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APPENDIX [illegible]

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JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF CONSTRUCTION

GOVERNMENT OF THE REPUBLIC OF KOREA

SURVEY REPORT
ON
THE LONG-TERM MULTIPURPOSE DAM SCHEMES

(FIRST STAGE)

APPENDIX I HYDROLOGY
HYDRO POWER
IRRIGATION
FLOOD CONTROL

JUNE 1978

JAPAN INTERNATIONAL COOPERATION AGENCY

SURVEY REPORT

ON

THE LONG-TERM MULTIPURPOSE DAM SCHEMES

Appendix 1

CONTENTS

1. HYDROLOGY

1. HYDROLOGY

1.1 Foreward

Precipitation in the Republic of Korea concentrates almost entirely in the summer and approximately 70% of the annual precipitation occurs in the 4-month period from June through September. Besides the distinct seasonal unbalance of rainfall in a year, the annual precipitation in a wet year is more than 5 times that of a dry year. Floods are brought by monsoon and typhoons, usually monsoon rain produces bigger flood.

The annual precipitation for all of the Republic of Korea is about 1,200mm on an average. According to the annual averaged isohyetal maps during a period of 1963 through 1972 shown in the Hydrologic Annual Report, the regional distribution of rainfall is as described below.

The areas where precipitation is comparatively large are the upper part of the Han River and the upper part of the Nam River, the southern tributary of the Nagdong River, at 1,300 to 1,500 mm, whereas, the upper part of the Nagdong River mainstream, the southern part of the South Han River, and the eastern side of the upper part of the Geum River have annual precipitation of 1,000 to 1,200 mm, less than the average over the country.

Regarding the condition of the catchment area of project sites in terms of forestation, it cannot be said that vegetation is very thick as a whole with the exception of the upstream part of the Han River, while the topographies are generally those of basins surrounded by relatively low mountains between which gentle gradient rivers flow down meandering in complex patterns. In addition, cultivated lands have developed in the mountaineous region so that it may be considered that evapotranspiration from paddies and fields is comparatively high and coefficients of runoff are relatively low between 50 to 60%.

The present hydrologic study was made referring to these rainfall data and basin conditions, and examining the existing data of numerous investigations given in "Report of Potential Hydro Power in Korea", "Report on Comprehensive Survey of Rivers in Korea" and others. The necessary hydrologic data for planning, namely, inflows at project sites, design flood discharges and flood hydrographs were calculated.

In making this study, since the principal objectives of the investigation were comparison studies of project sites and selection of the economic order of priority, special consideration was given that there would not be contradictions or lack of uniformity between the project sites.

1.2 State of Hydrologic Observations

Rain gaging stations are provided at one to several places in the catchment area of the project site and observations including those at automatic water gaging stations have been continued for a relatively long period of time. There are also gaging stations in the vicinities of practically all of the project sites. However, the gaging stations are mainly for measuring water levels, and especially at upstream parts of rivers, discharge observations are generally not being made.

The results of these observations are given in whole in Hydrologic Data in Korea and Hydrologic Annual Report in Korea.

1.3 Inflows at Project Sites

1.3.1 Principle of Examination

Of the runoff data obtained for the project sites in the present study, those which were available for all of the sites were the monthly inflow data by project site for the 10-year period of 1963 through 1972 given in Report of Potential Hydro Power in Korea.

The annual average precipitations for the same period as that of the annual average specific runoffs were compared, and studies were carried out taking into account the coefficients of runoff and basin conditions during this period, in addition to which other runoff data were used as reference.

The precipitations used in the study were the average values obtained by reading the rainfall amounts of the various sites outlining the appropriate catchment areas on the annual isohyetal maps (1963 - 1972) given in the Hydrologic Annual Report in Korea.

1.3.2 Contents of Examinations

As indicated in Table 1.3.1, when examinations were made in accordance with the above method, it was considered that modifications would be required to some extent for 13 sites, or approximately one half of the project sites. The reasons are described briefly below.

(1) The runoff standard gaging station of Bamseonggol is Hwacheon in the Report of Potential Hydro-Power, but the catchment area of the Hwacheon site is 4,145 km^2 and approximately 7 times the 582.7 km^2 of the catchment area of Bamseonggol. It would be thought generally the specific runoff of the Bamseonggol site with the smaller catchment area could well be larger.

The Bamseonggol site when compared with the Weolhak site is at the same longitude and only about 30 km apart in the direction of latitude, and since it was thought the basin conditions could not be especially different, it was considered that adopting the Inje standard gaging station runoff for the Weolhak group would be closer to actual.

(2) As a result of examination of part of the figures in the Report of Potential Hydro-Power, the standard gaging station runoff of Inje was modified.

(3) A modification was made for Weolhak as rainfall there is less than for the Inje group.

(4) The coefficient of runoff for the Inje group is slightly high compared with other sites, but this is not contradictory as topography is more of a valley-shape compared with others.

(5) Comparing the Hongcheon and Ganhyeon sites, both the catchment areas and rainfall amounts are similar, and since their rivers are adjacent and flow down in roughly the same directions, and in consideration of the relations with rainfall amounts and specific runoffs of other sites, the Ganhyeon standard gaging station runoff was applied in this case.

(6) Since not great difference could be seen in particular when comparing precipitations and specific runoffs of the Dalcheon standard gaging station and other neighboring sites, the figures given in the

Report of Potential Hydro-Power were adopted without alteration.

(7) The coefficient of runoff calculated in this study for Gujeol (Dogam) is high compared with that of the adjacent Pyeongchang group. Since there is no reason which can be seen for the coefficient of runoff to be high, the coefficient of runoff of Gujeol was modified based on the rainfall ratio with Pyeongchang.

(8) Bonghwa, when compared with Imha, shows almost no difference either in rainfall or catchment area, and therefore, it was decided that in this study unification would be made with the reference runoff of Imha.

