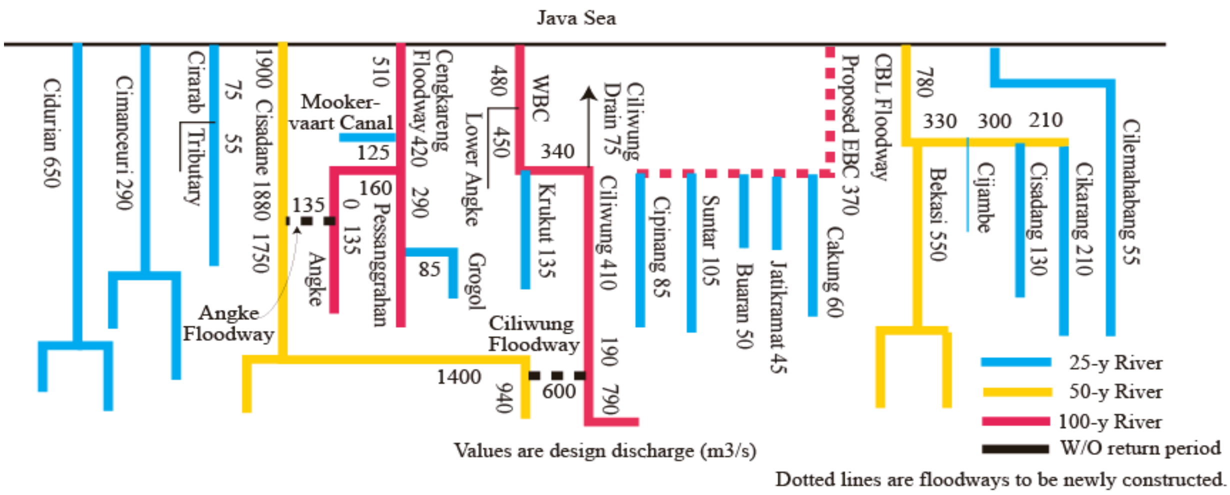


Figure 1.5-3 Allocation Plan of Water Discharge and Safety Level of Flood Control in the Master Plan in 1997

1.5.2 Improvement Plan of Ciliwung River

The following improvement works are planned by BBWS Ciliwung-Cisadane.

1) Construction of New Short Cut River Channel
2) Bridge Rehabilitation Plan
3) Improvement of Manggarai Gate and Karet Weir
4) Interconnection with East Banjir Canal
5) Conversion of Storage Pond
6) Storm Water Infiltration Facility

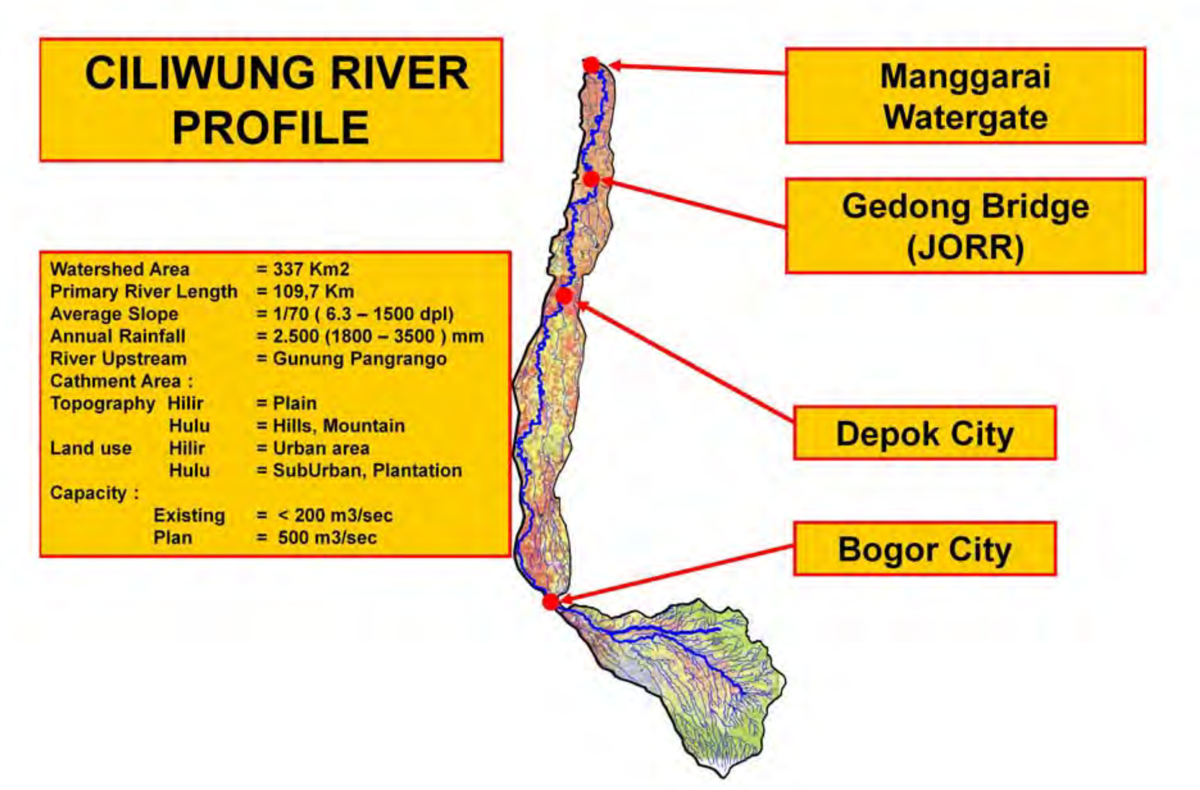


Figure 1.5-4 Feature of Ciliwung River

(1) Construction of New Short Cut River Channel

The construction of short cut river channel is planned at two locations of KAEBON BARU and KALIBATA. The existing river course after the short cutting will be used for the construction of housing complex.

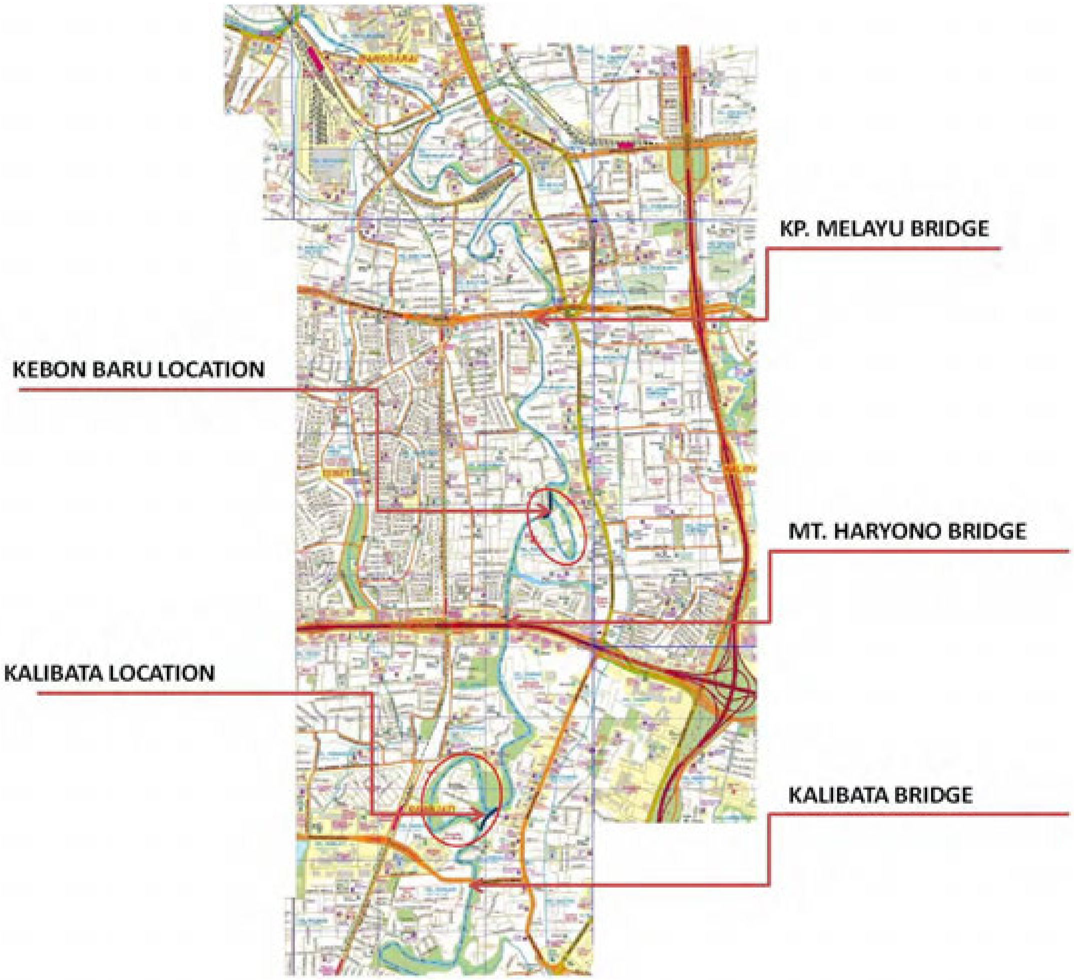
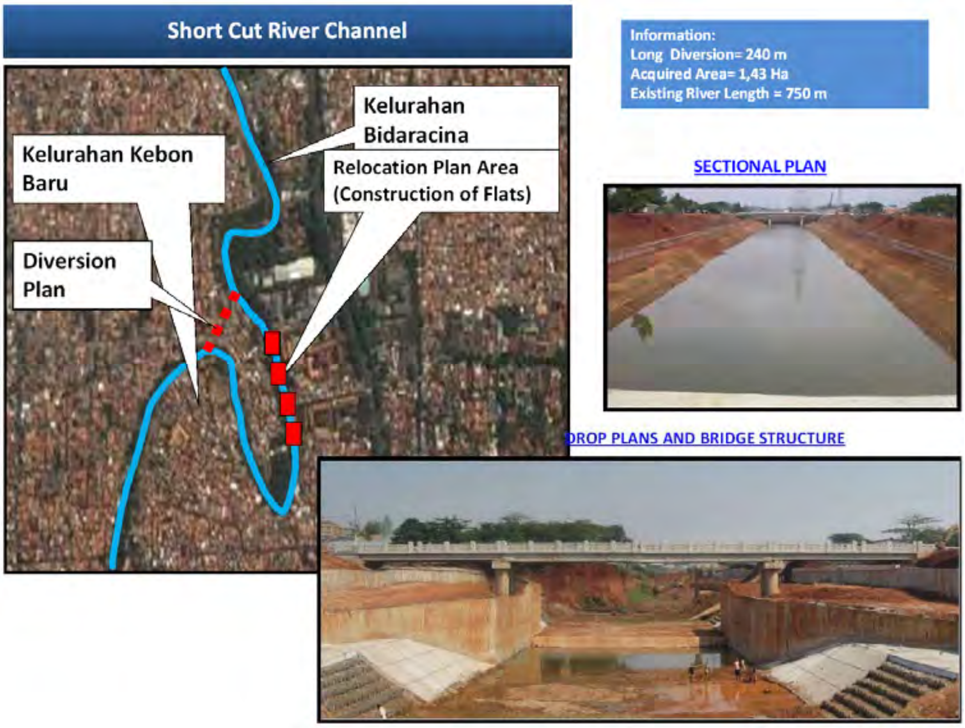
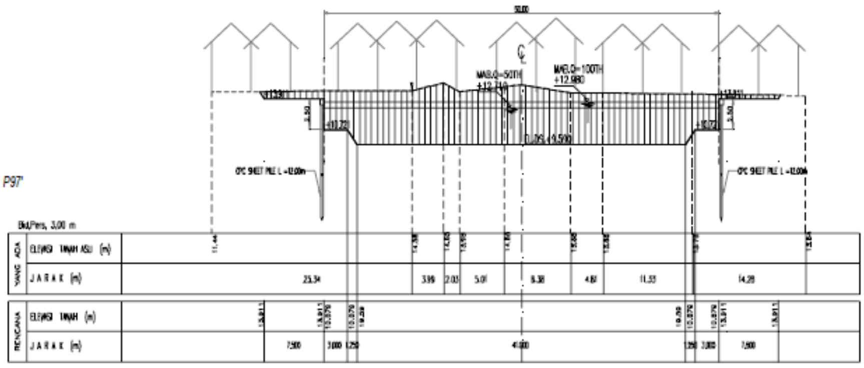


Figure 1.5-5 Planned Location of Short Cut River Channel





Flat Buildings Plan
Number of Block : 10 block
Total Occupancy : 1.000 unit
Occupancy Type : 36 m2

Stage 1 : 7 block, 700 unit
Stage 2 : 3 block, 300 unit

Figure 1.5-6 Plan of Short Cut River Channel Construction (KEBON BARU)

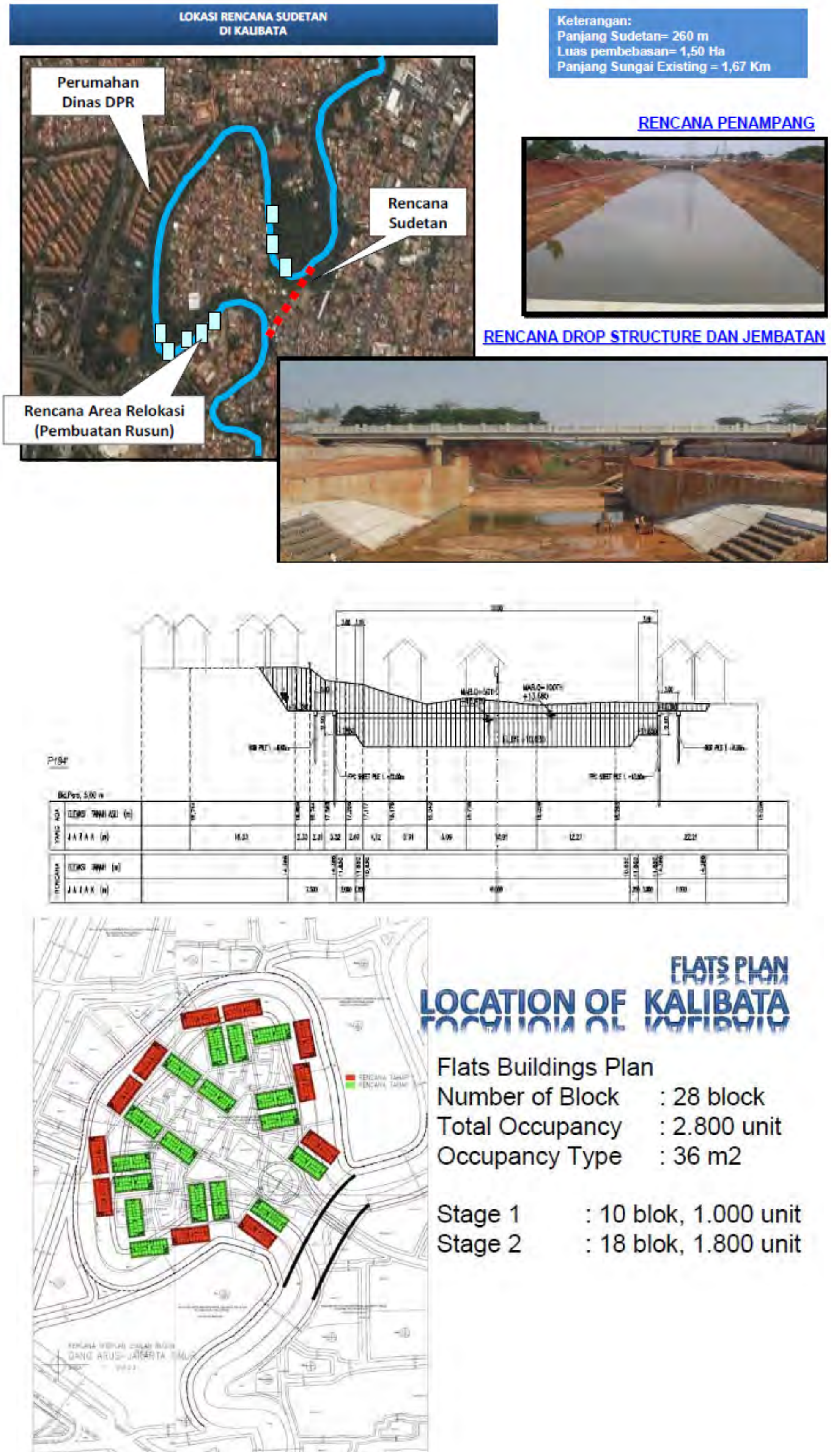
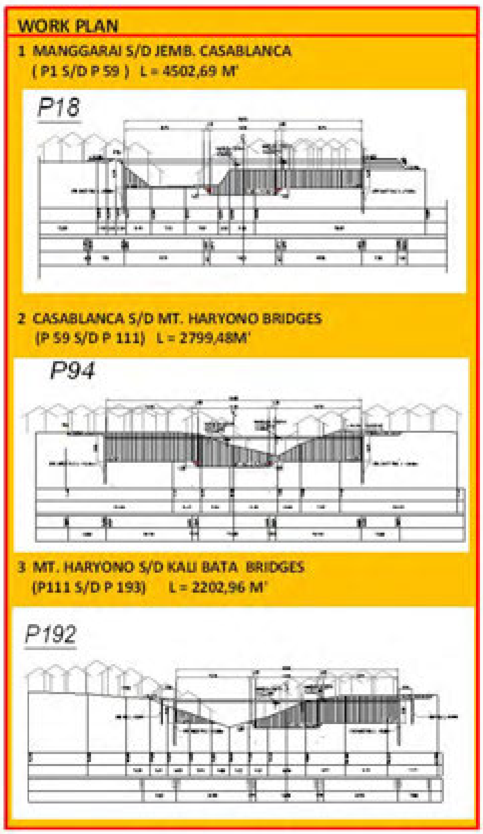


Figure 1.5-7 Plan of Short Cut River Channel Construction (KALIBATA)

(2) Bridge Rehabilitation Plan

The rehabilitation of existing bridges is planned at three locations of CASABLANKA, MTHARYONO and KALIBATA. Among those locations, the rehabilitation of KALIBATA bridge was already completed.



Rehabilitation of KALIBATA Bridge


Figure 1.5-8 Bridge Rehabilitation Plan and Current Condition of KALIBATA Bridge

(3) Improvement of Manggarai Gate and Karet Weir

At the MANGGARAI and KARET as current control points for flood management, a new gate will be constructed.

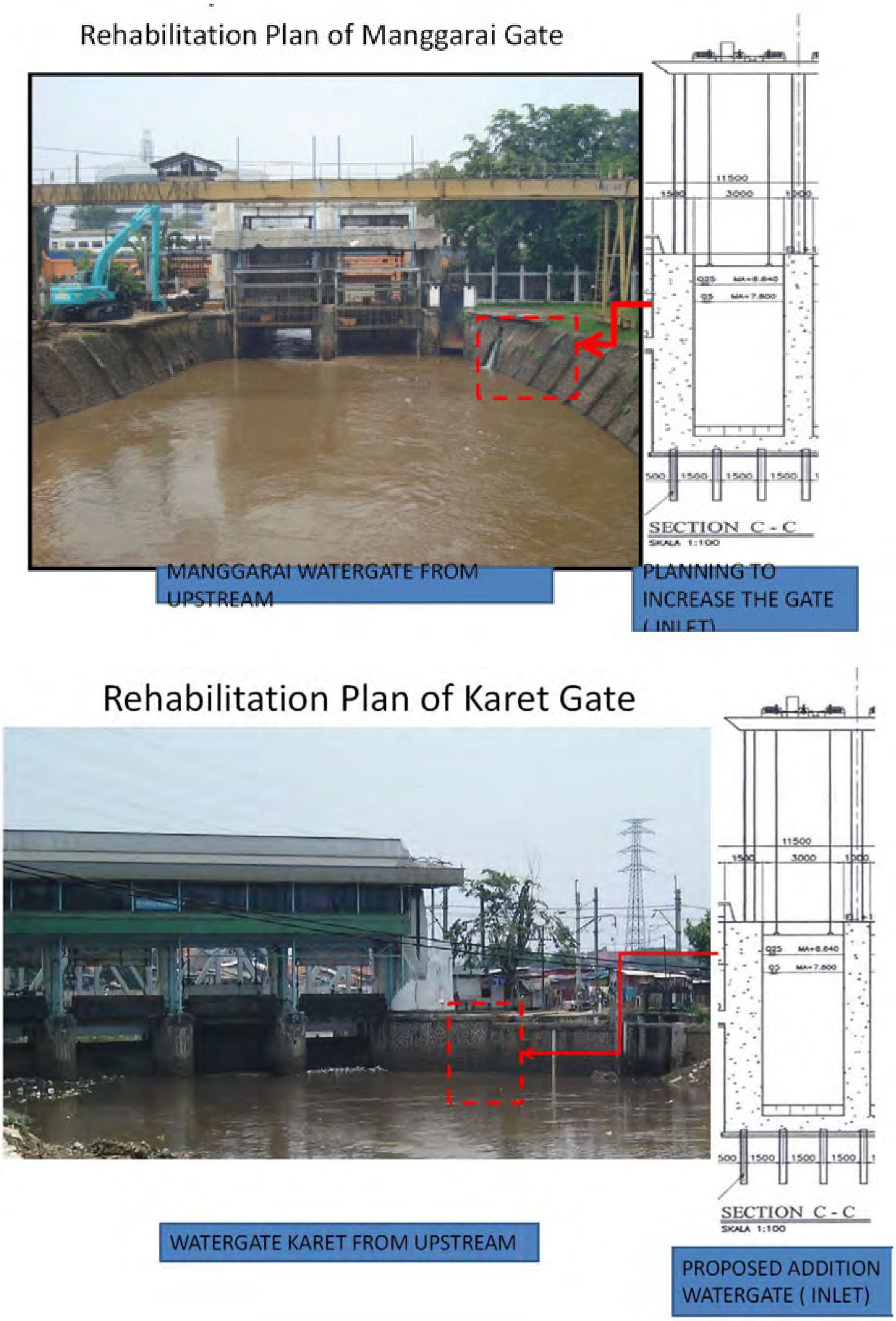


Figure 1.5-9 Image of Rehabilitation Plan of Manggarai Gate and Karet Weir

(4) Interconnection with East Banjir Canal

The construction of river channel interconnecting between Ciliwung river and East Banjir Canal is planned. The East Banjir Canal was designed in considering the increase of flow volume (approximately 60m^3/s) from Ciliwung river.

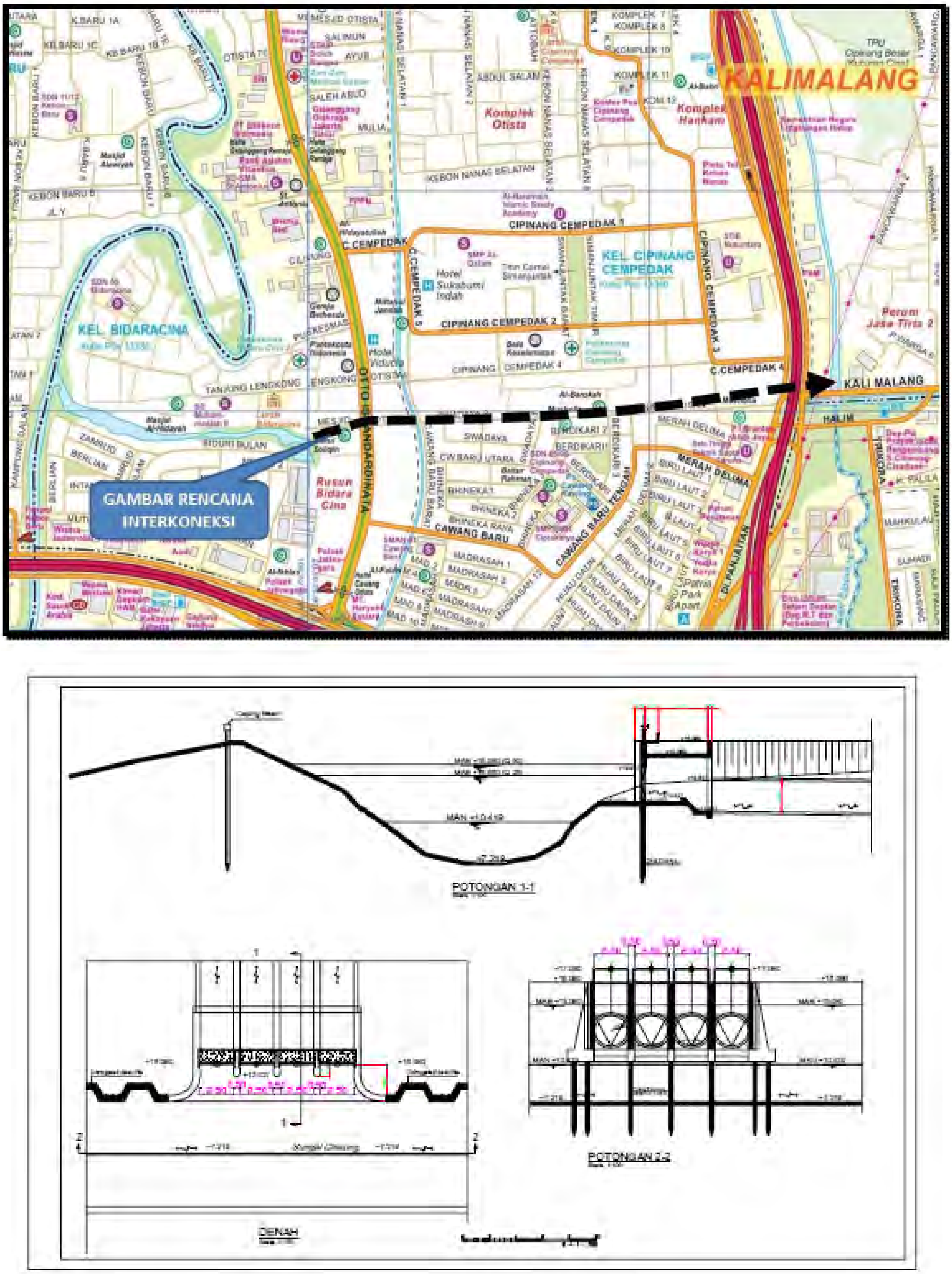
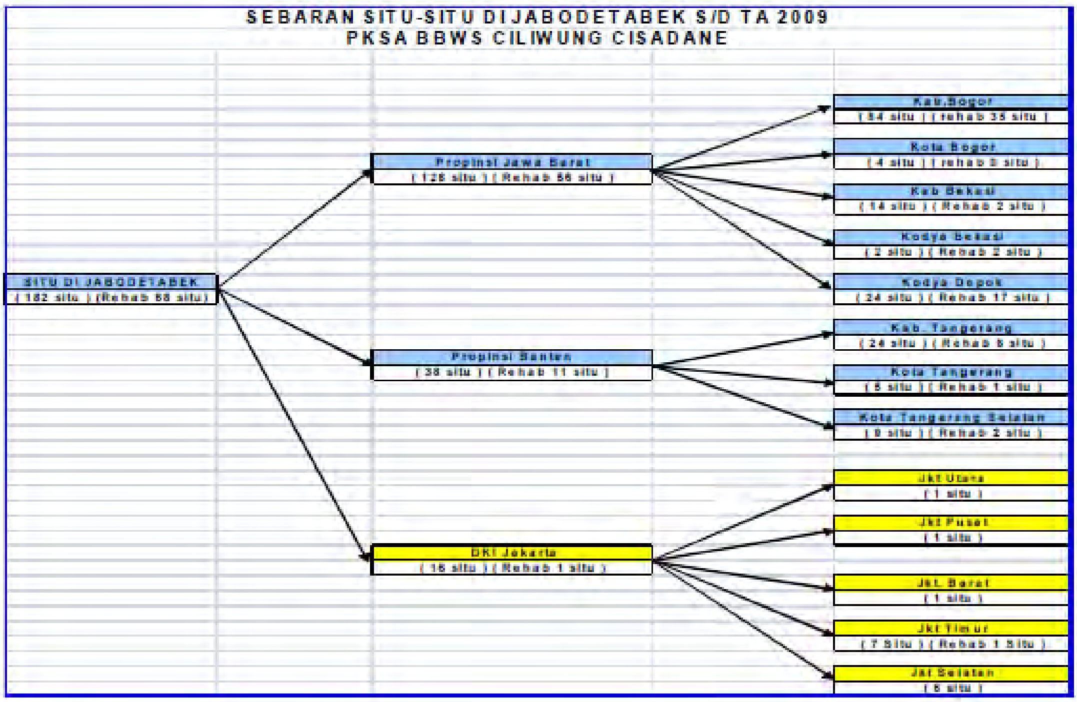


Figure 1.5-10 Outline of Interconnection Plan with East Banjir Canal

(5) Conversion of Storage Pond

The conversion works of Situ-Situ have been carried out.



(6) Storm Water Infiltration Facility

The infiltration wells have been constructed as storm water infiltration facility in Bogor city.

1.5.3 Flood Management Plan in Lowland Area

As for the flood management in lowland area, the construction of new pump stations and dredging of river and regulating ponds are planned.

(1) New Construction of Drainage Pump Station

- Pasar Ikan Gate Pump Station
- Marina Gate Pump Station
- Diri Pump Station

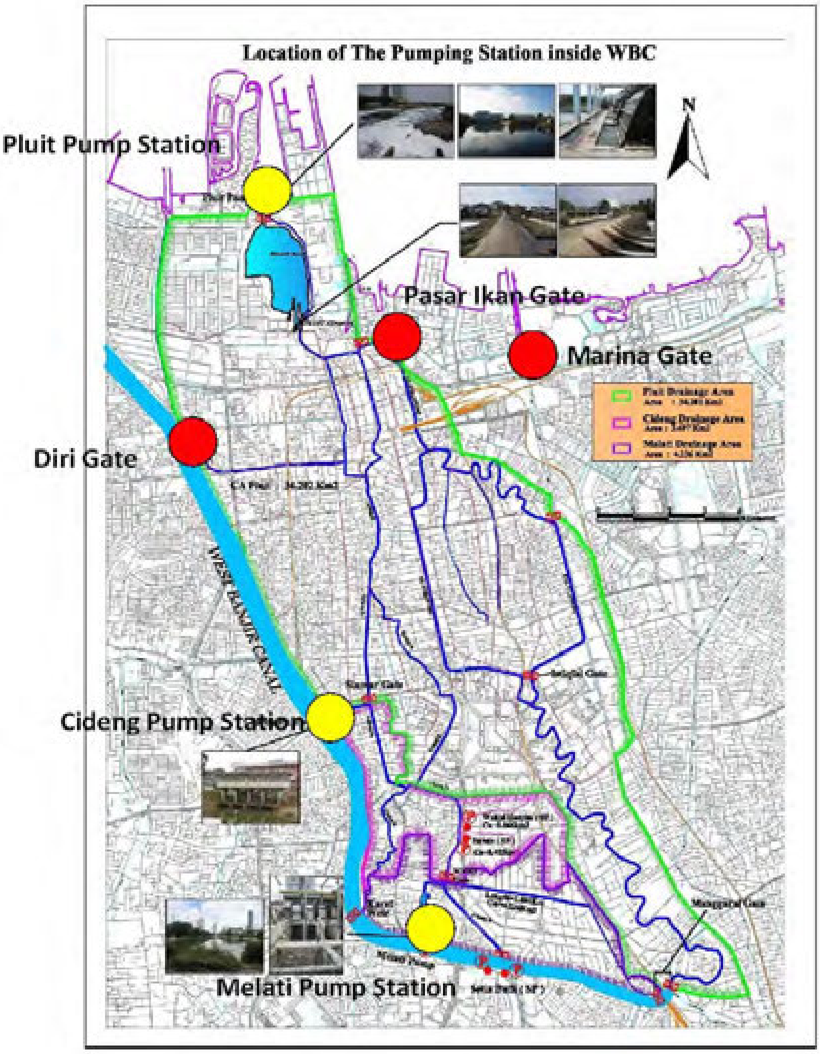


Figure 1.5-11 Location Map of Planned Pump Station

(2) Dredging Plan of River and Regulating Pond

Under the Jakarta Emergency Dredging Initiative (JEDI) project funded by World Bank, the dredging works are planned at 10 rives and 5 regulating ponds.

Figure 1.5-12 Location Map of Dredging Plan of River Channel and Regulating Pond

1.5.4 Related Projects funded by Other Donors

The related projects conducted by other donors are summarized in Table 1.5-2.

The outline of the World Bank project was mentioned in 1.5.3 (2) above.

Table 1.5-2 List of Related Projects

Project Name	Period	Donor
1) Jakarta Coastal Defense Strategy (JCDS)	2010-2012	Dutch
2) Jakarta Urgent Flood Mitigation Project（JUFMP) Jakarta Emergency Dredging Initiative（JEDI)	2010-	World Bank
3) Institutional Strengthening for IWRM in the 6Cis River Basin Territory	2010-2012	Asian Development Bank

(1) Jakarta Coastal Defense Strategy (JCDS) (Dutch)

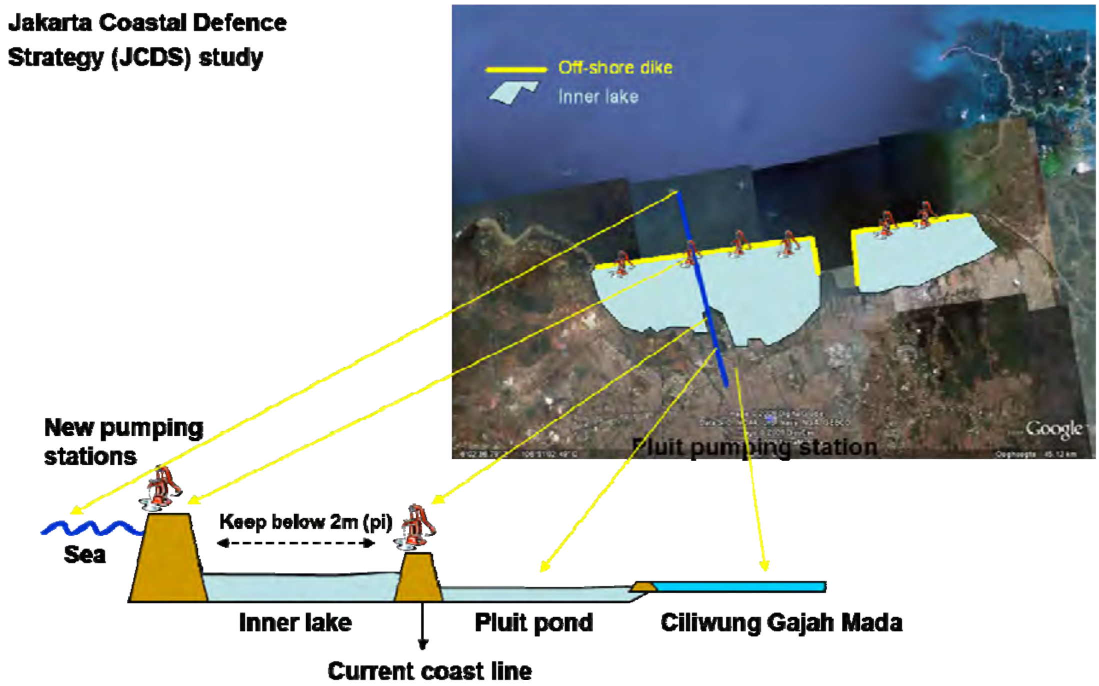
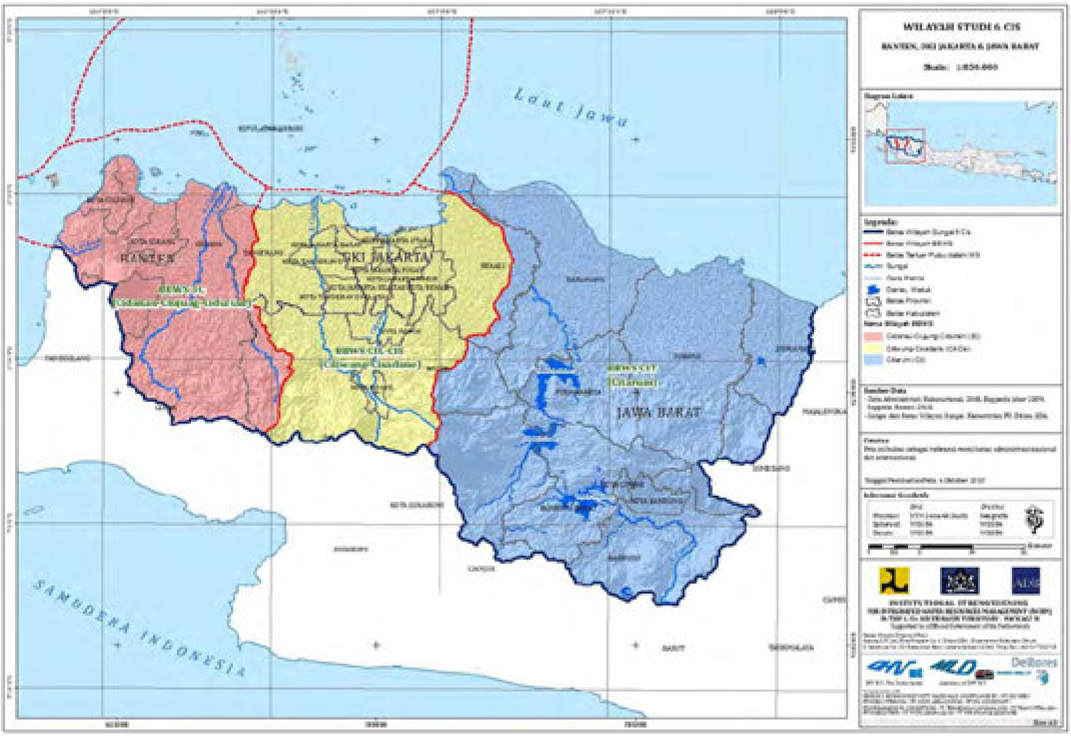


Figure 1.5-13 Outline of Planned Tide Wall

(2) Institutional Strengthening for IWRM in the 6Clis River Basin Territory (ADB)



provinces Banten, DKI Jakarta, Jawa Barat
28 kabupaten/kota

Package B

Component B1.A Institutional Strengthening for IWRM in 6 Ci's River Basin Territory (DGWR-MPW)

Component B1.B Formulate draft POLA and RENCANA for 6 Ci's River Basin Territory

Component B2 Spatial Planning in 6 Ci's River Basin Territory - Improve planning to enhance *link with spatial* planning (DGSP-MPW)

Component B3 Development of key Policies and strategies for WRM in CRB - to enhance water conservation and manage conflicts (BBWSC-MPW)

Consultants: DHV BV. Netherlands & Associates

Figure 1.5-14 Target Area and Project Outline

CHAPTER 2 HYDRAULIC AND HYDROLOGICAL ANALYSIS

2.1 Rainfall Observation Station and Rainfall Data Arrangement Status

The status of rainfall data arrangement of object rainfall observation station is shown in Table 2.1-1.

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 2.1-1 Rainfall Observation Station and Status of Rainfall Data Arrangement

Agency	BMG												BMG												BMG												BMG											
Station	Pondok Betung Ciledu g												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	N	N	N	N																								
1987	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	N	*	*	*	*	*	*	*	*																								
1988	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*																								
1989	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*																								
1990	*	*	*	*	*	*	*	*	*	*	*	*	N	N	*	N	*	*	*	*	*	*	*	*																								
1991	*	*	*	*	*	*	*	*	*	*	*	*	N	*	*	*	*	*	*	*	*	*	*	*																								
1992	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*												
1993	*	*	*	*	*	*	*	*	*	*	*	*	*	*	N	N	N	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*												
1994	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*												
1995	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	*	*	*	*	*												
1996	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*												
1997	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*												
1998	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	N	N	*	*	*	*	*	*	*	*	*	*	*	*												
1999	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*												
2000	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2001	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2002	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2003	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	N	N	N	N	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2004	*	*	*	*	*	*	*	*	*	*	*	*	N	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2005	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	N	N	N	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
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	*	*	*	*
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	*	*	*	*	*	0	*	*	*	*	*	*	*	*	*	*	*	*
2008	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Legend
*:Received(data available) N:Not received yet
-:Missing observation 0:Partly missing observation
[shaded box] Data can be applied.

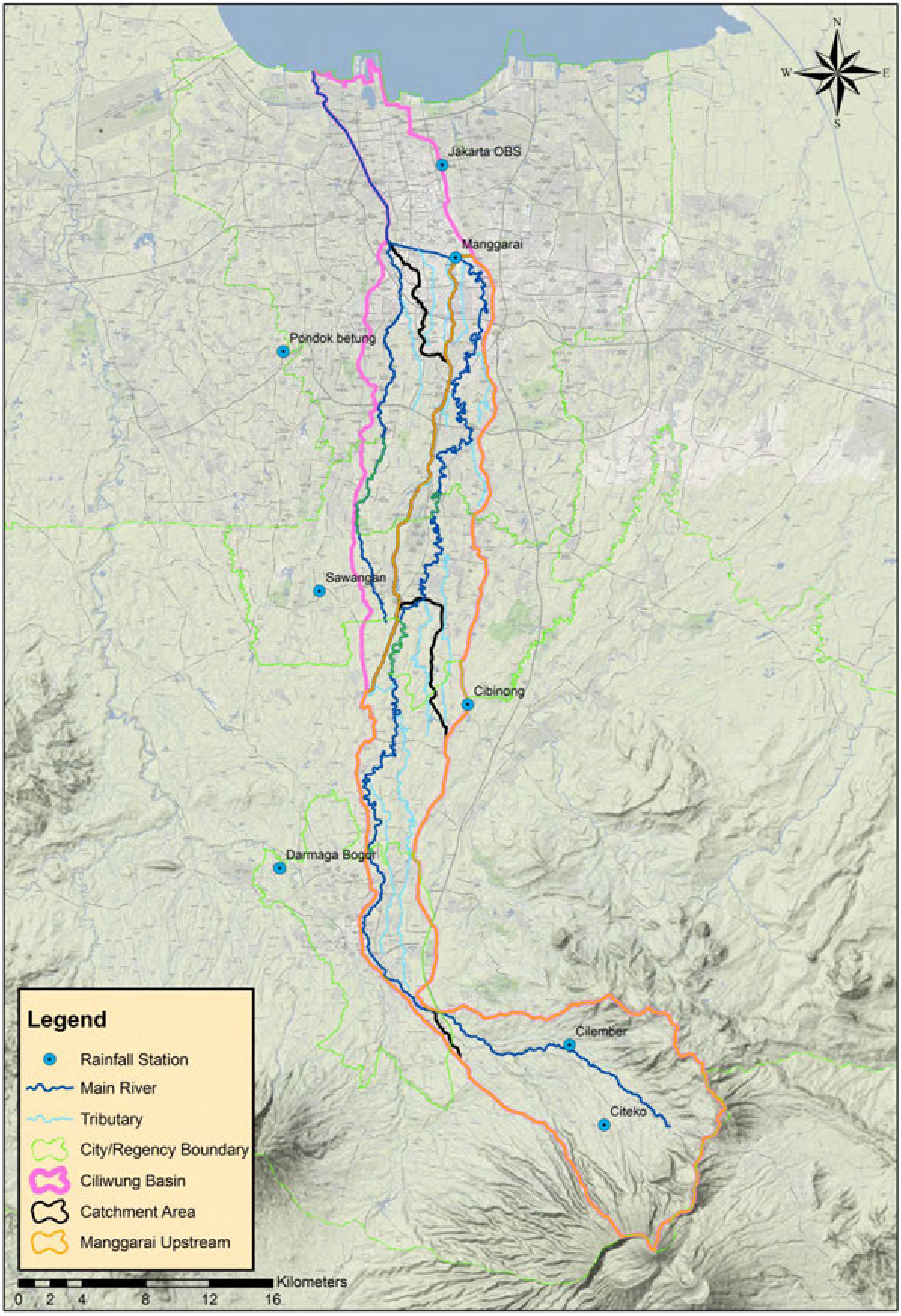


Figure 2.1-1 Location Map of Rainfall Observation Station

2.2 Probable Rainfall

For the rainfall observation station and existing rainfall data arranged above section, the annual maximum 1-hour rainfall, annual maximum 6-hour rainfall, annual maximum 12-hour rainfall, annual maximum 24-hour rainfall and annual maximum 48-hour rainfall are extracted.

2.2.1 Extraction of Annual Maximum Rainfall

Data arranged by each rainfall observation station are shown as tabulated in below Table 2.2-1 to Table 2.2-8.