(9) The runoff of Chibo in the Report of Potential Hydro-Power uses downstream Ilseongyo with a catchment area more than double as the standard gaging station and it is thought that the runoff smaller than actual has been calculated. Therefore, for this study the runoff at the Imha site was employed for the catchment areas of Bonghwa, Imha and Andong, and the Ilseongyo standard gaging runoff was adopted only for the remaining catchment area. The specific runoff for this site was synthesized from the catchment area ratio.

(10) For the Dogsan site the runoff of standard gaging station at Sancheong was used without alteration while for Hamyang a modification was made by rainfall ratio based on Dogsan.

(11) For Yongdam, Sutong and Myeongcheon in the Geum River catchment area, the standard gaging station runoffs for Yongdam, Sutong and Daecheung, respectively, in the Report of Potential Hydro-Power were used without alteration. However, with regard to Simcheon, even considering that it is near the upstream area of the Nagdong River and rainfall tends to decrease gradually in that direction, the figure for the standard gaging runoff in the Report of Potential Hydro-Power is extremely small. Considered from the conditions of the catchment area there are no factors recognizable to lessen the runoff coefficient compared with the Geum River mainstream and a modification was made by rainfall ratio so that the runoff coefficients would become roughly equal.

(12) For Jeokseong, since there were little data and adequate exami-

nations could not be made, the standard gaging runoff in the Report of Potential Hydro-Power was used without alteration.

(13) For Juam, a modification was made using a figure estimated based on the records of existing Boseonggang.

1.4 Design Flood Discharge

1.4.1 Existing Data

The design flood discharges of the sites subjected to comparison studies here have all been calculated in the Report of Potential Hydro-Power and other reports. These figures are indicated in Table 1-4-1. The data were divided into specific runoffs and catchment areas which were entered in a Creager's curve diagram and the data were compared on the diagram mainly by the C-value of the Creager Curve formula (Fig. 1-4-1).

1.4.2 Comparison Studies

On studying Fig. 1-4-1, the C-values for 100 years and 200 years return period discharge specific runoffs in the Report of Potential Hydro-Power are shown to be roughly between C = 47.5 and C = 65. Since C-value has conventionally been taken to be between 30 and 100 in the Creager formula, the range of the above figures falls between 25% and 50% of the conventional 30 - 100 range.

However, the C-values of Namgang, Soyanggang, Daecheong and others recently completed or under construction are about between 86 and 100 (range 80% - 100%), while in figures given in the Report of Potential Hydro-Power there are some questions such as that specific runoffs are greater at the Geum River thought to have less rainfall than at sites of the North Han River system thought to have relatively more rainfall.

Regarding the latter, examinations of rainfall characteristics by region were made from rainfall gaging stations data of 1-day maximum and 2-day maximum rainfalls which directly affect discharge. The results are given in Table 1-4-2-1, and summarizing the table, the following classifications can roughly be made based on quantity of peak rainfall.

Regions with relatively large discharge peaks:

North Han River catchment area with Ganhyeon included, and Dogsan catchment area.

Regions considered to have ordinary discharge peaks:

South Han River catchment area excepting Ganhyeon and Dalcheon, and catchment area from Seumjin River to Hamyang.

Regions considered to have relatively small discharge peaks:

Nagdong River upstream area to adjacent Geum River and South Han River south tributary Dalcheon catchment area.

The design flood discharges as a result of the present study were calculated employing the Creager formula, and based on the above classifications and the beforementioned existing C-values. In effect, C-value for sites in regions of relatively large discharge peaks was taken to be 100, C-value for sites in regions of small discharge peaks was taken to be 86, and C-value for sites in intermediate regions was taken to be 93, and the respective calculations were made. The results are as given in Table 1-4-2-2.

These values are roughly equal to the 200 years return period discharges of floods of Namgang, Soyanggang and Daecheong used as references, and therefore, may be said to correspond to 200 years return period discharges.

1.5 Examinations of Flood Hydrograph

In examination of flood hydrograph, those of 14 sites including present project sites and neighboring locations for which calculations had already been made were analyzed for discharge-time coefficients utilizing the techniques of the Nakayasu unit diagram.

The types of discharge time were classified from the discharge-time coefficients analyzed, and 4 forms of models were prepared.

The various project sites were classified according to type of model taking into account catchment area conditions (shape, catchment area size, average gradient of main river channel, forestration, stratigraphy, etc.) and past rainfall, and the discharge-time coefficient of each model was

calculated.

These discharge times were combined with the design flood discharges calculated in the preceding subsection to prepare simplified flood hydrograph, and flood discharge volumes were calculated from these hydrograph.

Discharge times and flood discharge volumes are indicated in Table 1-5, and simplified flood hydrograph in Fig. 1-5.

As an added note the symbols used in Table 1-5 are the following:

L : length of river channel (km)

$t_g = 0.4 + 0.058\ L$: time from rainfall peak to discharge peak, i.e., lag in discharge

T_1 : time until discharge reaches peak

T_2 : time from discharge peak until decrease to 30% of maximum design flood discharge, i.e., surface runoff time

T_3 : time from discharge 30% of maximum design flood discharge until decrease to 9%, i.e., intermediate flow time

T_4 : time from discharge 9% of maximum design flood discharge until end, i.e., base-flow time

Q_{max} : maximum design flood discharge (m^3/sec)