Table 2.2-1 Annual Maximum Rainfall (Pondok Betung Cileduk)

Unit：mm

Year	Annual maximum rainfall									
	1 hour		6 hour		12 hour		24 hour		48 hour	
	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date
1982	53.1	21-Jul	69.4	28-Mar	69.4	28-Mar	69.4	27-Mar	77.8	26-Mar
1983	59.3	27-Oct	74.6	27-Oct	74.6	27-Oct	74.7	26-Oct	131.1	27-Oct
1984	55.6	17-Mar	101.2	16-May	114.4	16-May	114.6	16-May	118.5	15-May
1985	54.0	01-Apr	105.4	20-May	105.5	20-May	105.5	20-May	107.0	19-May
1986	58.8	20-Nov	153.1	14-Dec	162.6	14-Dec	173.9	14-Dec	219.1	14-Dec
1987	68.0	09-Nov	76.9	07-Dec	80.5	09-Nov	81.8	05-Jun	121.3	07-Nov
1988	38.3	29-Oct	64.7	23-Oct	105.4	19-Dec	106.2	19-Dec	171.9	18-Dec
1989	74.1	08-May	81.8	08-May	86.6	07-Feb	129.2	06-Feb	139.3	06-Feb
1990	83.8	13-May	124.5	13-May	130.7	13-May	130.7	13-May	164.7	22-Jan
1991	75.9	01-May	116.6	24-Mar	118.3	24-Mar	125.2	16-Mar	163.7	22-Mar
1992	63.5	30-Dec	116.2	24-Apr	128.9	24-Apr	128.9	23-Apr	149.9	22-Apr
1993	81.9	22-Apr	102.5	22-Apr	102.7	22-Apr	130.2	08-Feb	144.0	30-Apr
1994	55.6	23-Apr	88.9	23-Apr	89.2	23-Apr	89.5	21-Jan	101.5	21-Mar
1995	70.0	25-Sep	104.2	25-Sep	125.3	18-Jun	125.3	18-Jun	138.9	17-Jun
1996	70.0	11-Feb	164.8	11-Feb	196.1	11-Feb	213.3	11-Feb	223.0	10-Feb
1997	46.8	23-Mar	79.5	10-Apr	83.4	14-Jan	110.9	14-Jan	126.8	14-Jan
1998	60.0	28-Mar	76.3	16-Apr	122.8	28-Mar	123.8	28-Mar	145.3	30-Jan
1999	54.0	14-Jan	110.0	14-Jan	110.3	14-Jan	113.2	14-Jan	123.6	27-Dec
2000	68.0	20-Feb	103.4	17-Nov	103.4	17-Nov	107.3	16-Nov	131.1	01-Apr
2001	68.5	02-Oct	103.8	02-Oct	104.0	02-Oct	112.9	02-Oct	112.9	01-Oct
2002	109.0	23-Jan	109.2	23-Jan	109.9	29-Jan	128.7	22-Jan	212.0	28-Jan
2003	50.0	13-May	107.4	14-Feb	130.4	14-Feb	130.4	13-Feb	132.8	13-Feb
2004	61.7	14-Mar	93.6	31-Jan	94.0	31-Jan	95.9	13-Mar	121.8	11-Jul
2005	63.5	03-Aug	99.0	25-Mar	99.0	25-Mar	109.6	24-Mar	170.4	15-Jul
2006	61.3	21-Apr	69.4	21-Apr	69.4	21-Apr	70.3	17-Jan	118.1	21-Apr
2007	80.0	07-Dec	187.1	02-Feb	246.4	02-Feb	346.3	02-Feb	461.9	01-Feb
2008	70.0	29-Jan	157.0	02-Feb	179.6	02-Feb	209.4	02-Feb	243.4	02-Feb

Table 2.2-2 Annual Maximum Rainfall (Darmaga Bogor)

Unit : mm

Year	Annual maximum rainfall									
	1 hour		6 hour		12 hour		24 hour		48 hour	
	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date
1985	82.0	21-Jul	101.7	05-Feb	119.9	04-Feb	123.8	04-Feb	160.9	03-Feb
1986										
1987	63.0	04-Oct	87.9	06-May	87.9	06-May	93.4	05-May	130.2	09-Nov
1988	49.5	18-Jan	83.4	18-Jan	84.2	18-Jan	93.4	18-Jan	140.8	17-Jan
1989	69.5	09-May	131.1	13-Feb	232.9	13-Feb	244.5	13-Feb	271.9	12-Feb
1990										
1991										
1992	99.7	27-Sep	111.2	27-Sep	112.2	04-Oct	117.5	05-May	135.9	04-Oct
1993										
1994	84.3	04-Apr	100.3	04-Apr	100.3	04-Apr	126.3	10-May	212.6	10-May
1995	93.5	01-Jul	93.5	01-Jul	101.8	09-Dec	132.8	06-Nov	173.7	10-Nov
1996	74.7	07-May	143.5	19-May	156.2	19-May	156.5	19-May	206.2	19-May
1997	77.6	26-Oct	108.8	20-May	113.5	20-May	113.5	20-May	131.1	01-Apr
1998	72.4	01-Oct	126.7	13-Apr	126.8	13-Apr	129.2	12-Apr	166.1	12-Jan
1999	73.8	15-Jan	149.7	29-Apr	149.7	29-Apr	172.4	29-Apr	241.7	28-Apr
2000	69.4	03-May	93.6	28-Aug	93.8	28-Aug	133.6	02-Feb	142.9	02-Feb
2001	73.1	26-Jul	107.9	24-May	107.9	24-May	111.5	28-Apr	135.4	22-May
2002	70.4	19-Oct	109.5	01-Feb	120.6	30-Jan	148.3	30-Jan	218.4	29-Jan
2003	81.6	13-May	123.5	13-May	123.6	13-May	124.7	13-May	182.6	11-May
2004										
2005	76.3	05-May	117.0	21-Feb	118.0	21-Feb	123.5	21-Feb	174.2	20-Feb
2006	73.6	23-Jun	135.7	13-Jan	136.1	13-Jan	136.1	12-Jan	194.8	12-Jan
2007	76.5	20-Jan	114.7	09-Sep	114.7	09-Sep	131.2	04-Feb	161.4	03-Feb
2008	94.7	13-Mar	104.2	13-Mar	104.3	13-Mar	114.2	17-Mar	149.1	11-Mar

Table 2.2-3 Annual Maximum Rainfall (Citeko)

Unit : mm

Year	Annual maximum rainfall									
	1 hour		6 hour		12 hour		24 hour		48 hour	
	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date
1992	70	28-Feb	93	20-Oct	124	26-Feb	128	26-Feb	166	25-Feb
1993	78	19-Dec	110	31-Jan	135	31-Jan	184	31-Jan	225	30-Jan
1994	56	11-Dec	71	11-Dec	80	22-Jan	130	22-Jan	185	21-Jan
1995	100	31-Dec	176	31-Dec	176	31-Dec	176	30-Dec	177	29-Dec
1996	71	03-Jan	133	07-Jan	187	07-Jan	209	06-Jan	282	03-Jan
1997	57	18-Apr	69	11-Dec	69	11-Dec	117	11-May	125	02-Jan
1998	54	26-Mar	87	05-Mar	88	05-Mar	126	04-Mar	187	03-Mar
1999	44	26-Feb	86	01-Jul	87	01-Jul	92	26-Feb	109	26-Feb
2000	48	03-Nov	95	03-Jul	95	03-Jul	97	02-Jul	143	26-Jan
2001	42	09-Jan	110	01-Mar	111	01-Mar	124	08-Feb	188	08-Feb
2002	51	21-Apr	111	21-Apr	126	21-Apr	151	30-Jan	223	29-Jan
2003	66	19-Aug	111	05-Feb	124	05-Feb	129	05-Feb	144	04-Feb
2004	42	12-Dec	74	21-Apr	79	21-Apr	112	20-Apr	154	27-Dec
2005	52	24-Feb	88	28-Jan	131	19-Jan	176	19-Jan	218	18-Jan
2006	44	14-Dec	98	24-Jan	111	24-Jan	142	24-Jan	198	24-Jan
2007	41	20-Dec	105	20-Dec	117	30-Jan	130	30-Jan	145	30-Jan
2008	45	07-Mar	64	21-Apr	71	02-Feb	100	02-Jan	137	10-Mar

Table 2.2-4 Annual Maximum Rainfall (Citeko)

Unit : mm

Year	Annual maximum rainfall									
	1 hour		6 hour		12 hour		24 hour		48 hour	
	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date
2000	40.0	24-Jan	94.8	26-Jan	97.8	25-Jan	99.4	25-Jan	117.8	25-Jan
2001	50.2	03-Aug	82.7	22-Jan	82.7	22-Jan	90.5	07-Jan	91.3	06-Jan
2002	70.0	01-Feb	142.4	01-Feb	144.7	01-Feb	168.5	01-Feb	201.2	01-Feb
2003	104.0	05-Feb	183.8	30-Dec	197.0	29-Dec	199.7	29-Dec	249.4	29-Dec
2004	60.0	21-Apr	120.0	21-Apr	129.3	21-Apr	129.3	20-Apr	154.5	18-Feb
2005	62.6	05-Mar	121.2	18-Jan	121.2	18-Jan	136.3	18-Jan	174.8	17-Jan
2006	57.0	11-Apr	72.0	13-Apr	75.2	26-Jan	99.5	11-Apr	133.8	12-Apr
2007	65.5	10-May	136.2	01-Feb	137.6	01-Feb	241.5	01-Feb	331.9	31-Jan
2008	70.0	07-Apr	176.0	01-Feb	216.6	31-Jan	309.1	31-Jan	309.7	31-Jan

Table 2.2-5 Annual Maximum Rainfall (Sawangan)

Unit : mm

Year	Annual maximum rainfall									
	1 hour		6 hour		12 hour		24 hour		48 hour	
	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date
2005	88.5	14-Oct	134.5	19-Nov	134.5	19-Nov	134.5	18-Nov	201.5	19-Nov
2006	63.0	19-Feb	94.5	20-Apr	94.5	20-Apr	115.5	20-Apr	120.5	19-Apr
2007	54.0	13-Dec	134.5	02-Feb	153.0	02-Feb	270.0	01-Feb	339.5	01-Feb
2008	83.0	14-Mar	128.5	14-Mar	128.5	14-Mar	128.5	13-Mar	153.0	12-Mar

Table 2.2-6 Annual Maximum Rainfall (Manggarai)

Unit : mm

Year	Annual maximum rainfall									
	1 hour		6 hour		12 hour		24 hour		48 hour	
	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date
2003	80.5	30-Dec	158.5	30-Dec	158.5	30-Dec	264.5	30-Dec	302.0	29-Dec
2004	50.5	23-Apr	120.0	21-Apr	133.5	21-Apr	133.5	20-Apr	144.0	24-Dec
2005	59.0	19-Jan	185.5	15-Jul	191.0	15-Jul	191.0	14-Jul	216.5	17-Jan
2006	104.0	09-Feb	117.5	08-Feb	125.5	08-Feb	129.0	08-Feb	170.5	11-Apr
2007	64.0	08-Apr	99.5	08-Apr	117.0	01-Feb	153.0	01-Feb	242.0	01-Feb
2008	61.0	01-Feb	160.0	01-Feb	185.0	01-Feb	227.5	31-Jan	262.0	01-Feb

Table 2.2-7 Annual Maximum Rainfall (Cibinong)

Unit : mm

Year	Annual maximum rainfall									
	1 hour		6hour		12 hour		24 hour		48 hour	
	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date
2003	81.5	06-Oct	146.0	06-Oct	146.0	06-Oct	146.5	06-Oct	171.5	05-Oct
2004	61.0	11-Apr	112.5	12-Dec	114.0	12-Dec	114.0	12-Dec	176.5	11-Dec
2005	102.0	12-Oct	129.5	12-Oct	129.5	12-Oct	129.5	11-Oct	155.5	18-Jan
2006	78.0	23-Dec	105.5	23-Dec	105.5	23-Dec	122.5	23-Dec	142.5	23-Dec
2007	59.0	03-Apr	85.0	03-Apr	85.5	03-Apr	97.0	03-Apr	129.5	29-Jun
2008	60.5	07-Mar	111.5	11-Apr	114.5	11-Apr	114.5	11-Apr	119.0	05-Mar

Table 2.2-8 Annual Maximum Rainfall (Cilember)

Unit : mm

Year	Annual maximum rainfall									
	1 hour		6 hour		12 hour		24 hour		48 hour	
	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall	Date
2004	49.0	23-Nov	70.5	23-Nov	76.0	19-Feb	84.0	17-Jan	107.0	17-Jan
2005	42.0	19-Feb	96.5	02-Aug	102.0	16-Sep	173.5	18-Jan	232.5	17-Jan
2006										
2007	59.5	16-Dec	193.5	03-Feb	291.0	03-Feb	347.5	03-Feb	399.5	03-Feb
2008	61.0	07-Apr	104.0	07-Apr	106.0	07-Apr	134.0	01-Jan	155.5	01-Jan

2.2.2 Probable Rainfall

The probable rainfall data will be shown in the following tables with the rainfall duration of 1 hour, 6 hours, 12 hours, 24 hours, and 48 hours of annual maximum rainfall.

For the calculation of probable rainfall, the Gunbel Probability Distribution Model is applied, which is commonly used in Indonesia.

Table 2.2-9 Probable Rainfall (Pondok Betung Cileduk)

Unit:mm

Return period	Rainfall duration				
	1hour	6hour	12hour	24hour	48hour
2	62.7	100.1	110.1	120.3	148.5
3	68.6	113.0	126.1	140.0	173.3
4	72.3	121.3	136.4	152.6	189.2
5	75.1	127.4	144.0	161.9	201.0
6	77.3	132.2	150.0	169.4	210.3
7	79.1	136.3	155.0	175.5	218.1
8	80.7	139.7	159.3	180.8	224.8
9	82.1	142.7	163.1	185.4	230.6
10	83.3	145.4	166.4	189.5	235.8
15	87.9	155.6	179.1	205.1	255.4
20	91.2	162.7	187.9	216.0	269.1
25	93.7	168.2	194.7	224.4	279.7
30	95.7	172.7	200.3	231.2	288.3
35	97.4	176.4	205.0	236.9	295.6
40	98.9	179.7	209.0	241.9	301.8
45	100.2	182.5	212.6	246.3	307.4
50	101.3	185.1	215.8	250.2	312.3
60	103.4	189.5	221.3	257.0	320.8
70	105.1	193.2	225.9	262.7	328.0
80	106.5	196.5	229.9	267.6	334.3
90	107.8	199.3	233.5	272.0	339.8
100	109.0	201.9	236.6	275.9	344.7
150	113.4	211.6	248.8	290.8	363.5
200	116.6	218.6	257.4	301.4	376.9
250	119.0	223.9	264.1	309.6	387.3
300	121.0	228.3	269.6	316.3	395.7
350	122.7	232.0	274.2	322.0	402.9
400	124.2	235.3	278.2	326.9	409.1
500	126.6	240.6	284.8	335.1	419.4
1000	134.2	257.3	305.6	360.6	451.6

Table 2.2-10 Probable Rainfall (Darmaga Bogor)

Unit:mm

Return period	Rainfall duration				
	1hour	6hour	12hour	24hour	48hour
2	74.7	109.6	116.4	128.1	168.4
3	79.6	117.9	128.8	140.5	185.9
4	82.7	123.2	136.8	148.4	197.1
5	85.0	127.1	142.7	154.3	205.4
6	86.9	130.3	147.4	158.9	212.0
7	88.4	132.9	151.3	162.8	217.5
8	89.7	135.1	154.6	166.1	222.2
9	90.8	137.0	157.5	169.0	226.3
10	91.9	138.8	160.1	171.6	230.0
15	95.7	145.3	169.9	181.4	243.8
20	98.4	149.9	176.8	188.2	253.5
25	100.5	153.4	182.1	193.5	261.0
30	102.2	156.3	186.4	197.8	267.0
35	103.6	158.7	190.1	201.4	272.2
40	104.8	160.8	193.2	204.5	276.6
45	105.9	162.7	196.0	207.3	280.5
50	106.9	164.3	198.5	209.7	284.0
60	108.6	167.2	202.7	214.0	290.0
70	110.0	169.6	206.3	217.6	295.1
80	111.2	171.7	209.5	220.7	299.5
90	112.3	173.5	212.2	223.4	303.3
100	113.3	175.1	214.7	225.9	306.8
150	117.0	181.4	224.1	235.3	320.1
200	119.6	185.9	230.8	241.9	329.5
250	121.6	189.4	236.0	247.1	336.9
300	123.3	192.2	240.2	251.3	342.8
350	124.7	194.6	243.8	254.9	347.9
400	125.9	196.7	246.9	258.0	352.2
500	127.9	200.1	252.1	263.1	359.5
1000	134.3	210.9	268.2	279.1	382.2

Table 2.2-11 Probable Rainfall (Citeko)

Unit:mm

Return period	Rainfall duration				
	1hour	6hour	12hour	24hour	48hour
2	53.9	94.5	106.6	131.1	169.2
3	60.5	105.7	121.4	145.4	188.5
4	64.8	112.9	130.9	154.6	200.9
5	68.0	118.2	138.0	161.4	210.0
6	70.5	122.5	143.6	166.8	217.3
7	72.6	126.0	148.2	171.2	223.4
8	74.4	129.0	152.2	175.1	228.5
9	76.0	131.6	155.7	178.4	233.1
10	77.3	133.9	158.8	181.4	237.1
15	82.6	142.8	170.5	192.7	252.3
20	86.3	149.0	178.7	200.6	263.0
25	89.2	153.8	185.0	206.7	271.3
30	91.5	157.7	190.2	211.6	278.0
35	93.4	161.0	194.5	215.8	283.6
40	95.1	163.8	198.3	219.4	288.5
45	96.6	166.3	201.6	222.6	292.8
50	97.9	168.5	204.5	225.5	296.6
60	100.2	172.4	209.6	230.4	303.3
70	102.2	175.6	213.9	234.5	308.9
80	103.8	178.5	217.6	238.1	313.7
90	105.3	180.9	220.9	241.3	318.0
100	106.6	183.2	223.8	244.1	321.8
150	111.7	191.7	235.1	254.9	336.5
200	115.3	197.7	243.1	262.6	346.9
250	118.1	202.4	249.3	268.6	354.9
300	120.4	206.2	254.4	273.5	361.5
350	122.3	209.5	258.7	277.6	367.1
400	124.0	212.3	262.4	281.2	371.9
500	126.8	216.9	268.5	287.1	380.0
1000	135.4	231.5	287.8	305.6	405.0

Table 2.2-12 Probable Rainfall (Jakarta OBS)

Unit:mm

Return period	Rainfall duration				
	1hour	6hour	12hour	24hour	48hour
2	61.4	118.4	125.0	150.8	180.7
3	68.9	136.4	146.9	183.9	219.7
4	73.7	147.9	160.9	205.0	244.7
5	77.2	156.5	171.2	220.7	263.2
6	80.0	163.3	179.5	233.2	277.9
7	82.3	168.9	186.3	243.6	290.1
8	84.3	173.7	192.2	252.4	300.6
9	86.1	177.9	197.3	260.2	309.7
10	87.6	181.7	201.9	267.0	317.8
15	93.5	195.9	219.2	293.2	348.6
20	97.6	205.9	231.3	311.5	370.2
25	100.8	213.5	240.6	325.6	386.8
30	103.4	219.8	248.2	337.0	400.3
35	105.6	225.0	254.6	346.7	411.7
40	107.5	229.6	260.1	355.1	421.6
45	109.1	233.6	265.0	362.4	430.3
50	110.6	237.2	269.3	369.0	438.0
60	113.2	243.4	276.8	380.3	451.4
70	115.3	248.6	283.2	389.9	462.7
80	117.2	253.1	288.6	398.2	472.5
90	118.8	257.1	293.5	405.5	481.1
100	120.3	260.6	297.8	412.1	488.8
150	126.0	274.3	314.4	437.2	518.5
200	130.0	284.0	326.2	455.0	539.5
250	133.1	291.5	335.3	468.8	555.7
300	135.6	297.7	342.8	480.1	569.0
350	137.8	302.9	349.1	489.6	580.3
400	139.6	307.4	354.6	497.9	590.0
500	142.7	314.9	363.7	511.7	606.2
1000	152.4	338.2	392.0	554.5	656.7

Table 2.2-13 Probable Rainfall (Manggarai)

Unit:mm

Return period	Rainfall duration				
	1hour	6hour	12hour	24hour	48hour
2	66.4	134.1	145.9	173.0	211.8
3	75.1	149.5	160.7	198.7	239.9
4	80.6	159.3	170.2	215.2	257.9
5	84.7	166.6	177.2	227.4	271.2
6	88.0	172.4	182.8	237.0	281.8
7	90.7	177.2	187.4	245.1	290.6
8	93.0	181.3	191.4	252.0	298.1
9	95.0	184.9	194.8	258.0	304.7
10	96.8	188.1	197.9	263.3	310.5
15	103.6	200.3	209.6	283.7	332.7
20	108.4	208.8	217.8	297.9	348.3
25	112.1	215.3	224.1	308.8	360.2
30	115.1	220.6	229.2	317.7	370.0
35	117.6	225.1	233.5	325.3	378.2
40	119.8	229.0	237.2	331.7	385.3
45	121.7	232.4	240.5	337.5	391.5
50	123.4	235.5	243.4	342.6	397.1
60	126.4	240.7	248.5	351.4	406.8
70	128.9	245.2	252.8	358.9	414.9
80	131.0	249.0	256.5	365.3	422.0
90	132.9	252.4	259.8	371.0	428.2
100	134.6	255.5	262.7	376.1	433.7
150	141.2	267.1	273.9	395.6	455.1
200	145.9	275.4	281.9	409.4	470.2
250	149.5	281.8	288.1	420.2	481.9
300	152.4	287.1	293.1	428.9	491.5
350	154.9	291.5	297.4	436.3	499.6
400	157.0	295.3	301.0	442.7	506.6
500	160.6	301.7	307.2	453.5	518.3
1000	171.8	321.6	326.3	486.7	554.6

2.3 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

2.3.1 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 2.3-1 Pattern of Thiessen Polygon

Agency	BMG	BMG	BMG	BMG	BBWS	BBWS	BBWS	BBWS	
Station	Pondok Betung Ciledug	Darmaga Bogor	Citeko	Jakarta OBS	Sawangan	Manggarai	Cibinong	Cilember	Pattern
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 2.3-2 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

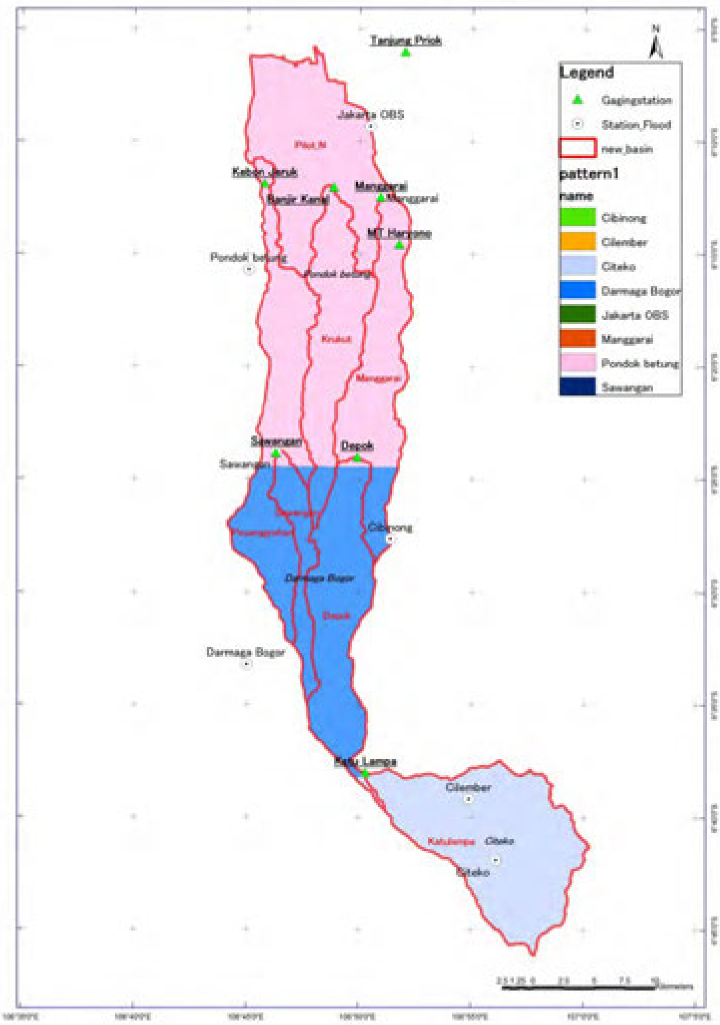


Figure 2.3-1 Thiessen Polygon (Pattern 1)

Table 2.3-3 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

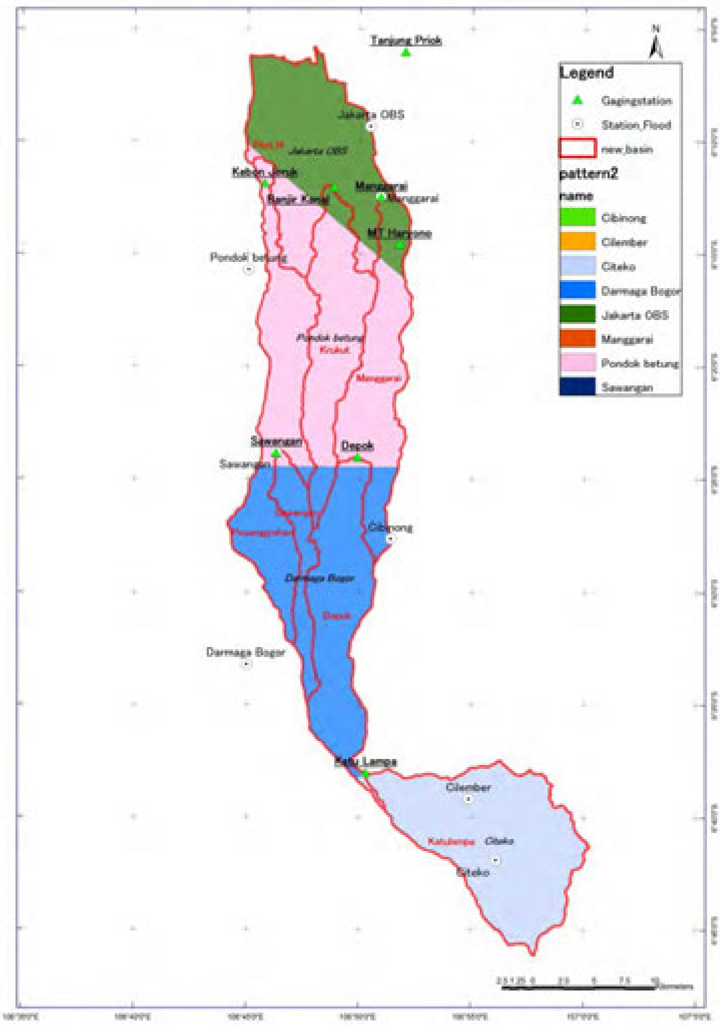


Figure 2.3-2 Thiessen Polygon (Pattern 2)

Table 2.3-4 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
Manggarai	91.58	Manggarai	36.37	39.71
		Pondok betung	41.07	44.84
		Darmaga Bogor	14.14	15.44
Krukut	84.96	Manggarai	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

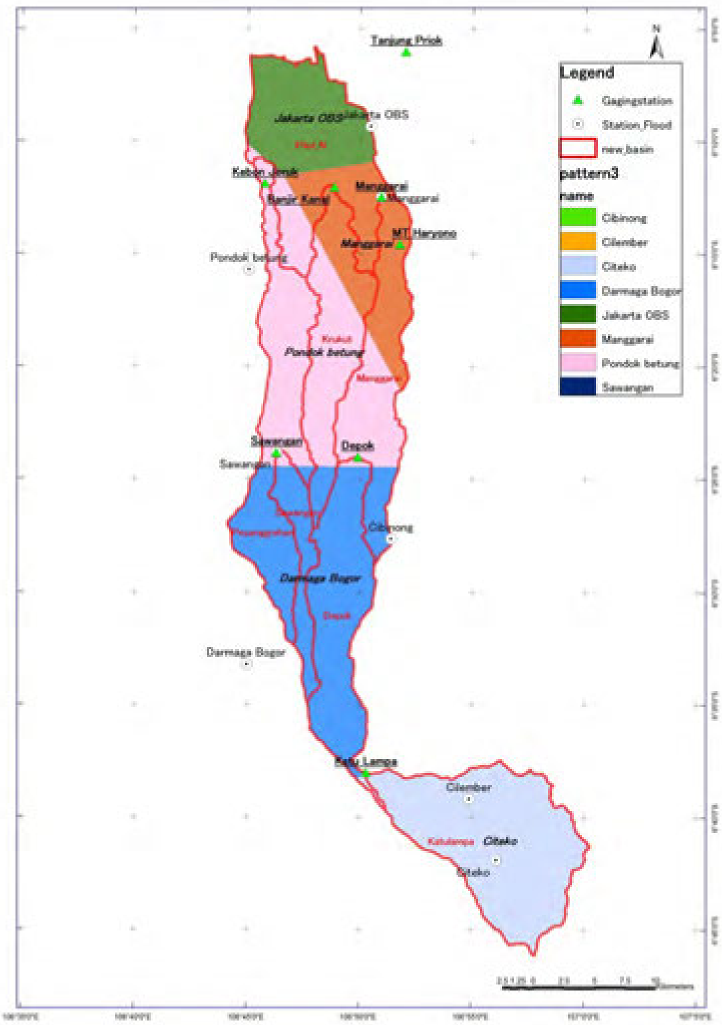


Figure 2.3-3 Thiessen Polygon (Pattern 3)

Table 2.3-5 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

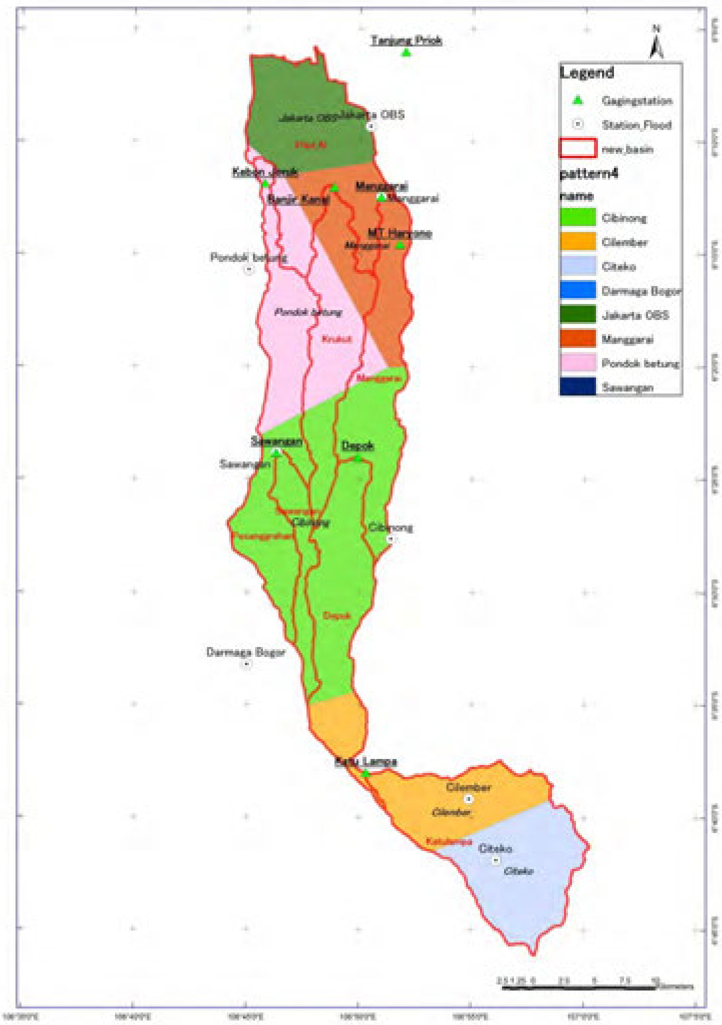


Figure 2.3-4 Thiessen Polygon (Pattern 4)

Table 2.3-6 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
		Darmaga Bogor	37.90	39.60
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
		Pondok betung	25.24	29.71
Pesanggrahan	111.25	Cibinong	1.95	1.76
		Sawangan	57.60	51.78
		Pondok betung	39.38	35.40
		Darmaga Bogor	12.26	11.02
		Jakarta OBS	0.06	0.05
Sawangan	30.10	Cibinong	4.72	15.69
		Sawangan	14.14	46.96
		Darmaga Bogor	11.24	37.35

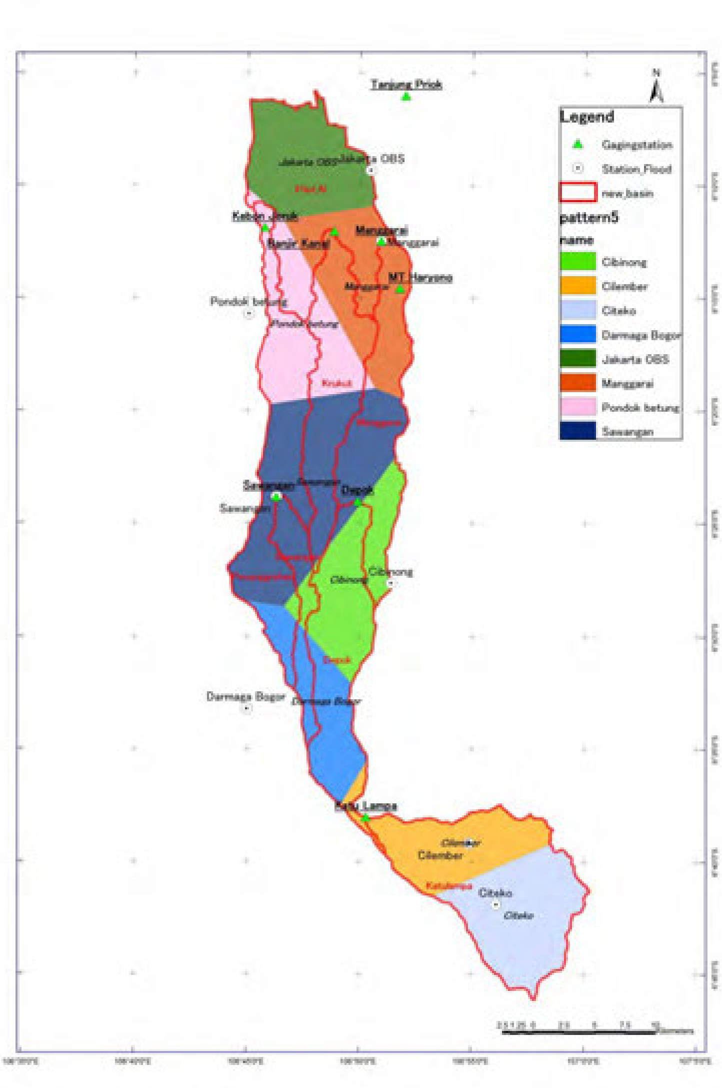


Figure 2.3-5 Thiessen Polygon (Pattern 5)

Table 2.3-7 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
		Pondok betung	25.24	29.71
Pesanggrahan	111.25	Cibinong	1.95	1.76
		Sawangan	57.60	51.78
		Pondok betung	39.38	35.40
		Darmaga Bogor	12.26	11.02
		Jakarta OBS	0.06	0.05
		Darmaga Bogor	0.00	0.00
Sawangan	30.10	Cibinong	4.72	15.69
		Sawangan	14.14	46.96
		Darmaga Bogor	11.24	37.35

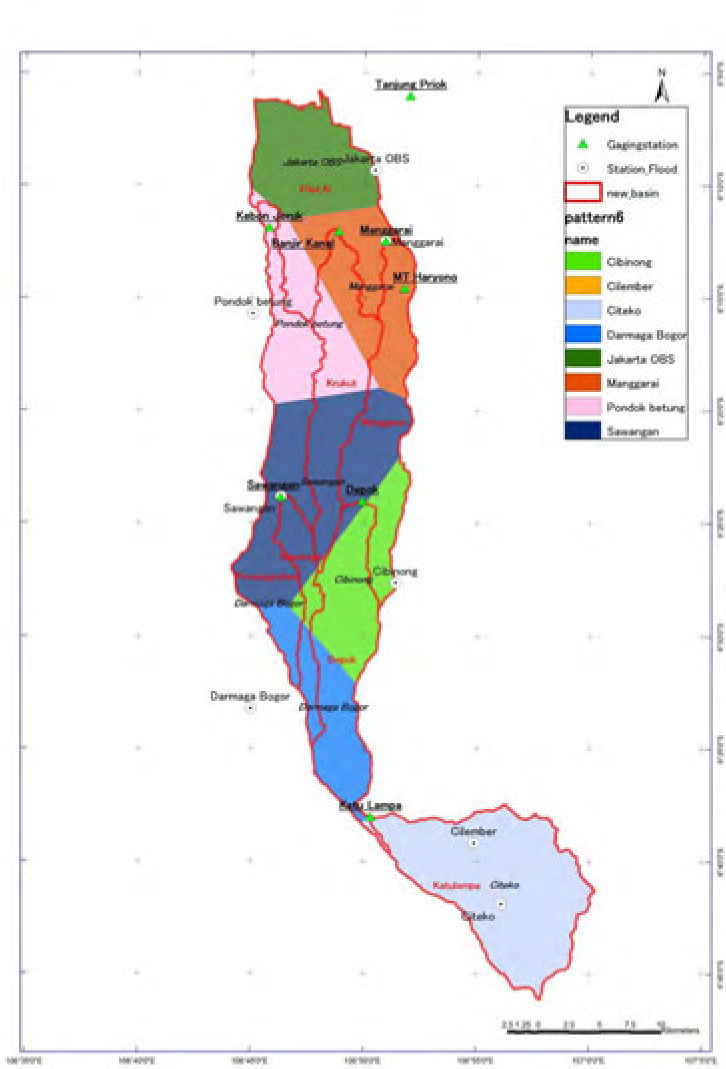


Figure 2.3-6 Thiessen Polygon (Pattern 6)

2.3.2 Annual Maximum Basin Average Rainfall

The annual maximum 6, 12, 24, 48, 96, 144, and 168 hourly rainfall data are extracted.

The annual maximum rainfall in each area is shown as below.

Table 2.3-8 Annual Maximum Rainfall (Krukut)

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	108.15	23-Apr	120.26	23-Apr	120.28	22-Apr	139.83	21-Apr	207.78	21-Apr	232.05	21-Apr	243.45	01-Oct
1994	84.18	22-Apr	85.60	22-Apr	87.86	20-Jan	98.90	20-Jan	145.47	18-Apr	194.33	16-Apr	195.07	15-Apr
1995	95.80	24-Sep	115.19	17-Jun	115.19	17-Jun	127.70	16-Jun	222.99	23-Sep	236.97	23-Sep	240.96	15-Jun
1996	153.87	10-Feb	183.60	10-Feb	204.50	10-Feb	213.70	09-Feb	256.94	07-Feb	275.63	07-Feb	276.36	07-Feb
1997	73.06	09-Apr	78.93	13-Jan	107.32	13-Jan	122.22	13-Jan	167.22	05-Apr	199.48	05-Apr	204.43	04-Apr
1998	71.63	15-Apr	113.72	27-Mar	114.66	27-Mar	139.31	30-Jan	169.59	28-Jan	222.58	02-Feb	232.74	30-Jan
1999	101.09	13-Jan	101.37	13-Jan	110.82	13-Jan	117.12	26-Dec	137.25	10-Jan	159.14	26-Dec	172.94	24-Dec
2000	90.76	16-Nov	92.74	25-Jan	97.45	25-Jan	117.41	01-Apr	138.06	30-Mar	161.33	01-Feb	178.00	03-Jan
2001	96.66	01-Oct	96.85	01-Oct	105.73	01-Oct	105.77	30-Sep	126.32	27-Dec	146.08	02-May	151.61	03-May
2002	98.85	22-Jan	98.93	22-Jan	111.56	21-Jan	206.21	27-Jan	289.13	25-Jan	361.54	26-Jan	394.62	22-Jan
2003	88.97	13-Feb	111.61	13-Feb	112.29	12-Feb	122.21	12-Feb	135.53	10-Feb	175.89	13-Nov	176.29	14-Nov
2004	63.09	21-Apr	69.20	21-Apr	69.20	21-Apr	98.35	18-Feb	163.38	16-Feb	189.04	14-Feb	212.06	13-Feb
2005	89.36	18-Jan	96.16	18-Jan	103.51	18-Jan	152.40	17-Jan	229.92	16-Jan	250.52	16-Jan	255.32	15-Jan
2006	69.33	20-Apr	69.33	20-Apr	78.22	20-Apr	107.74	17-Feb	138.41	16-Feb	160.46	11-Jan	181.91	22-Jan
2007	121.50	01-Feb	155.98	01-Feb	227.71	01-Feb	331.20	01-Feb	442.92	30-Jan	505.97	31-Jan	548.12	30-Jan
2007	72.63	01-Feb	85.85	01-Feb	99.14	31-Jan	176.93	01-Feb	203.28	31-Jan	242.48	29-Jan	249.21	29-Jan

Table 2.3-9 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

Table 2.3-10 Maximum Annual Rainfall (Depok)

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	75.78	26-Sep	78.36	25-Feb	85.59	25-Feb	122.42	24-Feb	209.34	23-Feb	261.01	23-Feb	276.42	22-Feb
1994	58.25	03-Apr	74.97	26-Jan	106.58	21-Jan	149.49	20-Jan	194.47	18-Jan	278.74	21-Jan	332.02	20-Jan
1995	108.67	30-Dec	108.67	30-Dec	125.67	30-Dec	141.07	29-Dec	166.21	06-Feb	215.34	06-Feb	236.90	05-Feb
1996	87.19	06-Jan	136.81	05-Jan	169.33	05-Jan	205.42	04-Jan	377.34	02-Jan	390.37	01-Jan	404.93	02-Jan
1997	44.48	19-May	51.46	10-May	79.60	19-May	97.55	01-Jan	121.03	10-May	170.97	01-Jan	192.98	01-Jan
1998	72.66	11-May	74.61	11-May	96.09	03-Mar	154.60	02-Mar	196.15	22-Mar	255.86	20-Mar	264.75	19-Mar
1999	86.77	30-Jun	90.46	30-Jun	90.46	30-Jun	94.99	12-Jan	132.66	12-Jan	166.04	15-Oct	186.78	14-Oct
2000	68.52	02-Jul	68.79	02-Jul	73.58	01-Feb	119.35	25-Jan	164.14	24-Jan	177.47	24-Jan	199.15	21-Jan
2001	72.65	28-Feb	79.87	08-Feb	108.44	07-Feb	167.24	07-Feb	226.38	05-Feb	292.65	06-Feb	321.07	05-Feb
2002	70.69	20-Apr	117.96	29-Jan	145.91	29-Jan	219.14	28-Jan	318.14	28-Jan	393.38	26-Jan	399.93	25-Jan
2003	83.73	04-Feb	92.61	04-Feb	95.94	04-Feb	131.15	11-Feb	163.09	04-Feb	211.03	07-Feb	229.34	07-Feb
2004	59.17	12-Dec	74.79	12-Dec	93.12	11-Dec	130.08	11-Dec	183.77	25-Dec	210.98	23-Dec	232.33	12-Feb
2005	60.30	12-Oct	81.94	18-Jan	144.72	18-Jan	194.20	17-Jan	277.61	15-Jan	304.89	14-Jan	331.24	12-Jan
2006	70.47	23-Jan	81.18	23-Jan	103.31	23-Jan	150.11	23-Jan	216.30	23-Jan	277.18	23-Jan	286.64	22-Jan
2007	116.40	03-Feb	185.31	03-Feb	225.66	03-Feb	304.58	03-Feb	385.69	31-Jan	461.34	29-Jan	524.68	29-Jan
2008	56.18	14-Mar	60.55	08-Apr	60.58	08-Apr	108.93	01-Jan	162.41	11-Mar	197.26	11-Mar	235.45	07-Mar

Table 2.3-11 Maximum Annual Rainfall (Katu Lampa)

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	93.30	19-Oct	123.50	25-Feb	128.00	25-Feb	165.70	24-Feb	259.90	23-Feb	327.20	23-Feb	337.80	22-Feb
1994	70.90	10-Dec	79.70	21-Jan	130.30	21-Jan	184.50	20-Jan	235.70	18-Jan	348.40	21-Jan	403.00	20-Jan
1995	176.41	30-Dec	176.41	30-Dec	176.81	30-Dec	188.41	29-Dec	216.60	07-Feb	267.50	07-Feb	281.00	06-Feb
1996	133.40	06-Jan	187.40	06-Jan	208.90	05-Jan	281.90	02-Jan	520.20	02-Jan	538.20	01-Jan	550.60	02-Jan
1997	69.00	10-Dec	69.00	10-Dec	117.00	10-May	125.40	01-Jan	166.90	10-May	230.00	01-Jan	252.80	01-Jan
1998	87.30	04-Mar	87.50	04-Mar	126.10	03-Mar	187.10	02-Mar	223.50	21-Mar	260.10	20-Mar	270.10	01-Mar
1999	86.30	30-Jun	86.50	30-Jun	92.30	25-Feb	109.20	25-Feb	147.90	23-Feb	196.20	20-Feb	214.10	20-Feb
2000	94.50	02-Jul	94.50	02-Jul	97.30	01-Jul	143.10	25-Jan	185.30	24-Jan	203.80	23-Jan	240.00	21-Jan
2001	110.00	28-Feb	111.30	28-Feb	124.20	07-Feb	187.60	07-Feb	258.10	05-Feb	358.80	06-Feb	392.30	06-Feb
2002	110.50	20-Apr	126.10	20-Apr	151.30	29-Jan	222.60	28-Jan	300.60	28-Jan	369.40	26-Jan	384.50	27-Jan
2003	110.50	04-Feb	124.30	04-Feb	128.80	04-Feb	143.80	03-Feb	213.00	04-Feb	244.20	02-Feb	264.40	01-Feb
2004	46.19	19-Feb	73.44	19-Feb	86.12	11-Dec	113.62	26-Dec	204.42	25-Dec	232.52	23-Dec	266.14	12-Feb
2005	72.09	27-Jan	117.68	18-Jan	172.83	18-Jan	221.93	17-Jan	306.79	15-Jan	344.68	13-Jan	367.31	12-Jan
2006	98.40	23-Jan	111.30	23-Jan	141.70	23-Jan	198.30	23-Jan	271.60	23-Jan	326.50	23-Jan	339.60	22-Jan
2007	174.58	03-Feb	255.89	03-Feb	310.62	03-Feb	409.01	03-Feb	505.73	31-Jan	593.00	30-Jan	690.28	29-Jan
2008	65.07	08-Apr	73.28	08-Apr	73.28	08-Apr	128.47	01-Jan	184.30	01-Jan	209.17	07-Apr	225.64	07-Apr

2.3.3 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 2.3-12 Probable Rainfall (Krukut)

Unit:mm

Return period	Rainfall duration						
	6hour	12hour	24hour	48hour	96hour	144hour	168hour
2	88.7	99.8	110.6	139.5	185.8	218.2	230.0
3	98.2	112.3	125.8	162.5	217.8	253.5	267.0
4	104.3	120.3	135.5	177.2	238.2	276.1	290.7
5	108.9	126.2	142.7	188.1	253.4	292.8	308.2
6	112.5	130.9	148.4	196.8	265.4	306.1	322.1
7	115.5	134.8	153.2	204.0	275.4	317.1	333.7
8	118.0	138.1	157.3	210.1	284.0	326.6	343.6
9	120.3	141.0	160.8	215.5	291.5	334.8	352.2
10	122.2	143.6	164.0	220.3	298.1	342.1	359.9
15	129.8	153.5	175.9	238.4	323.3	370.0	389.1
20	135.1	160.4	184.3	251.1	341.0	389.5	409.6
25	139.1	165.7	190.8	260.9	354.6	404.5	425.3
30	142.4	170.0	196.1	268.9	365.7	416.7	438.1
35	145.2	173.7	200.5	275.6	375.0	427.0	448.9
40	147.6	176.8	204.3	281.4	383.1	435.9	458.2
45	149.8	179.6	207.7	286.5	390.2	443.8	466.5
50	151.6	182.1	210.7	291.0	396.5	450.8	473.8
60	154.9	186.3	215.9	298.9	407.5	462.9	486.5
70	157.7	190.0	220.3	305.6	416.8	473.1	497.2
80	160.1	193.1	224.1	311.3	424.8	481.9	506.5
90	162.2	195.8	227.5	316.4	431.8	489.7	514.6
100	164.1	198.3	230.5	321.0	438.2	496.7	521.9
150	171.3	207.8	242.0	338.4	462.4	523.5	550.0
200	176.5	214.5	250.2	350.8	479.6	542.4	569.9
250	180.5	219.7	256.5	360.3	493.0	557.1	585.3
300	183.7	224.0	261.7	368.2	503.8	569.2	597.9
350	186.5	227.5	266.0	374.8	513.0	579.3	608.6
400	188.8	230.7	269.8	380.5	521.0	588.1	617.8
500	192.8	235.9	276.1	390.1	534.3	602.8	633.2
1000	205.2	252.0	295.8	419.8	575.7	648.4	681.0

Table 2.3-13 Probable Rainfall (Manggarai)

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

Table 2.3-14 Probable Rainfall (Depok)

Unit:mm

Return period	Rainfall duration						
	6hour	12hour	24hour	48hour	96hour	144hour	168hour
2	71.3	86.0	106.0	146.8	204.9	251.7	275.4
3	79.5	99.1	123.2	169.3	239.3	289.5	314.9
4	84.7	107.5	134.3	183.6	261.3	313.7	340.1
5	88.6	113.7	142.4	194.3	277.5	331.6	358.8
6	91.7	118.6	148.9	202.7	290.5	345.9	373.7
7	94.2	122.7	154.3	209.7	301.2	357.7	386.0
8	96.4	126.2	158.9	215.7	310.4	367.8	396.6
9	98.3	129.3	163.0	221.0	318.5	376.7	405.8
10	100.0	132.0	166.5	225.7	325.6	384.5	414.0
15	106.5	142.3	180.2	243.4	352.8	414.4	445.2
20	111.0	149.6	189.7	255.8	371.8	435.3	467.0
25	114.5	155.1	197.0	265.3	386.4	451.4	483.8
30	117.3	159.7	203.0	273.1	398.3	464.5	497.4
35	119.7	163.5	208.0	279.7	408.3	475.6	508.9
40	121.8	166.8	212.4	285.3	417.0	485.1	518.9
45	123.6	169.7	216.2	290.3	424.6	493.5	527.7
50	125.2	172.3	219.6	294.8	431.5	501.0	535.5
60	128.0	176.8	225.5	302.5	443.2	514.0	549.0
70	130.4	180.6	230.5	309.0	453.2	525.0	560.5
80	132.4	183.9	234.8	314.6	461.8	534.4	570.4
90	134.2	186.8	238.6	319.6	469.4	542.8	579.1
100	135.8	189.4	242.0	324.0	476.2	550.3	586.9
150	142.1	199.3	255.1	341.0	502.3	579.0	616.8
200	146.5	206.3	264.4	353.1	520.8	599.3	638.0
250	149.9	211.8	271.6	362.5	535.1	615.1	654.5
300	152.6	216.3	277.4	370.1	546.8	628.0	667.9
350	155.0	220.0	282.4	376.6	556.7	638.9	679.3
400	157.0	223.3	286.7	382.2	565.3	648.3	689.1
500	160.4	228.7	293.9	391.5	579.6	664.0	705.6
1000	171.0	245.7	316.2	420.5	624.0	713.0	756.6

Table 2.3-15 Probable Rainfall (Katu Lampa)

Unit:mm

Return period	Rainfall duration						
	6hour	12hour	24hour	48hour	96hour	144hour	168hour
2	93.7	110.6	132.6	176.4	245.8	296.9	322.2
3	109.4	131.0	155.5	206.3	288.4	344.6	373.8
4	119.5	144.1	170.2	225.4	315.7	375.1	406.9
5	126.9	153.8	181.0	239.6	335.8	397.7	431.4
6	132.8	161.6	189.7	250.9	351.9	415.6	450.8
7	137.7	168.0	196.8	260.2	365.2	430.6	467.0
8	141.9	173.5	203.0	268.2	376.6	443.3	480.9
9	145.6	178.2	208.3	275.2	386.6	454.5	492.9
10	148.8	182.5	213.1	281.4	395.5	464.4	503.7
15	161.2	198.7	231.2	305.0	429.1	502.1	544.5
20	169.9	210.0	243.8	321.6	452.6	528.4	573.0
25	176.5	218.7	253.6	334.3	470.8	548.7	595.0
30	182.0	225.8	261.5	344.6	485.5	565.3	612.9
35	186.6	231.8	268.2	353.4	498.0	579.2	628.0
40	190.5	236.9	274.0	360.9	508.7	591.2	641.1
45	194.0	241.5	279.1	367.6	518.2	601.8	652.5
50	197.1	245.6	283.6	373.5	526.7	611.3	662.8
60	202.5	252.6	291.5	383.8	541.3	627.7	680.5
70	207.0	258.5	298.1	392.4	553.6	641.5	695.5
80	211.0	263.6	303.9	399.9	564.3	653.4	708.5
90	214.4	268.2	308.9	406.5	573.7	664.0	719.9
100	217.5	272.2	313.5	412.4	582.1	673.4	730.1
150	229.4	287.8	330.9	435.1	614.5	709.6	769.3
200	237.9	298.8	343.2	451.2	637.4	735.3	797.1
250	244.4	307.3	352.7	463.7	655.2	755.1	818.6
300	249.7	314.3	360.5	473.8	669.7	771.4	836.2
350	254.3	320.2	367.1	482.4	681.9	785.1	851.1
400	258.2	325.3	372.8	489.9	692.6	797.0	864.0
500	264.7	333.8	382.4	502.4	710.3	816.9	885.5
1000	285.0	360.3	412.0	541.0	765.4	878.6	952.4

2.4 Examination of Rainfall Features

2.4.1 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 235m and that in Manggarai rainfall observation station is more than 800m.