$a = T_1/t_g$: discharge-time coefficient of T_1

$e = T_2/t_g$: discharge-time coefficient of T_2

$c = T_3/t_g$: discharge-time coefficient of T_3

$d = T_4/t_g$: discharge-time coefficient of T_4

TABLE 1-3-1 INFLOW AT ALL PROJECT SITES UNDER PLANNING

RIVER NAME	SITE NAME	CATCHMENT AREA (km^2)	PRECIPITATION 1963-1972 YEAR MEAN: ANNUAL (mm)	PRECIPITATION: DITTO CONVERTED SPECIFIC DISCHARGE ($m^3/sec/km^2$)	EXISTING DATA — REPORT OF POTENTIAL HYDRO-ELECTRICITY IN KOREA 1963 - 1972 YEAR MEAN: DATUM STATION	ANNUAL MEAN INFLOW (m^3/sec)	DITTO SPECIFIC INFLOW ($m^3/sec/km^2$)	DRAINAGE RATIO (%)	EXISTING DATA — OTHER REPORT: ANNUAL MEAN INFLOW (m^3/sec)	DITTO SPECIFIC INFLOW ($m^3/sec/km^2$)	ORIGINAL REPORT	ADJUSTED INFLOW: DATUM STATION	SPECIFIC INFLOW ($m^3/sec/km^2$)	DRAINAGE RATIO (%)	ANNUAL MEAN INFLOW (m^3/sec)
Han River															
	Bamseonggol (upp.)	582.7											0.0286	67	16.7
1-32	" (down)	593.0	1,350	0.0428	Hwacheon	14.8	0.0249	58					0.0286	67	17.0
	Hupyeong (upp.)	305.0											0.0286	66	8.7
	" ( )	351.9											0.0286	66	10.1
2-23	" (down)	576.2	1,360	0.0431	Inje	17.6	0.0303	70	(1922-1940) 15.03 (CA=592)	0.0254	Inje Report	Inje	0.0286	66	16.5
	Inje (upp.)	1,043.3											0.0286	67	29.8
3-22	" (down)	1,059.2	1,340	0.0425		32.4	0.0303	71	(1916-1938) 22.6	0.0210			0.0286	67	30.3
4-30	Weolhak	563.4	1,280	0.0406		17.2	0.0303	75					0.0280	69	15.8
5-A3	Hongcheon	1,473.0	1,430	0.0453	Hongcheon	47.4	0.0322	71	(1917-1940) 34.7	0.0236	Han River Basin Survey Report	Ganhyeon	0.0287	63	42.3
11-A1	Dalcheon	1,348.0	1,220	0.0387	Dalcheon	33.4	0.0248	64	(1917-1940) 33.5	0.0249		Dalcheon	0.0248	64	33.4
12-A2	Ganhyeon	1,180.0	1,420	0.0450	Ganhyeon	33.9	0.0287	64	(1917-1940) 29.4	0.0249	Ditto	Ganhyeon	0.0287	64	33.9
6-3	Gujeol	225.2	1,210	0.0384	Jeungseun	6.2	0.0276	72			Ditto	Jeungseun	0.0264	62	
	(Dogam)	100.8											0.0264	62	2.7
7-9	Pyeongchang	485.3	1,330	0.0422		13.0	0.0267	63					0.0267	63	13.0
8-10	Panun	651.9	1,320	0.0419	Pyengchang	17.4	0.0267	64					0.0267	64	17.4
9-13	Suiu	328.9	1,440	0.0457		3.8	0.0267	58				Pyengchang	0.0277	61	9.1
10-12	Dogog	492.6	1,420	0.0450		13.2	0.0267	59					0.0277	62	13.7
Nagdong River															
13-35	Bonhwa	1,105.0	1,020	0.0323	Andong	17.7	0.0160	50	18.97	0.0172	Bonhwa Report	Imha	0.0188	58	20.8
14-43	Imha	1,230.0	1,040	0.0330	Imha	23.1	0.0188	57	22.1	0.0190	Nagdong River Basin Survey Report		0.0188	57	23.1
15-36	Chibo	4,550.0	1,040	0.0330	Ilseungyo	64.2	0.0141	43			Ditto	Ilseungyo only	0.0170	50	77.4
	Hamyang (upp.)	264.0											0.0302	68	8.0
16-51	" (down)	367.3	1,400	0.0444	Sangcheung	11.5	0.0317	71	10.1	0.0275	Ditto	Sangcheong	0.0302	68	11.1
17-53	Dogsan	231.0	1,550	0.0492		7.3	0.0317	64	9.3	0.0403	Ditto		0.0317	64	7.3
Geum River															
18-62	Yongdam	949.0	1,340	0.0431	Yongdam	24.0	0.0256	59	(1958-1972) 25.0	0.0267	Geum River Basin Survey Rep.	Yongdam	0.0256	59	24.3
19-63	Sutong	1,526.0	1,310	0.0415	Stong	37.2	0.0244	59	(1958-1972) 39.1	0.0256	Ditto	Stong	0.0244	59	37.2
20-64	Myeongcheon	2,003.0	1,260	0.0400	Daecheong	47.7	0.0238	60	(1958-1972) 42.3	0.0211	Ditto	Daecheong	0.0238	60	47.7
21-69	Simcheon	640.3	1,160	0.0368	Simcheon	10.9	0.0170	46			Ditto	Simcheon	0.0229	62	14.7
Seumjin River															
22-77	Jeokseong	1,004.0 (241.0)	1,390	0.0441	Jeokseong	2.5	0.0246	56				Jeokseong	0.0246	56	5.9
23-82	Juam	1,010.0 (735.0)	1,410	0.0447	Juam	32.2	0.0319	71				Juam	0.0306	68	27.8
24-	No.2 Boseonggang	457.0 (182.0)											0.0306	68	11.4

Remarks; ( ): residuary catchment area.

TABLE 1-4-1 EXISTING DATA OF DESIGN FLOOD

RIVER NAME	SITE NAME	CATCHMENT AREA (km^2)	DESIGN FLOOD BY REPORT OF POTENTIAL HYDRO-ELECTRICITY IN KOREA: 100-YEAR RETURN PERIOD (m^3/sec)	SPECIFIC FLOOD (m^3/s/km^2)	200-YEAR RETURN PERIOD (m^3/sec)	SPECIFIC FLOOD (m^3/s/km^2)	DESIGN FLOOD BY OTHER REPORTS: CATCHMENT AREA (km^2)	DESIGN FLOOD (m^3/sec)	SPECIFIC FLOOD (m^3/s/km^2)	REMARK
Han River										
1-32	Bamseonggol	593.0	2,720	4.59	3,100	5.23				
2-23	Hupyeong	576.2	2,700	4.69	3,060	5.31	592.0	(200Y.R.P) 2,730	4.61	Hupyeong Report
3-22	Inje	1,059.2	4,000	3.78	4,480	4.23	1,076.2	2,976	2.77	Inje Report
4-30	Weolhak	563.4	2,700	4.79	3,040	5.40				
5-A3	Hongcheon	1,473.0					1,473.0	13,700	9.30	Hau River Basin Survey Report
11-A1	Dalcheon	1,348.0					1,348.0	13,000	9.64	"
12-A2	Ganhyeon	1,180.0					1,180.0	12,000	10.17	"
6-3	Gujeol	225.2	1,420	6.31	1,630	7.24				
7-9	Pyengchang	485.3	2,350	4.74	2,700	5.56				
8-10	Panun	651.9	2,900	4.45	3,280	5.03				
9-13	Suju	328.9	1,860	5.66	2,100	6.38				
10-12	Dogog	492.6	2,420	4.91	2,700	5.48				
Nagdong River										
13-35	Bonhwa	1,105.0	3,498	3.17	3,909	3.54	1,105.0	4,300	3.89	Bonhwa Report
14-43	Imha	1,230.0	3,730	3.03	4,168	3.39				
15-36	Chibo	4,550.0	7,920	1.74	8,851	1.95				
16-51	Hamyang	367.3	1,864	5.08	2,083	5.67				
17-53	Dogsan	231.0	1,410	6.10	1,594	6.90				
Geum River										
18-62	Yongdam	949.0	4,100	4.32	4,600	4.85				
19-63	Sutong	1,526.0	5,200	3.41	5,700	3.74	1,570.0	7,200	4.59	Sutong Report
20-64	Myeongcheon	2,003.0	6,000	3.00	6,600	3.29				
21-69	Simcheon	640.3	3,400	5.31	3,800	5.93				
Seumjin River										
22-77	Jeokseong	1,004.0	3,700	3.69	4,150	4.13				
23-82	Juam	1,010.0	3,700	3.66	4,180	4.14				
24-	No.2 Boseonggang	457.0								
Existing Dam										
	Namgang						2,285.0	(200Y.R.P) 10,574	4.63	
	Soyanggang						2,703.0	(200Y.R.P) 10,500	3.88	
	Daecheong						4,134.0	(100Y.R.Px1.2) 11,400	2.76	
	Hwacheon						4,145.0	9,500	2.29	
	Chungcheon						4,736.0	12,600	2.66	
	Andong						1,588.0	(200Y.R.P) 6,700	4.22	
	Hapcheon						925.0	5,100	5.51	Hapcheon Planning Report
	Yeongcheon						235.0	(200Y.R.P) 1,420	6.04	Yeongcheon Planning Report

TABLE 1-4-2-1 REGIONAL CLASSIFICATION BY DISCHARGE CHARACTERICTICS

RIVER NAME	SITE NAME	CATCHMENT AREA OBSERVATION AVERAGES, 1963 - 1972					
		1-DAY MAX. RAINFALL			2-DAY MAX. RAINFALL		
		(mm)	RATIO	ORDER	(mm)	RATIO	ORDER
Han River							
	Bamseonggol	387.0	1.00	1	387.0	1.00	3
	Hupyeong	279.2	0.72	4	410.3	1.06	1
	Inje	279.2	0.72	4	410.3	1.06	1
	Weolhak	252.0	0.65	6	347.0	0.90	5
	Hongcheon	285.6	0.74	3	371.5	0.90	5
	Dalcheon	123.3	0.32	22	163.6	0.42	23
	Ganhyeon	249.7	0.65	6	334.7	0.86	8
	Gujeol	116.5	0.30	23	182.5	0.47	21
	Pyeongchang	301.3	0.78	2	352.9	0.91	4
	Paun	245.8	0.64	8	294.7	0.76	9
	Suju	210.2	0.54	11	257.5	0.67	11
	Dogog	210.2	0.54	11	257.5	0.67	11
Nagdong River							
	Bonghwa	179.7	0.46	14	243.1	0.63	13
	Imha	139.2	0.36	21	167.5	0.43	22
	Chibo	157.4	0.41	17	200.0	0.52	19
	Hamyang	165.3	0.43	15	215.6	0.56	17
	Dogsan	236.0	0.61	9	337.0	0.87	7
Geum River							
	Yongdam	158.8	0.41	17	230.2	0.59	15
	Sutong	157.2	0.41	17	222.7	0.58	16
	Myeongcheon	151.2	0.39	20	207.6	0.54	18
	Simcheon	200.4	0.52	13	200.4	0.52	19
Seumjin River							
	Jokseong	160.7	0.42	16	231.3	0.60	14
	Juam	226.9	0.59	10	288.3	0.74	10

REGIONAL CLASSIFICATION BY EXTENT OF RAINFALL

Ratios are based on rainfall at Bamseonggol as 1 with regions divided into 3 classes using above ratios as measures.

(1) Case of 1-Day Maximum Rainfall

Ratio higher than 0.6;
Bamseonggol, Pyeongcheong, Hongcheon, Inje, Hupyeong, Weolhak, Ganhyeon, Paun, Dogsan

Ratio 0.6 - 0.5;
Chuam, Suju, Dogog, Simcheon

Ratio lower than 0.5;
Bonghwa, Hamyang, Chokseong, Yongdam, Sutong, Chibo, Myeongcheon, Imha, Dalcheon, Gujeol

(2) Case of 2-Day Maximum Rainfall

Ratio higher than 0.8;
Hupyeong, Inje, Bamseonggol, Pyeongcheon, Hongcheon, Dogsan, Ganhyeon

Ratio 0.8 - 0.6;
Panun, Chuam, Suju, Dogog, Bonghwa, Jokseon

Ratio lower than 0.6;
Yongdam, Sutong, Hamyang, Myeoncheon, Sincheon, Chibo, Gujeol, Imha, Dalcheon

(3) Regional Classification Considering (1) and (2) together

1 Regions of relatively large peak rainfalls are North Han River catchment area with Ganhyeon included, and Dogsan catchment area.