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 2.4-1 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

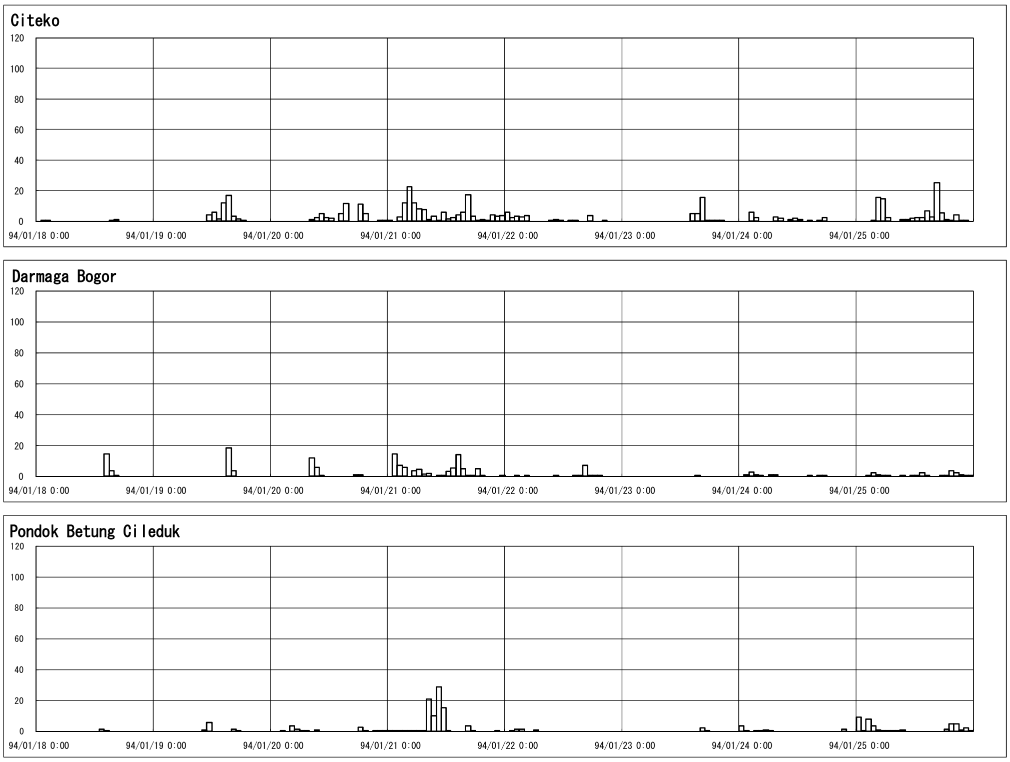


Figure 2.4-1 Observed Rainfall (Inundation in January 1994)

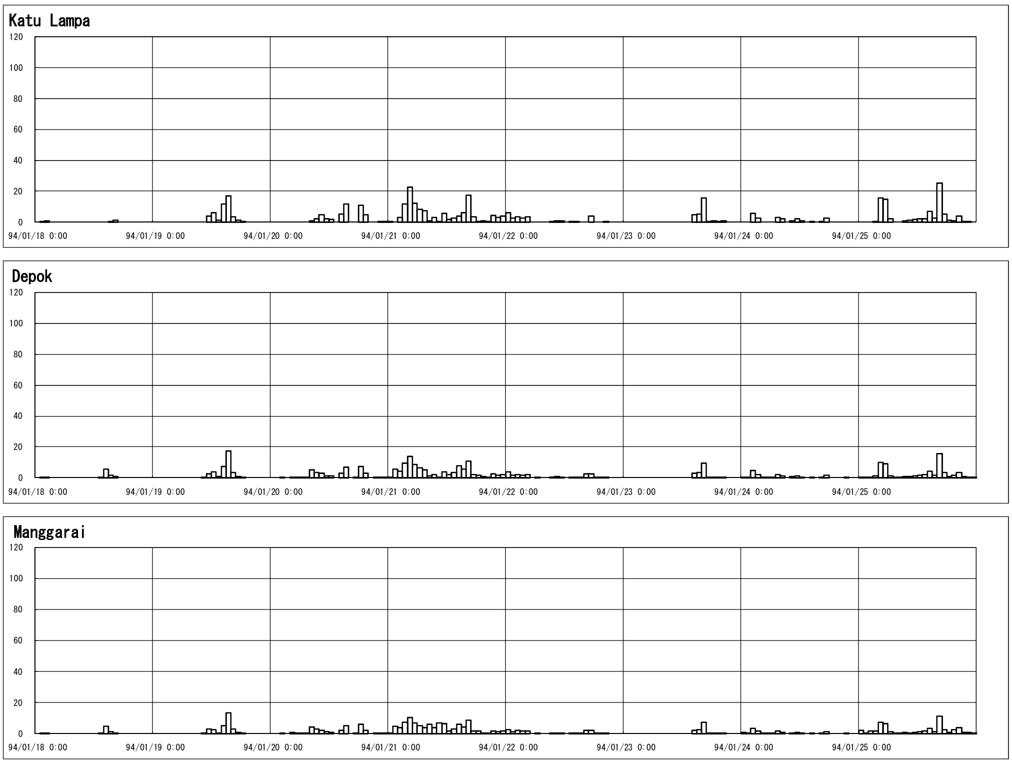


Figure 2.4-2 Basin Average Rainfall (Inundation in January 1994)

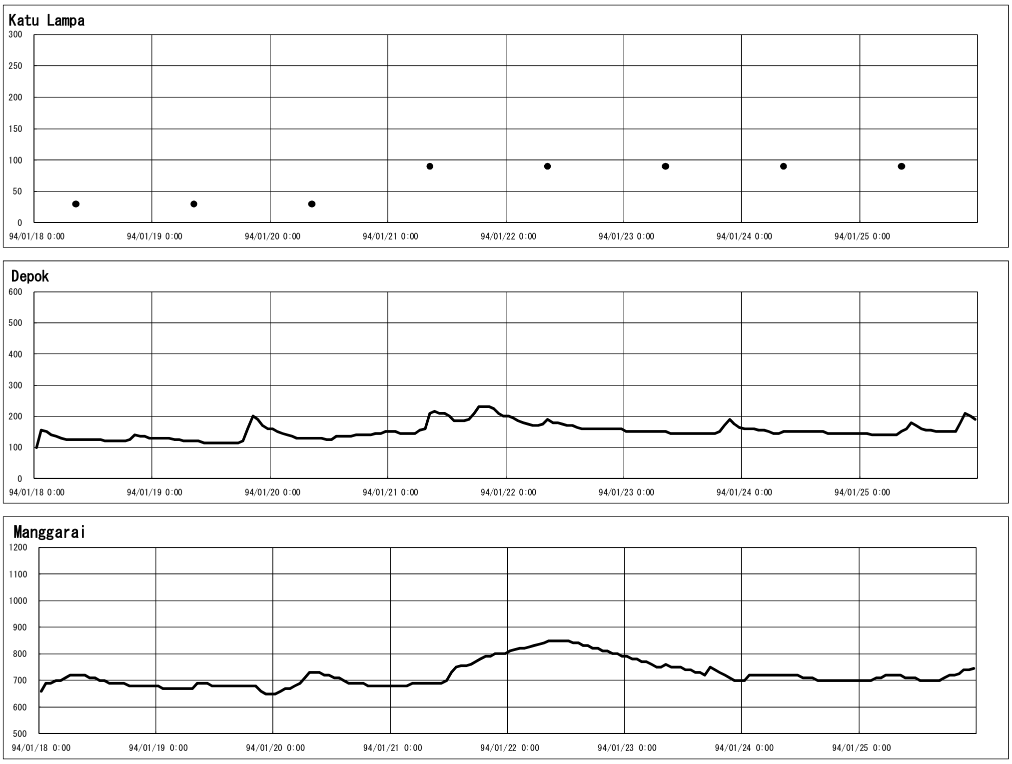


Figure 2.4-3 Observed Water Level (Inundation in January 1994)

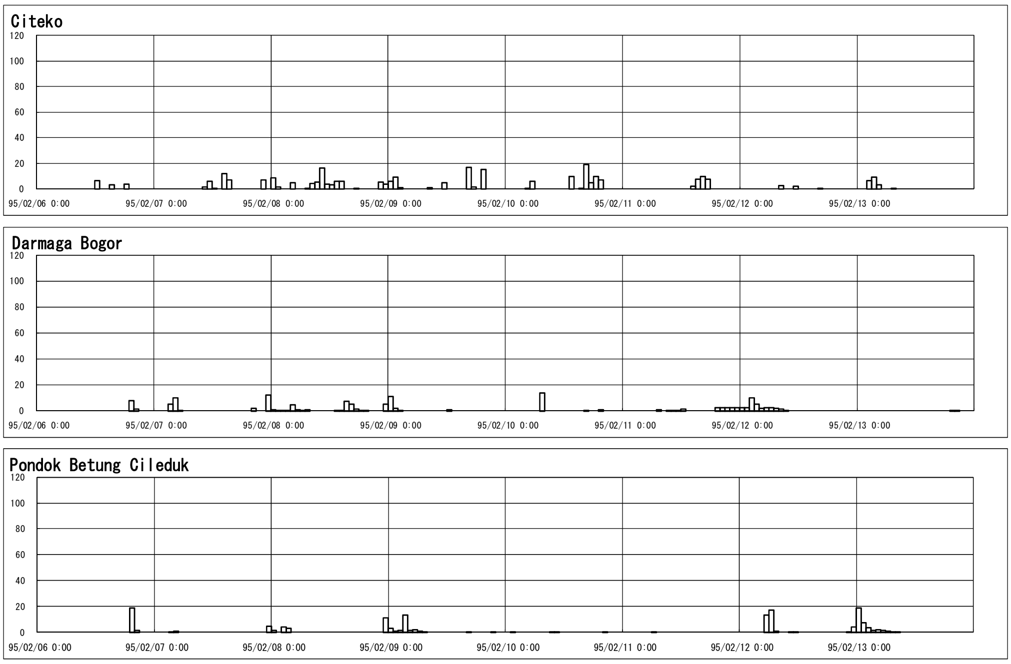


Figure 2.4-4 Observed Rainfall (Inundation in February 1995)

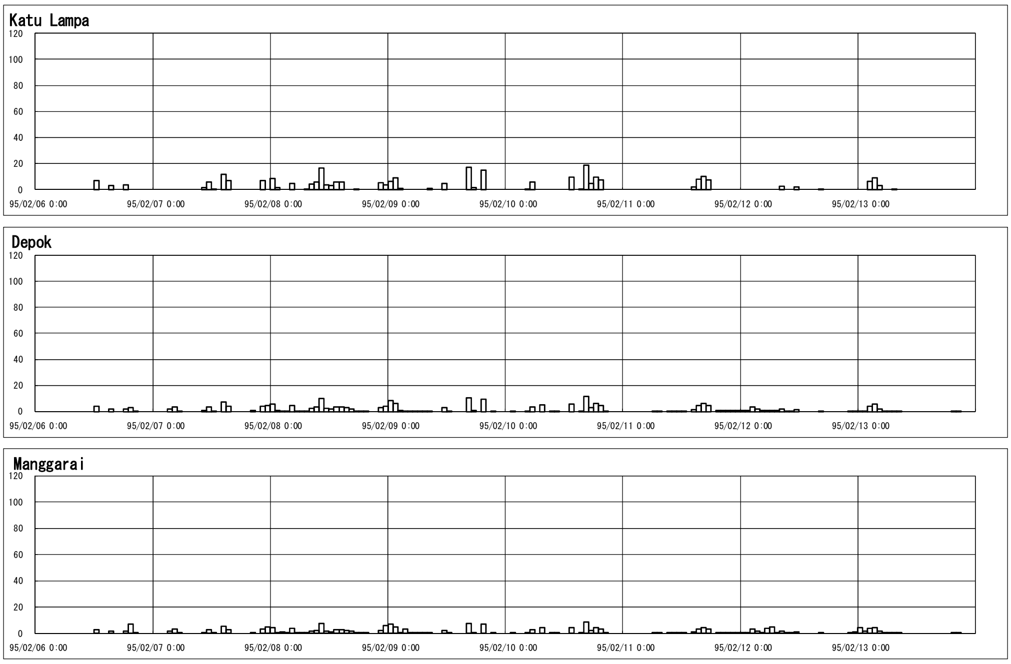


Figure 2.4-5 Basin Average Rainfall (Inundation in February 1995)

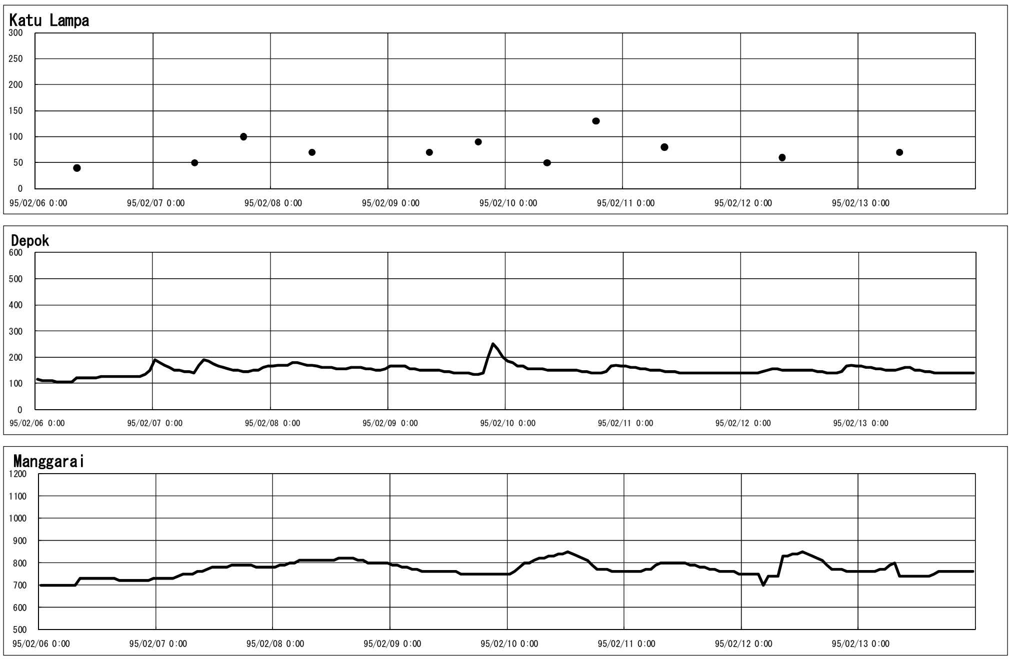


Figure 2.4-6 Observed Water Level (Inundation in February 1995)

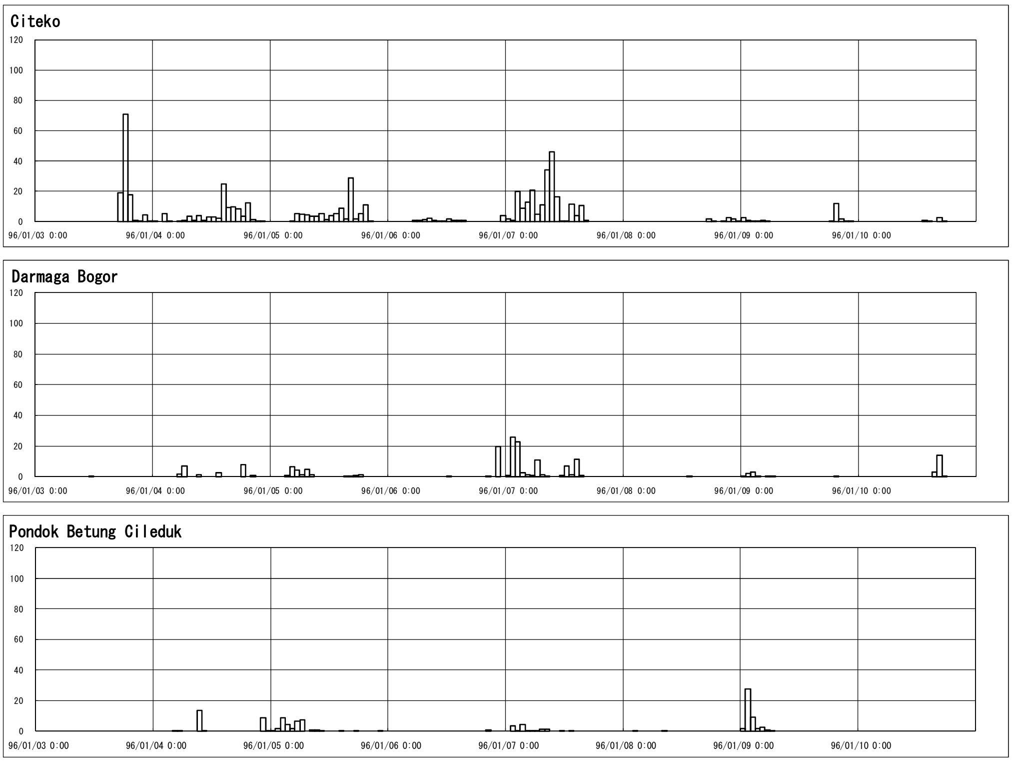


Figure 2.4-7 Observed Rainfall (Inundation in January 1996)

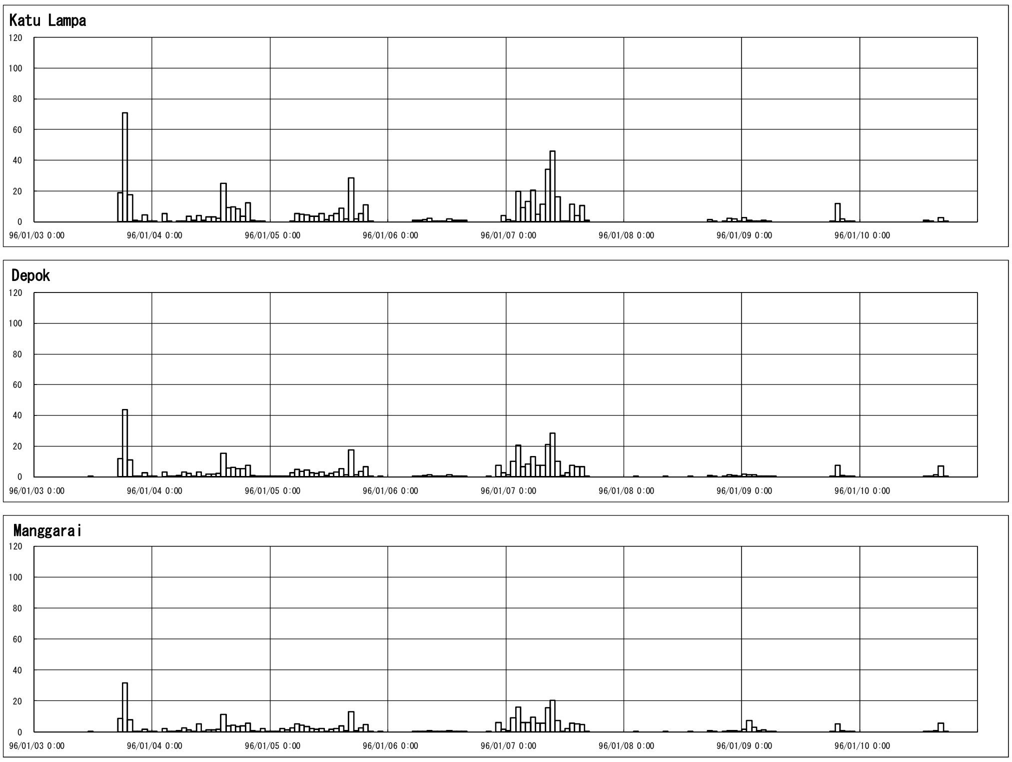


Figure 2.4-8 Basin Average Rainfall (Inundation in January 1996)

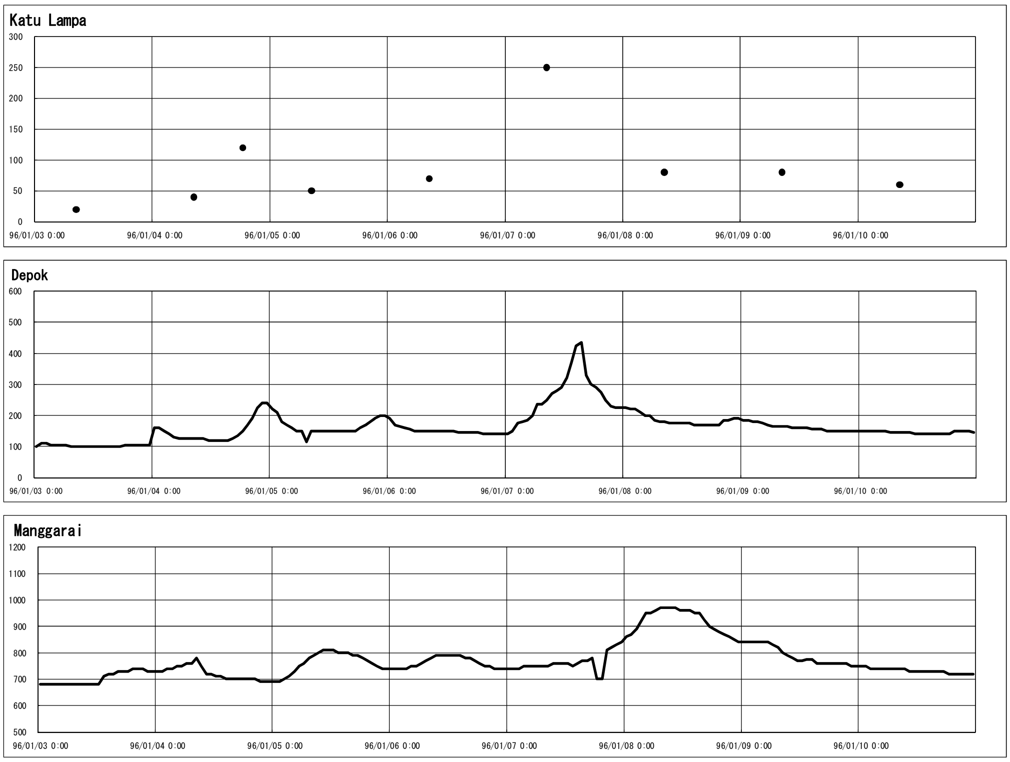


Figure 2.4-9 Observed Water Level (Inundation in January 1996)

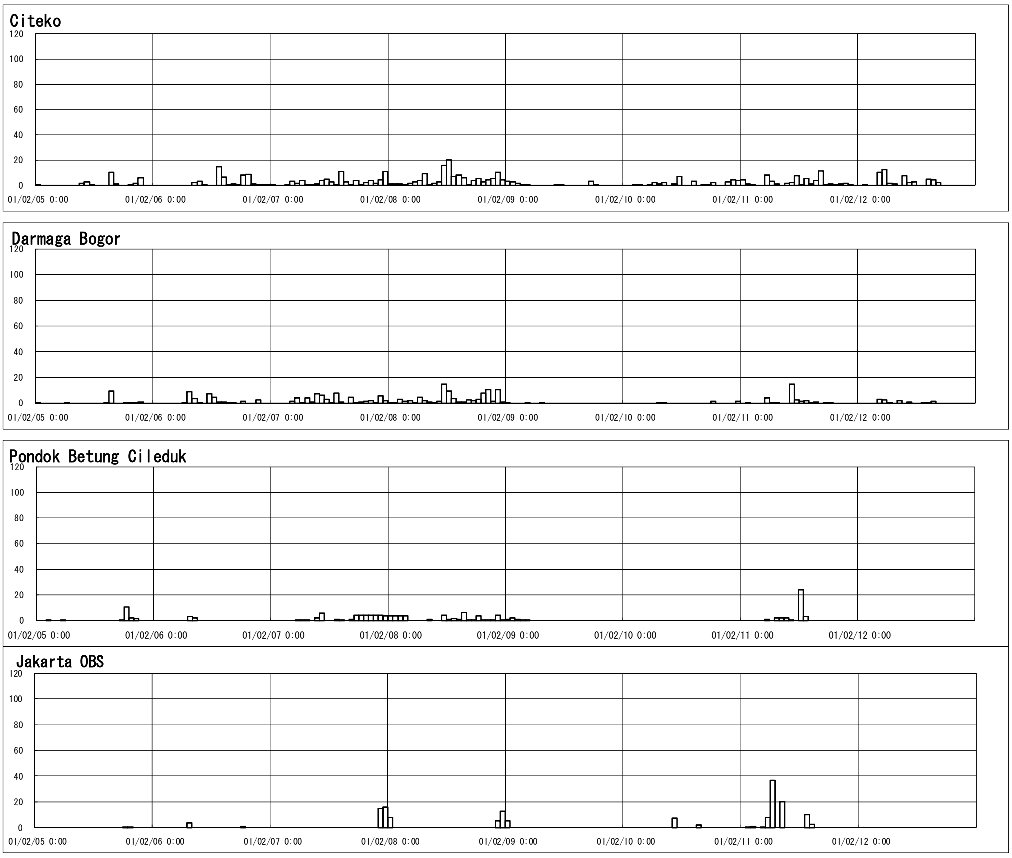


Figure 2.4-10 Observed Rainfall (Inundation in February 2001)

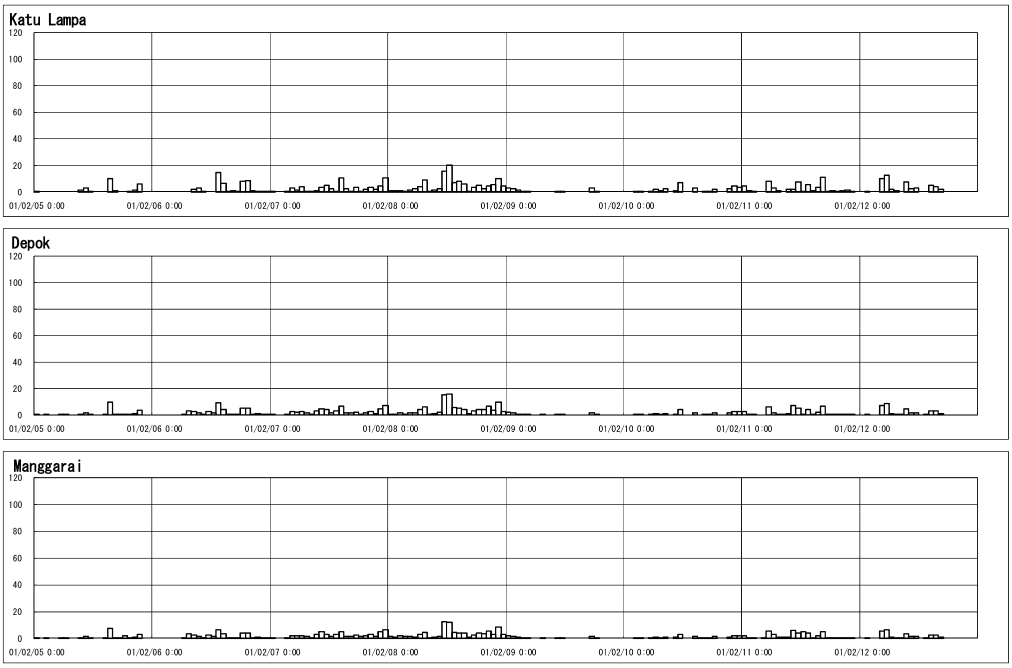


Figure 2.4-11 Basin Average Rainfall (Inundation in February 2001)

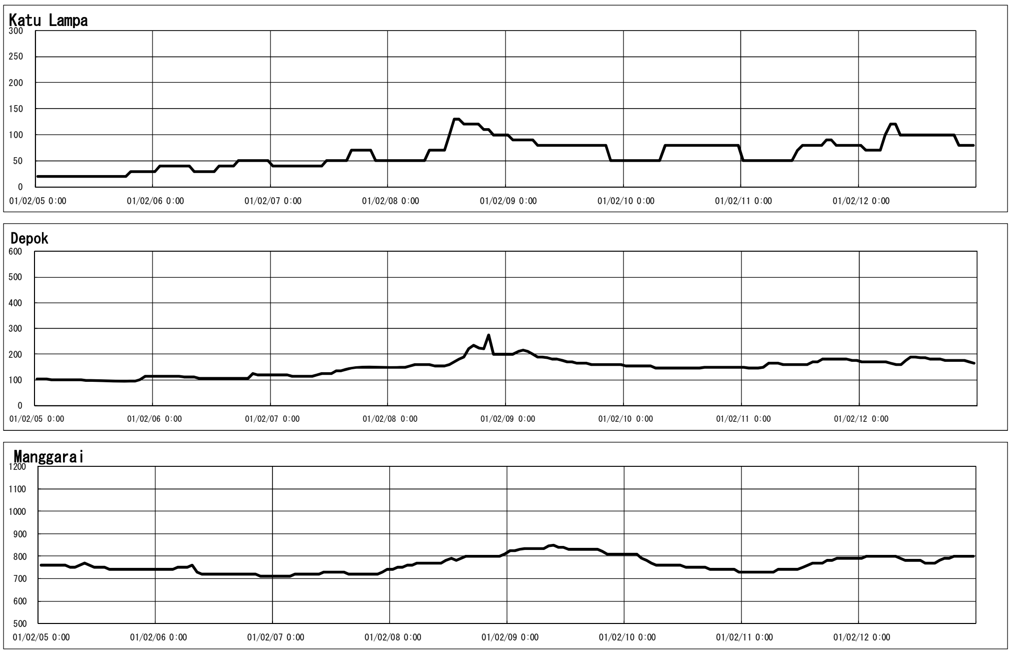


Figure 2.4-12 Observed Water Level (Inundation in February 2001)

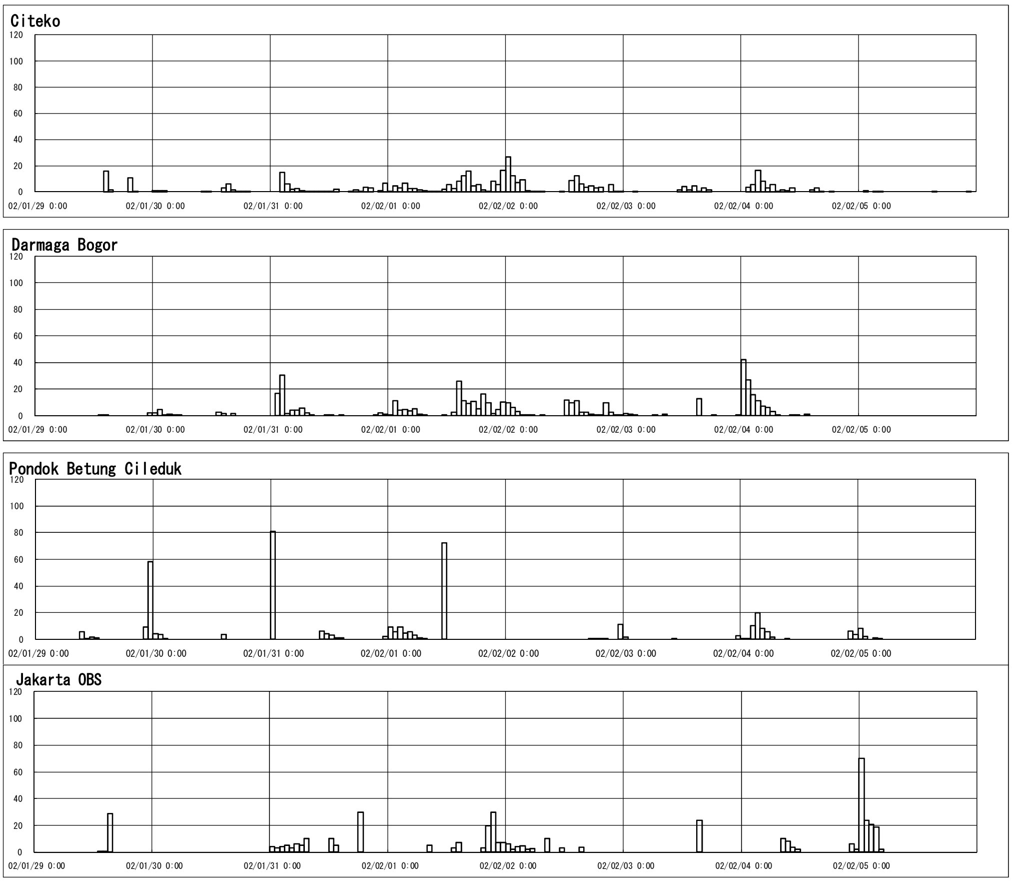


Figure 2.4-13 Observed Rainfall (Inundation in January 2002)

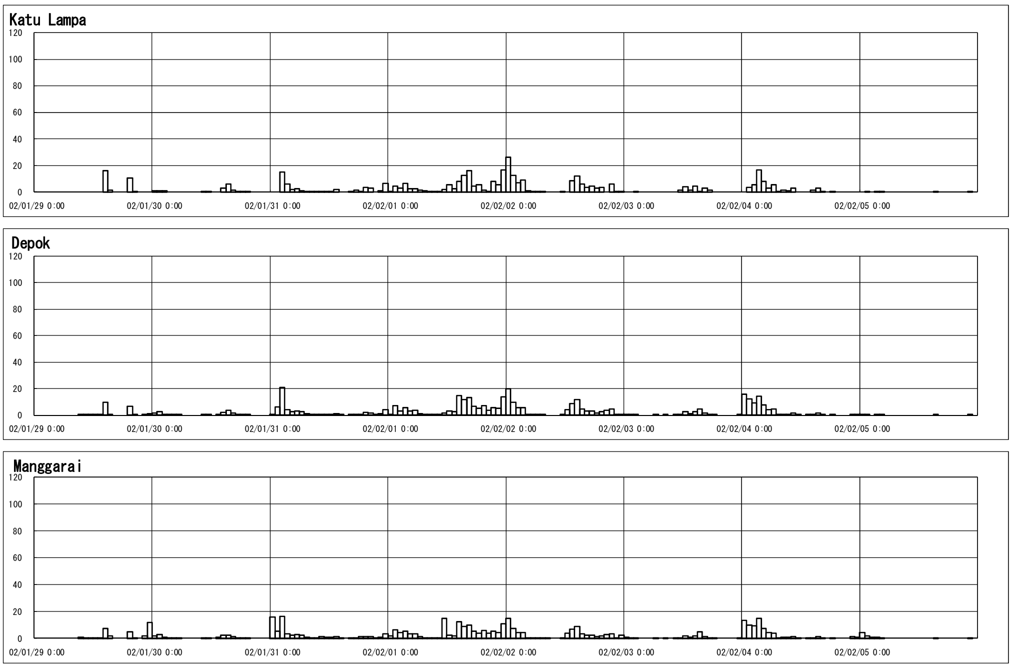


Figure 2.4-14 Basin Average Rainfall (Inundation in January 2002)

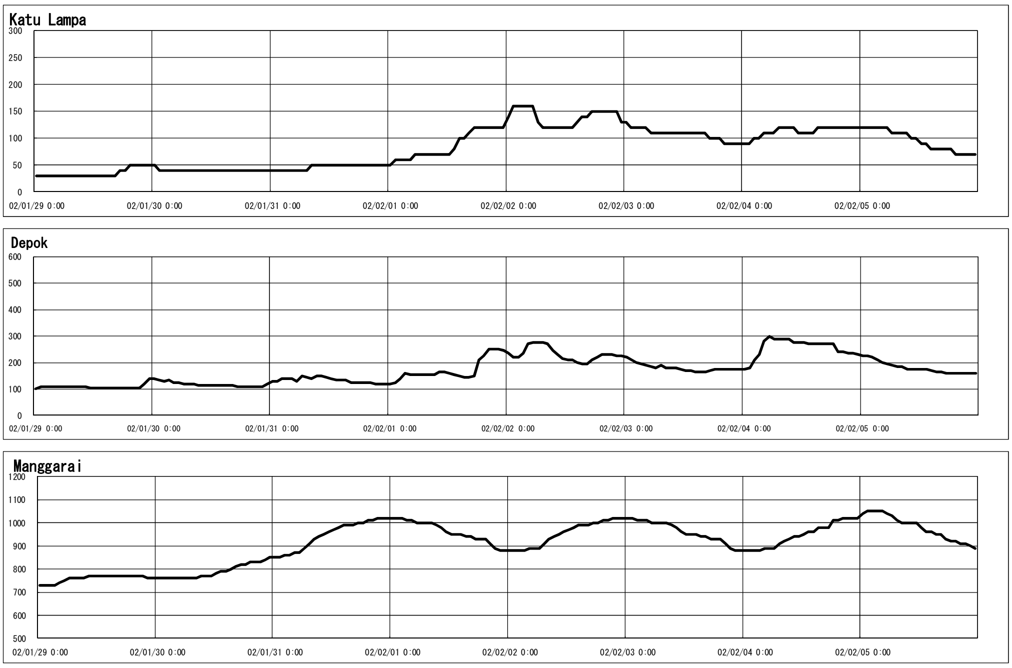


Figure 2.4-15 Observed Water Level (Inundation in January 2002)

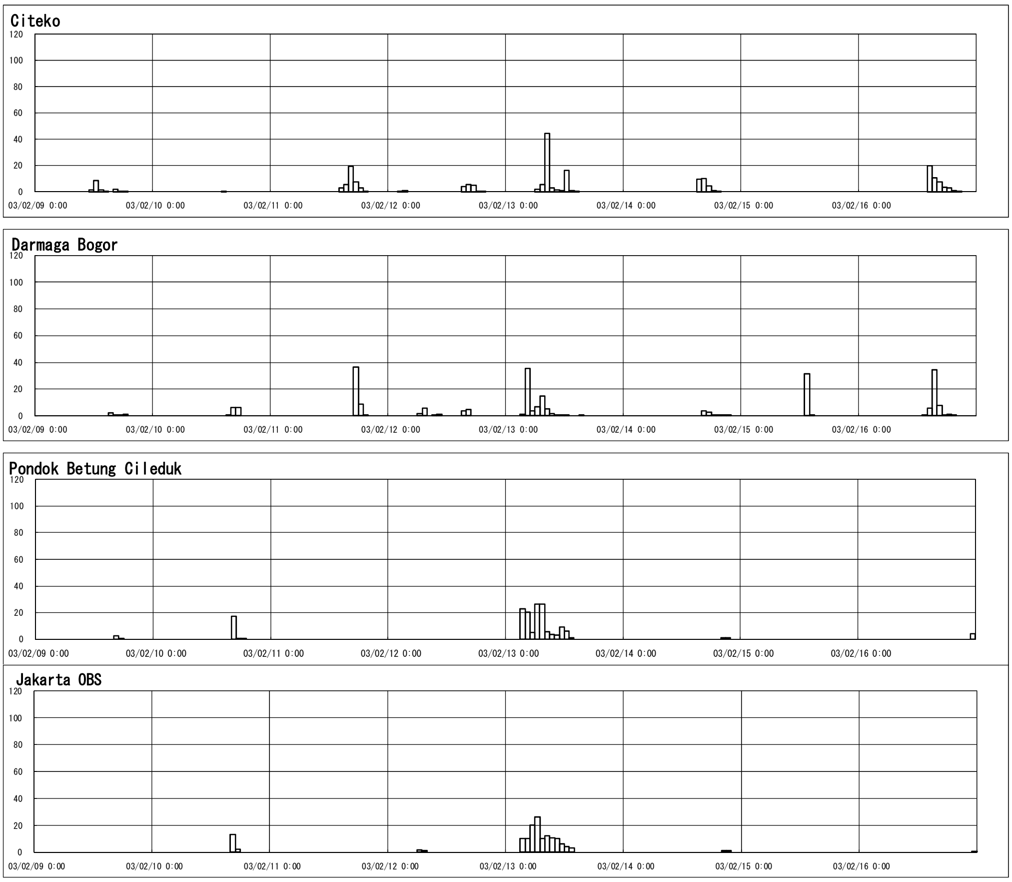


Figure 2.4-16 Observed Rainfall (Inundation in February 2003)

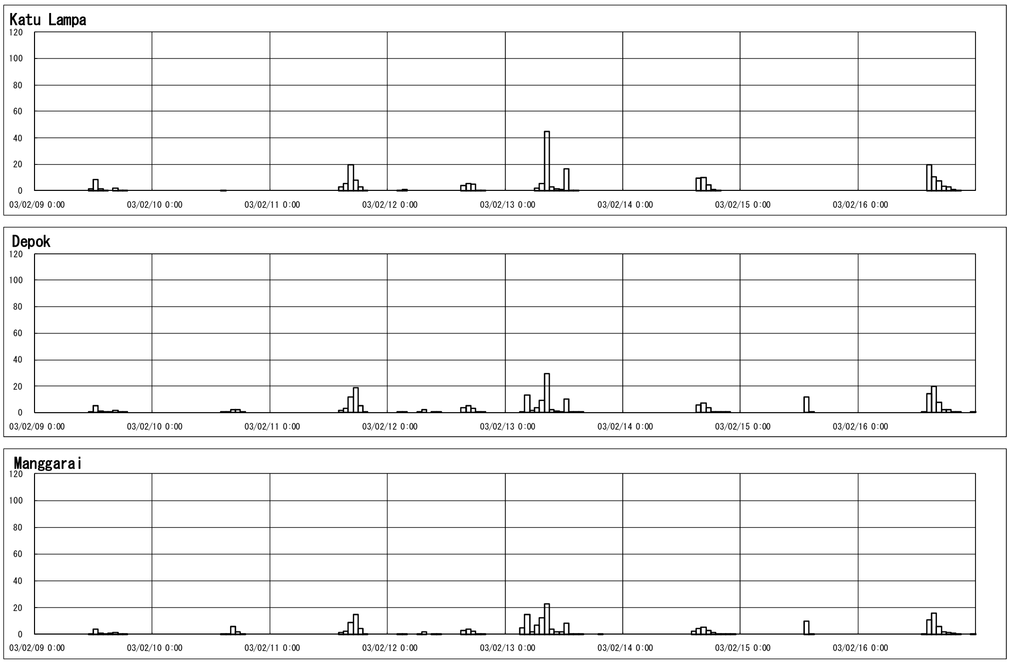


Figure 2.4-17 Basin Average Rainfall (Inundation in February 2003)

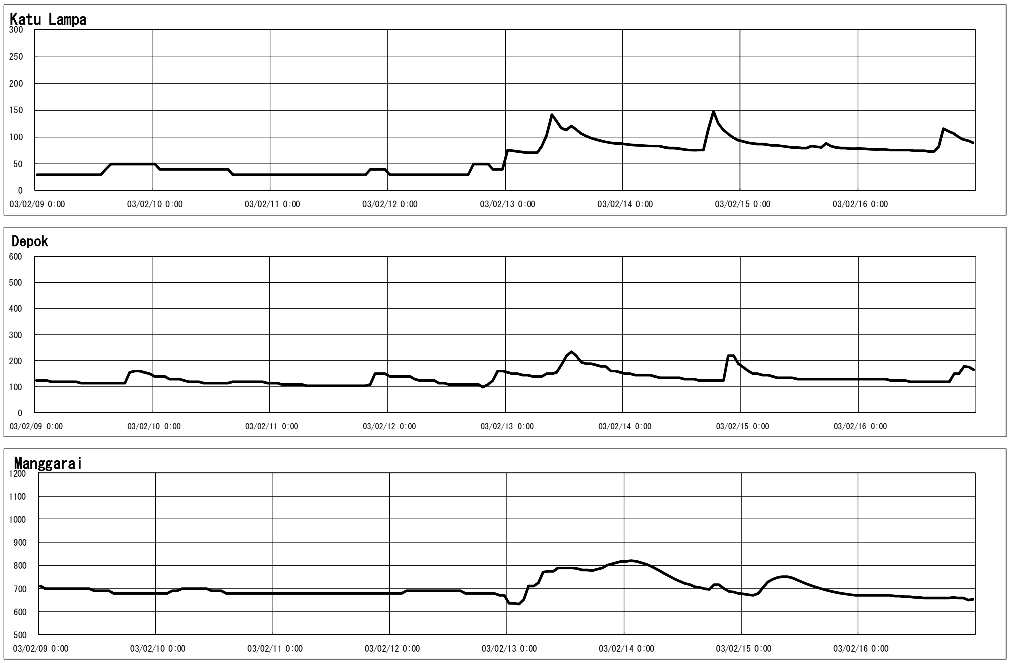


Figure 2.4-18 Observed Water Level (Inundation in February 2003)

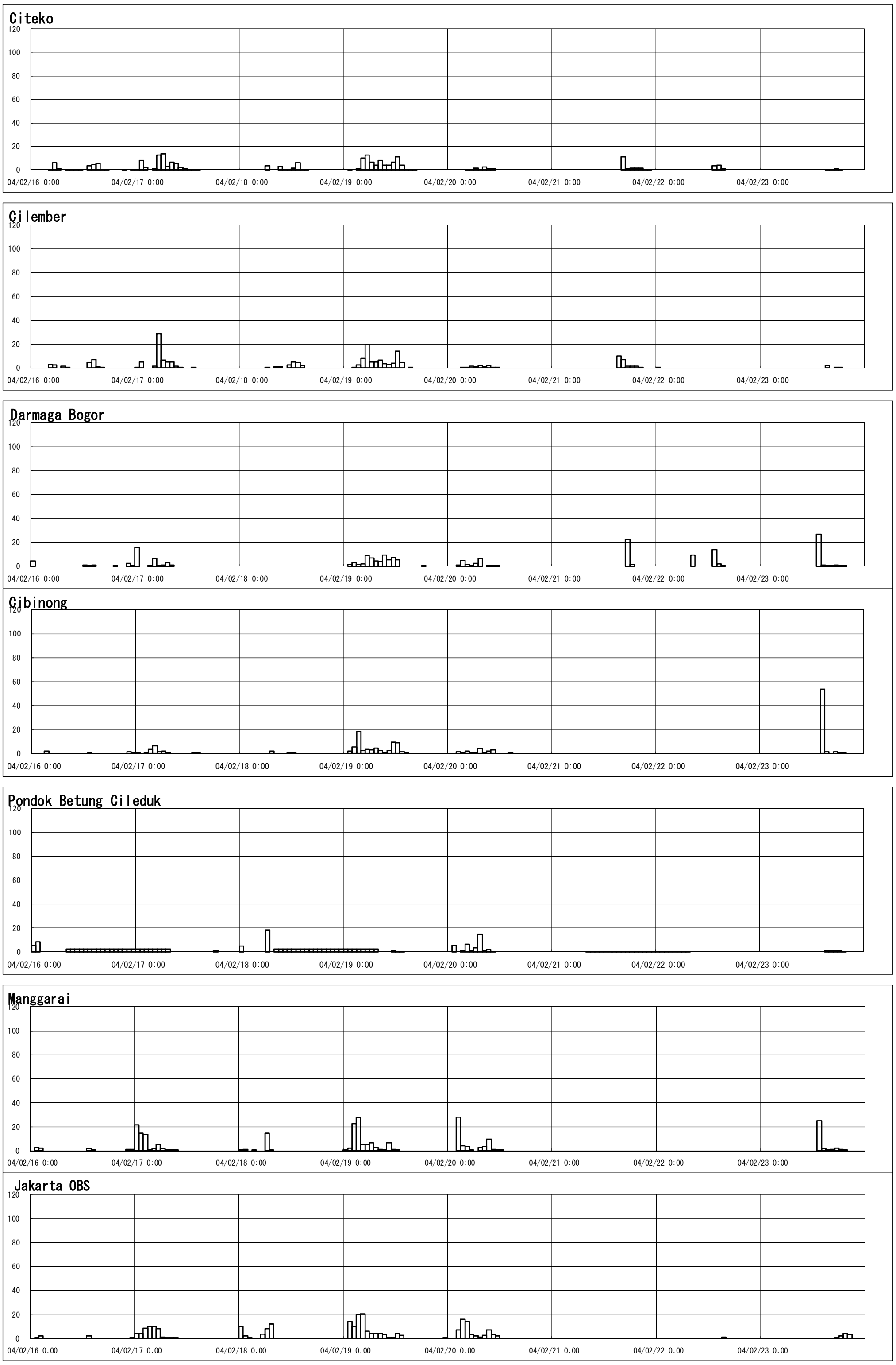


Figure 2.4-19 Observed Rainfall (Inundation in February 2004)

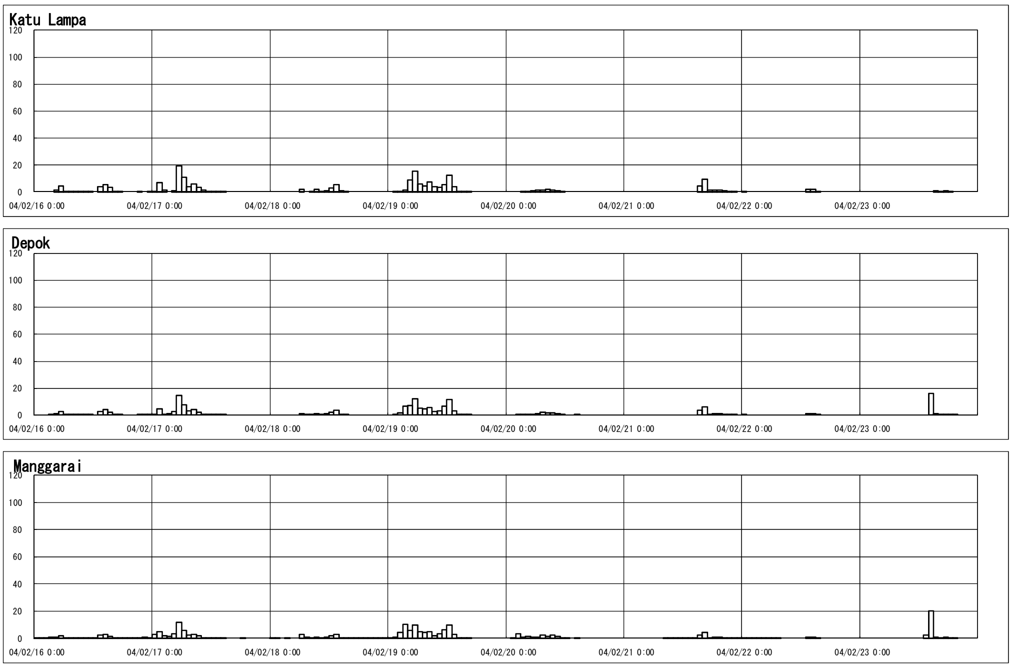


Figure 2.4-20 Basin Average Rainfall (Inundation in February 2004)

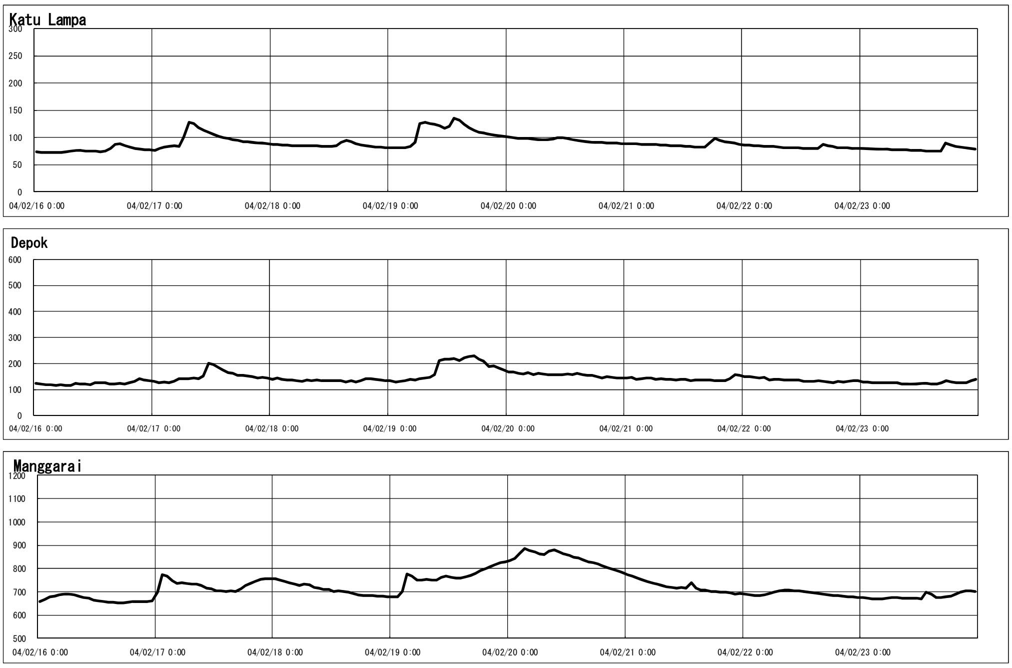


Figure 2.4-21 Observed Water Level (Inundation in February 2004)

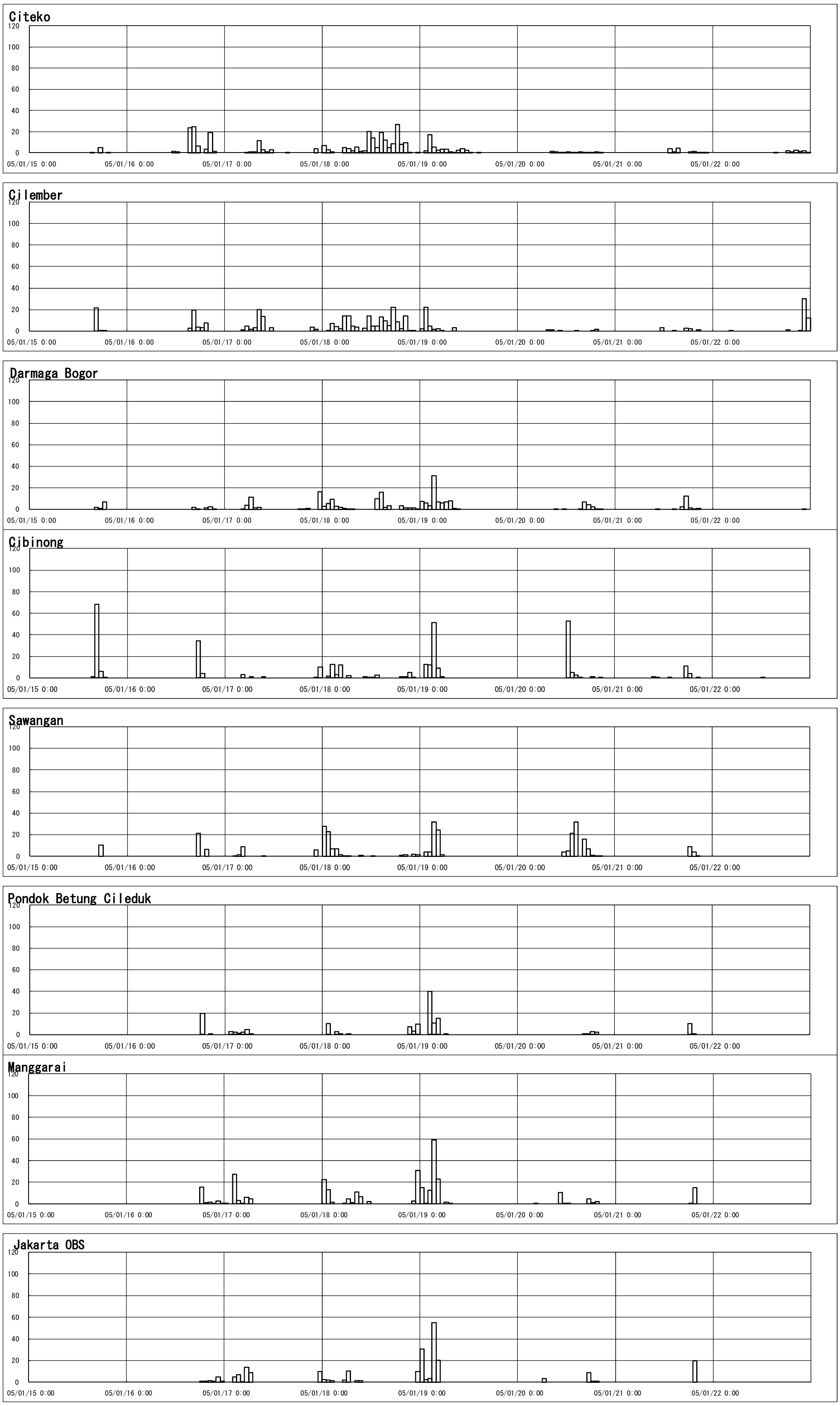


Figure 2.4-22 Observed Rainfall (Inundation in January 2005)

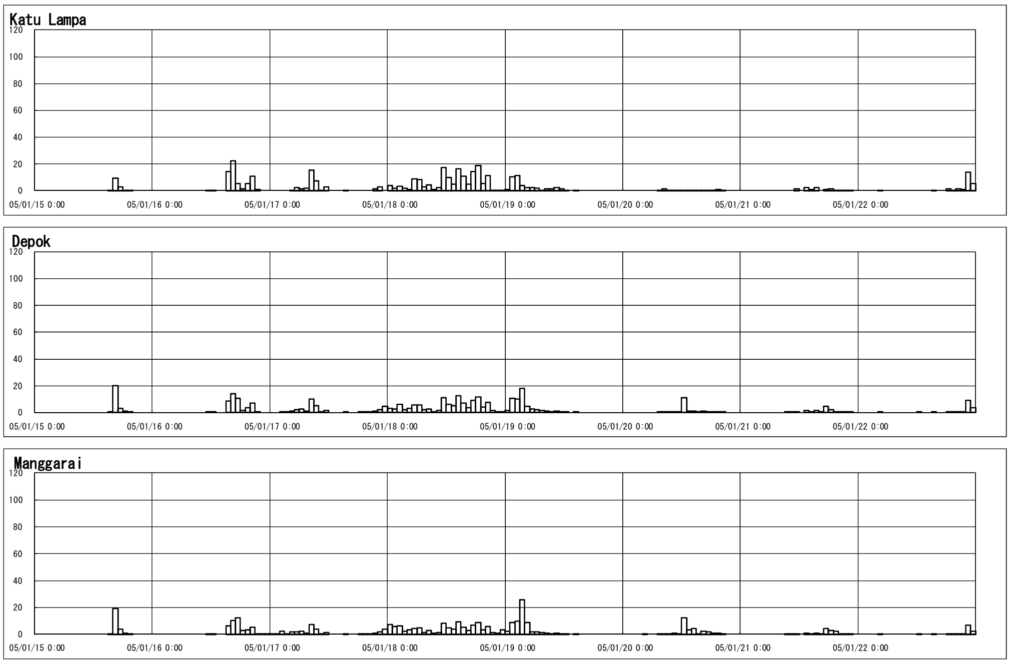


Figure 2.4-23 Basin Average Rainfall (Inundation in January 2005)

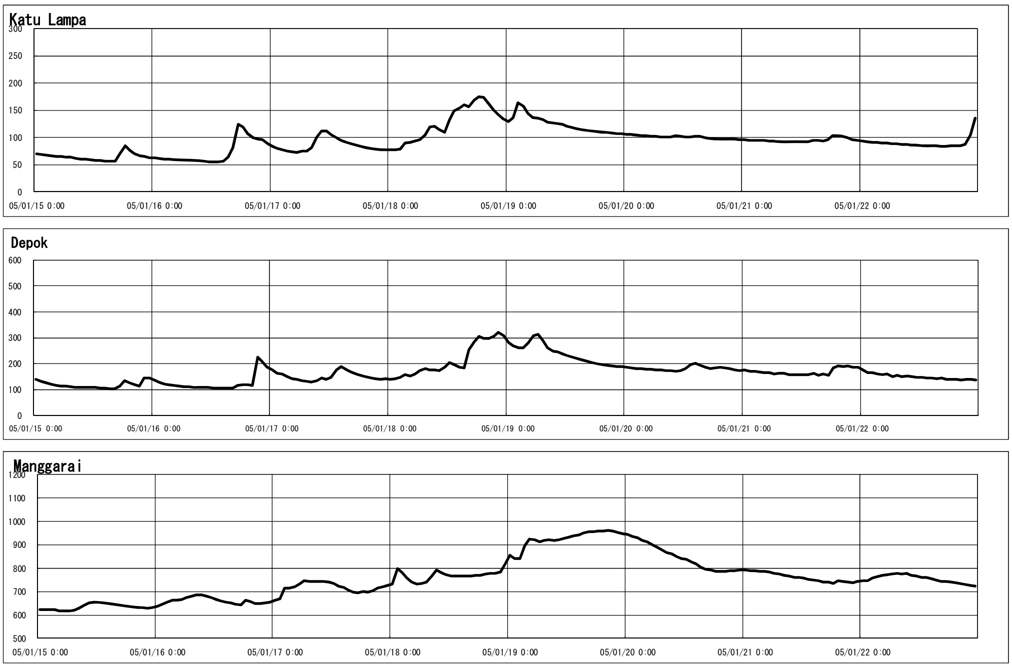
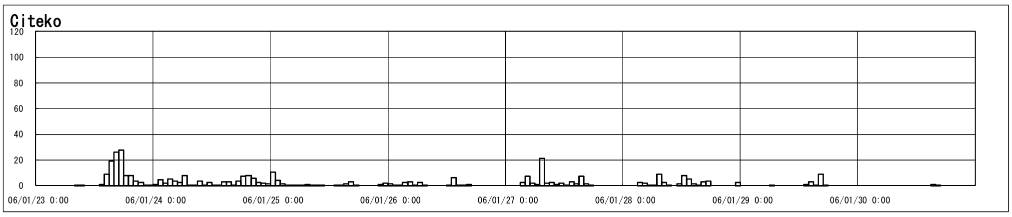


Figure 2.4-24 Observed Water Level (Inundation in January 2005)



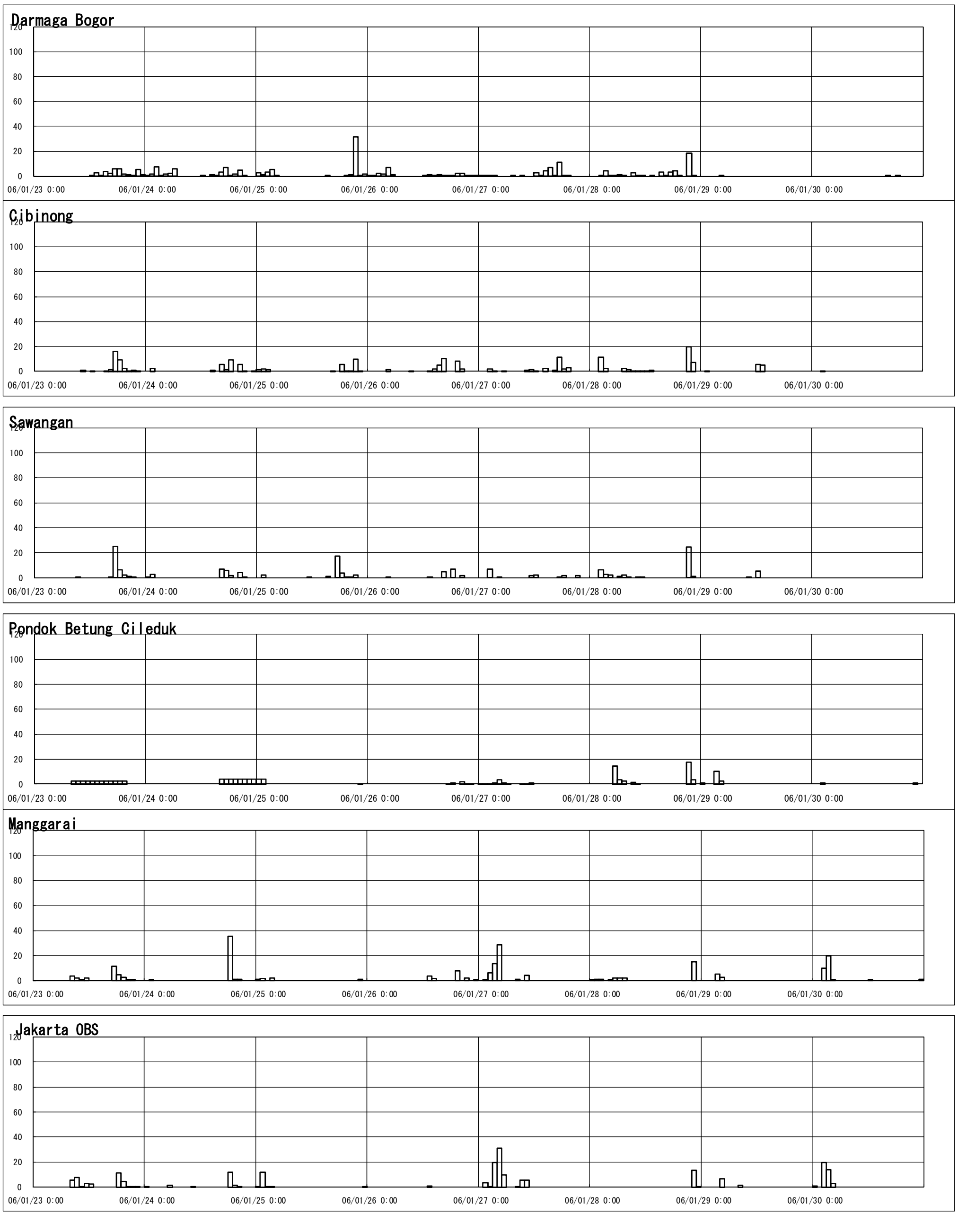


Figure 2.4-25 Observed Rainfall (Inundation in January 2006)

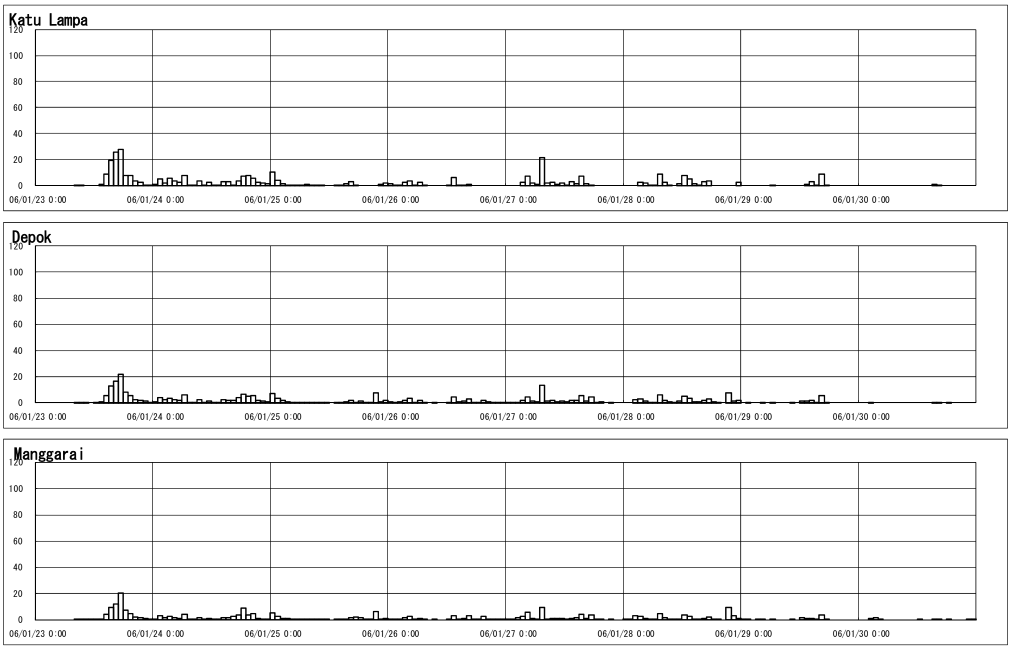


Figure 2.4-26 Basin Average Rainfall (Inundation in January 2006)

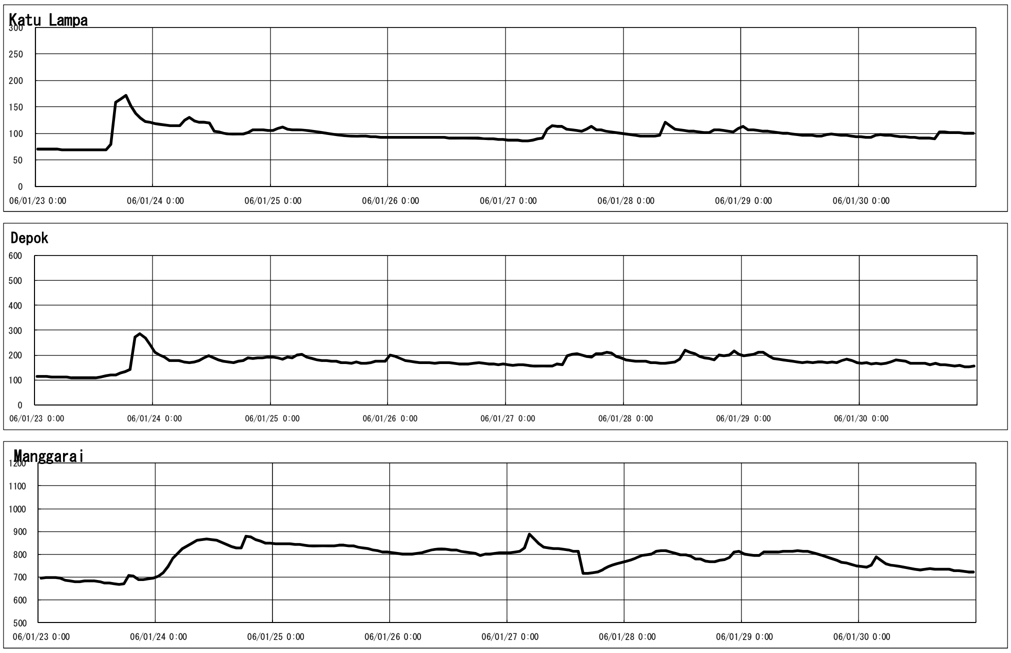


Figure 2.4-27 Observed Water Level (Inundation in January 2006)

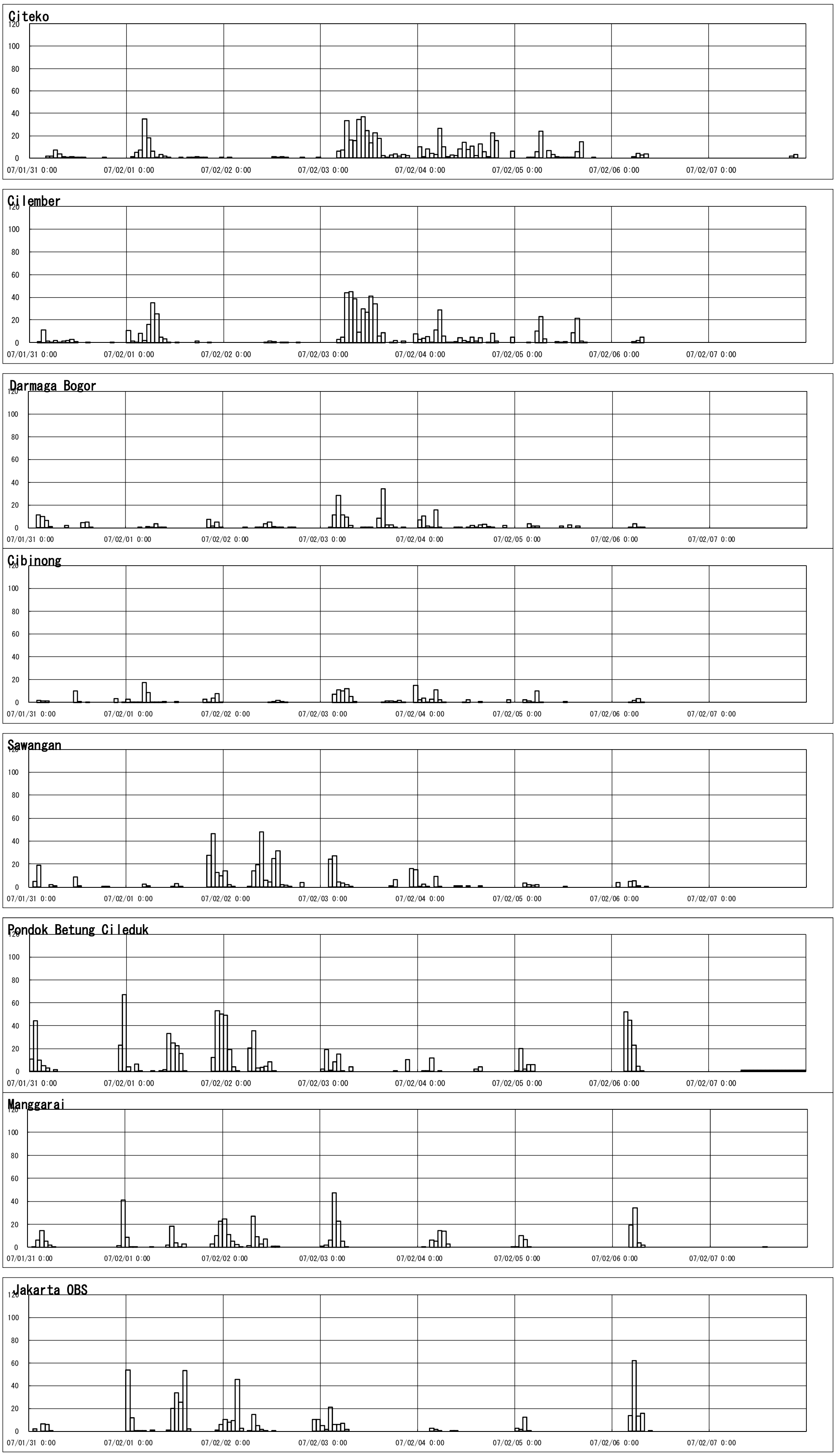


Figure 2.4-28 Observed Rainfall (Inundation in January 2007)

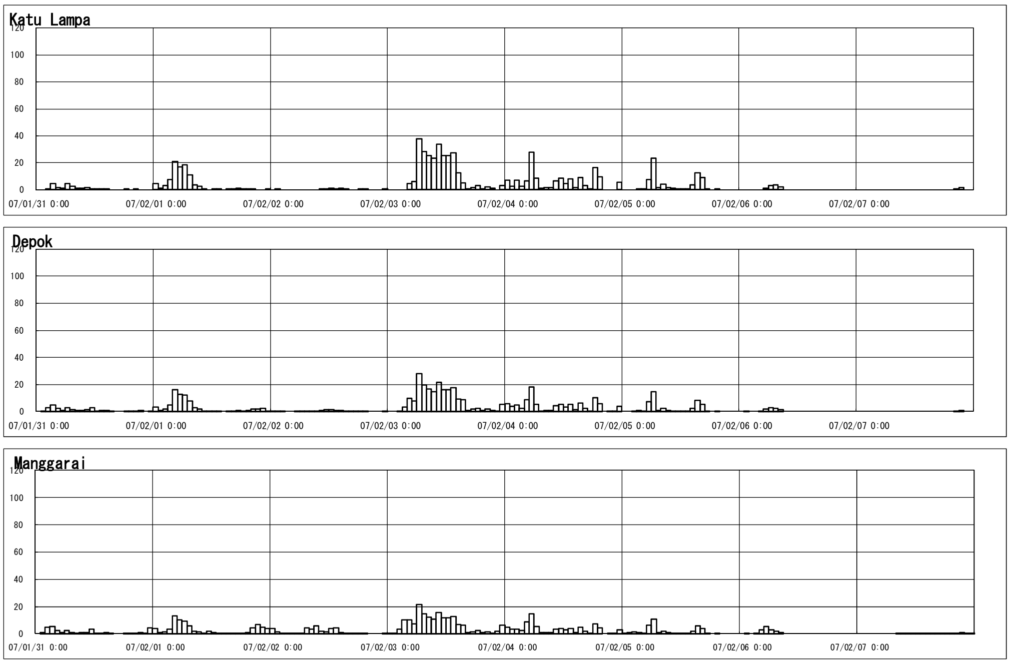


Figure 2.4-29　　Basin Average Rainfall (Inundation in January 2007)

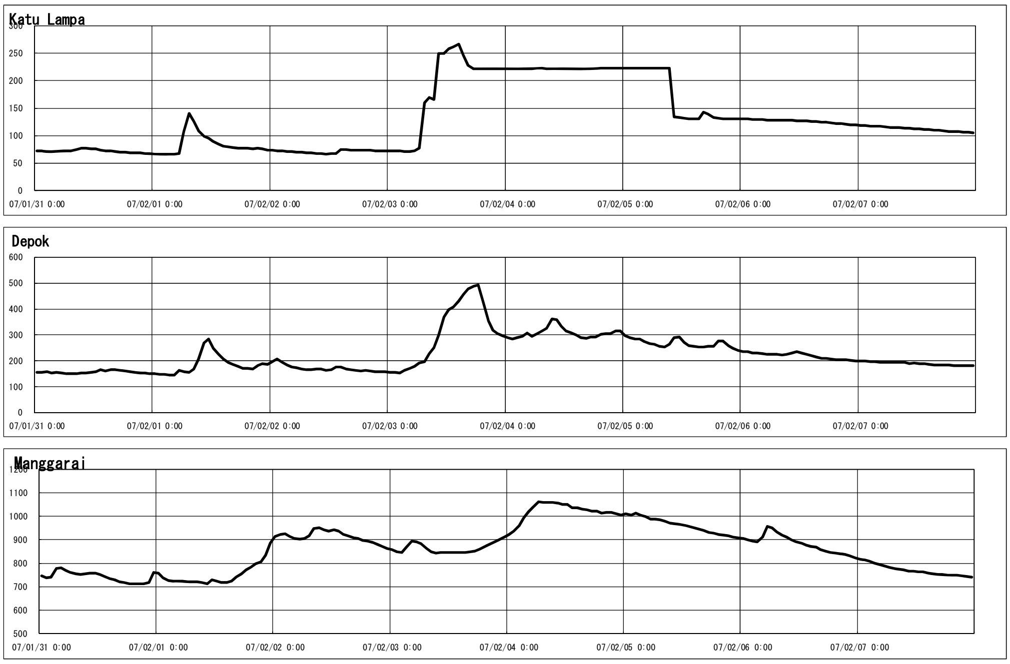


Figure 2.4-30　　Observed Water Level (Inundation in January 2007)

2.4.2 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 2.4-2.

Table 2.4-2 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 2.4-3 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

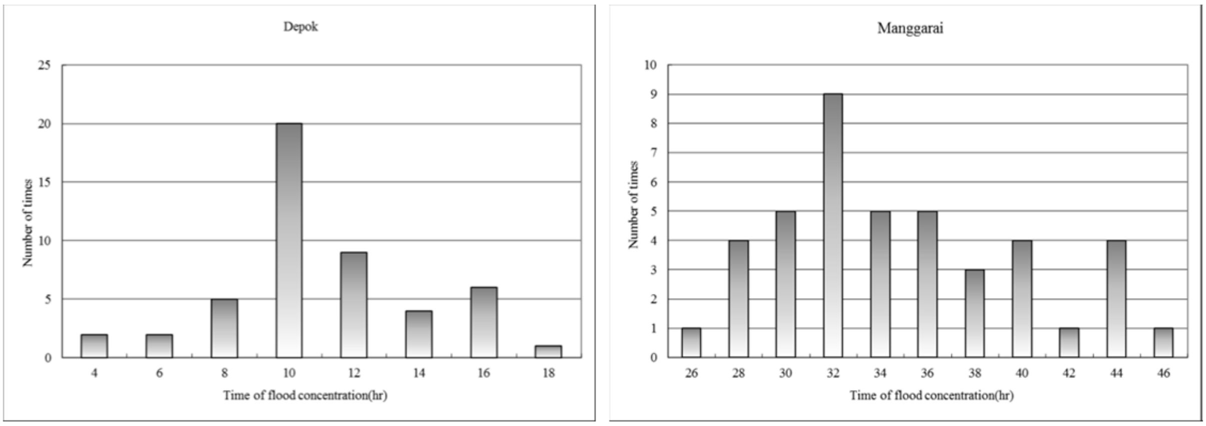


Figure 2.4-31 Distribution of Flood Arrival Time at Depok/Manggarai Benchmark

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.

2.4.3 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 2.4-4.

Table 2.4-4 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 2.4-5 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)

2.5 Capacity of Flow

For the calculation of Capacity of Flow, the steady flow is applied. Calculation conditions are as follows.

Table 2.5-1 Calculation Conditions

Item	Content
Boundary conditions of downstream	Mean high water level. PP +1.15 (HWL=MSL+0.550m LWL=MSL-0.600m PP.0m=MSL-0.600m)
Discharge	17 cases to 10～1000m^{3}s. 10,20,30,40,50,100,150,200,250,300,400,500,600,700,800,900,1000
Cross section	West Banjir Canal：As built drawing Ciliwung river：The Survey of JICA.(2008, 2011)
Roughness coefficient	WBC：n=0.025 Ciliwung river：n=0.040
Discharge rating curve	$Q=a(H+b)^2$ Least squares method
Elevation of evaluation	West Banjir Canal : MAB (Design high water level) Ciliwung river：Elevation of bank

The calculation result is shown below.

Although a capacity of flow is evaluation of about 600 in the West Banjir Canal, it is less than 200 from a weir upstream at many points.

Table 2.5-2 Calculation Result of Capacity of Flow

River Sta.	Name	Length	Elevation		Capacity of flow	
			Left bank	Right bank	Left bank	Right bank
1	WBC-001	0	-	-	-	-
2	WBC-002	100	-	2.68	-	1,663
3	WBC-003	200	-	3.01	-	2,555
4	WBC-004	300	-	1.56	-	303
5	WBC-005	400	-	2.76	-	1,299
6	WBC-006	500	-	2.70	-	1,217
7	WBC-007	600	-	2.83	-	1,225
8	WBC-008	700	-	2.78	-	1,088
9	WBC-009	800	-	2.80	-	1,104
10	WBC-010	900	-	2.79	-	1,080
11	WBC-011	1,000	-	2.86	-	1,088
12	WBC-012	1,100	-	2.78	-	950
13	WBC-013	1,200	-	2.78	-	920
14	WBC-014	1,300	-	2.71	-	833
15	WBC-015	1,400	-	1.06	-	49
16	WBC-016	1,500	-	2.00	-	355
17	WBC-017	1,600	-	1.32	-	104
18	WBC-018	1,700	1.21	1.39	71	166
19	WBC-019	1,800	1.42	1.54	141	188
20	WBC-020	1,900	1.21	1.38	76	125
21	WBC-021	2,000	2.07	1.50	333	139
22	Jembatan	2,015	2.26	2.26	284	284
23	WBC-022	2,035	3.05	2.54	632	431
24	P-236down	2,135	3.36	3.36	697	697
25	P-232down	2,235	3.39	3.39	654	654
26	P-228sown	2,335	3.43	3.43	670	670
27	P-224down	2,435	3.46	3.46	673	673
28	P-220down	2,535	3.50	3.50	684	684
29	P-216down	2,635	3.53	3.53	693	693
30	P-212down	2,735	3.57	3.57	736	736
31	Jembatan	2,755	3.59	3.59	655	655
32	P-208down	2,835	3.60	3.60	716	716
33	P-204down	2,935	3.64	3.64	699	699
34	P-200down	3,035	3.67	3.67	714	714
35	P-196down	3,135	3.71	3.71	560	560
36	P-192down	3,235	3.74	3.74	541	541
37	P-188down	3,335	3.78	3.78	521	521
38	P-184down	3,435	3.81	3.81	522	522
39	P-180down	3,535	3.85	3.85	523	523
40	P-176down	3,635	3.88	3.88	526	526
41	P-172down	3,735	3.92	3.92	529	529
42	P-168down	3,835	3.95	3.95	531	531
43	P-164down	3,935	3.99	3.99	533	533
44	P-160down	4,035	4.02	4.02	535	535
45	P-156down	4,135	4.06	4.06	539	539
46	P-152down	4,235	4.09	4.09	542	542
47	P-148down	4,335	4.13	4.13	546	546
48	P-144down	4,435	4.16	4.16	549	549
49	P-140down	4,535	4.20	4.20	559	559
50	P-136down	4,635	4.23	4.23	553	553
51	P-132down	4,735	4.27	4.27	557	557

Table 2.5-3 Calculation Result of Capacity of Flow

River Sta.	Name	Length	Elevation		Capacity of flow	
			Left bank	Right bank	Left bank	Right bank
1	WBC-001	0	-	-	-	-
2	WBC-002	100	-	2.68	-	1,663
3	WBC-003	200	-	3.01	-	2,555
4	WBC-004	300	-	1.56	-	303
5	WBC-005	400	-	2.76	-	1,299
6	WBC-006	500	-	2.70	-	1,217
7	WBC-007	600	-	2.83	-	1,225
8	WBC-008	700	-	2.78	-	1,088
9	WBC-009	800	-	2.80	-	1,104
10	WBC-010	900	-	2.79	-	1,080
11	WBC-011	1,000	-	2.86	-	1,088
12	WBC-012	1,100	-	2.78	-	950
13	WBC-013	1,200	-	2.78	-	920
14	WBC-014	1,300	-	2.71	-	833
15	WBC-015	1,400	-	1.06	-	49
16	WBC-016	1,500	-	2.00	-	355
17	WBC-017	1,600	-	1.32	-	104
18	WBC-018	1,700	1.21	1.39	71	166
19	WBC-019	1,800	1.42	1.54	141	188
20	WBC-020	1,900	1.21	1.38	76	125
21	WBC-021	2,000	2.07	1.50	333	139
22	Jembatan	2,015	2.26	2.26	284	284
23	WBC-022	2,035	3.05	2.54	632	431
24	P-236down	2,135	3.36	3.36	697	697
25	P-232down	2,235	3.39	3.39	654	654
26	P-228sown	2,335	3.43	3.43	670	670
27	P-224down	2,435	3.46	3.46	673	673
28	P-220down	2,535	3.50	3.50	684	684
29	P-216down	2,635	3.53	3.53	693	693
30	P-212down	2,735	3.57	3.57	736	736
31	Jembatan	2,755	3.59	3.59	655	655
32	P-208down	2,835	3.60	3.60	716	716
33	P-204down	2,935	3.64	3.64	699	699
34	P-200down	3,035	3.67	3.67	714	714
35	P-196down	3,135	3.71	3.71	560	560
36	P-192down	3,235	3.74	3.74	541	541
37	P-188down	3,335	3.78	3.78	521	521
38	P-184down	3,435	3.81	3.81	522	522
39	P-180down	3,535	3.85	3.85	523	523
40	P-176down	3,635	3.88	3.88	526	526
41	P-172down	3,735	3.92	3.92	529	529
42	P-168down	3,835	3.95	3.95	531	531
43	P-164down	3,935	3.99	3.99	533	533
44	P-160down	4,035	4.02	4.02	535	535
45	P-156down	4,135	4.06	4.06	539	539
46	P-152down	4,235	4.09	4.09	542	542
47	P-148down	4,335	4.13	4.13	546	546
48	P-144down	4,435	4.16	4.16	549	549
49	P-140down	4,535	4.20	4.20	559	559
50	P-136down	4,635	4.23	4.23	553	553
51	P-132down	4,735	4.27	4.27	557	557

Table 2.5-4 Calculation Result of Capacity of Flow

River Sta.	Name	Length	Elevation		Capacity of flow	
			Left bank	Right bank	Left bank	Right bank
103	P-219up	9,445	6.27	6.27	644	644
104	P-215up	9,540	6.31	6.31	650	650
105	P-211up	9,639	6.48	6.48	681	681
106	P-207up	9,739	6.48	6.48	662	662
107	P-203up	9,839	6.43	6.43	648	648
108	P-199up	9,939	6.46	6.46	658	658
109	P-195up	10,039	6.49	6.49	668	668
110	P-191up	10,140	6.52	6.52	661	661
111	P-187up	10,242	6.56	6.56	658	658
112	P-183up	10,342	6.59	6.59	657	657
113	P179up	10,442	6.62	6.62	652	652
114	P-175up	10,542	6.66	6.66	653	653
115	P-171up	10,642	6.69	6.69	657	657
116	P-167up	10,743	6.72	6.72	666	666
117	P-163up	10,843	6.75	6.75	668	668
118	P-159up	10,946	6.79	6.79	668	668
119	P-155up	11,134	6.82	6.82	664	664
120	P-151up	11,237	6.84	6.84	664	664
121	P-147up	11,336	6.89	6.89	668	668
122	P-143up	11,441	6.92	6.92	671	671
123	Jembatan	11,452	6.94	6.94	630	630
124	P-139up	11,542	6.97	6.97	677	677
125	P-135up	11,642	7.00	7.00	651	651
126	P-131up	11,742	7.04	7.04	655	655
127	P-127up	11,843	7.06	7.06	657	657
128	P-123up	11,945	7.11	7.11	661	661
129	P-119up	12,045	7.14	7.14	666	666
130	P-115up	12,246	7.18	7.18	667	667
131	P-107up	12,347	7.25	7.25	675	675
132	P-103up	12,421	7.28	7.28	681	681
133	P-100up	12,548	7.31	7.31	708	708
134	Jembatan	12,572	7.21	7.21	461	461
135	P-091up	12,672	7.11	7.11	461	461
136	P*089up	12,780	7.21	7.21	474	474
137	P-087up	12,906	7.28	7.28	504	504
138	P-085up	13,006	7.48	7.48	524	524
139	P-083up	13,108	7.63	7.63	532	532
140	Jembatan	13,142	7.76	7.76	503	503
141	P-081up	13,242	7.87	7.87	554	554
142	P-079up	13,342	8.34	8.34	618	618
143	P-077up	13,446	8.40	8.40	622	622
144	P-075up	13,547	8.47	8.47	627	627
145	P-073up	13,652	8.54	8.54	633	633
146	P-071up	13,763	8.61	8.61	640	640
147	P-069up	13,865	8.68	8.68	643	643
148	P-067up	13,964	8.74	8.74	645	645
149	P-065up	14,089	8.79	8.79	640	640
150	P-063up	14,189	8.86	8.86	648	648
151	P-061up	14,290	8.92	8.92	659	659
152	P-59up	14,390	8.97	8.97	649	649
153	P-057up	14,484	9.02	9.02	644	644

Table 2.5-5 Calculation Result of Capacity of Flow

River Sta.	Name	Length	Elevation		Capacity of flow	
			Left bank	Right bank	Left bank	Right bank
154	P-055up	14,542	9.08	9.08	659	659
155	P-053up	14,623	9.17	9.17	662	662
156	P-051up	14,723	9.21	9.21	662	662
157	P-049yp	14,829	9.55	9.55	711	711
158	P-047up	14,924	9.30	9.30	666	666
159	P-045up	15,024	9.33	9.33	669	669
160	P-043up	15,129	9.40	9.40	678	678
161	P-041up	15,224	9.42	9.42	675	675
162	P-039up	15,326	9.47	9.47	676	676
163	Jembatan	15,344	7.86	7.86	413	413
164	P-037up	15,424	9.51	9.51	681	681
165	P-035up	15,526	9.54	9.54	677	677
166	P-033up	15,621	9.58	9.58	676	676
167	P-031up	15,721	9.62	9.62	675	675
168	P-029up	15,769	9.67	9.67	680	680
169	P-027up	15,861	9.69	9.69	674	674
170	Jembatan	15,878	8.29	8.29	433	433
171	P-025up	15,958	9.65	9.65	652	652
172	P-023up	16,054	9.78	9.78	665	665
173	P-021up	16,152	9.88	9.88	691	691
174	Jembatan	16,178	8.98	8.98	504	504
175	P-019up	16,228	9.93	9.93	697	697
176	P-017up	16,327	10.02	10.02	709	709
177	P-015up	16,402	10.09	10.09	711	711
178	P-013up	16,502	10.12	10.12	720	720
179	P-011up	16,592	10.20	10.20	727	727
180	P-009up	16,679	10.32	10.32	773	773
181	P-007up	16,749	10.63	10.63	761	761
182	P-005up	16,808	10.67	10.67	729	729
183	P-003up	16,874	10.70	10.70	731	731
184	P-001up	16,894	10.74	10.74	735	735
185	Jembatan	16,982	9.16	9.16	381	381
186	Manggarai Weir	17,032	9.36	9.37	353	354
187	WBC-170	17,094	8.86	9.15	416	448
188	CIL-001	17,111	8.95	9.18	402	427
189	CIL-002	17,311	8.14	7.42	307	238
190	CIL-003	17,511	7.58	9.47	150	368
191	CIL-004	17,711	11.18	7.08	483	71
192	CIL-005	17,911	9.29	7.35	220	75
193	CIL-006	18,111	8.25	8.15	108	101
194	Jembatan	18,244	8.63	8.63	197	197
195	CIL-007	18,274	10.33	11.32	228	317
196	Jembatan	18,317	9.33	9.33	268	268
197	CIL-008	18,337	8.03	8.56	77	105
198	CIL-009	18,511	10.59	7.98	241	69
199	CIL-010	18,711	11.48	7.75	298	50
200	CIL-011	18,911	11.49	8.98	278	101
201	CIL-012	19,111	9.75	9.80	119	122
202	CIL-013	19,311	10.12	10.90	127	174
203	CIL-014	19,511	11.11	11.51	182	209
204	Jembatan	19,702	11.19	11.19	250	250

Table 2.5-6 Calculation Result of Capacity of Flow

River Sta.	Name	Length	Elevation		Capacity of flow	
			Left bank	Right bank	Left bank	Right bank
205	CIL-015	19,732	13.72	13.60	315	306
206	CIL-016	19,911	11.76	10.91	160	120
207	CIL-017	20,111	10.69	10.13	106	84
208	CIL-018	20,311	9.12	9.54	48	61
209	CIL-019	20,511	12.79	10.13	199	77
210	CIL-020	20,711	10.92	11.89	92	134
211	CIL-021	20,911	10.47	9.87	67	48
212	CIL-022	21,111	11.04	11.31	87	98
213	CIL-023	21,311	11.51	10.72	105	73
214	CIL-024	21,511	12.01	14.16	125	249
215	CIL-025	21,711	11.83	10.79	110	69
216	Jembatan	21,894	10.78	10.78	120	120
217	CIL-026	21,944	11.68	11.47	98	90
218	CIL-027	22,111	13.10	13.61	165	193
219	CIL-028	22,311	13.04	13.51	159	184
220	CIL-029	22,511	13.85	13.29	201	170
221	Jembatan	22,707	11.55	11.55	155	155
222	CIL-030	22,727	13.68	13.70	186	188
223	CIL-031	22,911	16.10	12.98	342	146
224	CIL-032	23,111	15.31	10.16	278	38
225	CIL-033	23,311	14.51	14.37	226	218
226	CIL-034	23,511	14.24	10.79	211	55
227	CIL-035	23,711	11.38	11.69	73	85
228	CIL-036	23,911	11.69	11.64	83	82
229	CIL-037	24,111	12.92	12.02	134	95
230	CIL-038	24,311	14.21	11.96	198	90
231	CIL-039	24,511	20.98	12.21	752	98
232	CIL-040	24,711	20.62	11.42	713	69
233	CIL-041	24,911	18.18	18.52	461	491
234	Jembatan	25,086	16.33	16.33	539	539
235	CIL-042	25,156	17.28	16.77	363	327
236	CIL-043	25,311	16.73	12.66	320	101
237	CIL-044	25,511	13.57	11.80	137	70
238	CIL-045	25,711	14.25	13.38	166	125
239	CIL-046	25,911	14.38	13.45	168	124
240	CIL-047	26,111	14.60	14.91	182	199
241	CIL-048	26,311	15.30	16.30	203	267
242	CIL-049	26,511	15.34	21.97	195	798
243	CIL-050	26,711	16.07	15.45	229	191
244	CIL-051	26,911	25.68	15.63	1,267	196
245	CIL-052	27,111	22.90	14.92	855	151
246	CIL-053	27,311	25.92	15.70	1,306	188
247	CIL-054	27,511	25.89	15.81	1,380	177
248	CIL-055	27,711	18.53	15.60	365	150
249	CIL-056	27,911	18.63	23.66	367	969
250	CIL-057	28,111	17.21	15.53	226	120
251	CIL-058	28,311	15.97	16.49	131	162
252	Jembatan	28,515	14.47	14.47	83	83
253	CIL-059	28,555	19.84	20.19	233	251
254	CIL-060	28,711	16.06	16.42	83	94
255	CIL-061	28,911	16.32	16.76	86	100

Table 2.5-7 Calculation Result of Capacity of Flow

River Sta.	Name	Length	Elevation		Capacity of flow	
			Left bank	Right bank	Left bank	Right bank
256	CIL-062	29,111	16.98	16.37	104	85
257	CIL-063	29,311	16.36	16.90	83	100
258	CIL-064	29,511	25.37	17.20	573	110
259	CIL-065	29,711	27.00	16.02	702	70
260	CIL-066	29,911	21.38	18.23	297	145
261	CIL-067	30,111	18.65	17.36	160	111
262	CIL-068	30,311	23.13	16.95	403	96
263	CIL-069	30,511	23.59	17.12	428	99
264	CIL-070	30,711	21.58	17.83	300	123
265	CIL-071	30,911	25.17	21.53	535	293
266	CIL-072	31,111	19.54	27.46	187	723
267	CIL-073	31,311	23.29	17.93	399	119
268	CIL-074	31,511	18.86	17.42	152	98
269	CIL-075	31,711	18.76	21.13	146	259
270	CIL-076	31,911	19.99	19.20	198	162
271	CIL-077	32,111	27.06	20.41	676	215
272	CIL-078	32,311	20.74	21.68	230	280
273	CIL-079	32,511	25.96	17.92	595	96
274	CIL-080	32,711	22.11	19.26	291	133
275	CIL-081	32,911	20.11	28.56	169	870
276	CIL-082	33,111	27.10	19.02	701	115
277	CIL-083	33,311	21.28	20.05	227	161
278	CIL-084	33,511	20.73	21.32	195	228
279	CIL-085	33,711	33.18	17.84	1,456	69
280	CIL-086	33,911	17.82	18.65	68	97
281	CIL-087	34,111	17.96	17.51	71	57
282	CIL-088	34,311	19.87	18.62	146	93
283	CIL-089	34,511	20.49	19.65	174	134
284	CIL-090	34,711	18.36	19.28	81	117
285	CIL-091	34,911	18.54	19.43	86	121
286	CIL-092	35,111	19.63	19.82	124	133
287	CIL-093	35,311	35.45	21.34	1,750	206
288	CIL-094	35,511	27.92	21.11	738	191
289	CIL-095	35,711	18.76	28.27	84	777
290	CIL-096	35,911	22.07	26.25	240	559
291	CIL-097	36,111	25.89	21.51	522	205
292	CIL-098	36,311	20.26	23.52	140	330
293	CIL-099	36,511	20.41	22.65	144	270
294	CIL-100	36,711	20.39	23.60	140	327
295	CIL-101	36,911	19.33	30.91	96	1,058
296	CIL-102	37,111	22.39	29.24	244	837
297	CIL-103	37,311	27.59	22.95	659	276
298	CIL-104	37,511	32.87	19.99	1,308	114
299	CIL-105	37,711	23.22	25.15	284	429
300	CIL-106	37,911	24.23	24.58	352	380
301	CIL-107	38,111	23.11	25.64	266	465
302	CIL-108	38,311	25.57	24.54	454	367
303	CIL-109	38,511	28.83	24.17	783	333
304	CIL-110	38,711	23.47	25.68	276	451
305	CIL-111	38,911	23.27	29.74	257	893
306	CIL-112	39,111	25.13	24.21	397	322

Table 2.5-8 Calculation Result of Capacity of Flow

River Sta.	Name	Length	Elevation		Capacity of flow	
			Left bank	Right bank	Left bank	Right bank
307	CIL-113	39,311	35.89	19.49	1,826	59
308	CIL-114	39,511	29.20	23.84	801	286
309	CIL-115	39,711	22.75	22.53	203	189
310	CIL-116	39,911	22.46	22.62	170	180
311	CIL-117	40,111	24.39	27.78	306	664
312	CIL-118	40,311	26.44	24.16	492	275
313	Jembatan	40,398	27.62	27.62	1,116	1,116
314	CIL-119	40,446	29.60	29.68	883	894
315	CIL-120	40,528	24.27	23.84	270	237
316	CIL-121	40,728	26.54	28.19	477	673
317	CLU001	40,975	29.22	30.87	809	1,067
318	Jembatan	41,035	27.57	27.57	1,040	1,040
319	CLU002	41,304	25.41	28.27	596	1,270
320	CLU003	41,457	25.57	24.82	531	407
321	CLU004	41,675	24.85	25.88	337	514
322	CLU005	41,862	25.91	25.49	425	360
323	CLU006	42,069	27.39	27.97	644	760
324	CLU007	42,268	24.09	28.55	163	871
325	CLU008	42,478	28.91	29.65	787	934
326	CLU009	42,676	29.82	31.74	906	1,329
327	CLU010	42,883	31.47	28.32	1,166	581
328	CLU011	43,077	35.84	28.85	2,182	626
329	CLU012	43,274	37.44	30.95	2,567	949
330	CLU013	43,468	29.88	44.48	735	5,090
331	CLU014	43,669	38.82	36.47	2,837	2,137
332	CLU015	43,880	32.57	47.01	1,089	5,541
333	CLU016	44,076	31.25	38.90	879	2,694
334	CLU017	44,280	31.24	30.94	796	748
335	CLU018	44,474	29.70	31.49	524	795
336	CLU019	44,673	29.82	29.20	508	427
337	CLU020	44,877	31.44	32.89	748	1,037
338	CLU021	45,081	38.97	31.34	2,788	703
339	CLU022	45,274	32.88	35.86	989	1,760
340	CLU023	45,471	29.12	34.53	305	1,303
341	CLU024	45,684	29.33	42.22	322	3,606
342	CLU025	45,881	31.59	33.69	585	1,013
343	CLU026	46,080	29.48	33.92	231	968
344	CLU027	46,278	45.65	33.86	4,991	870
345	CLU028	46,482	31.61	38.30	458	2,105
346	CLU029	46,702	36.24	35.74	1,204	1,093
347	CLU030	46,870	34.18	40.58	780	2,434
348	CLU031	47,080	32.76	40.44	462	2,278
349	CLU032	47,271	31.54	56.75	295	11,848
350	CLU033	47,484	30.91	53.54	178	7,803
351	CLU034	47,677	32.46	36.93	303	965
352	CLU035	47,876	40.08	41.13	1,709	1,988
353	CLU036	48,074	33.77	40.38	450	1,891
354	CLU037	48,280	32.67	52.24	266	6,275
355	CLU038	48,473	34.44	54.79	430	6,721
356	CLU039	48,681	33.25	44.33	270	2,760
357	CLU040	48,881	45.31	41.41	2,743	1,629