2 Regions of relatively, ordinary peak rainfalls are South Han River catchment area and catchment area from Seumjin River to Hamyang.

3 Regions of relatively small peak rainfalls are Nagdong River upstream area to Geum River and South Han River South Tributary Dalcheon catchment area adjacent to west.

Data insufficient for Kujeol and this site not included in examination.

TABLE 1-4-2-2 MAX. DESIGN FLOOD DISCHARGE

RIVER NAME	SITE NAME	CATCHMENT AREA (km^2)	C-VALUE	SPECIFIC FLOOD ($m^3/s/km^2$)	MAX. DESIGN FLOOD DESCHARGE (m^3/sec)
Han River					
1-32	Bamseonggol(upp.)	582.7	100	9.27	5,400
2-23	Hupyeong (upp.)	305.0	100	12.57	3,830
3-22	Inje (upp.)	1,043.3	100	6.90	7,200
4-30	Weolhak	563.4	100	9.42	5,310
5-A3	Hongcheon	1,473.0	100	5.74	8,460
11-A1	Dalcheon	1,348.0	86	5.18	6,980
12-A2	Ganhyeon	1,180.0	100	6.50	7,670
6-3	Gujeol (Dogam)	100.8	93	18.57	1,870
7-9	Pyeongchang	485.3	93	9.42	4,570
8-10	Panun	651.9	93	8.15	5,310
9-13	Suju	328.9	93	11.30	3,720
10-12	Dogog	492.6	93	9.35	4,610
Nagdong River					
13-35	Bonhwa	1,105.0	86	5.76	6,360
14-43	Imha	1,230.0	86	5.45	6,700
15-36	Chibo	4,550.0	86	2.59	11,780
16-51	Hamyang (upp.)	264.0	93	12.47	3,290
17-53	Dogsan	231.0	100	14.22	3,280
Geum River					
18-62	Yongdam	949.0	86	6.23	5,910
19-63	Sutong	1,526.0	86	4.84	7,390
20-64	Myeongcheon	2,003.0	86	4.17	8,350
21-19	Simcheon	640.3	86	7.61	4,870
Seumjin River					
22-77	Jeokseong	1,004.0	93	6.55	6,580
23-82	Juam	1,010.0	93	6.52	6,590
24-	No.2 Boseonggang	457.0	93	9.69	4,430

TABLE 1-5 FLOOD DISCHARGE TIME AND FLOOD DISCHARGE

RIVER NAME	SITE NAME	L (Km)	tg (hr)	DISCHARGE TIME a	T_1	b	T_2	c	T_3	d	T_4	TOTAL	FLOOD DISCHARGE (m^3/sec) Qmax	0.3Qmax	0.09Qmax	FLOOD DISCHARGE VOLUME (10^6 m^3)
Han River																
1-32	Bamseonggol (upp.)	54.0	3.5	2.0	7.0	2.9	10.2	2.4	8.4	4.4	15.4	41.0	5,400	1,620	486	241.6
2-23	Hupyeong (upp.)	26.5	1.9	"	3.8	"	5.5	"	4.6	"	8.4	27.3	3,830	1,149	345	93.0
3-27	Inje (upp.)	89.0	5.6	"	11.2	"	16.2	"	13.4	"	24.6	65.4	7,200	2,160	648	515.5
"-20	Weolhak	52.0	3.4	"	6.8	"	9.9	"	8.2	"	15.0	39.9	5,310	1,593	478	230.8
5-A3	Hongcheon	139.5	8.5	1.8	15.3	2.1	17.9	1.4	11.9	4.2	35.7	80.8	8,460	2,538	761	706.0
11-A1	Dalcheon	113.0	7.0	"	12.6	"	14.7	"	9.8	"	29.4	66.5	6,980	2,094	628	479.4
12-A2	Ganhyen	81.4	5.1	2.0	10.2	2.9	14.8	2.4	12.2	4.4	22.4	59.6	7,670	2,301	690	500.0
6-3	Gujeol (Dogam)	22.0	1.7	1.8	3.1	2.1	3.6	1.4	2.4	4.2	7.1	16.2	1,870	561	168	31.1
7-9	Pyeongchang	64.3	4.1	"	7.4	"	8.6	"	5.7	"	17.2	38.9	4,570	1,371	411	183.8
8-10	Panun	105.5	6.5	"	11.7	"	13.7	"	9.1	"	27.3	61.8	5,310	1,593	478	338.7
9-13	Suju	50.5	3.3	"	5.9	"	6.9	"	4.6	"	13.9	31.3	3,710	1,113	334	120.0
10-12	Dogog	69.0	4.4	"	7.9	"	9.2	"	6.2	"	18.5	41.8	4,610	1,383	415	199.0
Nagdong River																
13-31	Bonhwa	108.0	6.3	1.3	8.2	1.9	12.0	1.4	8.8	1.9	12.0	41.0	6,360	1,908	572	323.5
14-43	Imha	95.0	5.9	"	7.7	"	11.2	"	8.3	"	11.2	38.4	6,700	2,010	603	319.5
15-36	Chibo	227.3	13.6	"	17.7	"	25.8	"	19.0	"	25.8	88.3	11,780	3,534	1,060	1,294.1
15-51	Hamyang (upp.)	25.5	1.9	2.0	3.8	2.9	5.5	2.4	4.6	4.4	8.4	22.3	3,290	987	296	80.3
17-53	Dogsam	24.5	1.8	"	3.6	"	5.2	"	4.3	"	7.9	21.0	3,280	984	295	95.3
Geum River																
18-62	Yongdam	70.5	4.5	"	9.0	"	13.1	"	10.8	"	19.8	52.8	5,910	1,773	532	340.2
19-63	Sutong	109.0	6.7	1.6	10.7	2.0	13.4	2.2	14.7	5.3	35.5	74.3	7,390	2,217	665	493.2
20-64	Myeongcheon	153.5	9.3	"	14.9	"	18.6	"	20.5	"	40.3	103.3	8,350	2,505	752	773.8
21-69	Simcheon	64.5	4.1	"	6.6	"	8.2	"	9.0	"	21.7	45.5	4,870	1,461	438	198.7
Seumjin River																
22-77	Jeokseong	116.0	7.1	1.3	9.2	1.9	13.5	1.4	9.9	1.9	13.5	46.1	6,580	1,974	592	377.4
22-82	Juam	123.8	7.6	"	9.9	"	14.4	"	10.6	"	14.4	49.8	6,590	1,977	593	404.7
24	No.2 Boseonggang	66.3	4.2	"	5.5	"	8.0	"	5.9	"	8.0	27.4	4,430	1,329	399	150.3