Table 2.5-9 Calculation Result of Capacity of Flow

River Sta.	Name	Length	Elevation		Capacity of flow	
			Left bank	Right bank	Left bank	Right bank
358	CLU041	49,085	42.65	36.28	1,826	547
359	CLU042	49,271	49.85	44.43	4,332	2,372
360	CLU043	49,474	35.28	36.90	362	581
361	CLU044	49,676	33.68	34.68	160	246
362	CLU045	49,870	38.02	33.42	653	132
363	CLU046	50,081	35.54	52.88	305	5,213
364	CLU047	50,286	36.33	45.29	351	2,359
365	CLU048	50,476	46.86	35.26	2,827	216
366	CLU049	50,675	49.20	39.36	3,496	746
367	CLU050	50,872	45.21	36.03	2,128	238
368	CLU051	51,052	50.35	43.57	4,021	1,588
369	CLU052	51,280	36.56	40.29	218	801
370	CLU053	51,492	36.75	43.77	204	1,565
371	CLU054	51,696	41.83	50.81	977	3,888
372	CLU055	51,875	41.93	52.76	911	4,558
373	CLU056	52,076	48.29	38.47	2,608	300
374	CLU057	52,280	42.15	36.66	920	111
375	CLU058	52,482	44.04	45.57	1,110	1,466
376	CLU059	52,701	41.84	52.59	625	3,659
377	CLU060	52,875	51.68	42.22	3,202	650
378	CLU061	53,076	55.93	43.81	4,628	855
379	CLU062	53,282	46.72	41.19	1,504	429
380	CLU063	53,434	52.08	49.79	2,723	2,050
381	Jembatan	53,474	50.80	50.80	2,097	2,097
382	CLU064	53,688	41.05	47.47	330	1,368
383	CLU065	53,861	49.09	43.91	1,687	666
384	CLU066	54,092	53.04	40.37	2,718	204
385	CLU067	54,289	46.19	45.72	898	820
386	CLU068	54,474	42.98	45.99	430	854
387	CLU069	54,654	45.02	48.19	668	1,234
388	CLU070	54,861	41.68	55.73	241	3,342
389	CLU071	55,069	51.11	42.93	1,865	336
390	CLU072	55,289	63.72	46.50	6,029	741
391	CLU073	55,490	46.76	44.60	760	449
392	CLU074	55,610	43.86	44.09	355	382
393	CLU075	55,883	47.15	51.82	708	1,637
394	CLU076	56,068	51.34	45.55	1,549	431
395	CLU077	56,277	52.09	51.61	1,549	1,434
396	CLU078	56,469	53.96	48.56	2,029	768
397	CLU079	56,679	58.87	50.73	3,682	1,172
398	CLU080	56,875	45.61	57.56	287	3,050
399	CLU061	57,083	47.71	45.96	488	276
400	CLU082	57,298	46.03	58.20	257	3,069
401	CLU083	57,488	49.19	51.80	625	1,118
402	CLU064	57,683	52.41	47.54	1,150	354
403	CLU065	57,889	53.12	63.20	1,368	4,790
404	CLU086	58,089	57.07	54.45	2,223	1,531
405	CLU087	58,252	54.62	59.28	1,492	2,789
406	CLU088	58,467	50.32	62.10	629	3,819
407	CLU089	58,675	50.45	60.49	560	2,970
408	CLU90	58,889	54.23	56.92	1,243	1,913

Table 2.5-10 Calculation Result of Capacity of Flow

River Sta.	Name	Length	Elevation		Capacity of flow	
			Left bank	Right bank	Left bank	Right bank
409	CLU091	59,078	53.09	55.90	880	1,448
410	CLU092	59,298	49.65	57.21	358	1,736
411	CLU093	59,467	56.15	61.19	1,392	2,707
412	CLU094	59,666	64.18	68.02	3,404	4,771
413	Jembatan	59,706	66.40	66.40	3,978	3,978
414	CLU095	59,874	50.86	66.42	404	4,397
415	CLU096	60,080	53.30	60.86	713	2,434
416	CLU097	60,309	55.62	66.25	1,096	4,148
417	CLU098	60,488	56.09	63.63	1,108	3,120
418	CLU099	60,672	59.71	67.23	2,087	4,974
419	CLU120	60,759	69.69	69.54	7,019	6,927
420	Jembatan	60,799	62.62	62.62	2,816	2,816
421	CLU100	60,871	60.49	67.27	2,278	5,039
422	CLU101	61,085	58.82	64.96	1,739	3,979
423	CLU102	61,275	55.42	60.93	780	2,164
424	CLU103	61,487	52.44	72.34	310	7,566
425	CLU104	61,655	59.84	64.82	1,754	3,435
426	CLU105	61,874	56.59	74.45	881	8,294
427	CLU106	62,074	58.32	69.80	1,240	5,903
428	CLU107	62,300	66.65	61.02	3,793	1,773
429	CLU108	62,458	64.87	60.09	2,960	1,433
430	CLU109	62,635	62.12	62.63	1,868	2,019
431	Jembatan	62,675	56.91	56.91	551	551
432	CLU110	62,875	69.00	63.05	4,317	2,031
433	CLU111	63,076	60.30	71.87	1,159	5,476
434	CLU112	63,288	62.05	62.93	1,545	1,801
435	CLU113	63,499	71.78	62.72	5,819	1,701
436	CLU114	63,689	67.30	68.57	3,241	3,816
437	CLU115	63,858	56.60	75.21	246	7,258
438	CLU116	64,075	58.99	62.71	673	1,916
439	CLU117	64,272	59.11	80.93	354	19,330
440	CLU119	64,416	67.87	67.64	3,917	3,768
441	Jembatan	64,448	66.32	66.32	2,011	2,011
442	CLU118	64,467	71.90	71.66	8,424	8,167
443	Jembatan	64,507	70.58	70.58	3,646	3,646

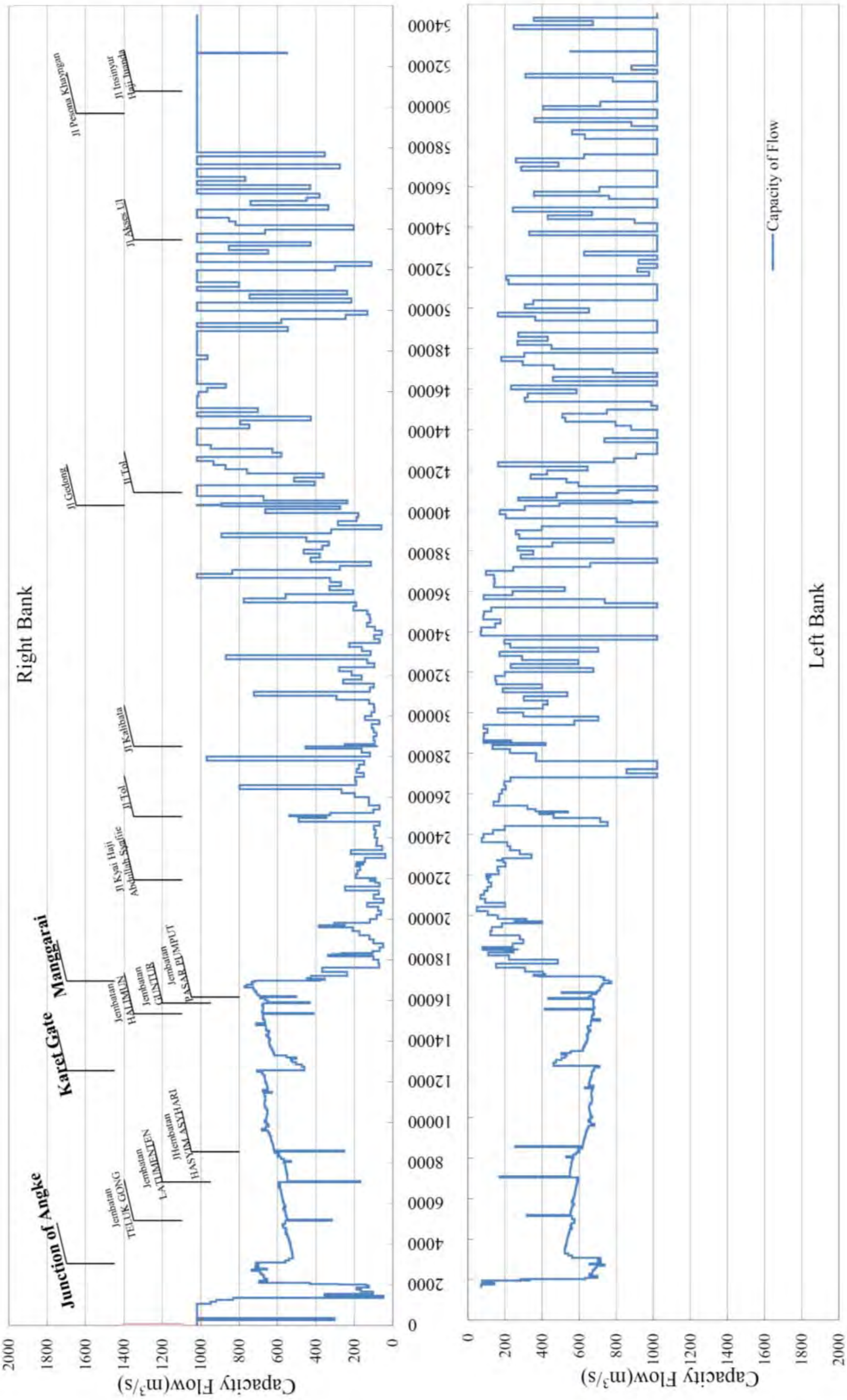


Figure- 2.5-1 Calculation Result of Capacity of Flow

2.6 Tide Level

2.6.1 Datum

PP datum was established as a basis for an extensive precision leveling undertaken on Java in 1925 and determined as the mean Low Water Spring (LWS).

Table 2.6-1 Tidal Level

Tidal Level	P.P. (m)
Mean high water spring	P.P. + 1.15
Mean high water	P.P. + 0.90
Mean tidal level	P.P. + 0.60
Mean low water	P.P. + 0.25
Mean low water spring	P.P. = 0.00

2.6.2 Tide Level

Data arranged by Tangjung Priok observation station are shown as tabulated in below. A highest high tide level is about PP +1.9m.

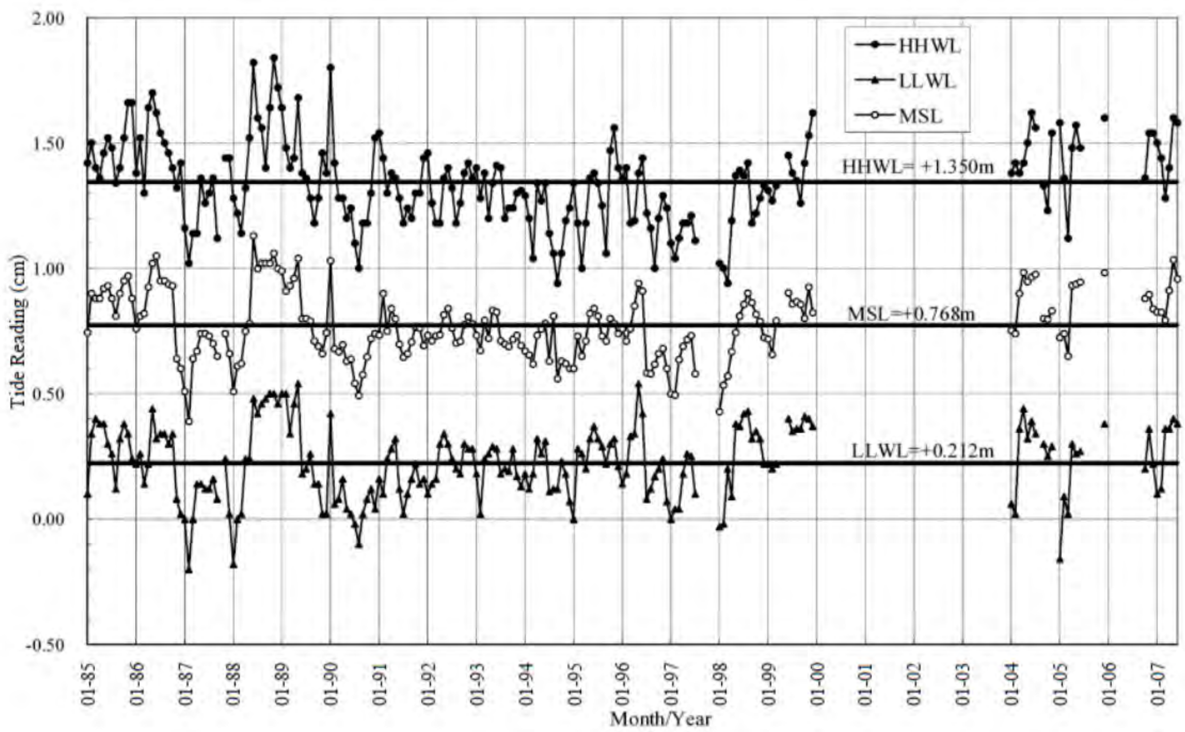


Figure- 2.6-1 Tide Level（Tanjung Priok Station、1985～2007）

CHAPTER 3 EXAMINATION OF ANNUAL PROBABLE FLOOD DISCHARGE

3.1 Examination Policy

The distribution flood inundation analysis model is used for the examination of flood discharge volume in each return period.

In the Project, the distribution flood inundation analysis model in the previous project is modified as shown below.

Table 3.1-1 Revision of Flood Inundation Analysis Model

Model	Modification
Rainfall Model	1) reflection of rainfall external force Probable rainfall curve in 2007 and design probable rainfall were reflected.
River Model	1) reflection of river improvement works The river section was revised considering the dredging West Banjir Canal and topographic survey results in upstream of Ciliwung river. 2) reflection of Ciliwung river improvement River improvement of Ciliwung river (Manggarai-Outer Ring Road) and improvement of Manggarai gate and Karet Gate were reflected.
Discharge Basin Model	1) consideration of sub-basins The basin boundaries were revised to interface with boundary of sub-basin setup by run-off control plan. 2) reflection of revised future land use Future land use (as of 2030) based on the spatial plans of related local governments was reflected. 3) reflection of Dams and Gate Dams for Flood control facilities Flood control effect of Dams located in the upstream at Katulampa and Gate dams at Depok were reflected.
Inundation Area Model	1) reflection of revised future land use Future land use (as of 2030) based on the spatial plans of related local governments was reflected.

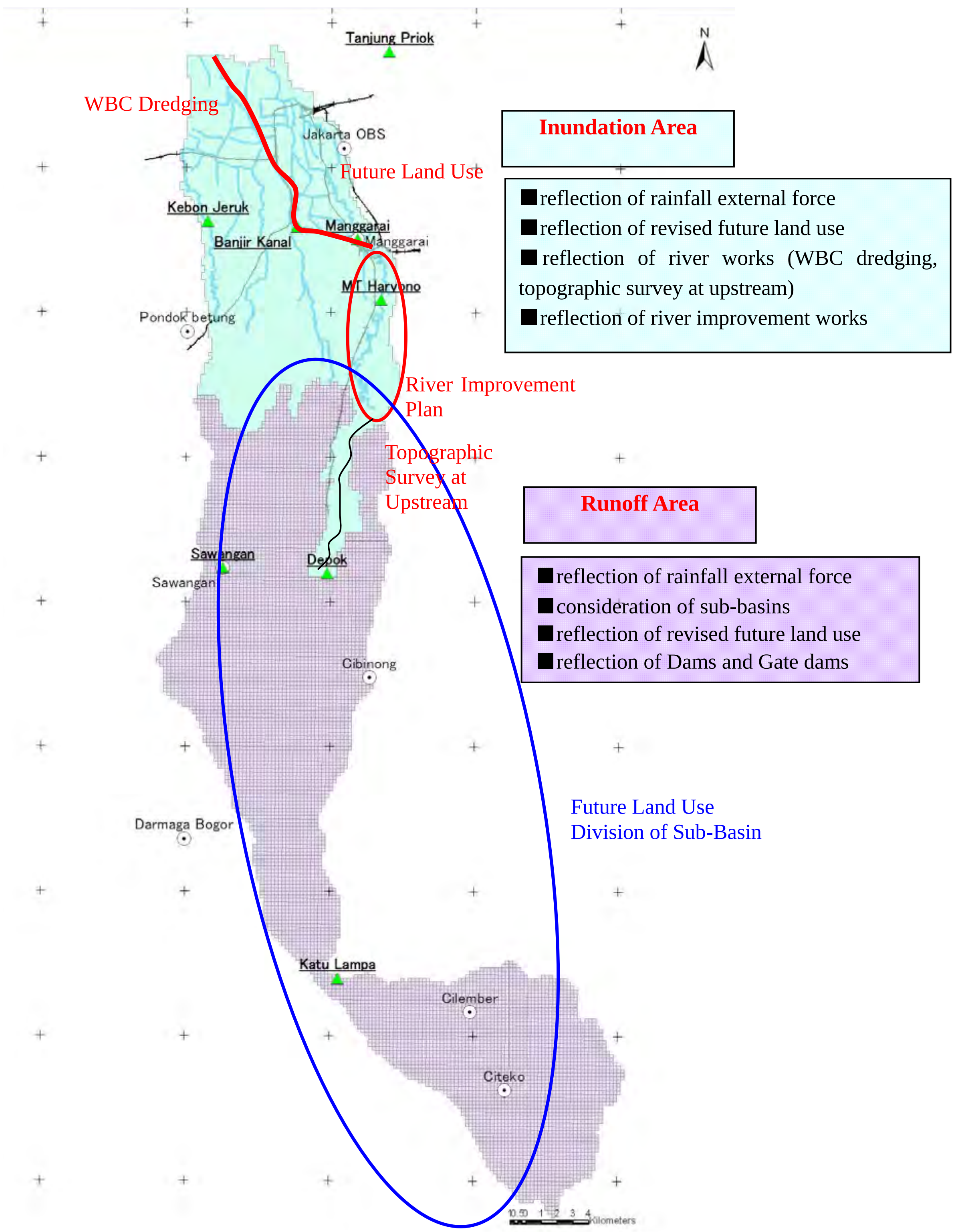


Figure 3.1-1 Revision of Flood Inundation Analysis Model

3.2 Outline of Flood Inundation Analysis Model

3.2.1 Selection of Flood Inundation Analysis Model

Flood inundation model will be selected to comprehend following functions:

- Reflecting the features of the basin (topography, land use, etc.) and flooding of both inland water and external water are able to be simulated
- Effectiveness of various flood control measures in the basin is able to be evaluated.

Previously, concentration models such as rational formula, tank model, storage function model have been applied to analyze the discharge from the basin. Parameters required in these models were the average value or representative value of the basin, and outcomes derived from these models were limited to the information of the exit points of the basin.

In recent years, however, the information on the consecutive water level and flow velocity of the random points in the basin is required. Since the concentration models cannot meet such requirements thoroughly, distribution models have been proposed as the alternative model.

In the distribution model, whole basin area will be split into micro meshes and the information on geographical features, geological condition, land use, etc. will be reflected in each mesh. And rainfall can be provided to each mesh directly in order to track the flow between meshes.

Distribution model will be applied in this analysis due to the following reasons:

- The rainfall discharge and the process of the flooding at random location in the basin are required to be analyzed.
- The effectiveness of the various flood control measures are to be inspected.

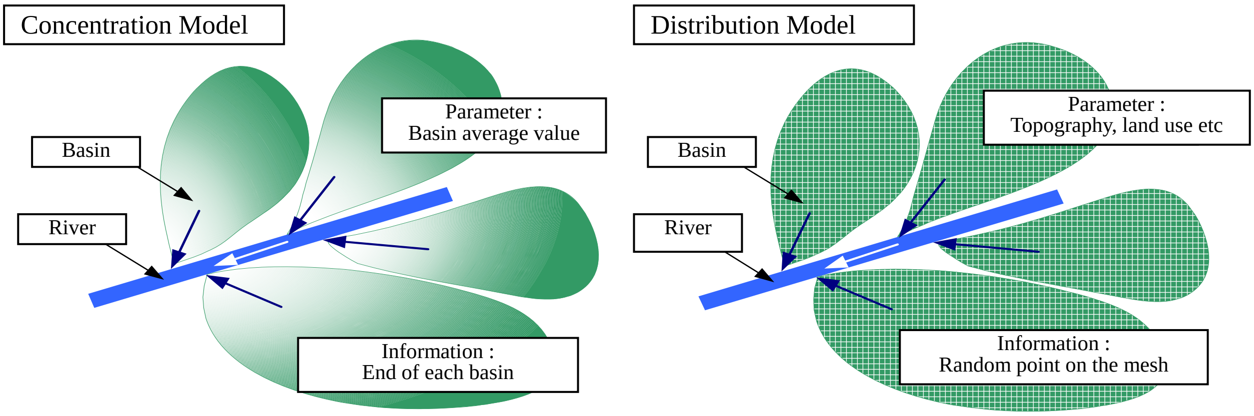


Figure 3.2-1 Image of Concentration Model and Distribution Model

Flood inundation model of the target area shall be separated into 2 areas, “discharge basin” and “inundation area” by the physical features of the area.

In this analysis, (a) mountain areas and hilly areas are regarded as discharge basin, (b) low-lying areas are regarded as inundation area, and adequate hydraulic model will be applied according to each type of flow. Brief overviews of hydraulic models for discharge basin and inundation area are shown as follows:

(a) Model for Discharge Basin

Kinematic Wave Method will be applied because it is able to present the flow of the slope regardless of water level in the downstream. Adopted form of the model is Distributed Runoff Model, which has the same mesh structure with the inundation area and is able to track flow of each mesh along with the land features and slopes, in order to provide the flow volume according to the minute meshes of inundation area.

(b) Model of Inundation Area

Dynamic Wave Method, which is able to present the change of flows affected by the land features and structures such as drains, will be applied and trace the inundation flows. And adopted form of the model is Two Dimensional Un-Steady Flow Model which is able to recreate the propagation phenomena of flooding flow in greatest detail.

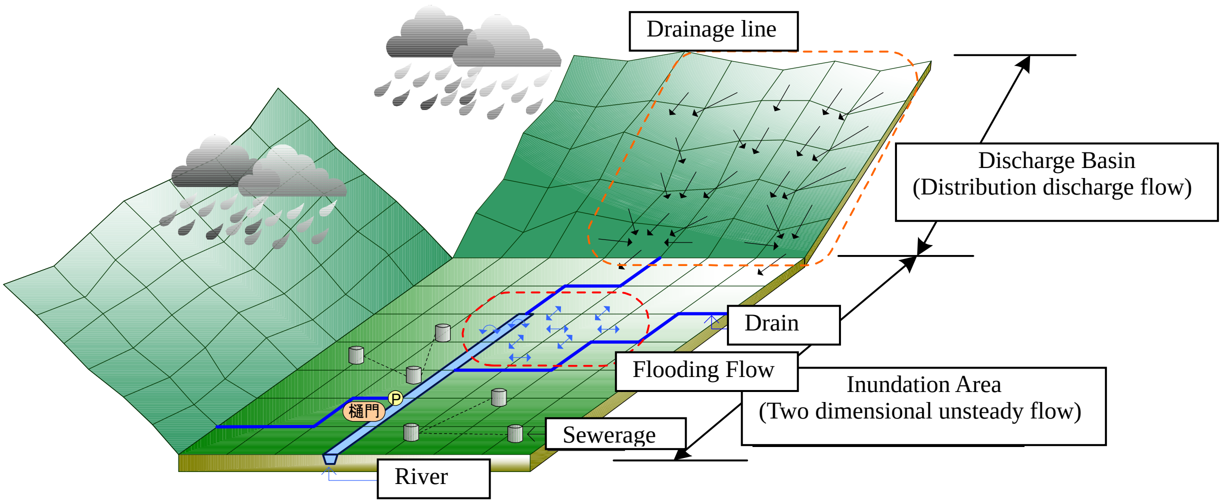


Figure 3.2-2 Image of Flood Inundation Analysis Model

Table 3.2-1 Discharge Pattern Expected by Land Feature

Land Features	①Upstream areas are mountainous and moderate slope descending to the lowland areas. ②Downstream areas are low-lying areas.
At rainfall	①Rainfall flows down through the slopes in mountainous areas and mid-stream areas to the lowland area. ②In lowland area, drainage is damaged by affection of sea water level and external water and flooding occurs.
Possible flooding situation	①Flooding disaster will not be occurred in the uphill areas. ②In the lowland area, flooding is spread under the influence of water level of downstream.

Figure 3.2-3 Land Features of the Basin

3.2.2 Segmentation of Mesh in the Whole Basin

To analyze the discharge of whole basin, the whole basin will be segmented into orthogonal meshes and track the flow of individual mesh. Mesh segmentation of whole basin will be 230m square (7.5”) in order to represent the inundation condition which is easily affected by the humble land features.

The number of mesh for this survey is approximately 13,610 in total; 8,810 for discharge basin and 4,800 for inundation area respectively as described in the next chapter.

Mesh is settled to cover the basin and segmented both latitude and longitude by 7.5”, resulting in 230m east to west and 230m north to south.

Table 3.2-2 Number of Mesh for the Model

Item	Number of mesh
Inundation area	4,800
Discharge basin	8,810
Total	13,610

3.2.3 Settlement of Discharge Basin and Inundation Area

Flood inundation model of target basin is generally divided into “discharge basin” and “inundation area” by the features of land. Target inundation area is the range enveloping the inundation record map.

Segmentation map of discharge basin and inundation area is shown in Figure 3.2-4.

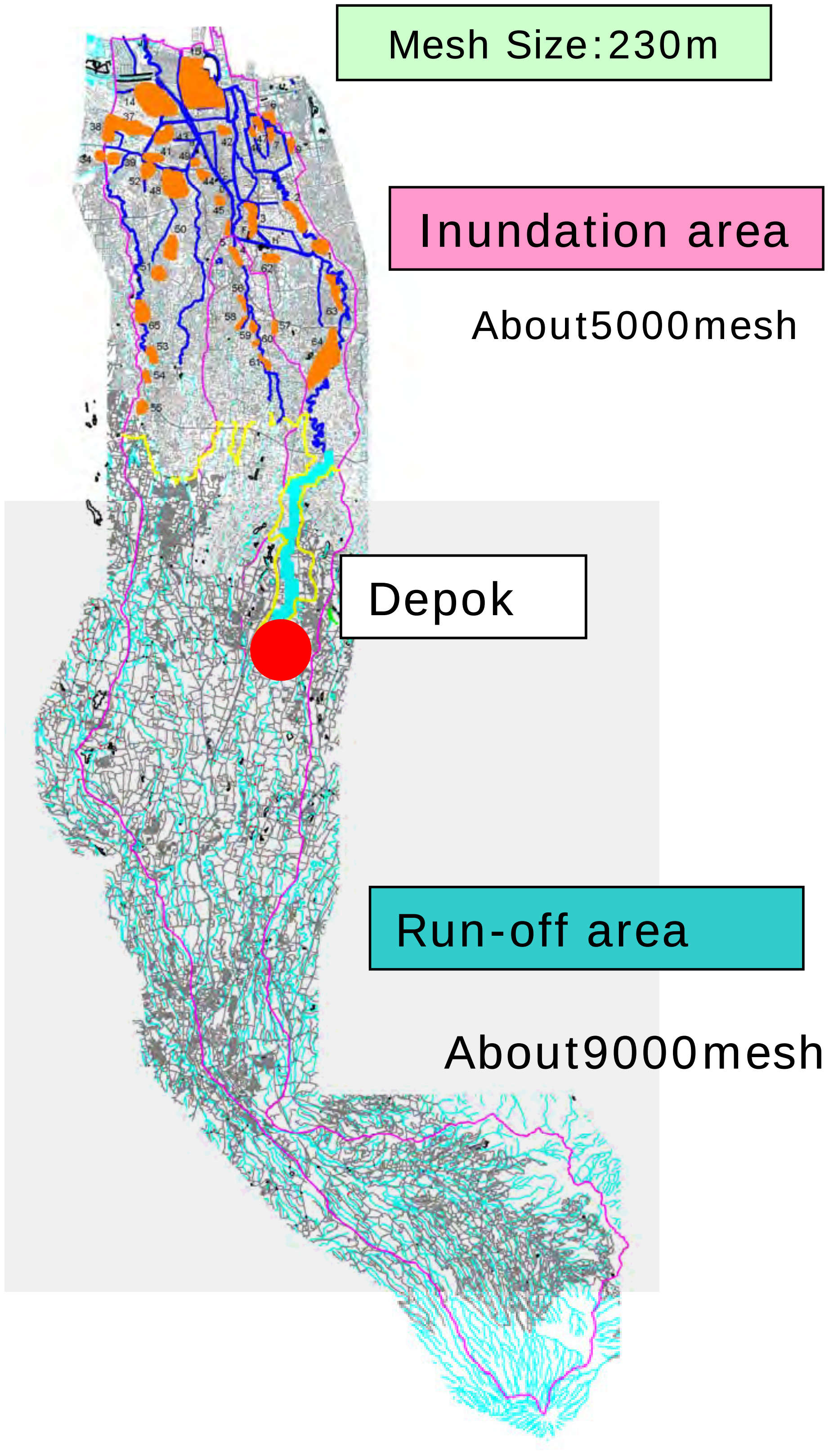


Figure 3.2-4 Settlement of Discharge Basin and Inundation Area

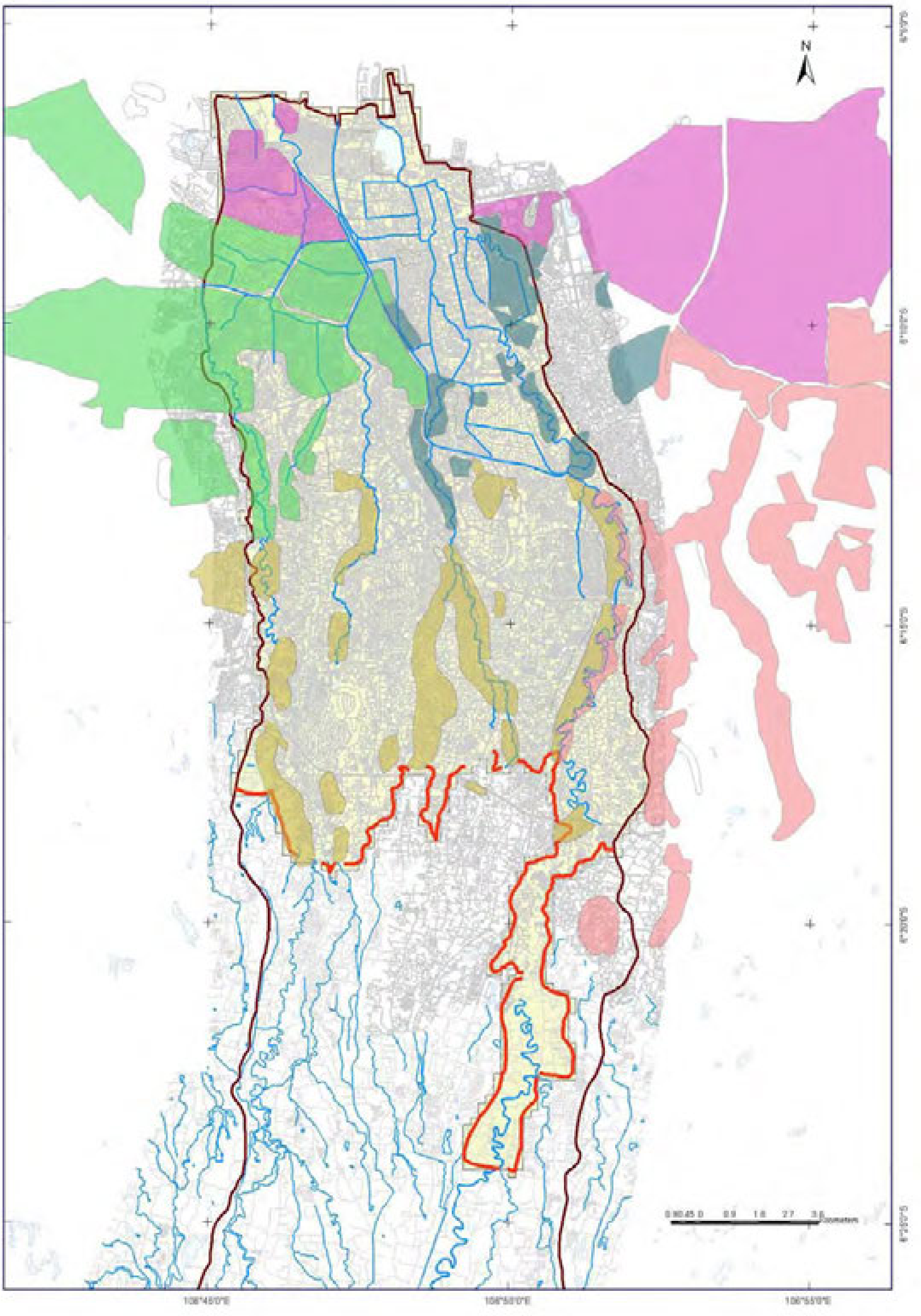


Figure 3.2-5 Inundation Record Map of 2007 Flood and Inundation Segment

3.2.4 Basic Structure of Flood Inundation Model

To settle the basis structure of flood inundation model, the features of target basin need to be reflected. The features of target basin are shown in the following.

- Target basin is divided into "discharge basin" and "inundation area".
- Target basin has been urbanized significantly, therefore surface drainage facilities such as rainwater drainage system are developed within the basin.
- High frequency of flooding

Required functions for structuring model are described as follows:

Duplicate the combined flooding of inland flooding and external flooding.

Analyze discharge and inundation in the basin as consistent phenomena.

Duplicate time-series fluctuation considering the downstream water level, runoff volume from discharge basin and effect of bridges.

As for dimensional expansion of flood steam and propagation velocity, duplicate the flow-down resistance, etc. considering the land use and density of houses.

Be able to secure high accuracy with consideration for the effect of drainage, earth fill and subtle land features.

Reflect the sluice way and discharge by pumping under the effect of inland and external water level.

Settle the retention facilities and reflect the initial flood adjustment functions.

Then following model is required to satisfy the functions described above.

- <u>Rainfall Model</u>
  Time series distribution of rainfall is given to overall basin (mesh) with consideration of loss phenomenon.
- <u>River Model</u>
  Forced discharge to the river and tide level at the mouth of the river are reflected in the river level and hourly fluctuation is duplicated by One Dimensional Un-Steady Flow Model which can describe the overflow and the dike break.
- <u>Discharge Basin Model</u>
  Runoff volume to the discharge basin which is fixed based on land features is duplicated by Distributed Runoff Model (Kinematic Wave) which can trace the runoff volume in accordance with the actual flow channels.
- <u>Inundation Area Model</u>
  Propagation of flooding flow is traced by Distributed Runoff Model under the effect of water channels, sewerages, drainage system from pump stations, earth fill, as well as the land features of inundation area.

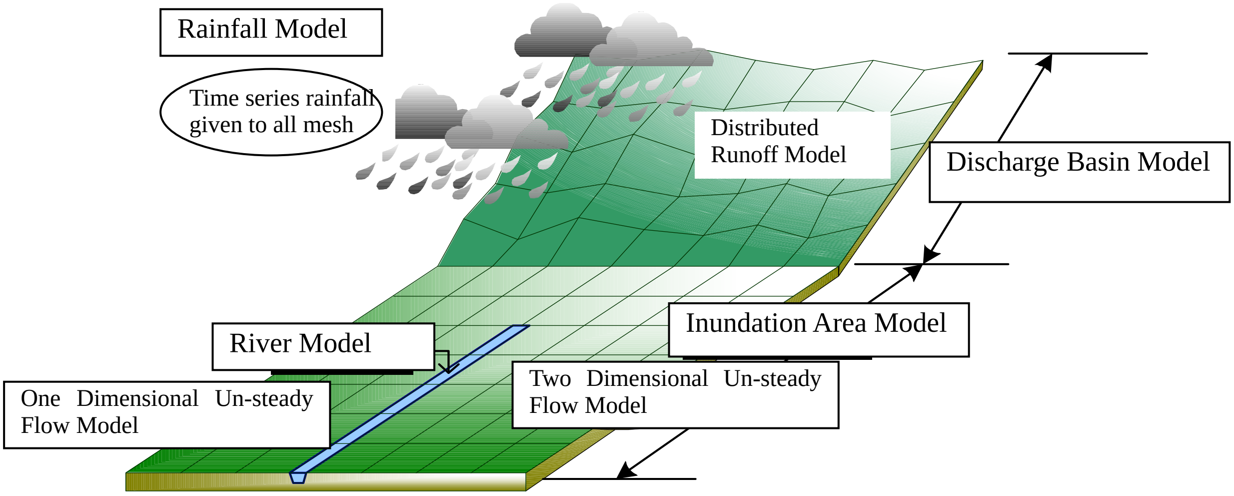


Figure 3.2-6 Basic Structure of Discharge and Flooding Analysis Model

3.2.5 Formulation of Flood Inundation Model

(1) Brief Summary of Flood Inundation Model

Brief summary of flood inundation model is shown in Table 3.2-3.

Table 3.2-3 List of Flood Inundation Analysis Model

Items		Conditions	Remarks
Analysis Model	River	One dimensional un-steady flow model(Dynamic Wave)	
	Floodplain	Two dimensional un-steady flow model(Dynamic Wave)	
	Discharge basin	Distributed runoff model (Kinematic Wave)	
Built-in Model	Condition on the river	Bridges, gates, pumps	
	Inundation land feature mesh	Canals, earth fills, culvert	
	Intervals of river and floodplain land feature mesh	Overflows, sluice pipes, pumps	
River	Current Condition	River section surveyed in 2008, 2011 and As-built Drawings	
	Improvement Plan	River Improvement Plan by BBWS-CilCis	
Land Feature	Basic mesh	Discharge basin 230m(7.5”), inundation area 230m(7.5”)	
	Inundation area land feature	Formulated based on 1/5000 Topographic map(2008) and GPS data	
	Discharge basin land feature	Formulated based on 1/25000 Topographic map(2008)	
	Land use (discharge basin)	Based on satellite images and topographic maps	
	Land use (inundation area)	Based on spatial plans of related local governments in the basin	
Facilities	Earth fills	Main local roads and railways over 50cm	
	Canals	Secondary affluent	
	Others		
Overflows	Overflow volume	Considering the side-overflow based on the formula of HONMA	
	Overflow height	Current dike height	
	Overflow point	All intervals are targeted	
Pump operating condition		Follow the operation rules of each pump station	
Rainfall distribution		Waveform of flood (provided dimensionally by Thiessen method)	
Equivalent roughness	N	Urban : 0.1,Settlement : 0.3, paddy field: 2, firm field/forests: 0.9	Identification value
Effective rainfall	F1	Urban area: 0.6-0.7, paddy field: 0.0, firm field: 0.15, forests: 0.25	Standard value
	Rsa	Urban area: 55mm, paddy field: 50mm, firm field: 300mm, forests: 150mm (In case of Identification: Urban area: 55mm, paddy field: 50mm, other: 0mm)	Standard value Identification value
	fsa	firm field/forests: 0.6, other: 1.0	Standard value

1) Mesh Segmentation Map

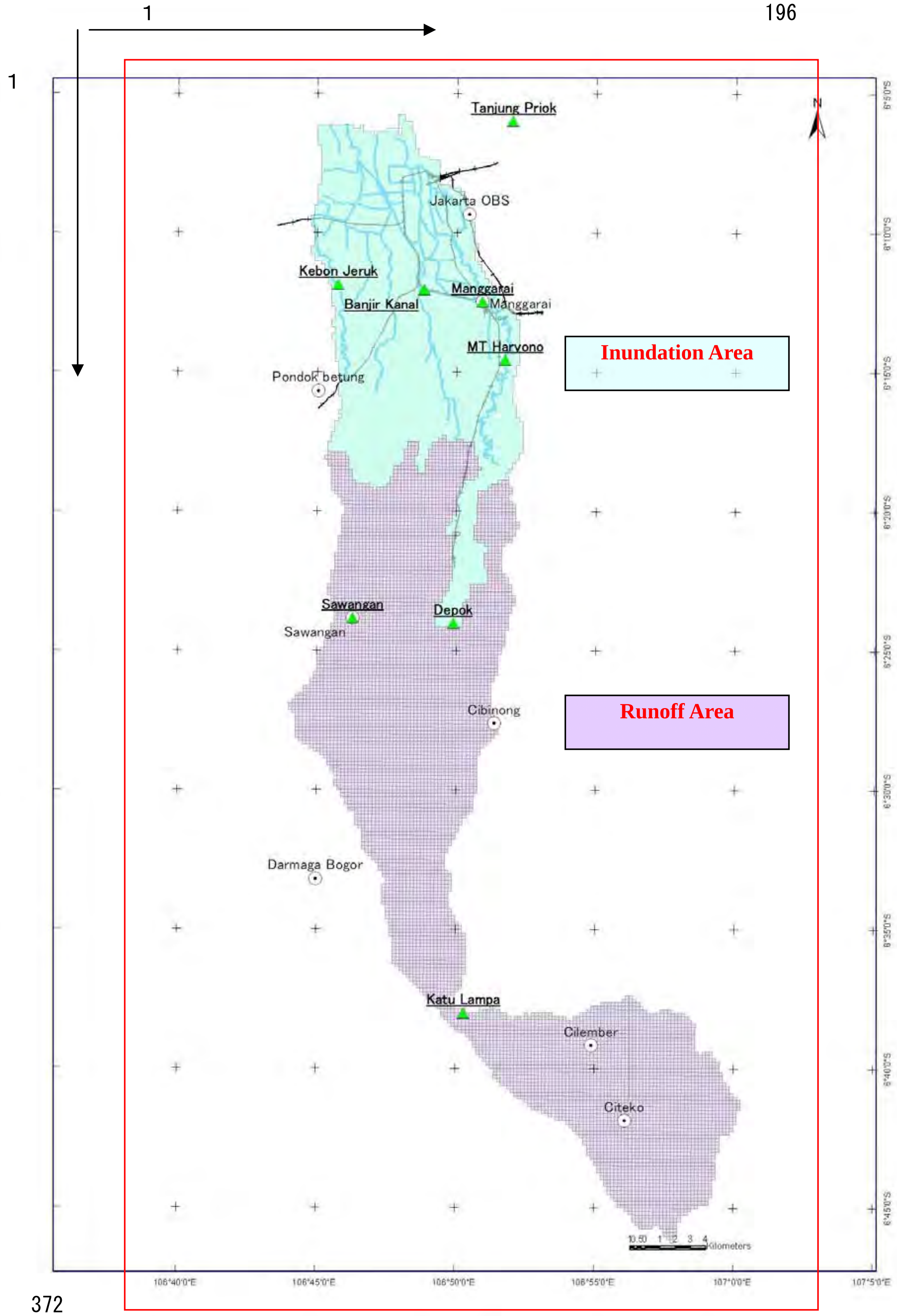


Figure 3.2-7 Segmentation of Mesh

2) Rainfall Distribution

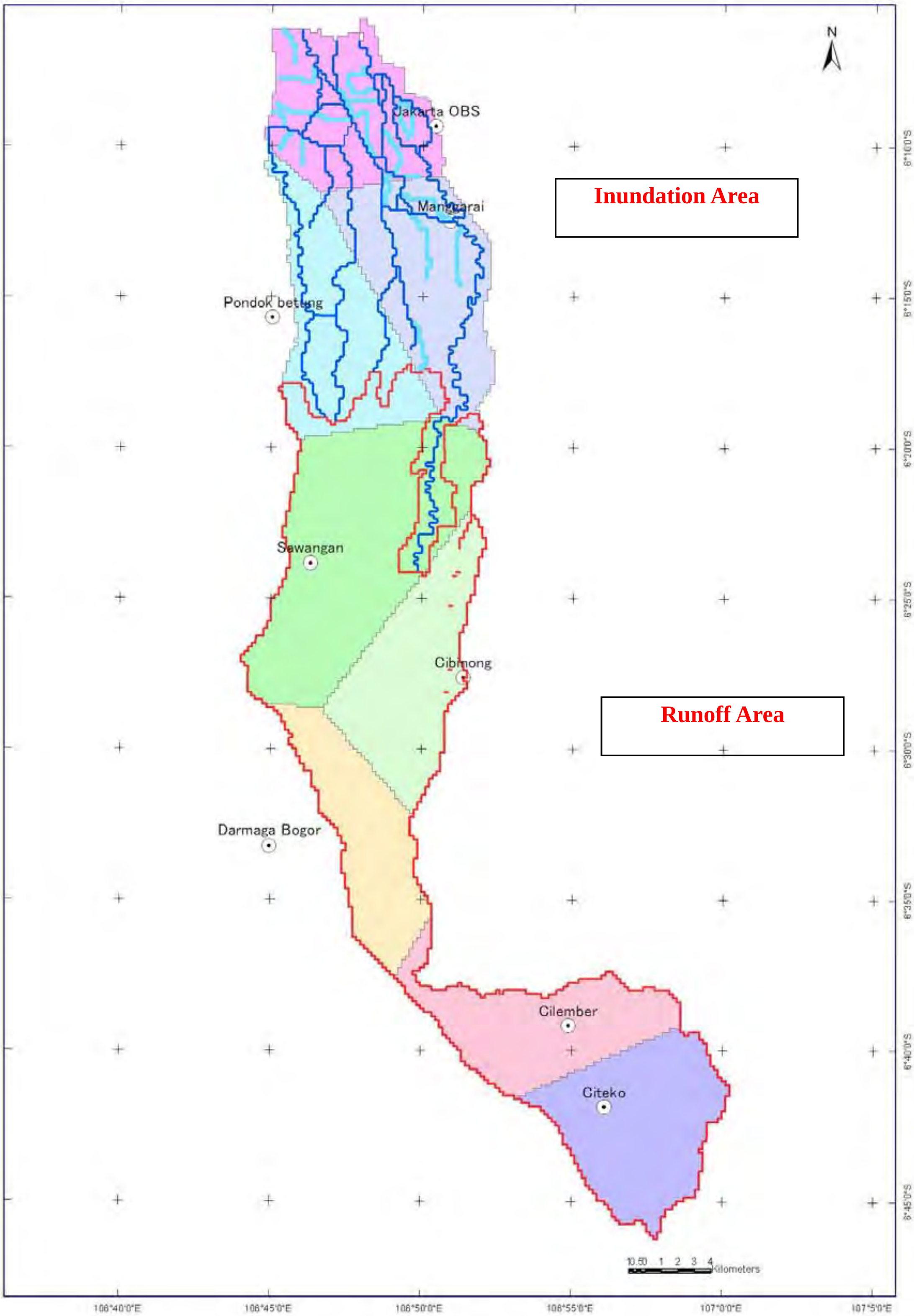


Figure 3.2-8 Thiessen Segmentation

3) Inundation Area Model

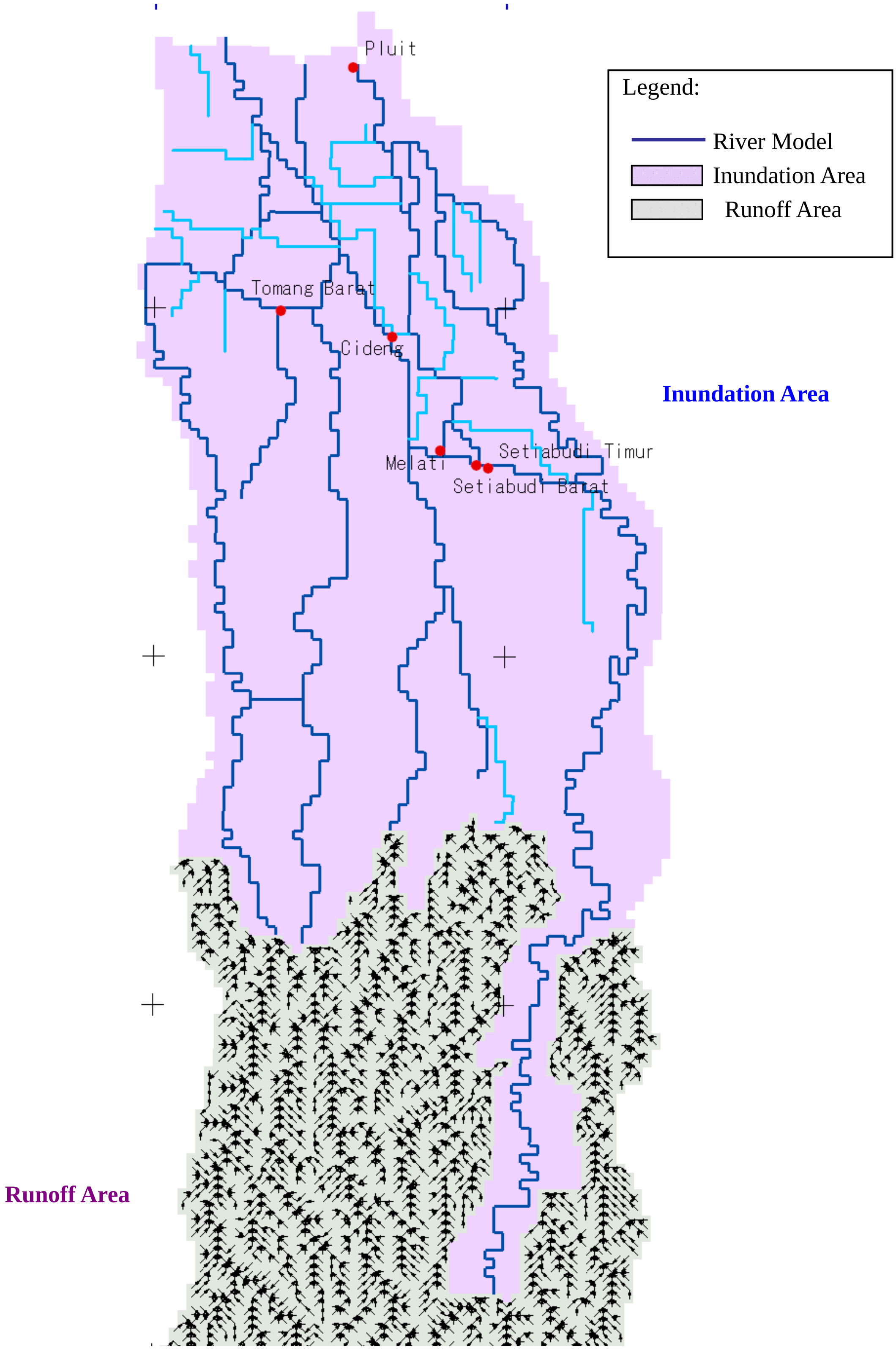


Figure 3.2-9 Outline Map of Inundation Area Model

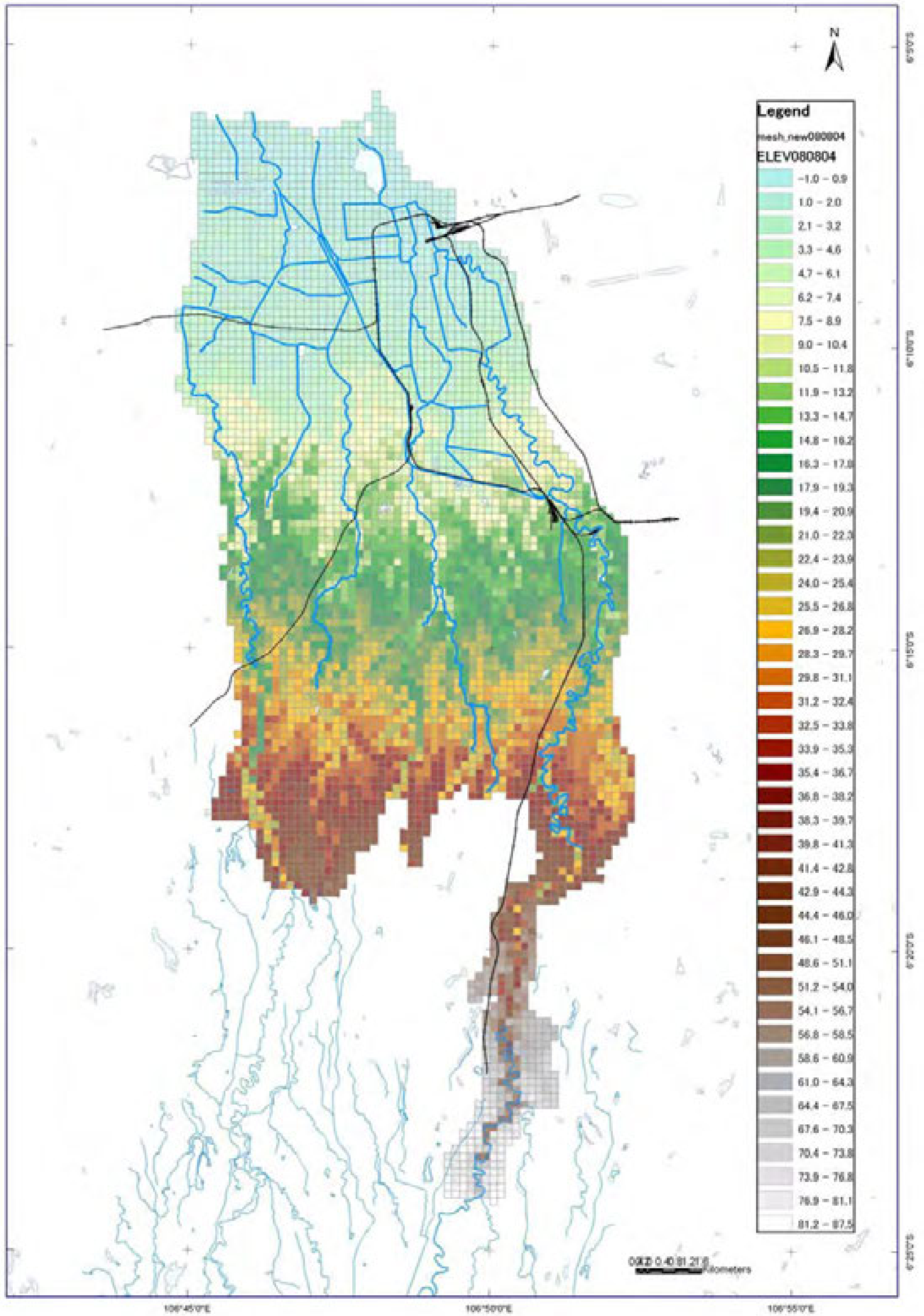


Figure 3.2-10 Average Ground Level (Inundation Area, as of Year 2008)

(a) Roughness Coefficient (Inundation Area)

Roughness coefficient of inundation area is settled as follows.

- Settle the occupancy and roughness coefficient for each land use of each mesh
- Obtain the roughness coefficient of lands and buildings through following formula based on the bed roughness

$$n^2 = n_0^2 + 0.02 \times (\theta/(100 - \theta)) \times h^4/^3$$

Here θ: building occupancies, h: water depth

- Obtain the bed roughness of any other than buildings through following weighted average formula

$$n_0^2 = (n_1^2 A_1 + n_2^2 A_2 + n_3^2 A_3)/(A_1 + A_2 + A_3)$$

Here A_1: firm land area　　n_1: firm land roughness coefficient＝0.060
A_2: road area　　n_2: road roughness coefficient＝0.047
A_3: others area　　n_3: others roughness coefficient＝0.050

Land use segmentations are reclassified into 4 classifications as shown in Table 3.2-4.

Table 3.2-4　　Land Use Classification

Item	Land Use Classifications	Roughness coefficient
Buildings	Settlement, Urban area	Calculated by building occupancies
Firm Lands	Upland crop field, Forest, Paddy field	0.060
Roads	Road & Rail	0.047
Others	Water area, Open area	0.050

The building occupancy is estimated as the rate of settlement area classification (settlement, urban area) in 230m mesh.

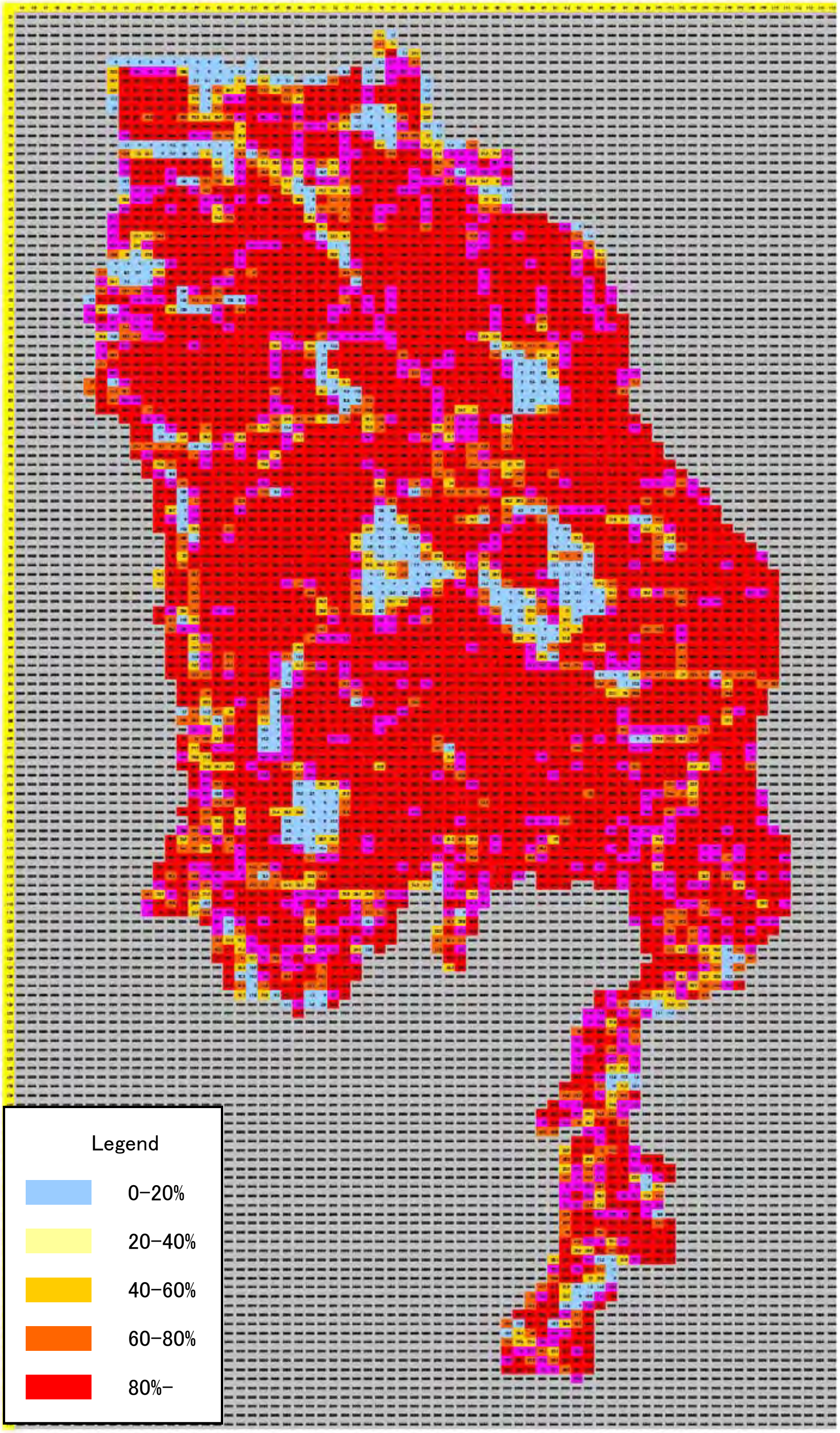


Figure 3.2-11 Building Occupancies (as of Year 2008)

4) Discharge Basin Model

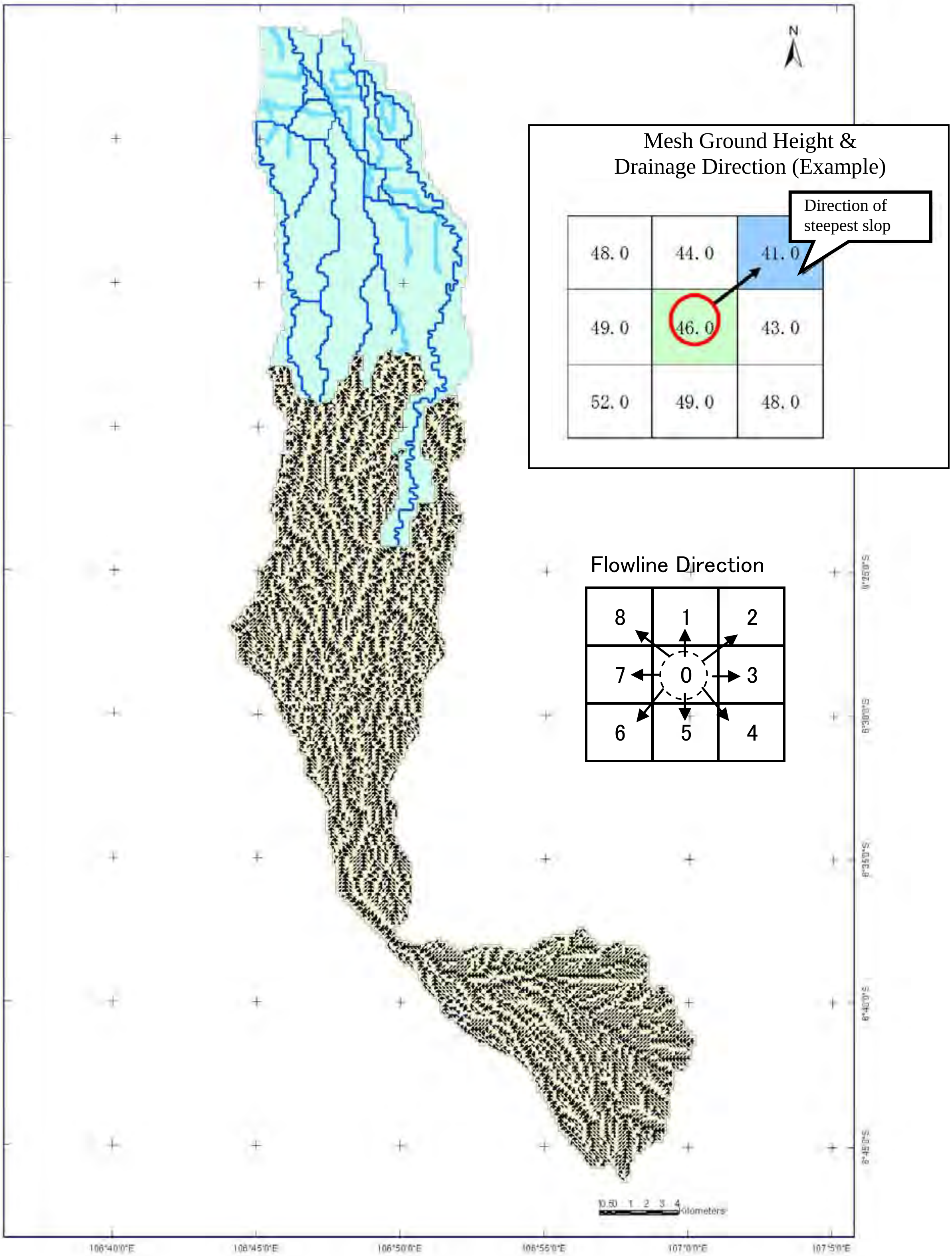


Figure 3.2-12 Drainage Direction Map (Discharge Basin)

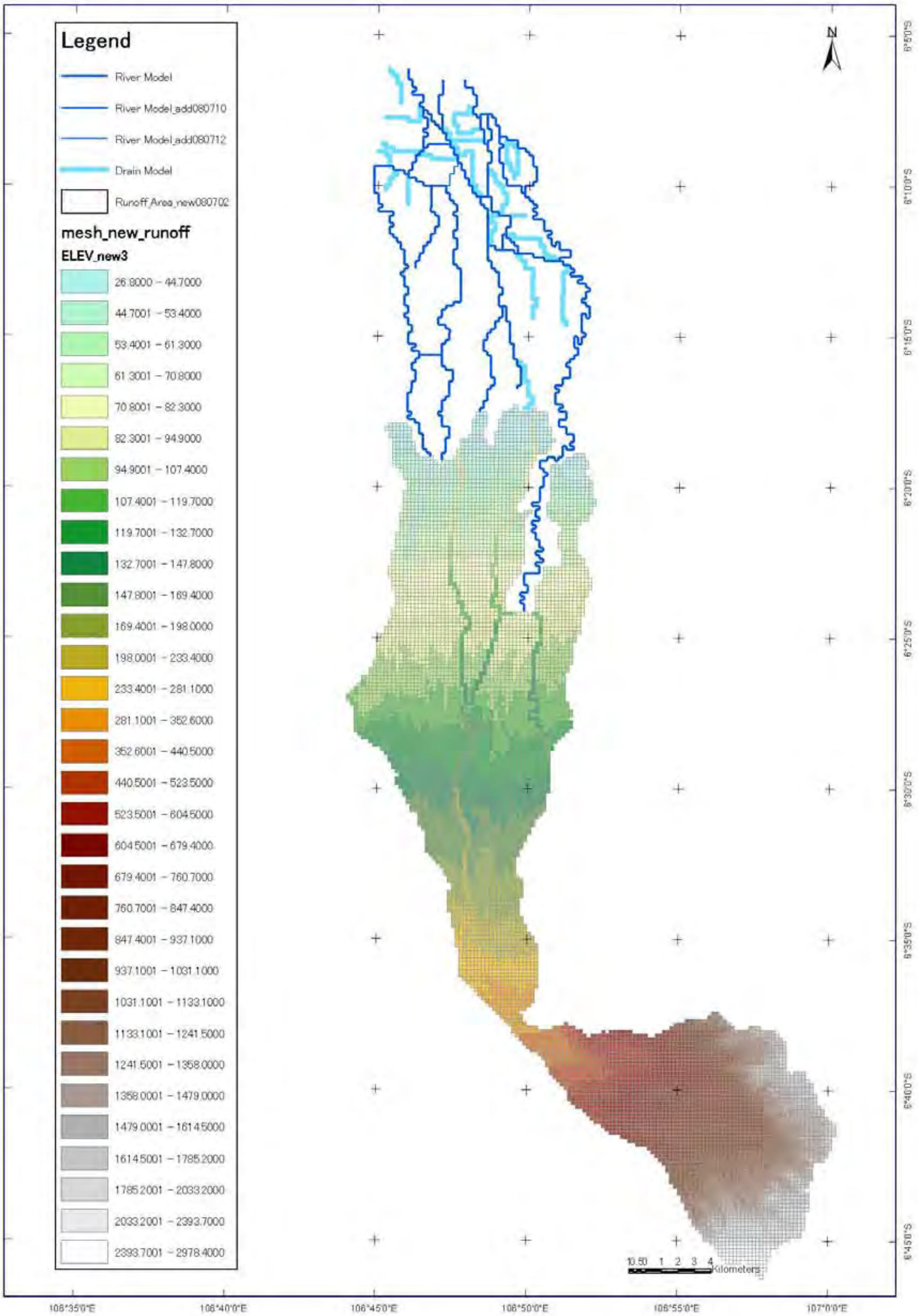


Figure 3.2-13 Average Ground Level Map (Discharge Basin)

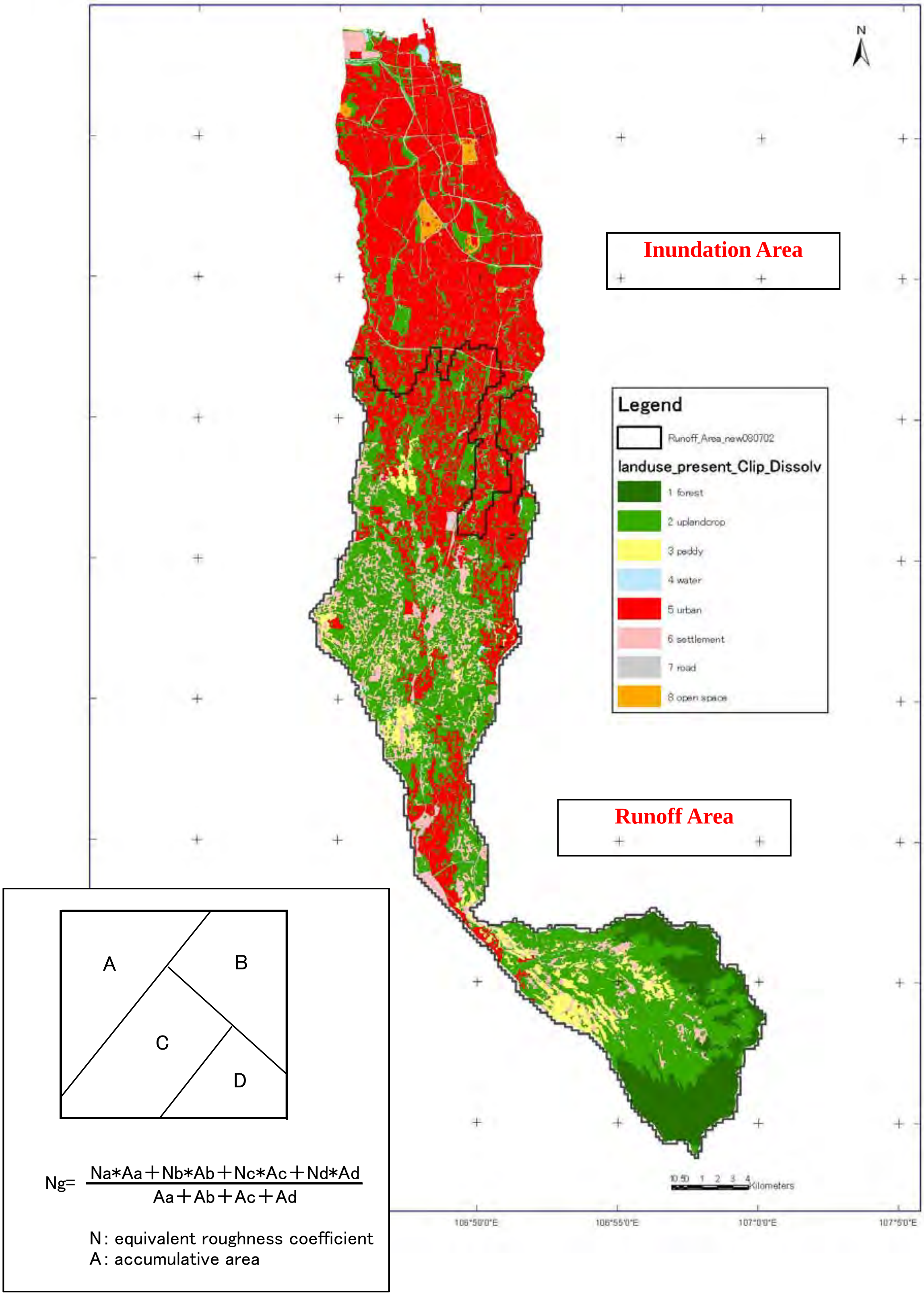


Figure 3.2-14 Land Use Map (as of Year 2008)

(a) Equivalent Roughness (Discharge Basin)

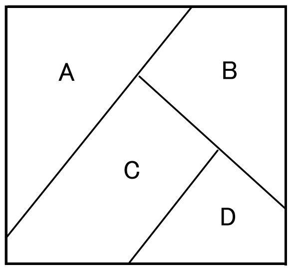
Equivalent roughness can be settled by land use of each mesh. Equivalent roughness in accordance with land use structure is shown in Table 3.2-5.

Equivalent roughness of each mesh (230m mesh) is settled as the synthetic equivalent roughness by the rate of dimension.

Table 3.2-5 Land Use Structure and Equivalent Roughness

Land Use Classification	Equivalent Roughness※n($m^{-1/3}s$)	Applicable Land Use Structure
Water area	0.0(0.0)	Water Surface
Paddy field	2.0(2.0~3.0)	Paddy Field
Upland crop field, Open area	0.9(0.6~1.2)	Hills and Forest land
Forest	0.9(1.0~2.0)	Mountain
Settlement	0.3(0.3~0.5)	Upland field, Farm, Golf course
Road &R ail, Urban area	0.1(0.01~0.04)	Urban Area

NOTE: ( ) is Standard Value



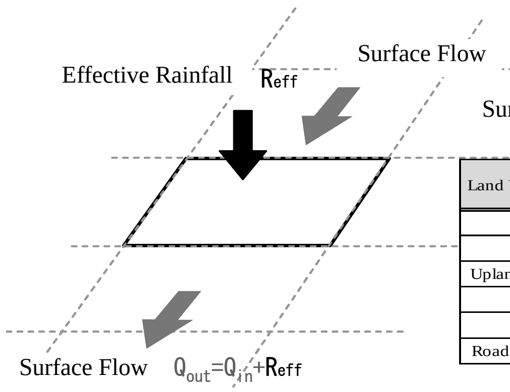
$$Ng = \frac{Na*Aa + Nb*Ab + Nc*Ac + Nd*Ad}{Aa + Ab + Ac + Ad}$$

N : equivalent roughness coefficient
A : accumulative area

(b) Abstraction Model

As for discharge of rainfall, effective rainfall after taking into losses is provided as runoff depth of mesh. Effective rainfall is the value of rainfall reduced by deduction of penetration to the land and discharge to retention facilities etc.

And Figure 3.2-15 shows image of effective rainfall, primary runoff ratio and saturated rainfall. And Figure 3.2-16 shows effective rainfall image by land use.



Land Use classificatton	f1	Rsa	fsa	Application
Water area	1.0	0	1	Water surface
Paddy field	0	50	1	Paddy field
Uplandcrop,Open area	0.15	300	0.6	Hills and Forest land
Forest	0.25	150	0.6	Mountain
Settlment	0.6	55	1	Upland field, Farm, Golf course
Road&Rail,Urban area	0.7	55	1	Urban Area

Figure 3.2-15 Image of Effective Rainfall

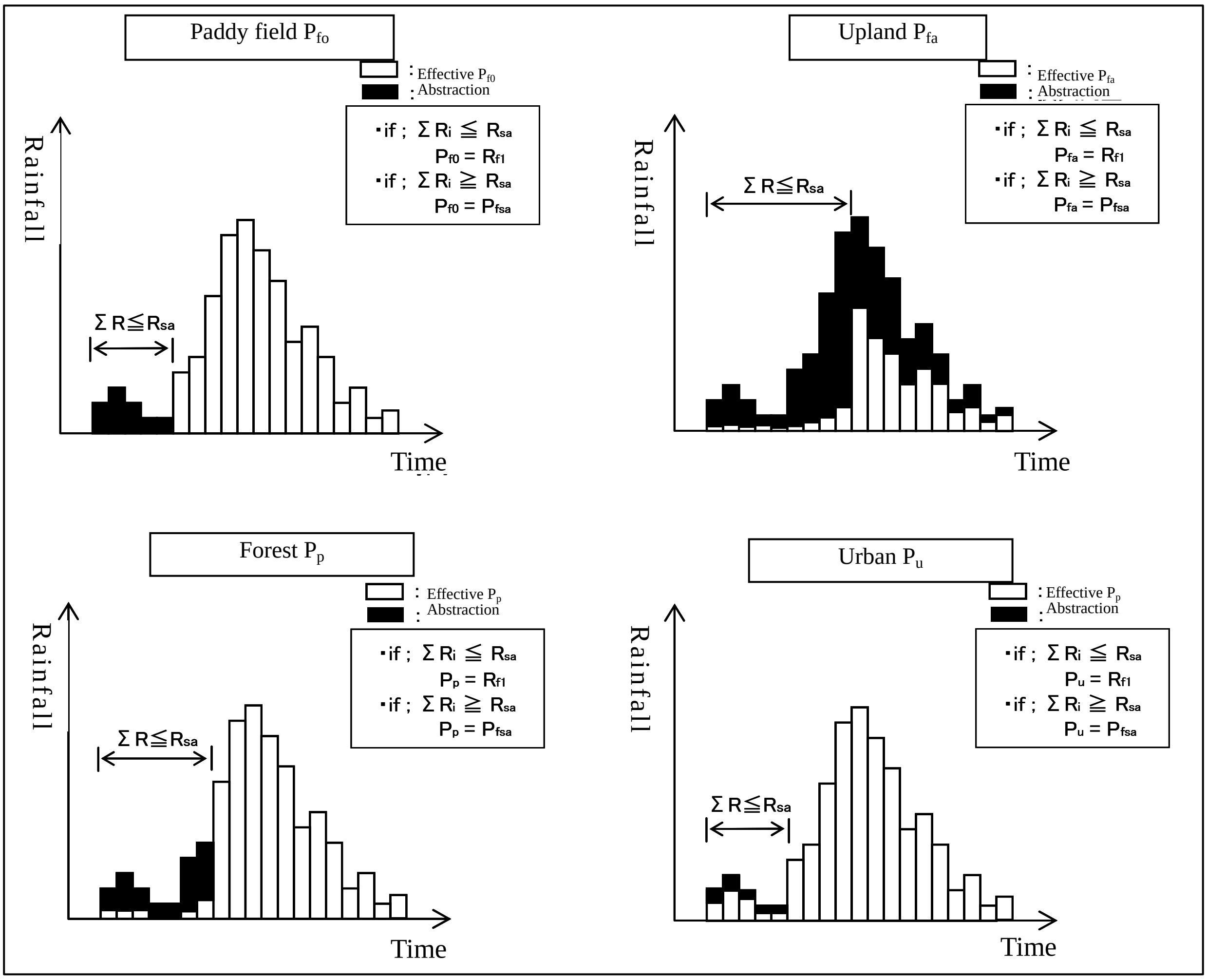


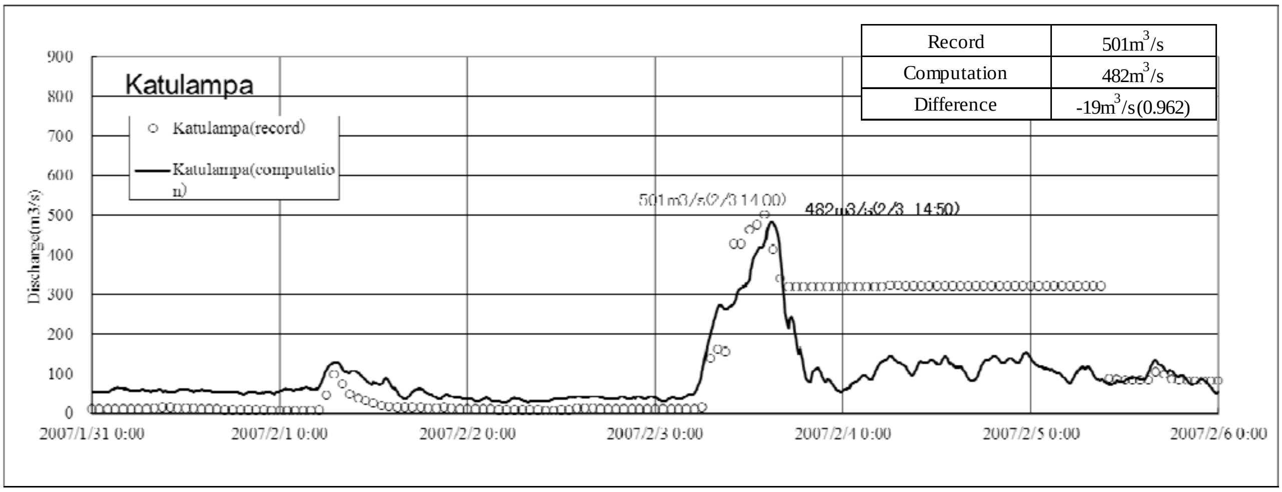
Figure 3.2-16 Effective Rainfall by Land Classification

(2) Reproducibility of the Model

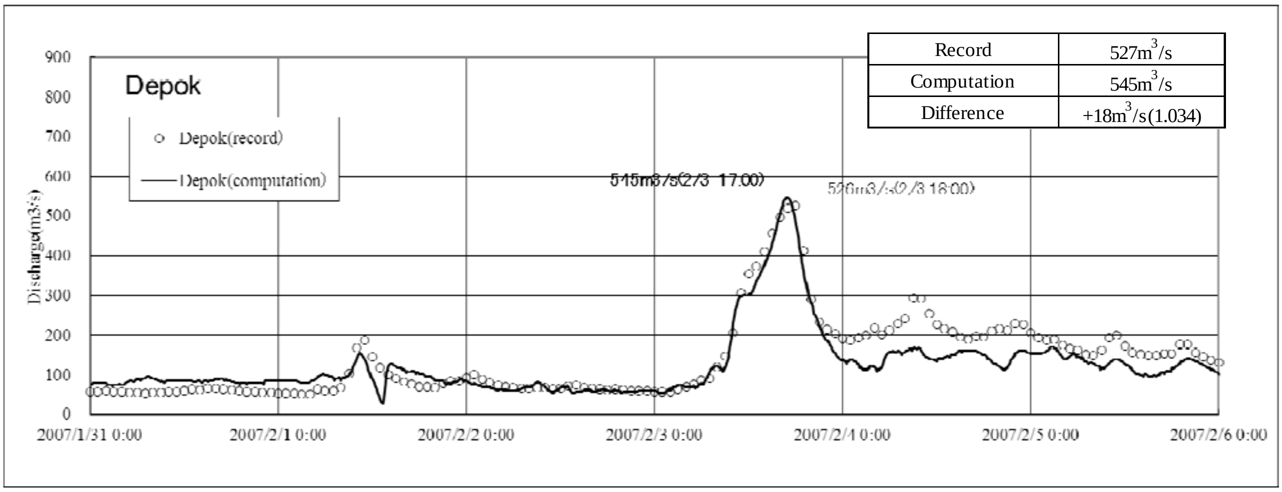
Reproduction of recent most severe flood in February 2007 will be implemented in the model. Model validity is verified by actual flow volume (HQ adjusted value) at Depok and Katulamapa reference point for discharge basin model and by actual water level and actual inundation area at Manggarai reference point for inundation area model.

1) River Flow Volume

Results of reproductive calculation for river flow volume at Depok and Katulampa are shown as follows. The peak discharge and whole curve are almost reproduced.



Record	$501m^3/s$
Computation	$482m^3/s$
Difference	$-19m^3/s$(0.962)



Record	$527m^3/s$
Computation	$545m^3/s$
Difference	$+18m^3/s$(1.034)

Figure 3.2-17 Discharge Hydro (Depok)

2) River Water Level

Results of reproductive calculation for river flow volume at Manggarai are shown as follows. The near a peak and the reduction part of water level hydro was reproduced in general.

Record	9.926 p.p.m
Computation	9.982 p.p.m
Difference	+0.056 m(1.001)

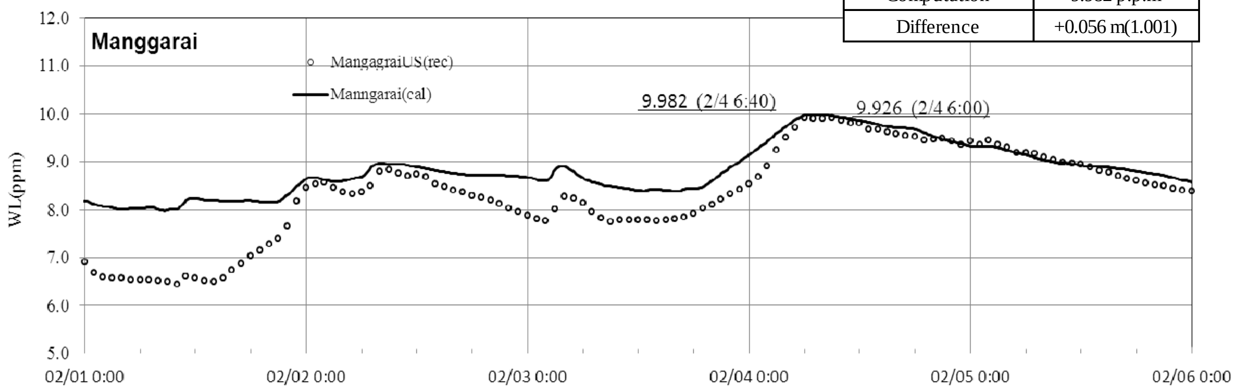


Figure 3.2-18 Water Level Hydro (Manggarai)

3) Inundation Area

Results of reproductive calculation for inundation area based on the results above are shown in the next page.

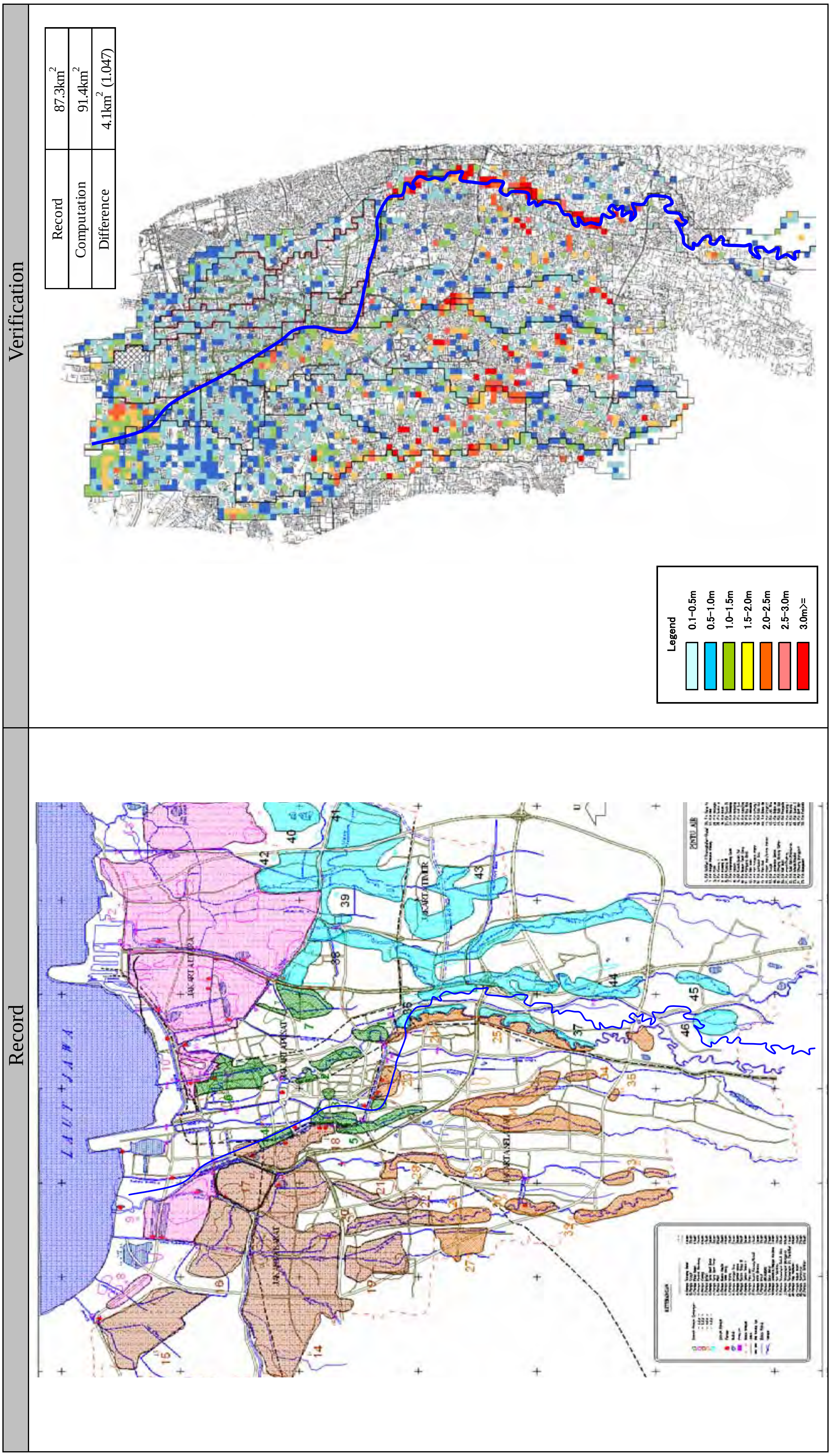


Figure 3.2-19 Maximum Inundation Depth

3.3 Examination of Annual Probable Flood Discharge

3.3.1 Objective of Examination

The flood inundation analysis with different return period is conducted by using 2007 flood curve, and it can be used as a basic data for the determination of basin basic high water discharge volume.

3.3.2 Conditions of Examination

The conditions of examination are shown as follows. The targeted flood is assumed as February 2007 flood.

Table 3.3-1 Conditions of Examination

Contents	Without Overflow	Without Overflow
Land Use	Current Condition/Future Condition	
Terrain Condition	Current Condition(2008)	
River	Current Condition(2011)	
Drainage Facility	Current Condition(2011)	
Target Flood	Flood in Feb. 2007	
Scale of External Force	1/5, 1/10, 1/25, 1/50, 1/100	
Basin Condition	Standard Condition	

Note: West Banjir Canal : After dredging

- Objective Flood: February 2007 Flood
- Probability of Rainfall: 1/5, 1/10, 1/25, 1/50, 1/100
- Probable Rainfall: Manggarai Point (Gumbel)

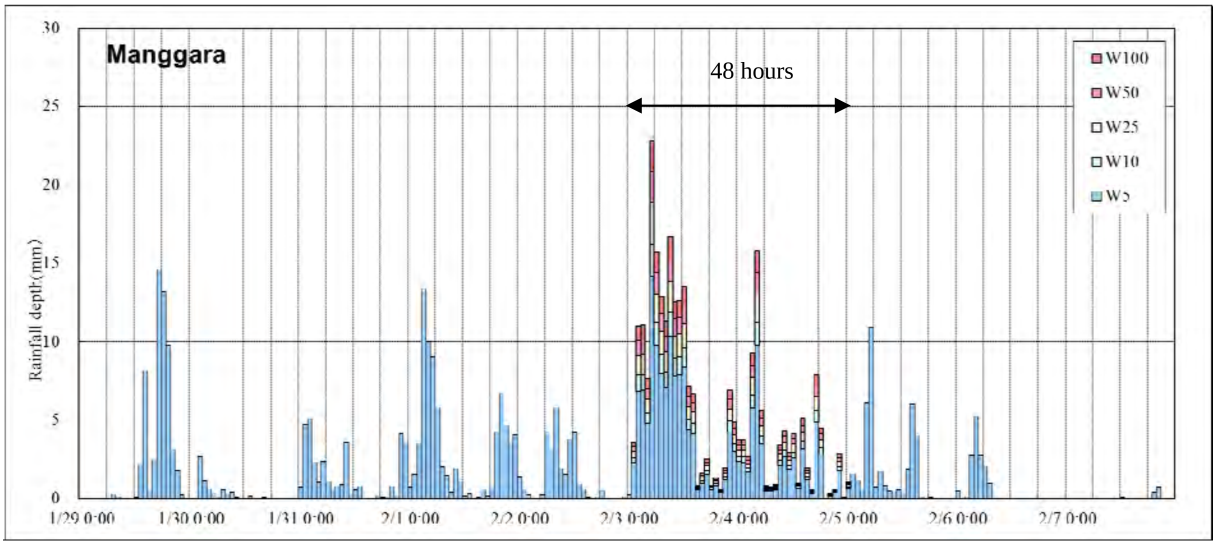


Figure 3.3-1 Rainfall Curve of February 2007 Flood with Different Probability (Manggarai Point)

3.3.3 Result of Examination

The examination results are summarized as below.

Table 3.3-2 Result of Examination (Without Overflow)

River Condition	Overflow	Land Use	Return Period of Rainfall	Peak Discharge volume(m^3/s)		
				Manggarai (1)	Depok (2)	Katulampa (3)
Current (2011)	without	Current (2008)	100	506	545	501
			50	472	532	491
			25	425	448	419
			10	357	381	352
			5	294	328	288
		Future (2030)	100	801	849	767
			50	720	769	644
			25	655	692	608
			10	563	588	513
			5	494	510	446

Table 3.3-3 Result of Examination (With Overflow)

River Condition	Overflow	Land Use	Return Period of Rainfall	Peak Discharge volume(m^3/s)		
				Manggarai (1)	Depok (2)	Katulampa (3)
Current (2011) 200m3/s*1 [356m3/s]*2	with	Current (2008)	100	311	545	501
			50	291	532	491
			25	282	448	419
			10	238	381	352
			5	216	328	288
		Future (2030)	100	397	849	767
			50	386	769	644
			25	380	692	608
			10	361	588	513
			5	341	510	446

Note:
*1: capacity flow between Manggari and Depok
*2: [ ] : capacity flow at Manggari

(1) Without Overflow

1) Current Land Use

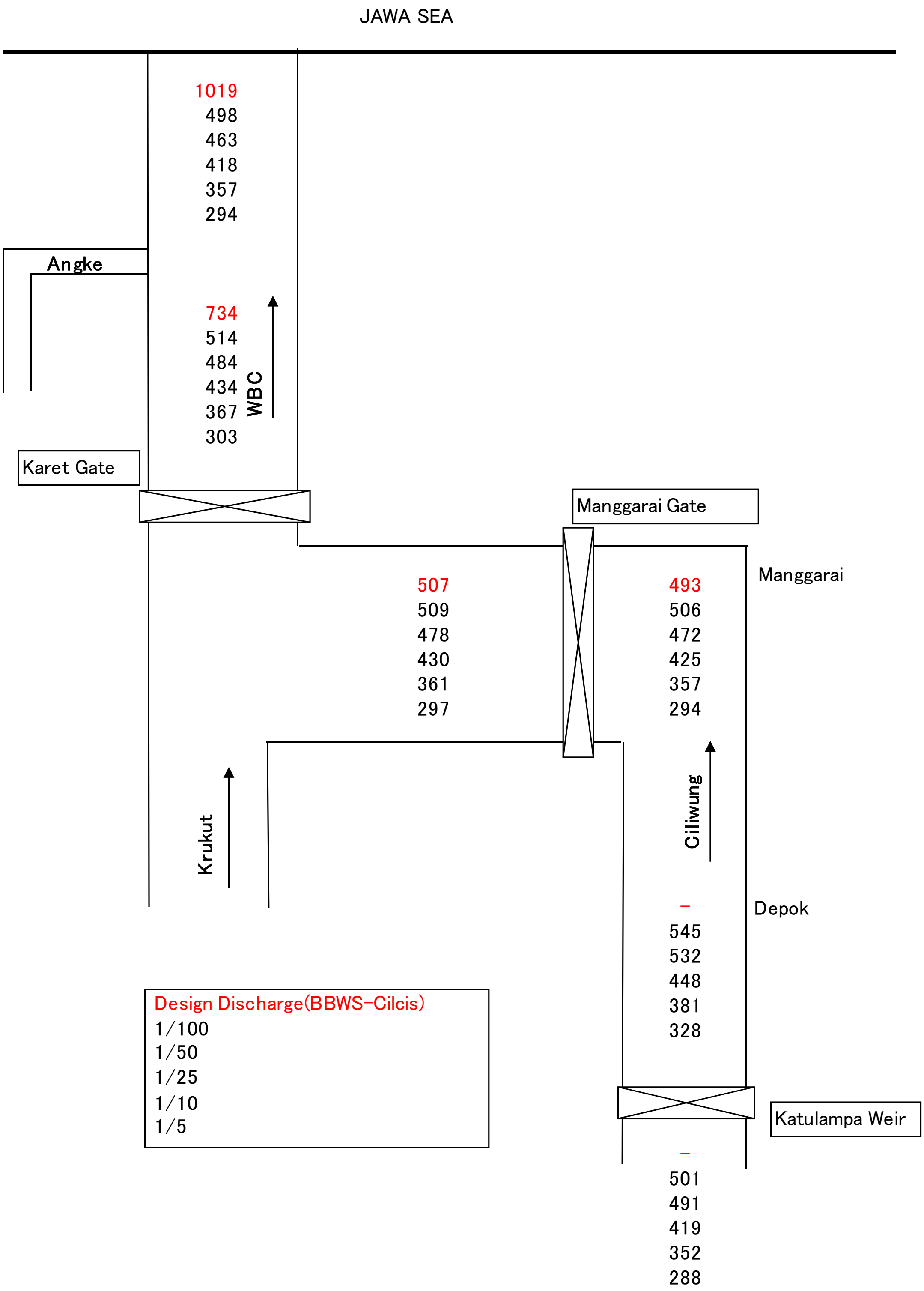


Figure 3.3-2 Discharge Distribution Map with Different Design Discharge (Current Land Use, without Inundation, Current River Condition)

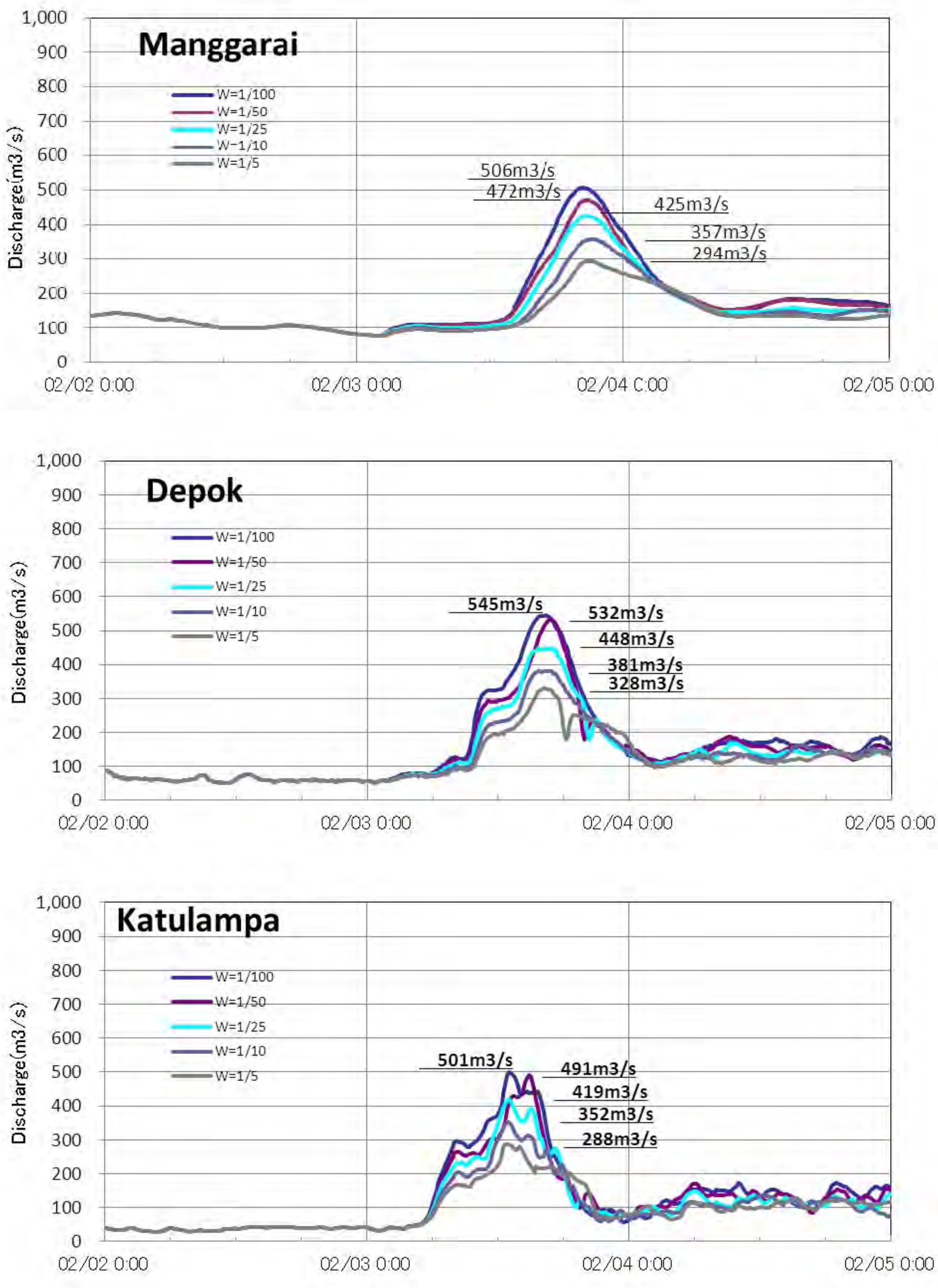


Figure 3.3-3 Discharge Volume Hydro with Different Design Discharge (Current Land Use, without Inundation, Current River Condition)