TABLE 1-6 PRESENT FIRM DISCHARGE

RIVER NAME	SITE NAME		PRESENT FIRM DISCHARGE (m^3/sec)
Han River			
1-32	Bamseonggol (upp.)		2.32
2-23	Hypyeong (upp.)		1.21
3-22	Inje (upp.)		4.14
4-30	Weolhak		2.19
5-A3	Hongcheon		5.08
11-A1	Dalcheon		1.60
12-A2	Ganhyeon		1.59
b-3	Gujeol (Dogam)		0.36
7-9	Pyeongchang		1.74
8-10	Panun		2.33
9-13	Suju		1.22
10-12	Dogog		1.83
Nagdong River			
13-35	Bonhwa		0.77
14-43	Imha		0.86
15-36	Chibo	*-1	28.06
16-51	Hanyang (upp.)		0.98
17-53	Dogsan		0.90
Geum River			
18-62	Yongdam		3.31
19-63	Sutong		5.07
20-64	Myeongcheon		6.49
21-69	Simcheon		2.00
Seumjin River			
22-77	Jeokseong	*-2	0.75
23-82	Juam	*-3	2.84
24	No.2 Boseonggang	*-4	0.70

Remarks:
*-1 Including Andong dam effect
*-2 Excluding Seumjingang dam river basin
*-3
*-4 Excluding Boseonggang river basin

TABLE 1-7-1

MONTHLY INFLOW AT INJE (麟蹄)

Unit: $m^3/sec/1,000km^2$

MONTH / YEAR	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	MEAN
1916	6.1	4.9	4.3	39.5	12.1	69.6	47.3	54.2	51.9	7.1	8.6	4.3	310.2	25.9
1917	3.1	3.4	4.3	10.4	6.9	2.9	23.4	47.8	51.4	7.0	4.2	7.1	171.9	14.3
1918	3.4	8.7	5.4	8.4	11.4	5.9	64.4	71.6	8.7	6.5	8.8	4.1	207.3	17.3
1919	4.9	3.0	4.3	9.9	15.9	12.4	27.8	30.6	14.6	16.5	4.2	4.3	148.4	12.4
1920	3.7	5.5	6.9	8.4	9.4	24.0	170.6	53.9	15.3	6.6	5.9	4.6	314.8	26.2
1921	3.1	3.5	4.3	10.6	6.5	6.7	40.9	30.3	9.8	6.6	4.4	4.0	130.7	10.9
1922	3.7	15.7	6.1	8.1	13.3	15.7	153.7	89.9	25.9	8.4	4.8	4.1	349.4	29.1
1923	6.5	3.1	7.2	22.4	4.9	20.1	148.3	13.5	50.7	7.8	9.8	5.4	299.7	25.0
1924	3.2	11.5	5.2	17.9	9.8	10.5	135.2	4.1	6.7	6.7	5.5	4.3	220.0	18.4
1925	3.3	3.5	9.4	9.3	37.1	1.0	339.1	78.8	21.3	6.5	6.2	8.7	524.2	43.7
1926	4.8	4.7	4.5	9.5	15.8	3.0	261.1	45.8	83.0	11.7	5.4	4.3	453.6	37.8
1927	6.7	3.3	10.6	25.7	17.6	8.4	113.3	50.8	21.0	7.1	4.2	6.1	274.8	22.9
1928	7.7	3.4	6.7	5.9	5.8	7.4	38.1	9.2	58.5	7.3	12.1	4.1	166.2	13.9
1929	3.3	4.4	6.0	14.2	5.7	13.7	21.1	45.2	9.7	6.9	4.1	9.4	143.7	12.0
1930	3.0	9.3	15.2	28.0	7.3	3.2	310.7	39.5	6.6	8.2	4.6	4.0	439.6	36.6
1931	3.4	3.3	10.6	7.7	15.3	5.1	65.4	92.5	19.3	6.6	8.1	10.2	247.5	20.6
1932	3.9	4.3	5.1	7.3	8.1	10.4	30.1	72.8	8.7	7.0	5.0	4.6	167.3	13.9
1933	3.2	8.2	5.0	7.7	37.9	15.3	67.8	39.9	21.2	9.7	4.3	5.4	225.6	18.8
1934	3.2	5.7	5.2	8.6	2.0	17.2	41.4	48.3	47.0	8.7	6.9	4.5	198.7	16.6
1935	3.3	3.0	4.9	16.2	11.6	27.0	112.5	24.0	6.6	7.1	9.0	4.0	229.2	19.1
1936	3.0	3.9	5.6	30.8	4.4	2.9	46.7	138.2	37.1	7.2	5.6	8.4	293.8	24.5
1937	4.1	5.3	4.2	23.1	7.9	3.5	55.3	35.7	30.1	9.3	4.6	4.7	187.8	15.7
1938	4.6	3.9	13.8	6.4	20.7	19.8	45.2	13.0	19.0	13.2	4.2	5.5	169.3	14.1
TOTAL	95.2	125.5	154.8	336.0	287.4	305.7	2359.4	1129.9	624.1	189.7	140.5	126.1	5,874.3	489.5
MEAN	4.1	5.5	6.5	14.6	12.5	13.3	102.6	49.1	27.1	8.2	6.1	5.3	255.4	21.3