2) Future Land Use

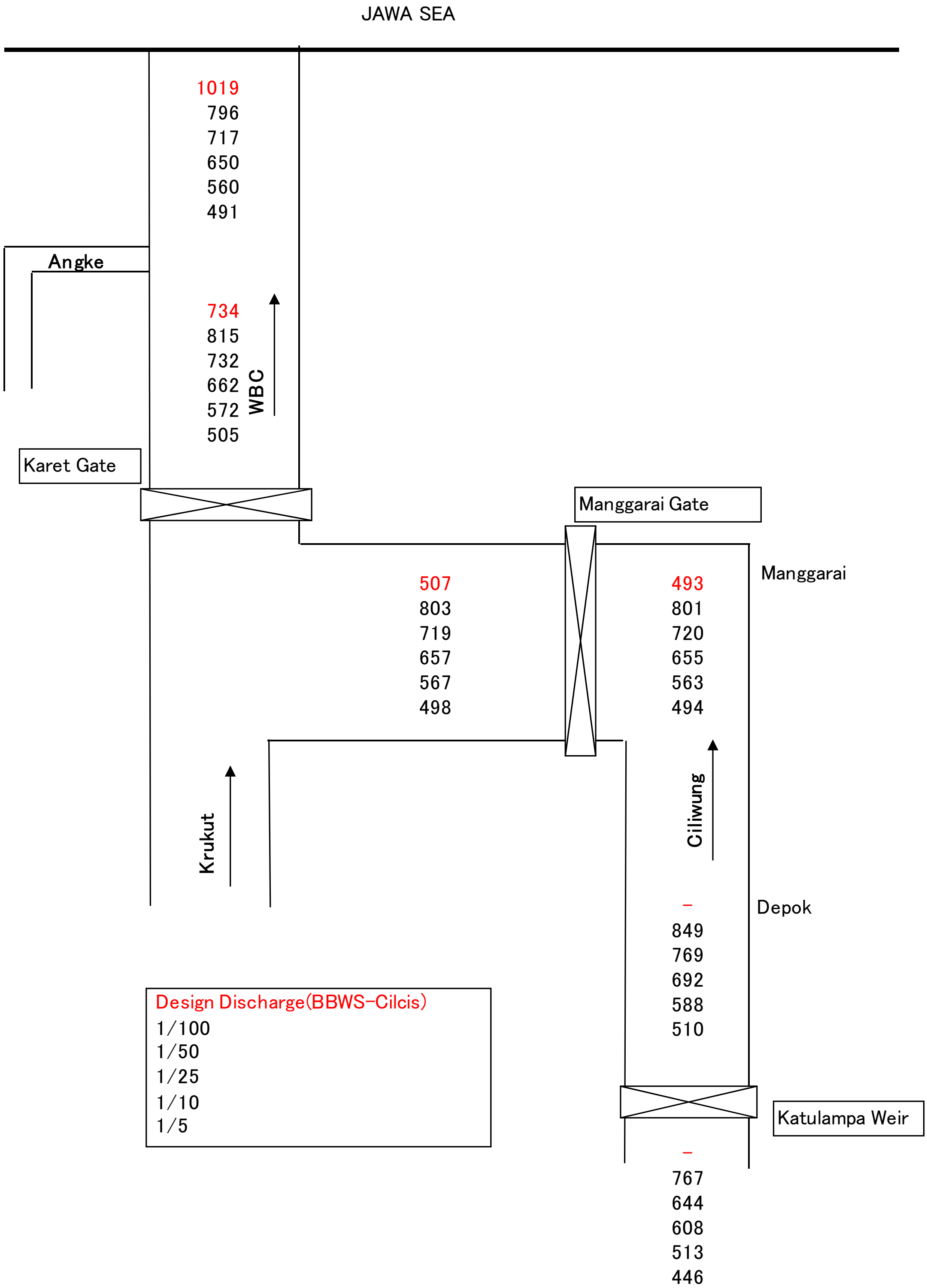


Figure 3.3-4 Discharge Distribution Map with Different Design Discharge (Future Land Use, without Inundation, Current River Condition)

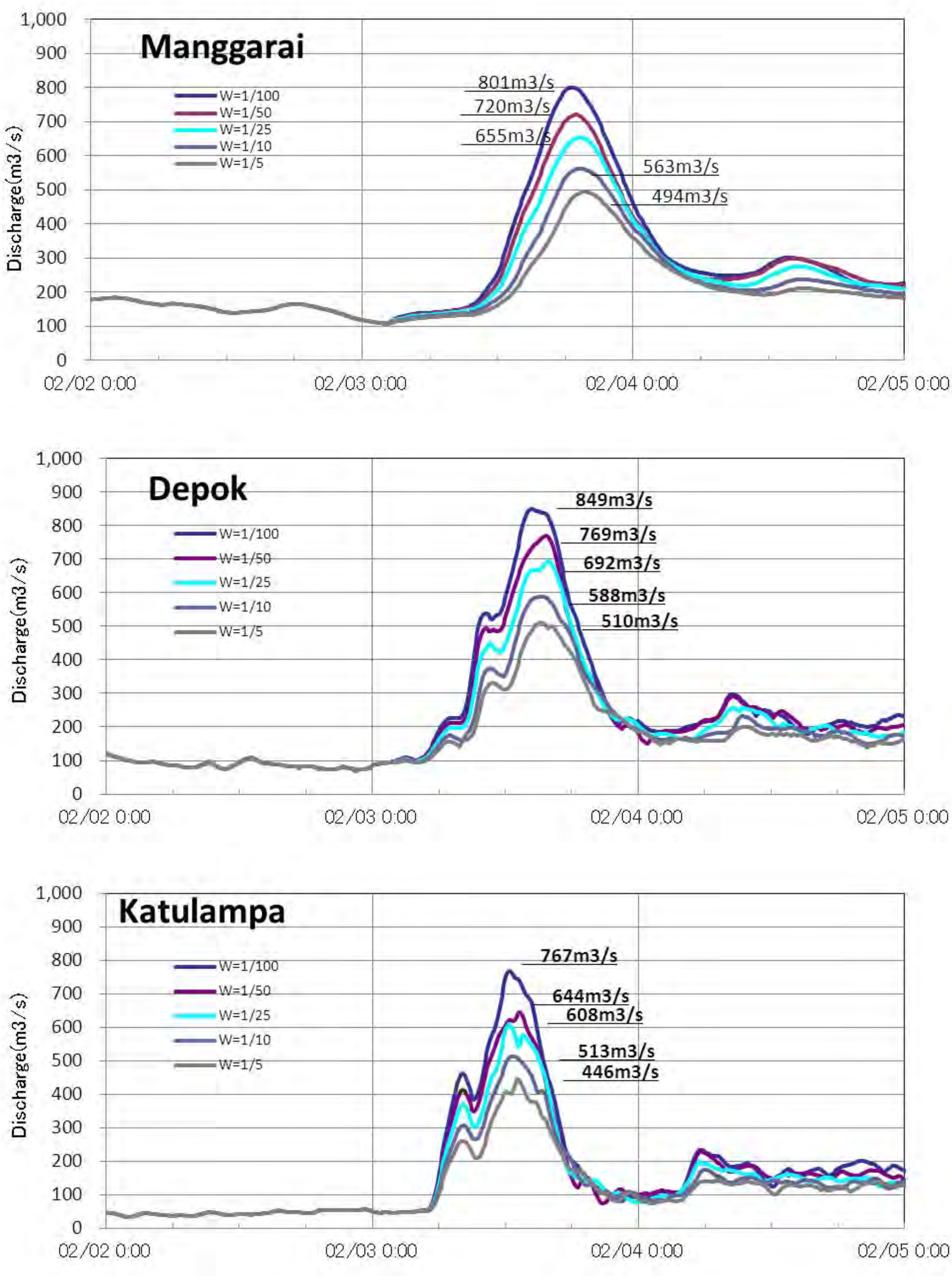


Figure 3.3-5 Discharge Volume Hydro with Different Design Discharge (Future Land Use, without Inundation, Current River Condition)

(2) With Overflow

1) Current Land Use

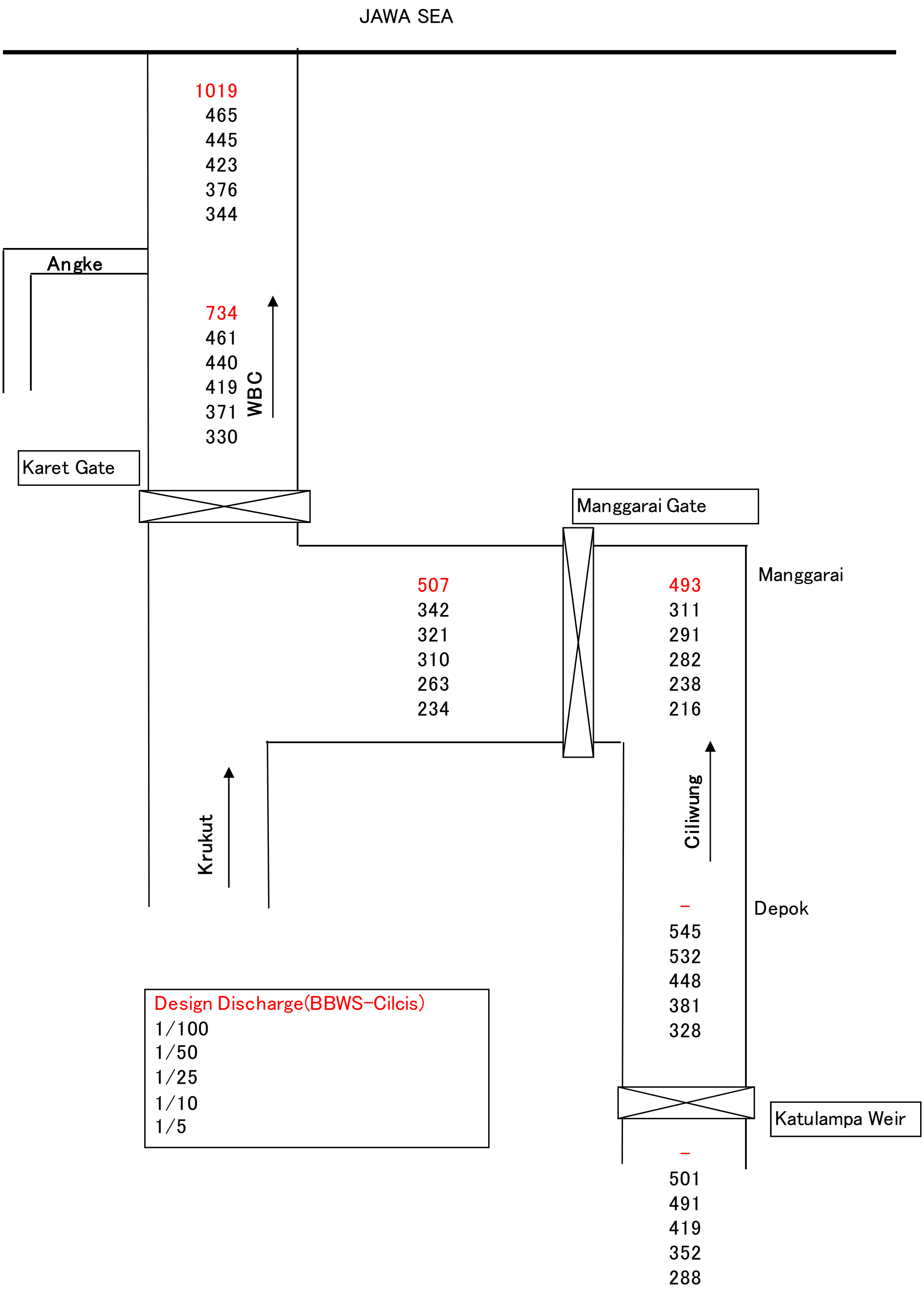


Figure 3.3-6 Discharge Distribution Map with Different Design Discharge (Current Land Use, with Inundation, Current River Condition)

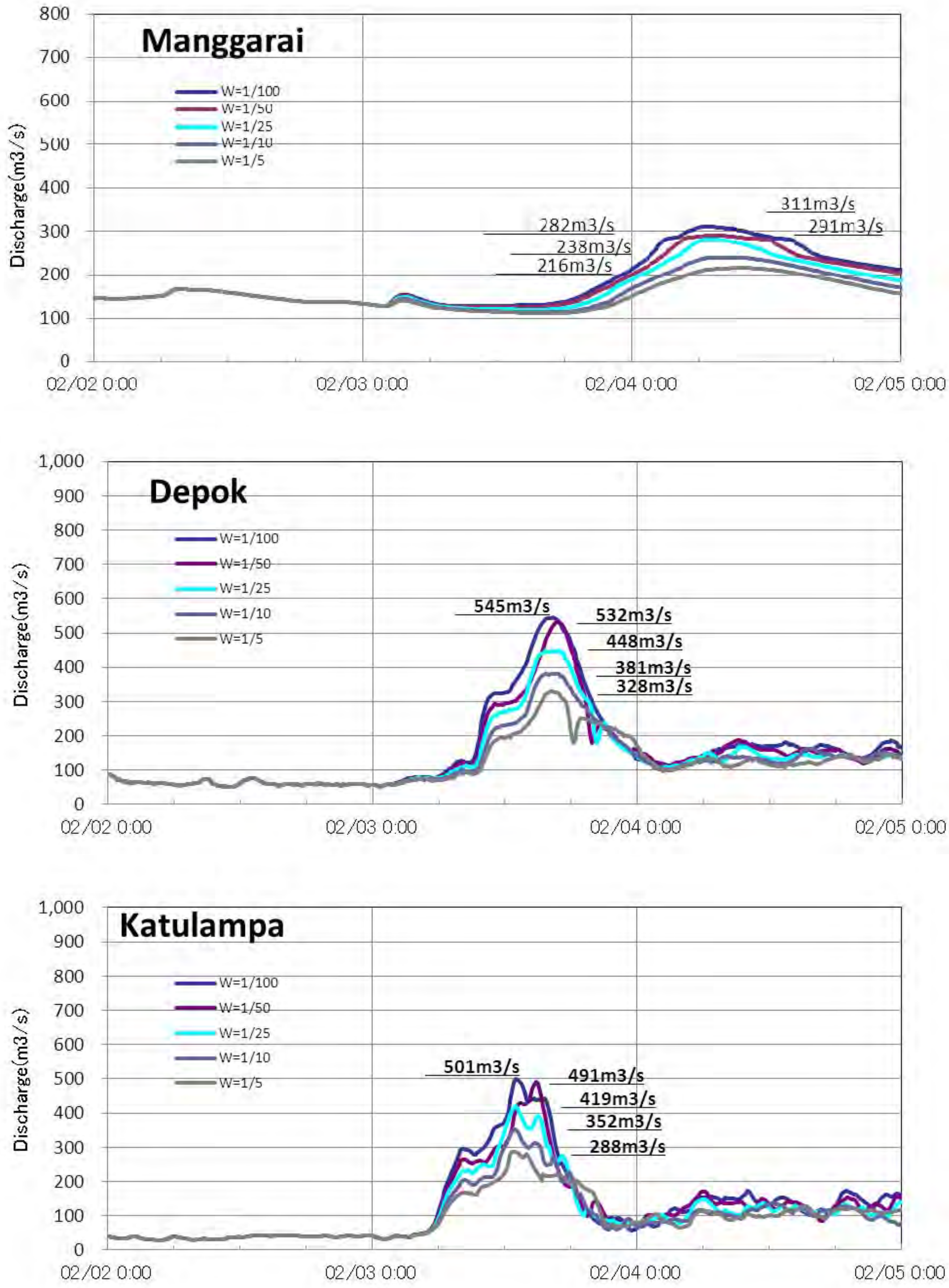


Figure 3.3-7 Discharge Volume Hydro with Different Design Discharge (Current Land Use, with Inundation, Current River Condition)

2) Future Land Use

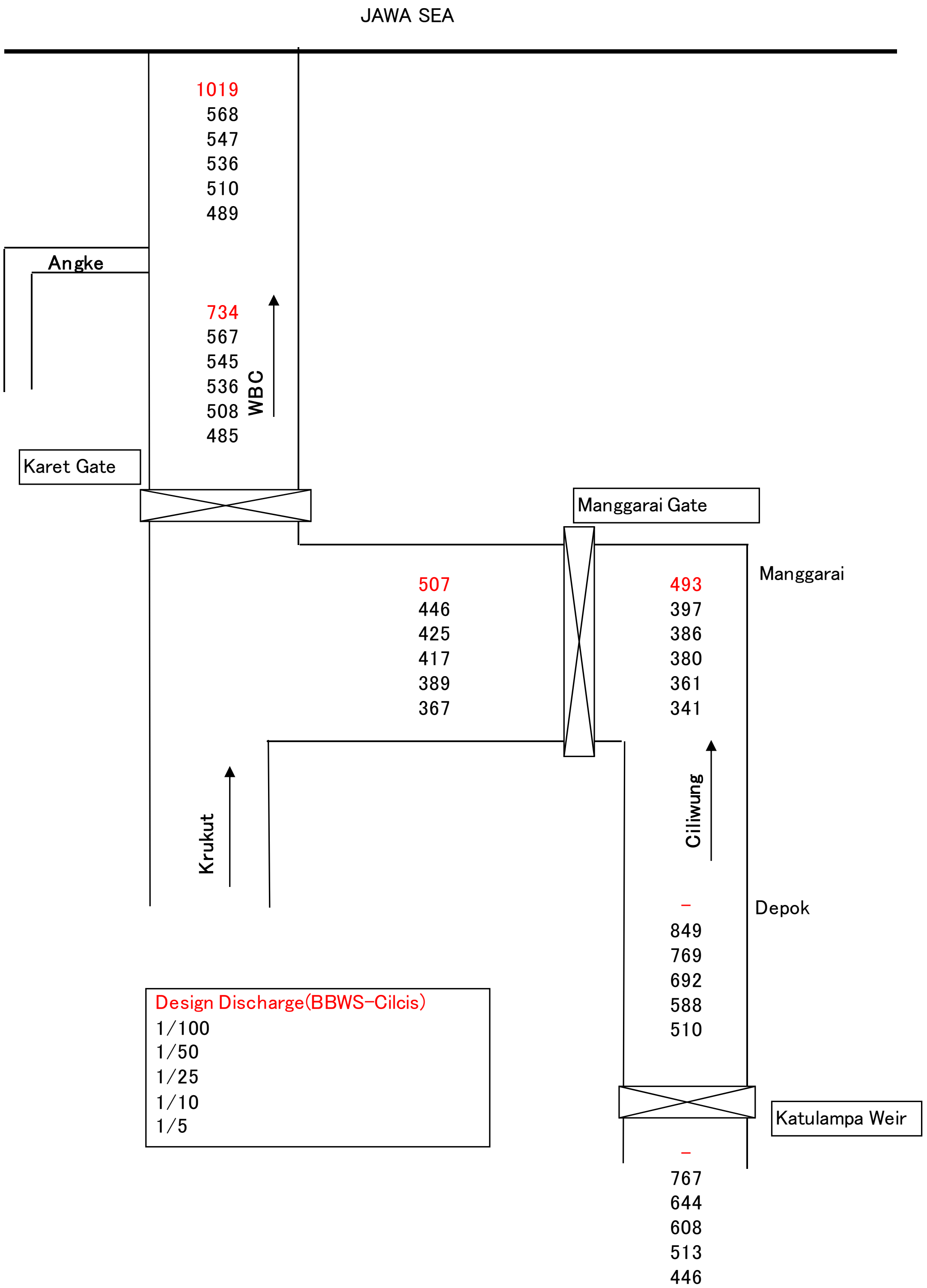


Figure 3.3-8 Discharge Distribution Map with Different Design Discharge (Future Land Use, with Inundation, Current River Condition)

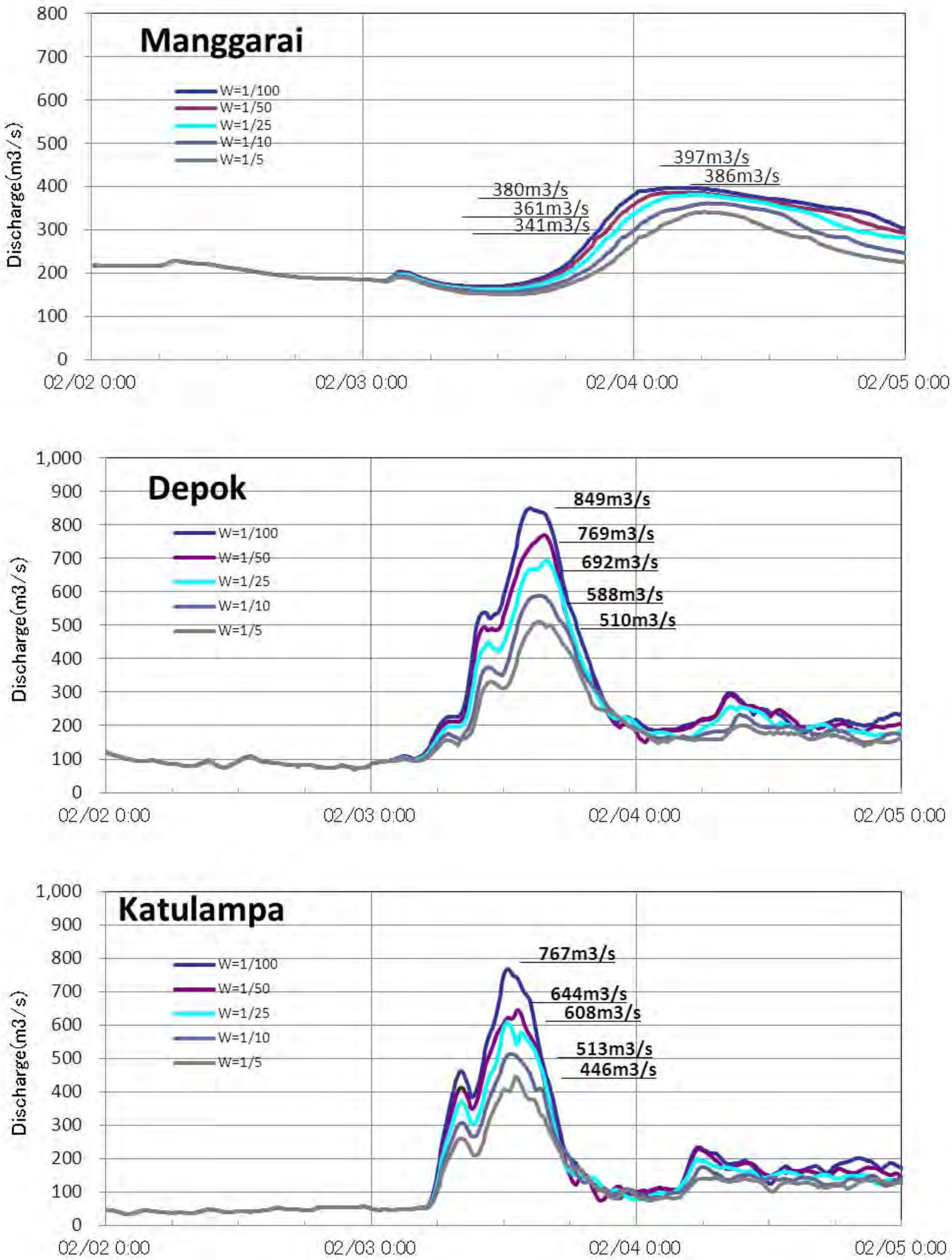


Figure 3.3-9 Discharge Volume Hydro with Different Design Discharge (Future Land Use, with Inundation, Current River Condition)

CHAPTER 4 FLOOD INUNDATION ANALYSIS

4.1 Methodology

The following flood inundation analysis is conducted by distribution model.

- The pattern of inundation conditions in accordance with land use change
- The inundation conditions in different return period

4.2 Comparison of Flood Inundation Conditions in line with Land Use Change

4.2.1 Objective of Analysis

The objective of the analysis is to confirm the flood inundation conditions in accordance with the land use change by the distribution model.

The changes of basin discharge volume and flood damages in line with land use change (present and future) are analyzed by flood inundation analysis model. The analysis is conducted on February 2007 flood.

4.2.2 Conditions of Analysis

(1) Transition of Land Use and Future Land Use

The transition of land use and future land use are shown in Table 4.2-1 and Figure 4.2-1.

The urbanization rate in the basin is also shown as below. It indicates that the urbanization rate will reach to 70% in the future.

- the rate will increase with 49% from the current rate (47.6%) to future (70.9%).

Table 4.2-1 Transition of Land Use

	Year	Urbanization Rate	Remarks
Present	2008	47.6%	Based on satellite images and topographic maps
Future	2030	70.9%	Based on spatial plans of related local governments in the basin

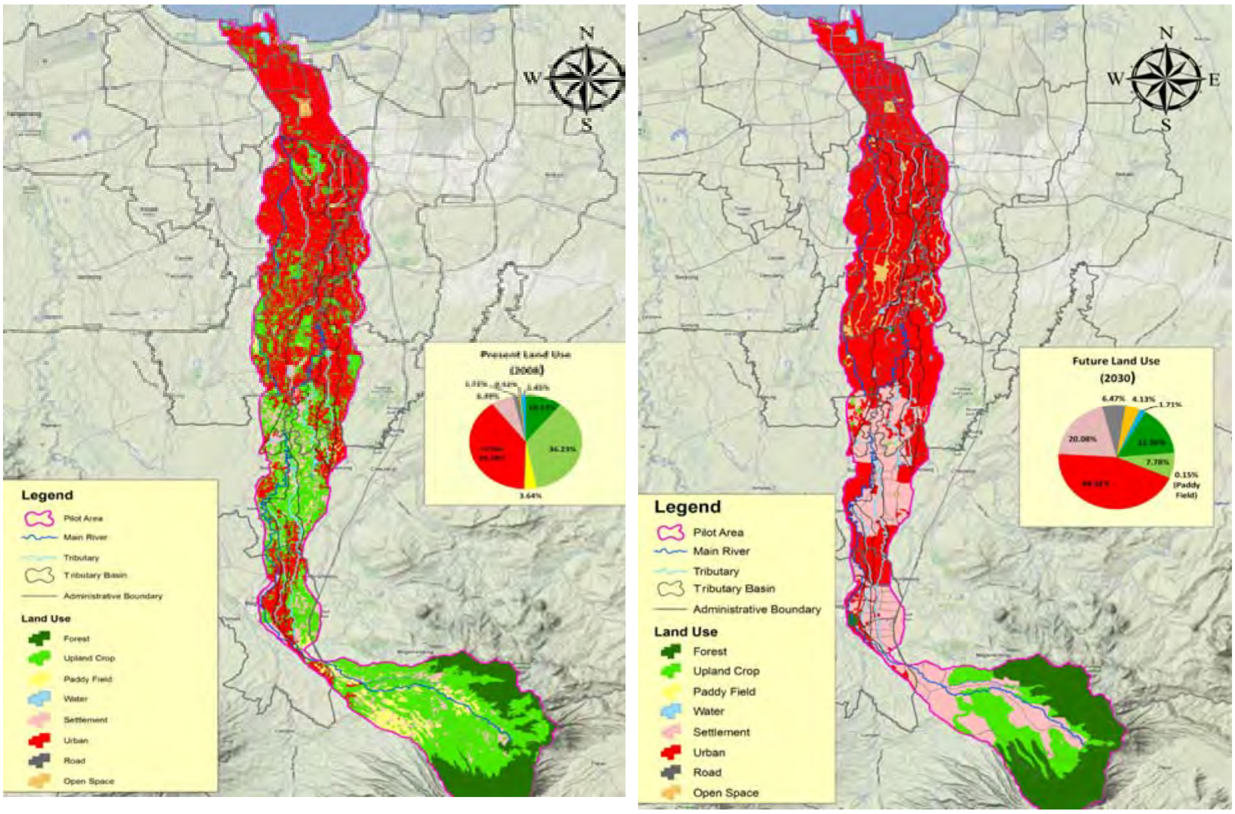


Figure 4.2-1 Transition Map of Land Use (Present and Future)

(2) Conditions of Analysis

The conditions of examination are summarized as below.

Table 4.2-2 List of Examination Conditions

Contents	Current	Future(2030)
Land Use	Current Condition	Future Condition
Terrain Condition	Current Condition(2008)	
River	Current Condition(2011)	
Drainage Facility	Current Condition(2011)	
Target Flood	Flood in Feb. 2007	
Scale of External Force	Actual	
Basin condition	Feb. 2007 Condition(Identification value)	

4.2.3 Results of Analysis

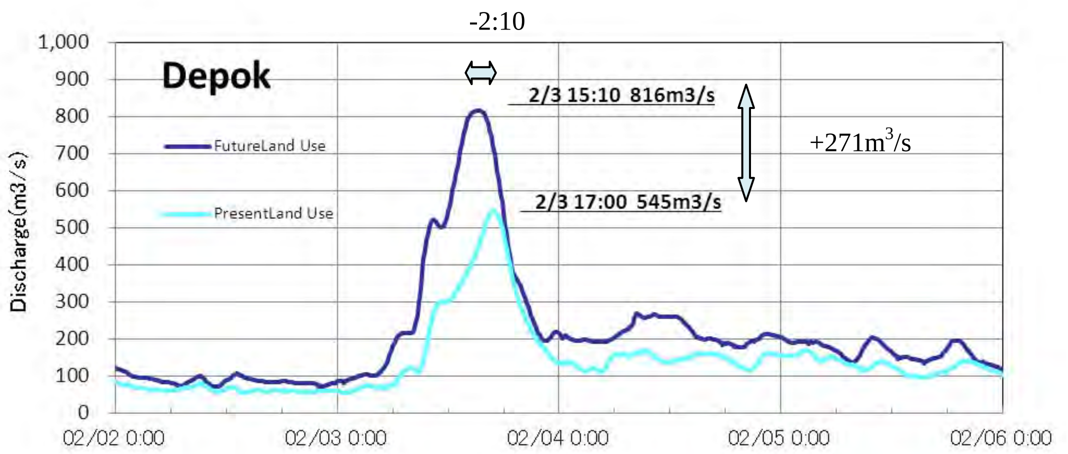
Due to the rapid urbanization in DKI Jakarta, it is assumed that DKI Jakarta will suffer from the frequent inundation in the future. Hence, the analysis on the change of basin discharge volume and inundation conditions will be the basic data to examine the necessity of the water retention functions in the basin.

Table 4.2-3 Results of Examination

Item	Area	Methodology
Basin Discharge Volume	DEPOK Point Manggarai Point	Discharge volume Hydrograph Peak volume, peak time
River Water Revel	Manggarai Point	Discharge volume Hydrograph Peak volume, peak time
Inundation Condition	Inundation Area	Maximum inundation depth map, inundation area, inundation volume

(1) Basin Discharge Volume

The current and future run-off hydrographs at Depok and Manggarai points are shown in Figure 4.2-2.



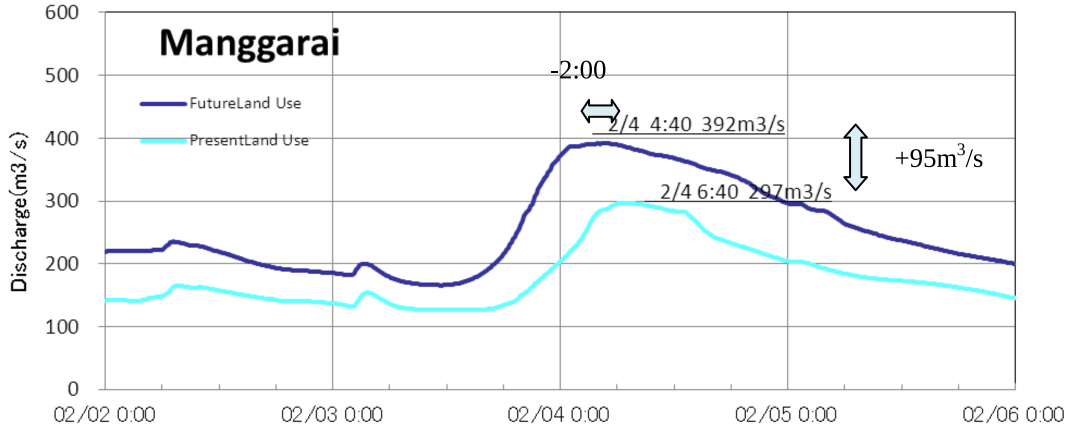


Figure 4.2-2 Run-off Volume Hydrograph in Different Land Use

(2) River Water Level

The current and future river water level hydrographs at Manggarai point are shown in Figure 4.2-3.

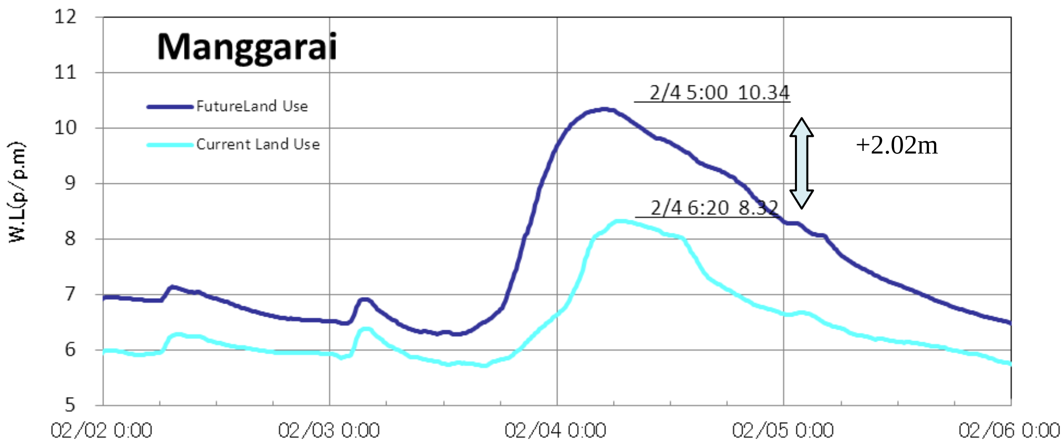


Figure 4.2-3 River Water Level Hydrograph in Different Land Use

(3) Inundation Condition

The past, current and future maximum inundation depths in the inundation area are shown in Figure 4.2-4.

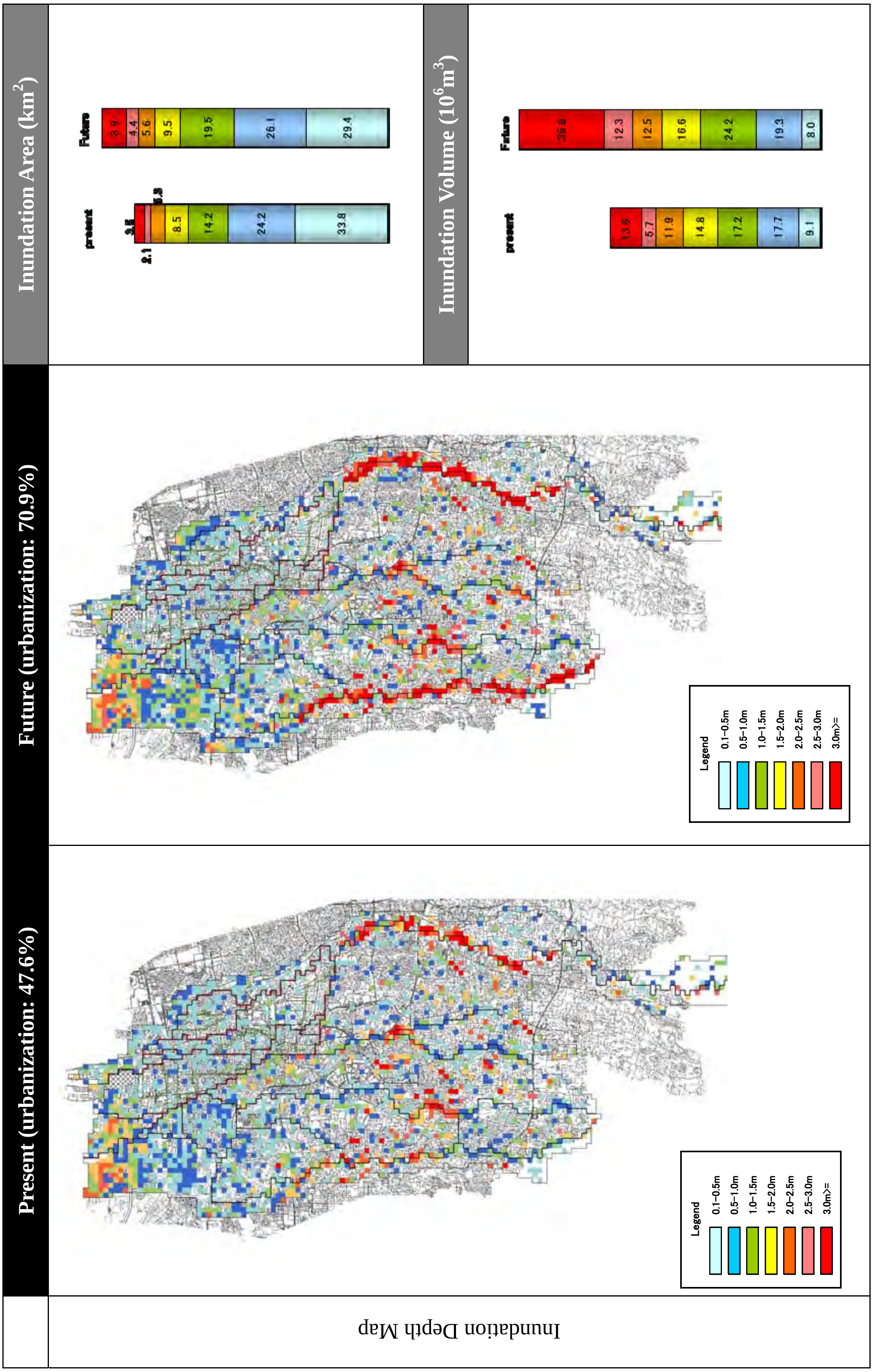


Figure 4.2-4 Comparison of Inundation Condition in Different Land Use

4.3 Flood Inundation Analysis

4.3.1 Objective of Examination

The flood inundation conditions in each return period are evaluated by using distribution flood inundation analysis model.

4.3.2 Conditions of Examination

The conditions of examination are as follows.

Table 4.3-1 List of Examination Conditions

Contents	Current Condition (2011)	After Improvement of Ciliwung River
Land Use	Current Condition /Future Condition	
Terrain Condition	Current Condition(2008)	
River	Current Condition(2011)	Ciliwung Improvement Plan
Drainage Facility	Current Condition(2011)	
Target Flood	Flood in Feb. 2007	
Scale of External Force	W=1/5, 1/10, 1/25, 1/50, 1/100	
Basin condition	Standard Condition	

- Objected Flood : February 2007 Flood
- Probability of Rainfall: 1/5, 1/10, 1/25, 1/50, 1/100
- Probable Rainfall: Manggarai Point (Gumbel)

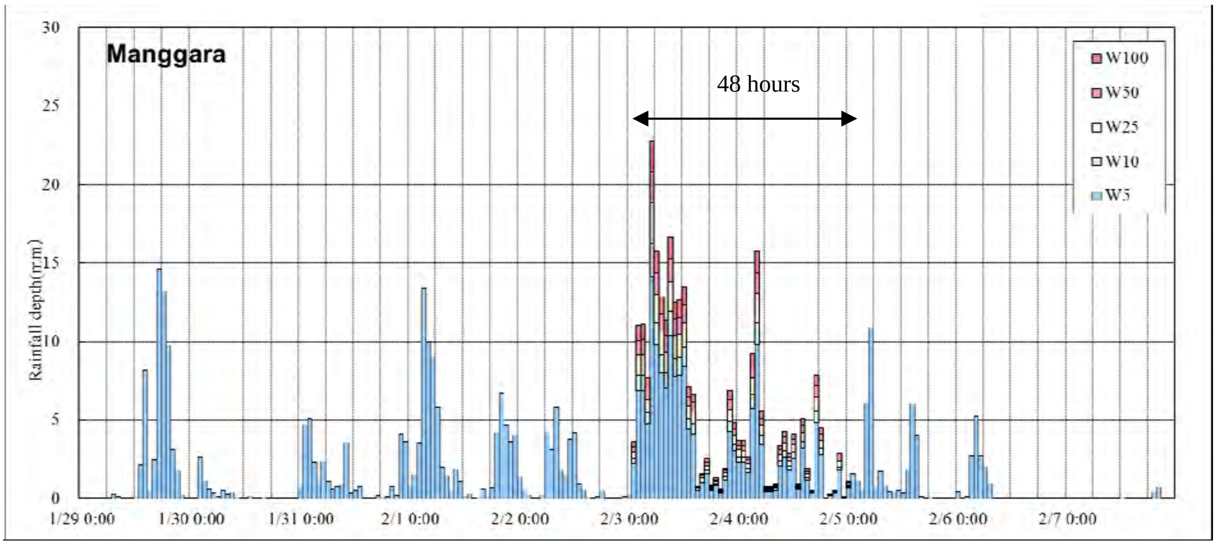


Figure 4.3-1 Rainfall Curve of February 2007 Flood with Different Probability (Manggarai Point)

4.3.3 Results of Examination

The examination results are as follows.

- Due to the bridge and bottleneck in Ciliwung river, the inundation occurs along the river and the peak discharge at Depok point decreases to about 48 % at Manggarai point.

In the future, the inundation along the river will decrease and discharge volume at Manggarai point will increase if the Ciliwung river is improved.

- According to the results of flood inundation analysis, the inundation area spreads along the Ciliwung river and does not expand to the lowland area.
- However, the inundation areas are scattered in the boghole areas. Thus, in order to mitigate the inundation damages, it is necessary to construct the drainage system and on-site measures.

Table 4.3-2 Inundation Volume and Peak Discharge at Major Points

River Condition	Overflow	Land Use	Return Period of Rainfall	Peak Discharge volume(m3/s)			Peak Discharge volume(m^3/s)		Water Level (p.p.m)		Inundation Area and Depth		
				Downstream Angke river confluence	Karet	Karet-Manggarai	Manggarai (1)	Depok (2)	Manggarai	MT.Haryono	Area (km^2)	Volume ($10^6 m^3$)	Average Depth(m)
Current (2011) 200m3/s*1 [356m3/s]*2	with	Current (2008)	100	465	461	342	311	545	8.59	16.35	7.78	16.01	2.06
			50	445	440	321	291	532	8.21	16.07	7.51	14.59	1.94
			25	423	419	310	282	448	8.04	15.87	7.51	13.36	1.78
			10	376	371	263	238	381	7.23	15.49	6.98	11.36	1.63
			5	344	330	234	216	328	6.78	15.16	6.61	9.55	1.44
		Future (2030)	100	568	567	446	397	849	10.50	17.96	9.05	26.23	2.90
			50	547	545	425	386	769	10.18	17.67	8.78	23.49	2.68
			25	536	536	417	380	692	10.01	17.49	8.52	21.46	2.52
			10	510	508	389	361	588	9.52	17.11	8.15	18.33	2.25
			5	489	485	367	341	510	9.14	16.63	7.67	15.83	2.06
Plan*3 493m3/s [507m3/s]	with	Current (2008)	100	626	636	532	529	545	9.31	13.09	5.66	5.53	0.98
			50	599	607	502	498	532	9.09	12.92	5.56	5.37	0.97
			25	550	559	450	447	448	8.70	12.63	5.50	5.21	0.95
			10	485	491	380	375	381	8.13	12.21	5.34	5.01	0.94
			5	424	430	319	315	328	7.62	11.85	5.34	4.89	0.92
		Future (2030)	100	728	743	635	656	849	10.76	14.29	6.98	8.16	1.18
			50	721	733	626	646	769	10.46	14.07	6.08	6.93	1.14
			25	715	723	620	637	692	10.31	13.84	5.87	6.21	1.06
			10	668	680	581	577	588	9.65	13.34	5.82	5.62	0.97
			5	614	626	518	515	510	9.22	13.01	5.71	5.36	0.94

Note:
*1: capacity flow between Manggari and Depok
*2: [ ] : capacity flow at Manggari
*3: Plan: Ciliwung river :River Improvement Plan by BBWS-CilCis(Manggari- OuterRing)
Gate Improvement: Improvement of Manggarai and Karet Gates(additional one Gate)

(1) Current River Condition, Current Land Use

1) River Water Level

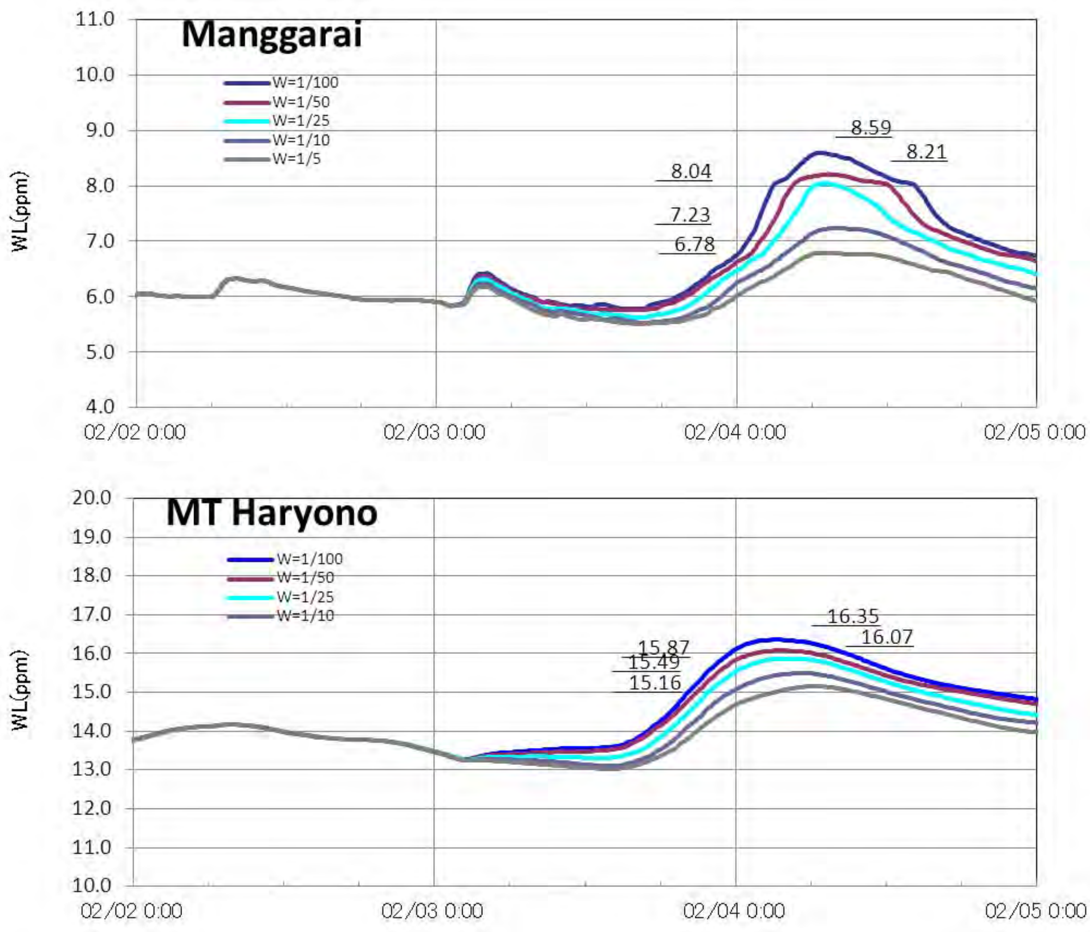


Figure 4.3-2 River Water Level Hydro with Different Design Discharge (Current River Condition, Current Land Use)

2) Inundation Condition

The results of flood inundation analysis with current land use are shown in Figure 4.3-3 to Figure 4.3-5.

The inundation areas along the Ciliwung river are limited in the riverside without expansion to the lowland areas.