- continued -

TABLE 1-7-1

Unit: $m^3/sec/1,000km^2$

MONTH / YEAR	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	MEAN
1963	3.4	3.3	4.4	45.9	32.2	56.3	168.4	12.4	7.2	13.0	4.4	5.1	356.0	29.7
1964	4.0	5.9	5.8	70.8	9.5	4.7	102.5	91.0	88.2	9.9	4.3	4.0	400.6	33.4
1965	3.7	3.7	7.5	6.5	6.5	4.5	238.2	51.8	8.0	8,8	12.3	4.2	355.7	29.6
1966	3.6	3.9	12.7	10.0	13.8	68.6	253.1	39.0	56.7	14.3	8.2	4.0	487.9	40.7
1967	4.7	4.0	7.2	14.2	8.4	13.8	86.9	56.1	31.2	5.5	3.1	3.9	239.0	19.9
1968	3.0	3.2	6.7	6.5	8.6	10.0	82.3	61.1	22.3	39.3	9.0	2.7	254.7	21.2
1969	6.7	4.7	4.6	47.8	29.4	8.7	139.6	93.8	27.3	6.3	5.0	4.1	373.0	31.5
1970	7.0	4.2	3.7	5.9	10.6	13.6	61.0	45.6	99.9	8.0	10.9	4.4	274.8	22.4
1971	10.0	11.6	22.5	31.1	11.5	15.1	80.9	57.4	34.6	6.5	4.1	4.1	289.4	24.1
1972	8.7	5.8	5.9	6.4	5.7	3.3	19.4	221.5	87.0	7.9	17.6	4.0	393.2	37.8
TOTAL	54.8	50.3	81.0	245.1	136.2	198.6	1,232.3	729.7	462.4	119.5	78.9	40.5	3,429.3	285.8
MEAN	5.5	5.0	8.1	24.5	13.6	19.9	123.2	73.0	46.2	12.0	7.9	4.1	342.9	28.6

TABLE 1-7-2

MONTHLY INFLOW AT HONGCHEON (洪川)

Unit: $m^3/sec/1,000km^2$

YEAR \ MONTH	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	MEAN
1917	2.5	2.4	4.1	6.5	17.4	3.3	25.1	15.8	68.9	7.6	4.6	3.5	161.7	13.5
1918	0.9	2.8	4.1	6.8	10.4	5.5	46.5	93.8	8.8	4.2	4.6	3.4	191.8	15.9
1919	2.2	2.4	4.0	5.3	11.8	26.8	70.0	16.6	16.4	5.2	5.1	4.7	170.5	14.2
1920	2.4	3.9	9.8	12.7	6.4	26.4	111.8	105.8	8.6	9.0	7.5	5.0	310.1	25.8
1921	3.9	3.2	6.8	16.6	7.2	10.7	29.7	14.0	10.5	7.5	4.7	3.5	118.3	9.5
1922	3.0	8.0	9.3	13.8	21.6	7.4	97.1	97.3	23.7	8.9	6.0	4.4	300.5	25.0
1923	3.7	4.2	19.1	20.7	13.4	3.6	31.0	41.8	57.0	5.5	10.9	7.8	218.7	18.2
1924	4.3	15.7	5.3	16.4	12.4	7.6	109.5	17.9	6.1	3.2	2.7	2.9	204.0	17.0
1925	2.1	1.8	2.0	4.6	14.3	21.8	273.7	57.3	32.7	13.8	10.6	11.0	445.7	37.1
1926	9.9	7.9	12.2	21.6	19.9	9.3	157.9	80.9	38.3	11.7	12.4	6.0	388.0	32.3
1927	15.6	11.9	18.2	34.9	33.8	6.5	89.0	84.4	20.2	9.2	7.2	6.4	337.3	28.1
1928	7.3	7.6	18.5	10.6	5.9	4.1	33.2	9.5	68.9	9.5	13.2	8.2	196.5	16.4
1929	4.4	2.2	5.8	14.1	8.8	18.3	31.7	25.8	17.3	7.4	5.5	13.0	154.3	12.9
1930	6.4	6.9	27.2	56.1	34.4	10.0	216.0	36.9	26.2	8.2	7.5	5.6	441.4	36.8
1931	4.6	5.1	11.2	33.3	43.7	8.1	56.5	118.1	33.6	9.0	14.2	20.0	357.4	29.8
1932	14.0	8.3	12.2	19.2	12.3	9.3	24.5	42.1	44.0	11.7	10.0	14.3	221.9	18.5
1933	9.0	7.5	10.1	24.9	41.6	40.2	114.1	54.9	42.2	13.6	7.7	6.5	372.3	31.0
1934	4.4	5.3	13.4	25.4	21.1	18.3	62.6	64.4	37.7	22.9	11.9	8.9	296.3	24.7
1935	6.0	5.1	9.2	13.9	12.4	25.1	113.8	59.3	18.9	7.4	11.4	5.8	288.3	24.0
1936	4.0	4.0	5.8	45.3	12.5	5.2	32.7	170.8	54.5	11.3	8.3	12.0	366.4	30.5
1937	7.6	7.4	9.0	35.0	14.4	6.3	40.9	56.3	35.4	12.9	11.2	7.8	244.2	20.4
1938	6.8	4.9	43.0	17.4	20.5	56.3	71.7	17.6	43.2	13.5	6.1	5.0	306.0	25.5
1939	3.9	4.8	6.0	14.7	27.9	6.0	11.4	5.8	7.9	5.8	10.5	8.1	112.8	9.4
1940	7.5	5.6	6.0	11.1	14.0	8.4	306.2	36.9	96.6	12.3	10.0	7.2	521.8	43.5
TOTAL	136.4	138.9	272.3	480.9	438.1	344.5	2,156.6	1,324.0	817.6	231.3	203.8	181.8	6,726.2	560.5
MEAN	5.7	5.8	11.3	20.0	18.3	14.4	89.9	55.2	34.1	9.6	8.5	7.6	280.3	23.4