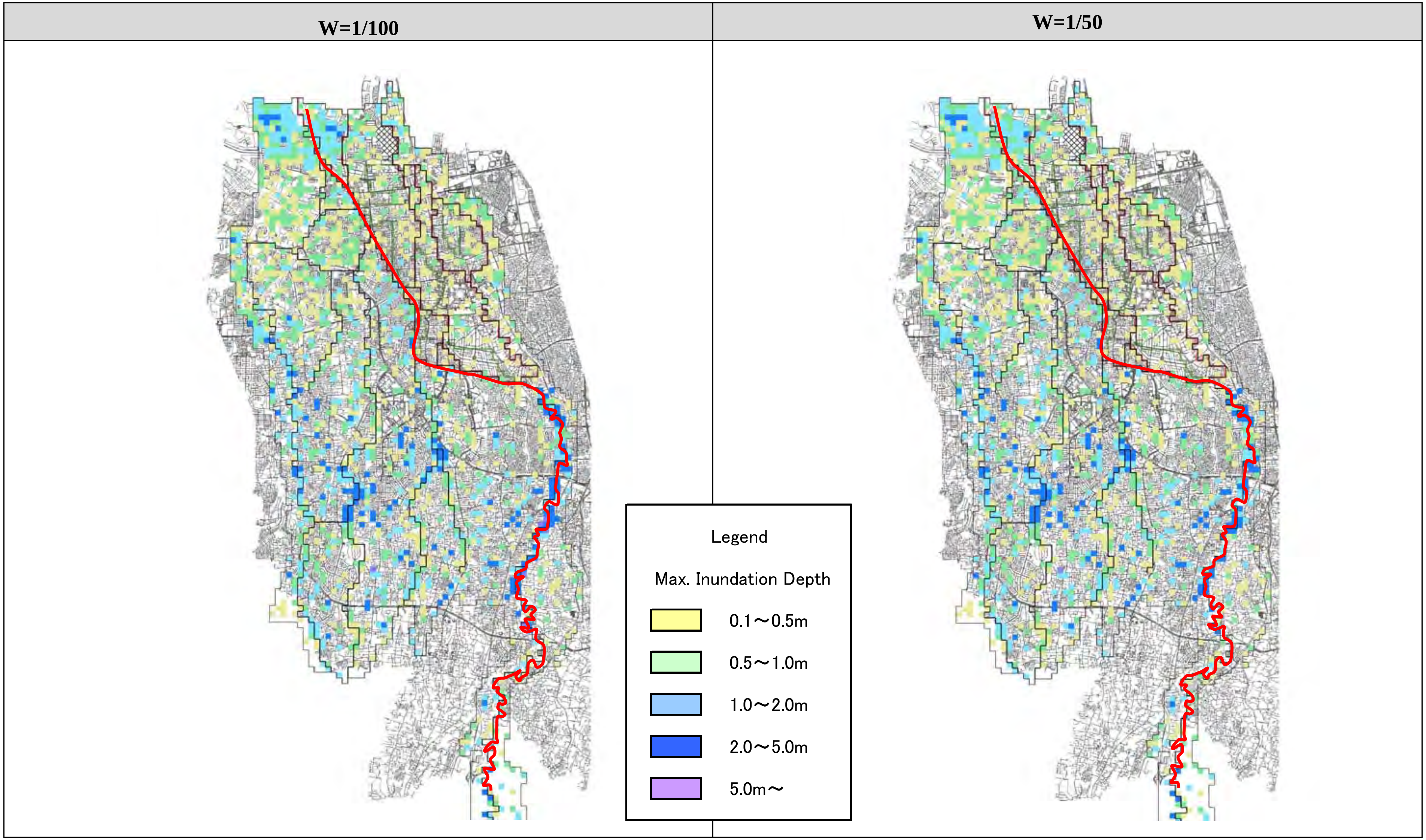


Figure 4.3-3 Inundation Area Map with Different Return Period (Left Map: W=1/100, Right Map: W=1/50, Current River Condition, Current Land Use)

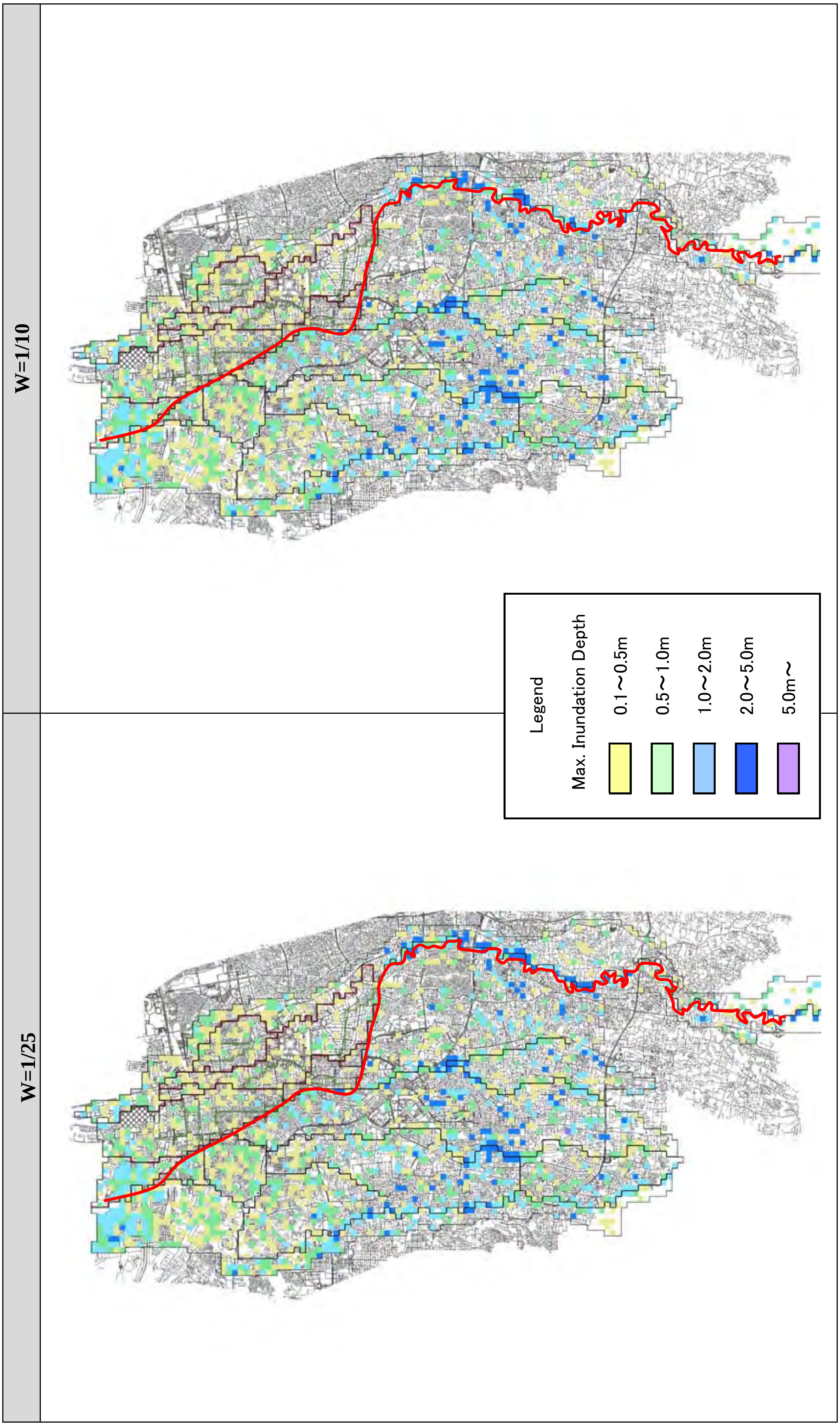


Figure 4.3-4 Inundation Area Map with Different Return Period (Left Map: W=1/25, Right Map: W=1/10, Current River Condition, Current Land Use)

W=1/5	

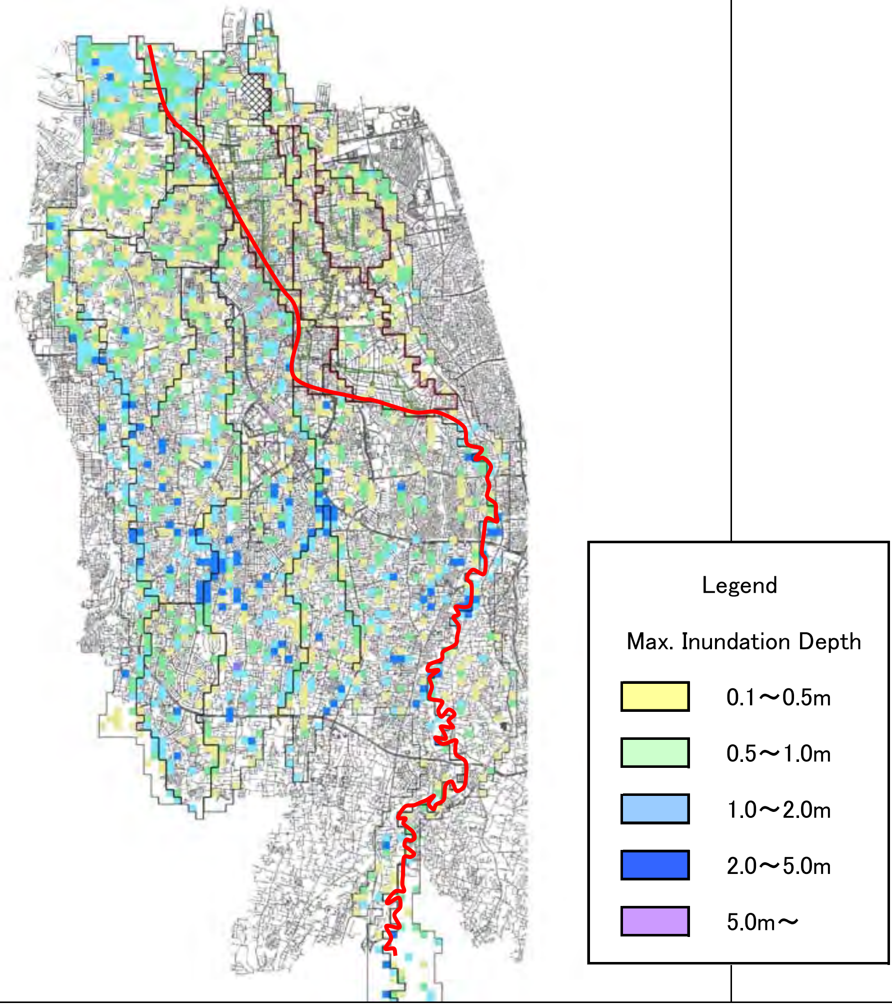
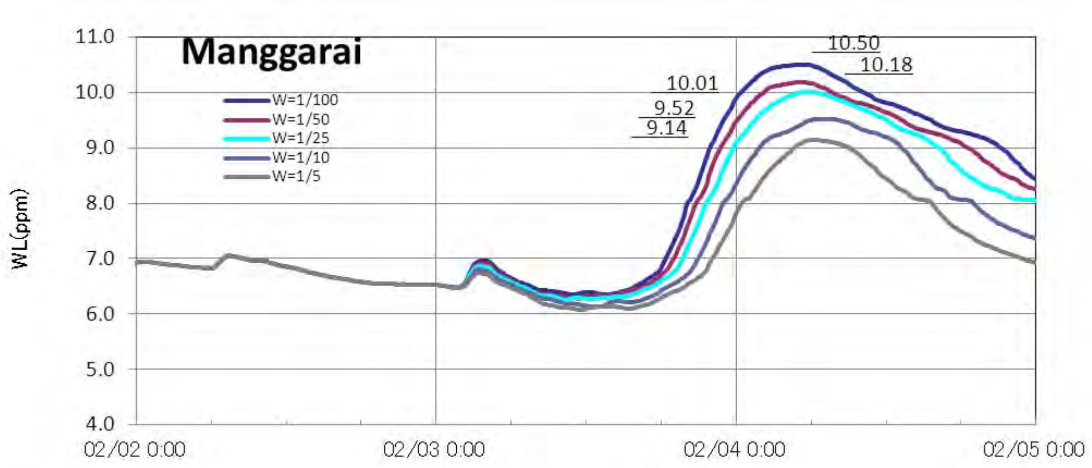


Figure 4.3-5 Inundation Area Map with Different Return Period (Left Map: W=1/5, Current River Condition, Current Land Use)

(2) Current River Condition, Future Land Use

1) River Water Level



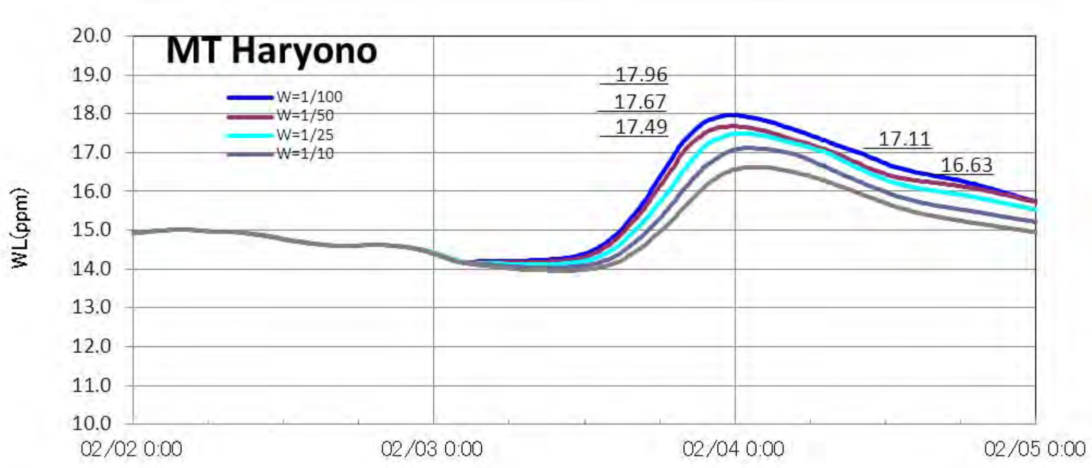


Figure 4.3-6 River Water Level Hydro with Different Design Discharge (Current River Condition, Future Land Use)

2) Inundation Condition

The results of flood inundation analysis with current land use are shown in Figure 4.3-7 to Figure 4.3-9.

The inundation areas along the Ciliwung river are limited in the riverside without expansion to the lowland areas.

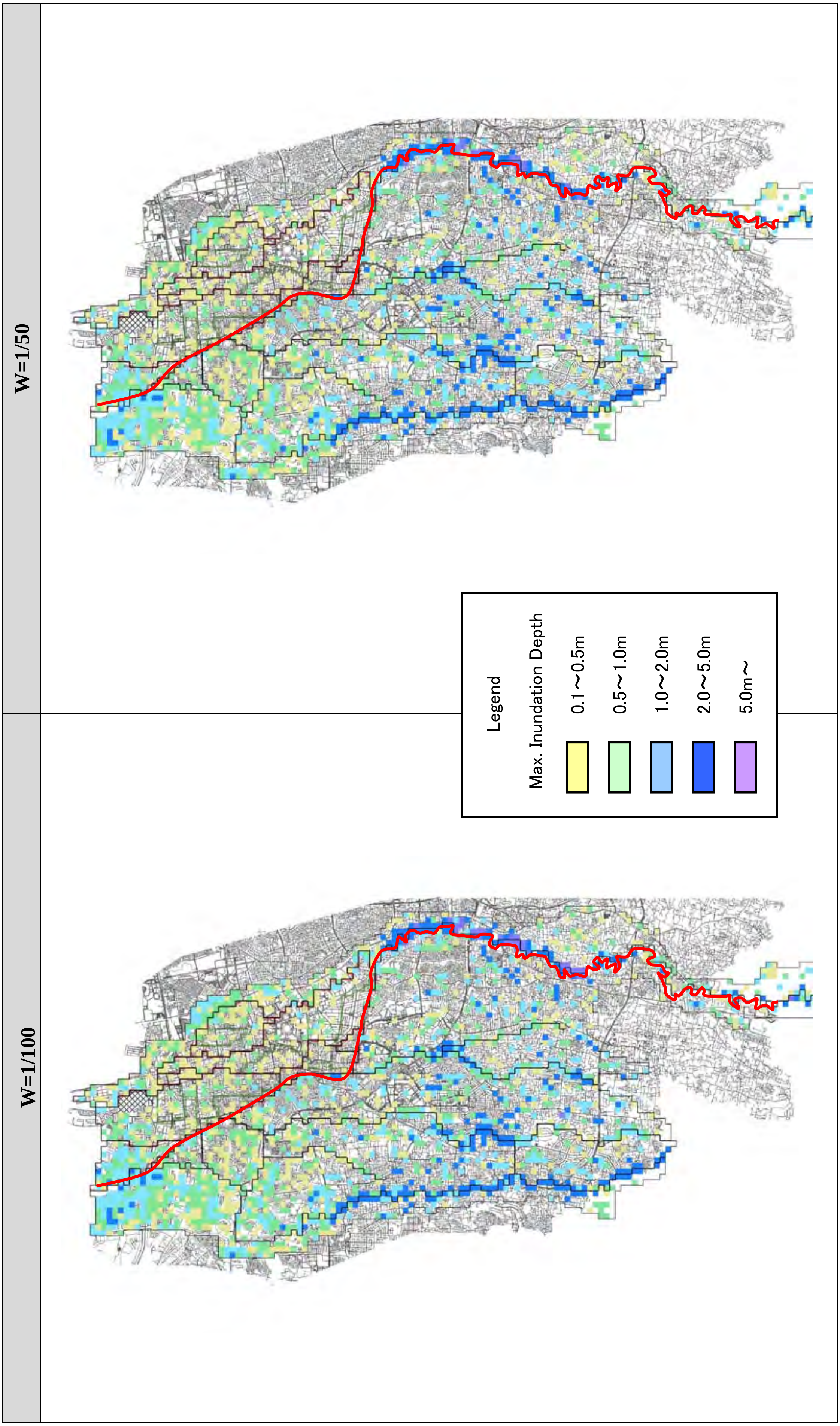


Figure 4.3-7 Inundation Area Map with Different Return Period (Left Map: W=1/100, Right Map: W=1/50, Current River Condition, Future Land Use)

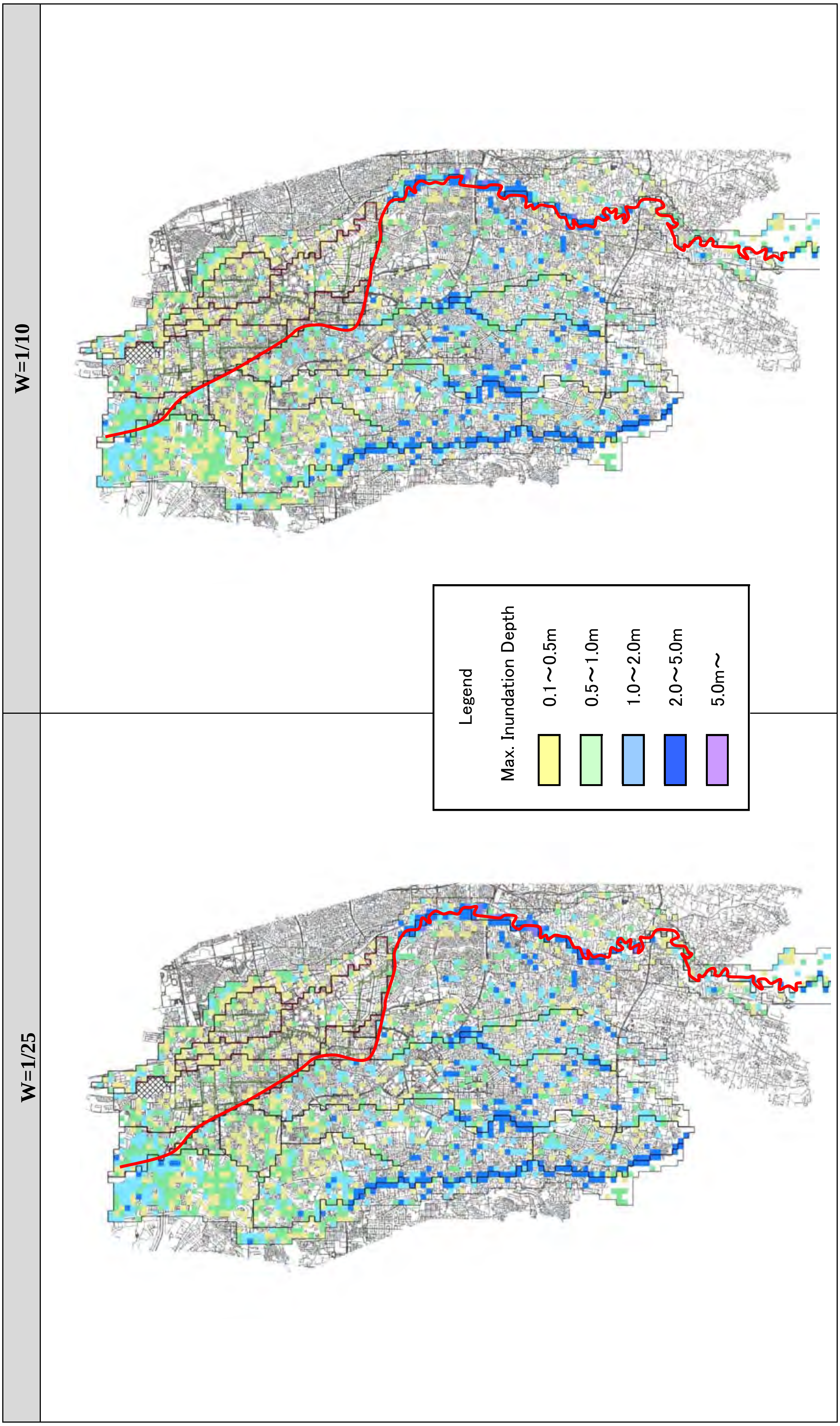


Figure 4.3-8 Inundation Area Map with Different Return Period (Left Map: W=1/25, Right Map: W=1/10, Current River Condition, Future Land Use)

W=1/5	

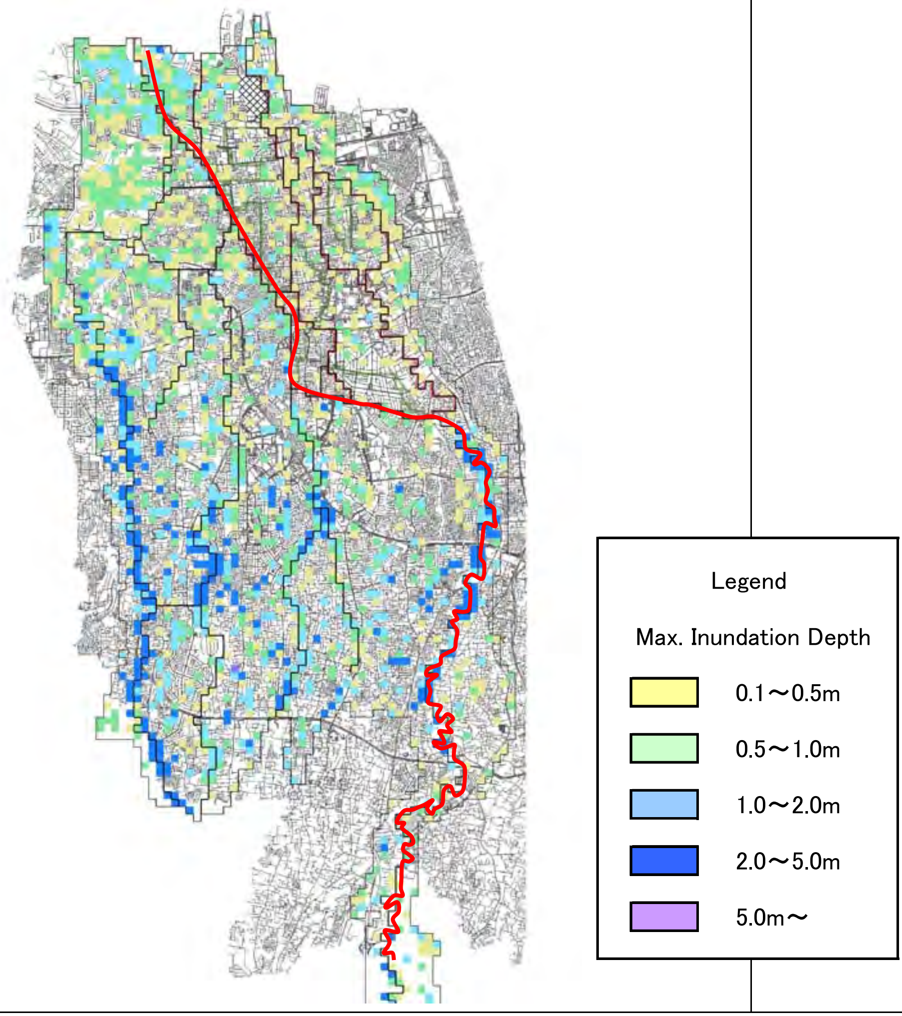
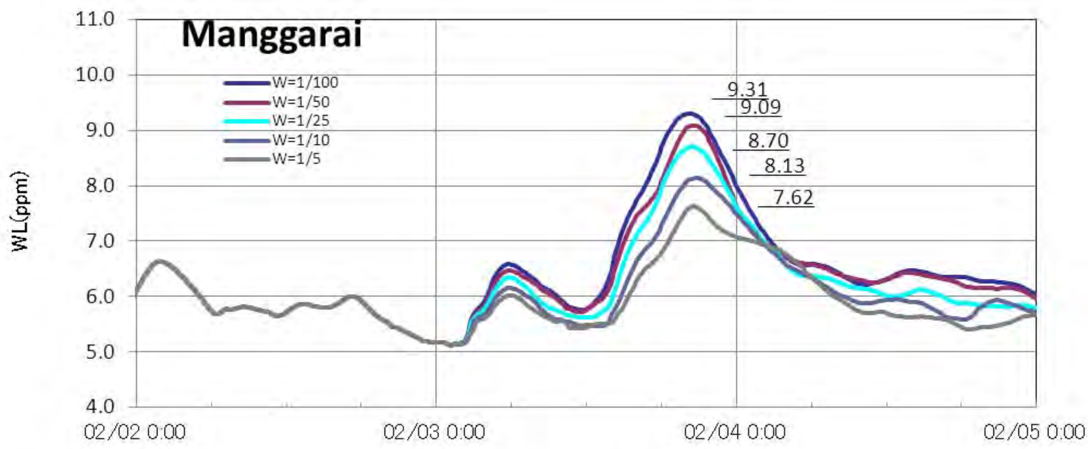


Figure 4.3-9 Inundation Area Map with Different Return Period (Left Map: W=1/5, Current River Condition, Future Land Use)

(3) After River Improvement, Current Land Use

1) River Water Level



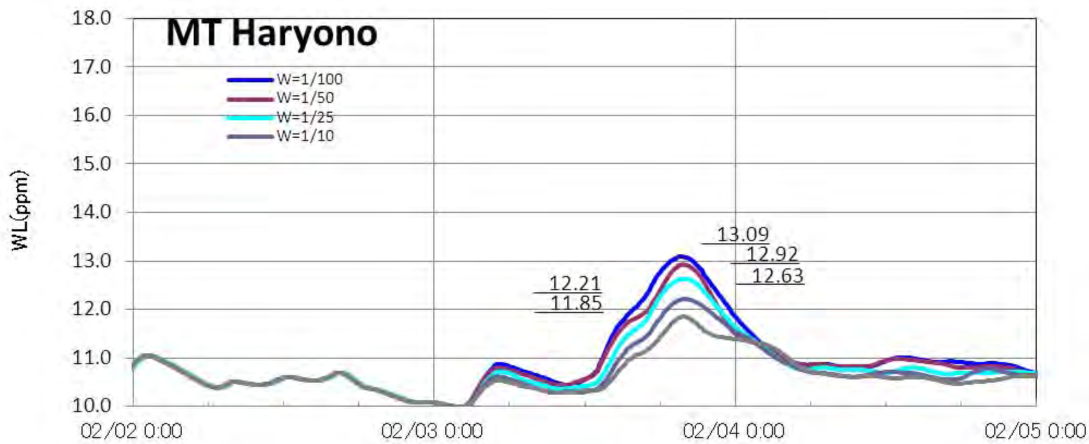


Figure 4.3-10 River Water Level Hydro with Different Design Discharge (After River Improvement, Current Land Use)

2) Inundation Condition

The results of flood inundation analysis with current land use are shown in Figure 4.3-11 to Figure 4.3-13.

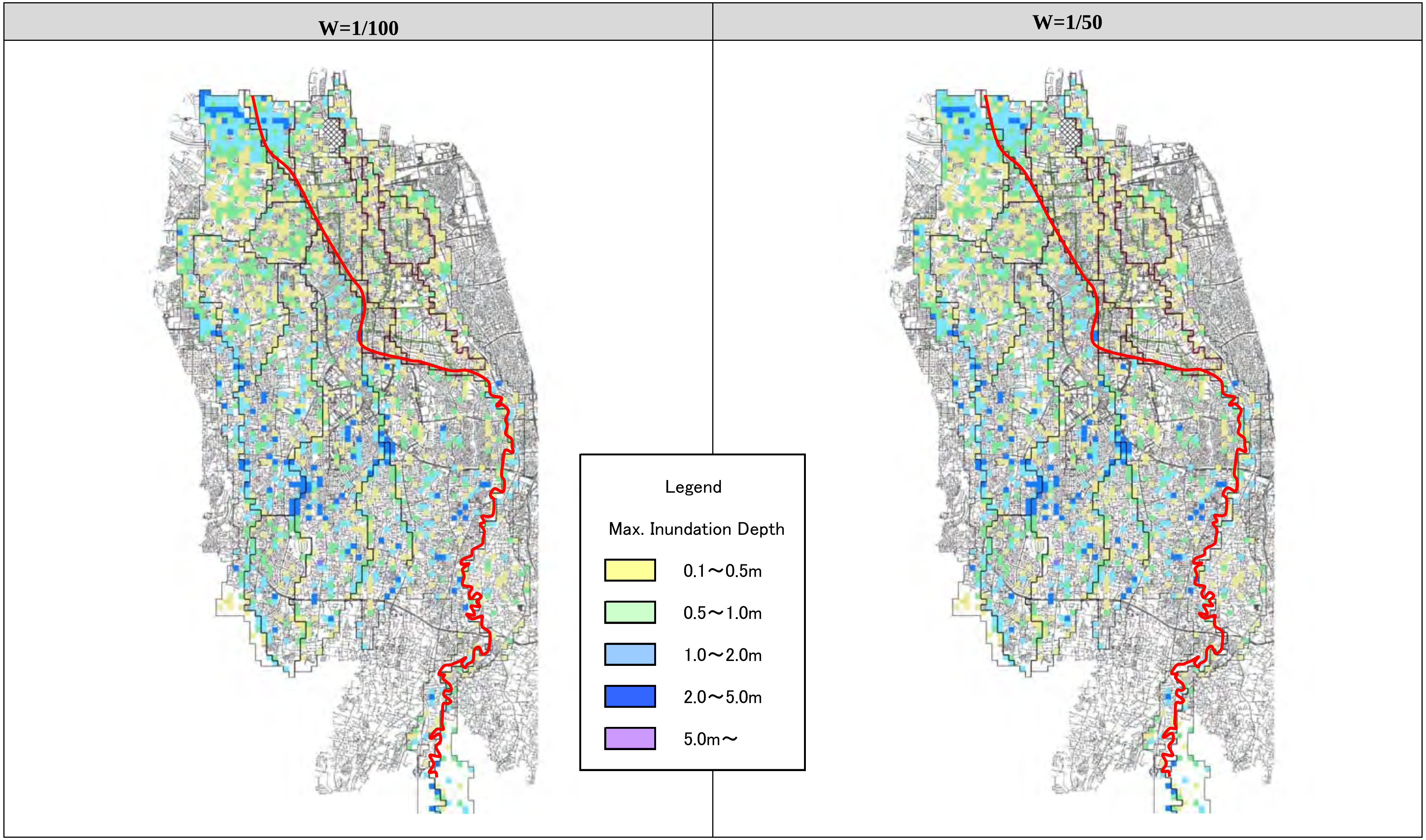


Figure 4.3-11 Inundation Area Map with Different Return Period (Left Map: W=1/100, Right Map: W=1/50, After River Improvement, Current Land Use)

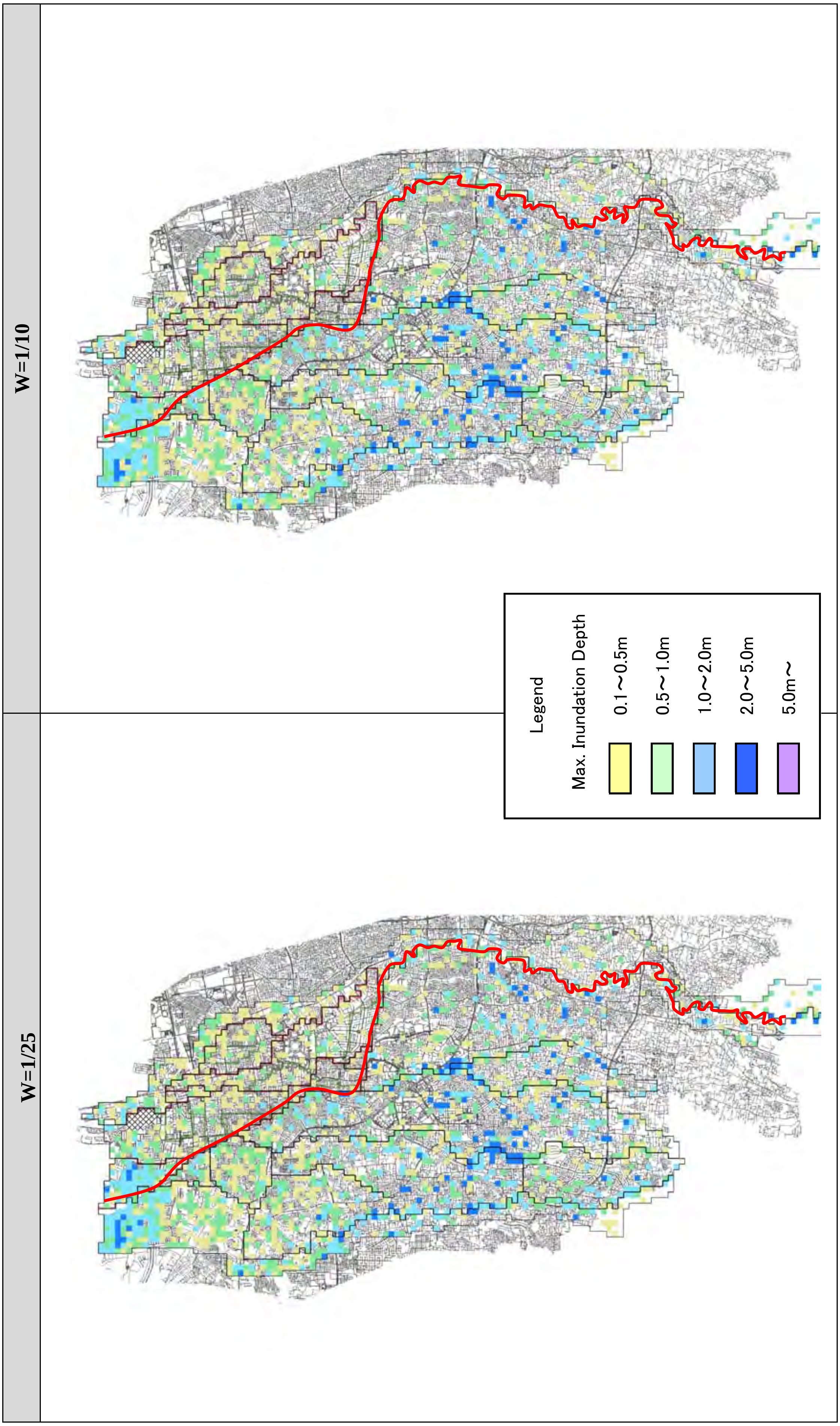


Figure 4.3-12 Inundation Area Map with Different Return Period (Left Map: W=1/25, Right Map: W=1/10, After River Improvement, Current Land Use)

W=1/5	

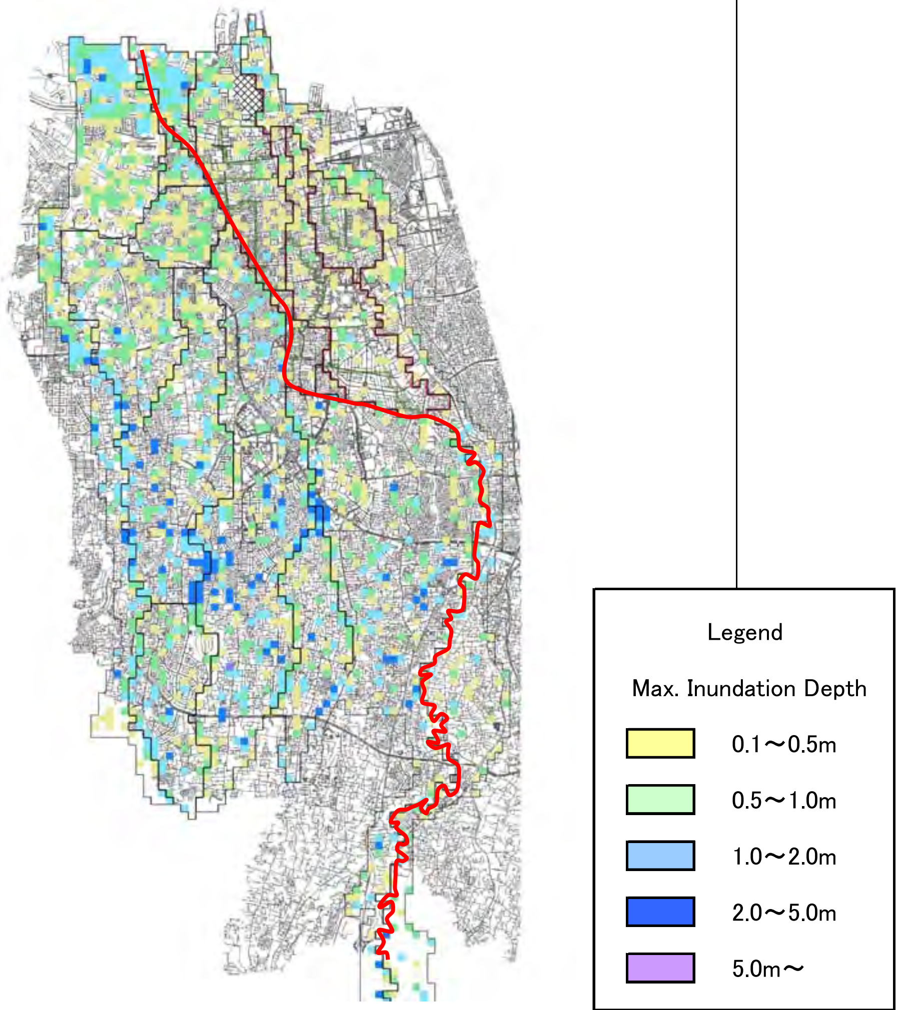
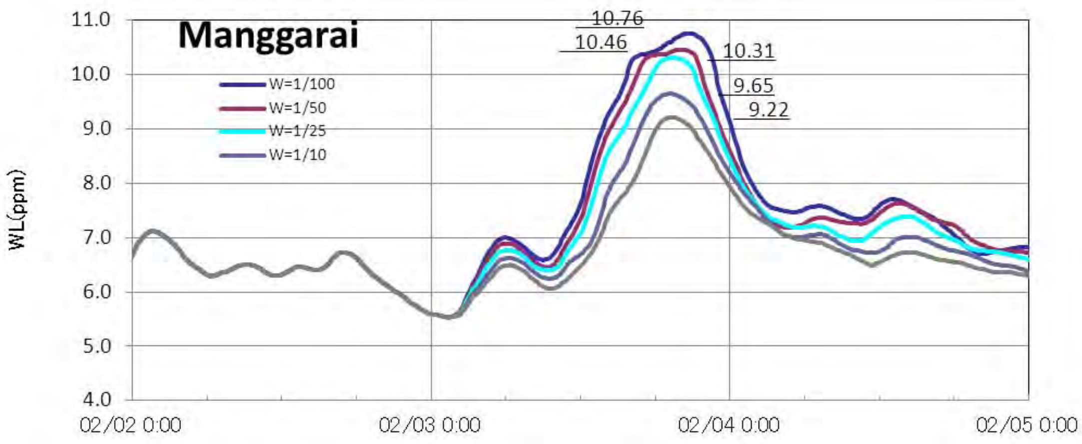


Figure 4.3-13 Inundation Area Map with Different Return Period (Left Map: W=1/5, After River Improvement, Current Land Use)

(4) After River Improvement, Future Land Use

1) River Water Level



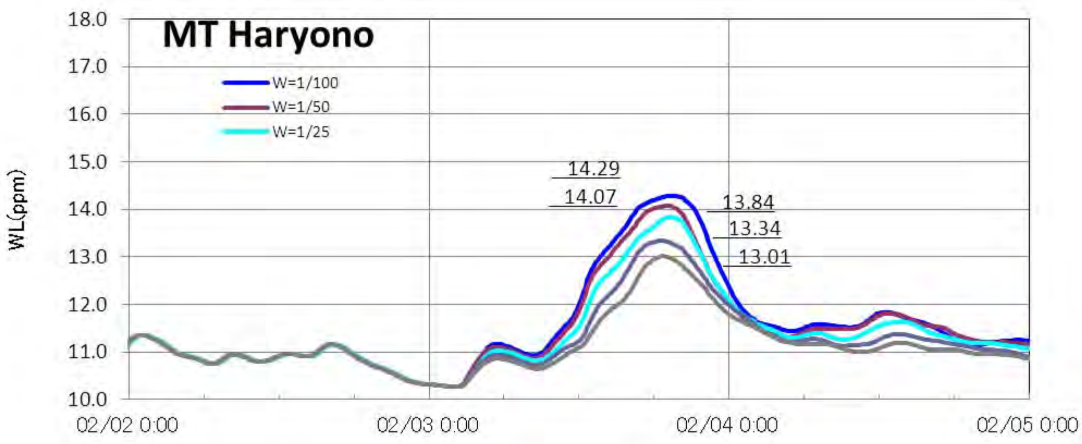


Figure 4.3-14 River Water Level Hydro with Different Design Discharge (After River Improvement, Future Land Use)

2) Inundation Condition

The results of flood inundation analysis with current land use are shown in Figure 4.3-15 to Figure 4.3-17.

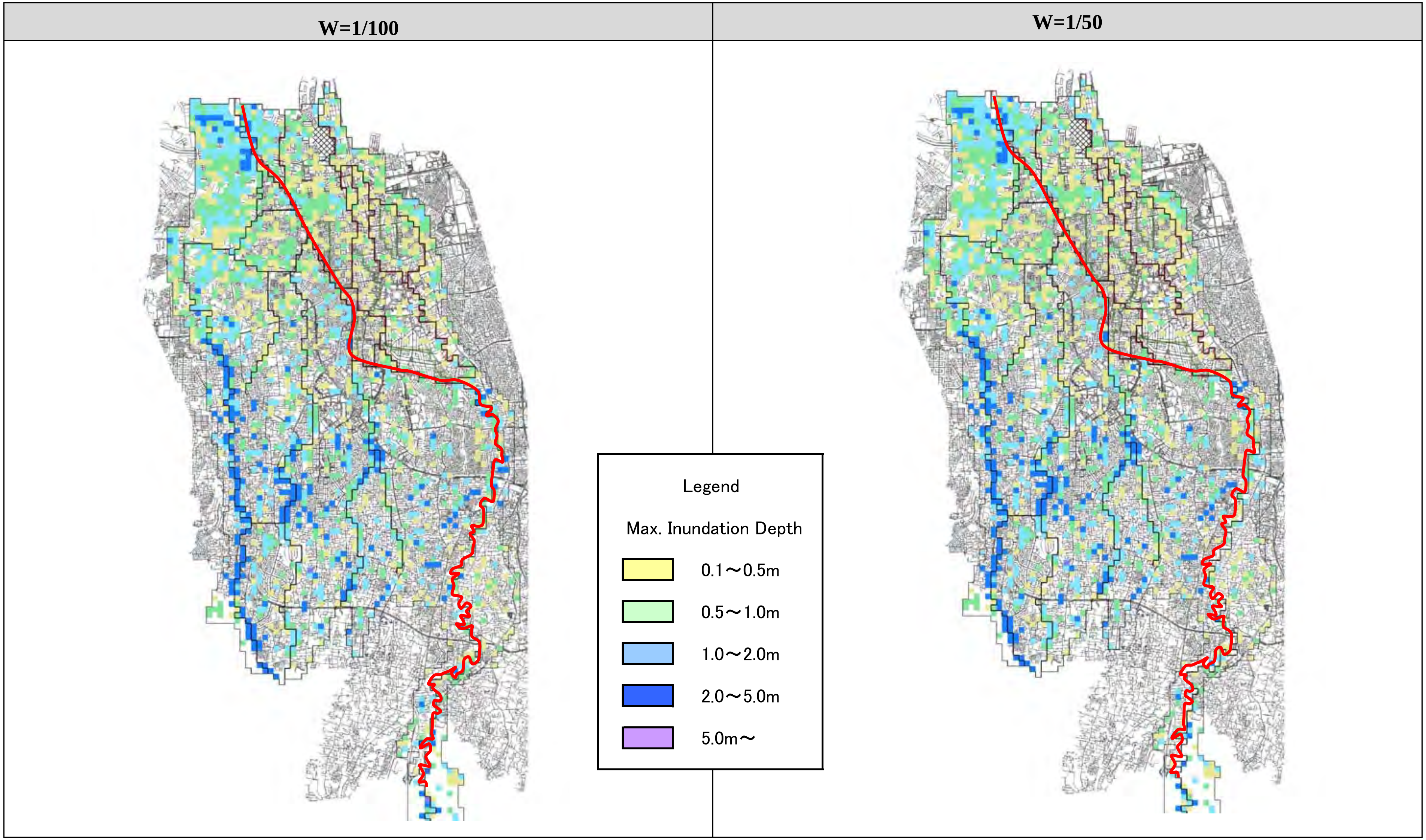


Figure 4.3-15 Inundation Area Map with Different Return Period (Left Map: W=1/100, Right Map: W=1/50, After River Improvement, Future Land Use)

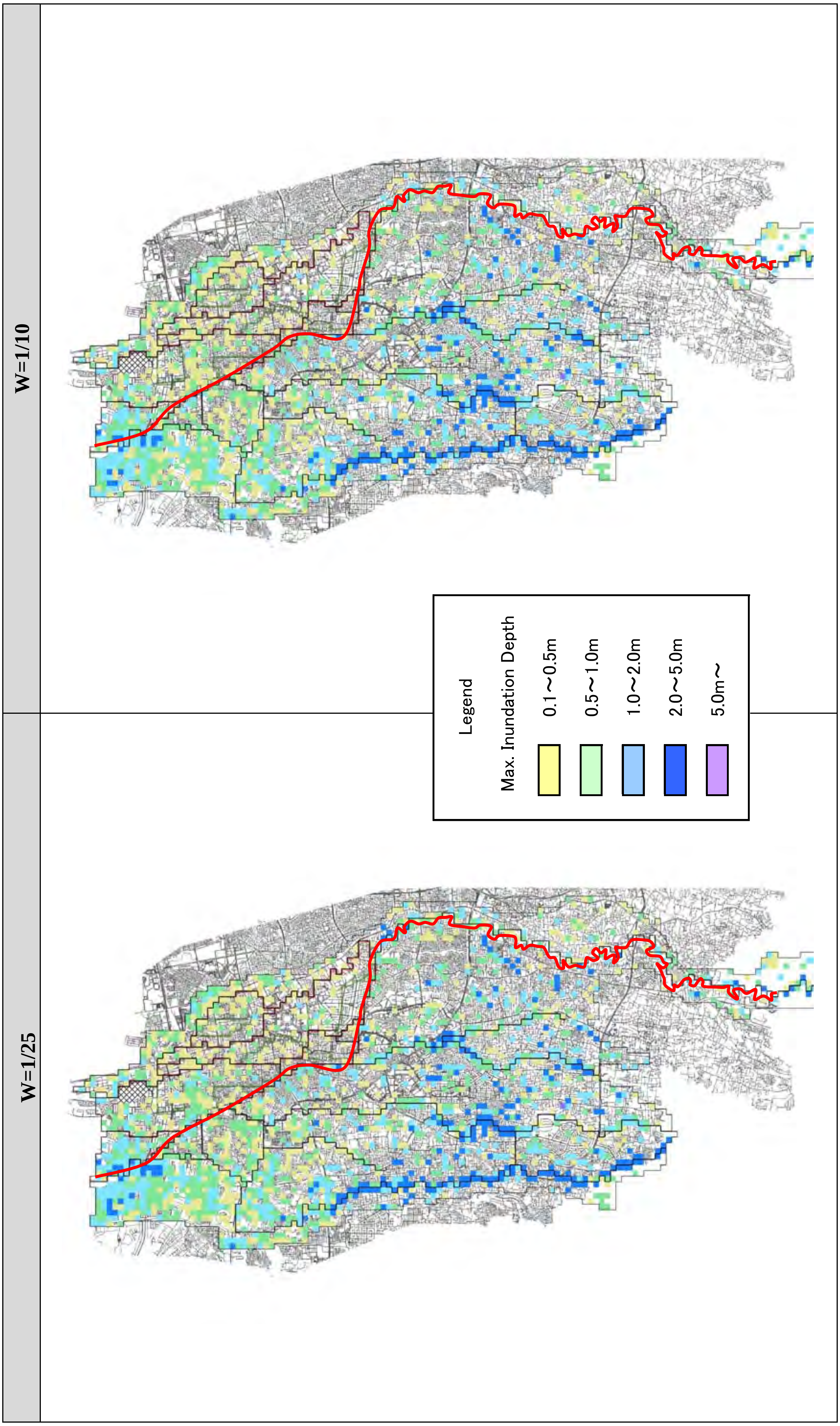


Figure 4.3-16 Inundation Area Map with Different Return Period (Left Map: W=1/25, Right Map: W=1/10, After River Improvement, Future Land Use)

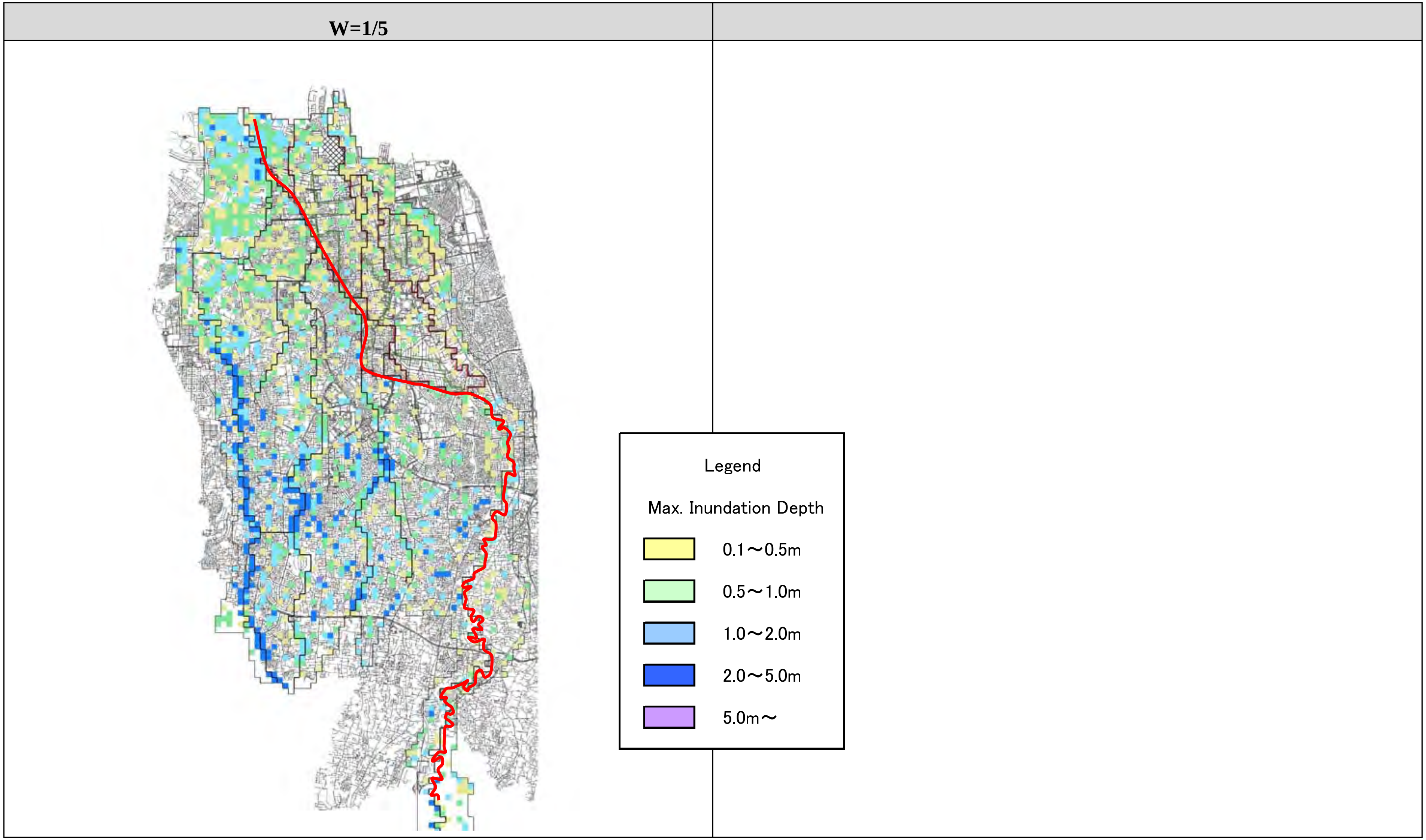


Figure 4.3-17 Inundation Area Map with Different Return Period (Left Map: W=1/5, After River Improvement, Future Land Use)