- continued -

TABLE 1-7-2

Unit: $m^3/sec/1,000km^2$

MONTH / YEAR	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	MEAN
1960	3.4	3.5	6.1	6.4	16.8	29.1	118.8	17.2	40.8	6.3	10.8	5.8	265.0	22.0
1961	3.7	4.3	6.5	9.9	21.6	20.0	27.9	79.8	56.6	18.4	17.4	5.7	271.8	22.7
1962	3.3	6.2	4.9	22.4	4.2	18.1	37.2	113.5	74.1	6.8	8.5	4.6	303.8	25.3
1963	8.2	3.7	8.0	52.0	33.2	80.0	212.1	25.1	7.5	6.5	4.8	4.4	445.5	37.1
1964	17.4	14.9	4.7	115.6	15.5	20.3	146.9	114.7	17.7	8.8	4.2	5.0	485.7	40.5
1965	8.0	3.8	7.8	6.6	7.2	1.6	270.7	70.7	6.9	11.4	103.3	4.1	502.1	41.8
1966	3.1	5.2	14.9	9.8	11.5	58.2	330.2	37.3	41.1	14.4	8.0	3.8	537.5	44.8
1967	3.3	6.5	6.7	14.3	8.4	15.5	82.7	57.6	30.9	6.4	11.0	10.7	254.0	21.2
1968	3.4	4.3	10.0	7.1	7.7	15.7	74.6	92.3	14.3	24.2	8.5	4.3	266.4	22.2
1969	8.0	5.2	4.1	38.9	16.1	5.9	122.3	105.1	62.0	8.2	5.9	4.1	385.8	32.1
1970	3.0	7.9	4.5	6.4	11.8	8.5	112.1	15.1	116.0	17.3	5.2	4.5	312.3	26.0
1971	3.3	6.1	4.5	6.5	11.9	31.5	113.5	47.3	34.2	12.4	4.2	5.9	281.3	23.4
1972	9.1	3.8	9.8	11.8	12.0	3.2	18.7	248.9	37.9	13.3	17.6	4.8	390.9	32.6
TOTAL	77.2	75.4	92.9	307.7	177.9	307.6	1,667.7	1,024.6	540.0	151.4	209.4	67.7	4,702.1	391.8
MEAN	5.9	5.8	7.1	23.6	13.6	23.6	128.2	78.8	41.5	11.6	16.1	5.2	361.7	30.1

TABLE 1-7-3

MONTHLY INFLOW AT DALCHEON (達川) AND GANHYEON (艮峴)

Unit: $m^3/sec/1,000km^2$

MONTH / YEAR	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	MEAN
1917	1.1	1.0	2.3	1.6	4.5	0.7	22.9	6.9	36.3	3.7	2.0	1.1	84.1	7.0
1918	0.9	1.4	3.6	4.9	1.7	13.2	60.7	42.1	3.2	3.1	3.5	2.4	140.7	11.7
1919	1.5	0.9	2.5	3.7	5.6	9.4	95.6	6.8	2.9	12.5	1.5	1.2	144.1	12.0
1920	1.4	1.9	4.1	9.2	9.2	0.7	145.6	39.1	12.9	6.9	3.2	3.6	237.8	19.8
1921	4.7	4.9	6.1	14.9	4.6	3.9	81.6	3.2	6.5	6.7	9.1	3.4	149.6	12.5
1922	1.8	3.7	2.7	14.7	8.4	0.4	243.5	140.9	17.0	6.6	4.7	2.2	446.6	37.2
1923	1.1	2.6	15.6	13.2	1.2	5.1	95.0	8.1	43.1	6.8	8.9	5.2	205.9	17.2
1924	0.9	5.3	0.4	2.7	1.7	4.3	127.1	3.1	5.3	5.9	1.4	2.5	160.6	13.4
1925	3.2	2.2	3.3	5.0	2.9	3.0	443.7	51.2	44.5	10.2	15.5	17.3	602.0	50.2
1926	10.2	13.3	10.0	19.2	6.9	4.6	134.8	142.4	10.6	32.6	16.8	6.9	408.3	34.0
1927	5.9	1.3	11.0	9.3	33.8	5.7	18.6	48.1	2.3	13.1	1.2	2.3	152.6	12.7
1928	3.5	29.0	11.4	9.8	4.9	8.4	3.3	3.1	55.5	11.1	1.3	7.2	148.5	12.4
1929	5.0	3.8	6.1	9.8	7.2	10.4	12.8	12.7	6.8	5.2	2.6	0.2	82.6	6.9
1930	3.8	2.3	14.1	44.1	28.5	13.3	347.3	63.6	18.1	10.4	1.0	3.4	549.9	45.8
1931	1.6	3.6	15.5	25.2	1.7	14.7	15.7	99.8	21.3	9.5	9.2	11.2	229.9	19.1
1932	10.7	8.7	7.7	5.5	8.5	6.8	7.0	7.8	23.4	7.6	5.2	2.7	101.6	8.5
1933	3.3	1.4	1.0	0.1	22.1	5.4	60.0	106.2	51.2	5.0	9.3	0.5	265.5	22.1
1934	4.5	4.9	13.1	22.4	21.9	2.3	130.2	111.1	28.2	26.2	2.0	6.1	372.9	31.1
1935	9.3	2.2	1.9	3.9	8.5	11.2	101.1	45.7	4.4	4.4	7.2	3.1	202.9	16.9
1936	7.3	1.3	1.4	38.1	16.5	2.8	18.5	529.0	165.9	22.7	15.9	22.3	841.7	70.1
1937	24.3	32.6	49.9	28.0	13.6	8.5	73.5	28.4	27.1	11.1	11.1	5.8	313.9	26.1
1938	3.5	5.0	27.3	13.9	13.9	29.4	105.9	2.1	34.6	3.8	20.9	19.7	280.0	23.3
1939	2.2	5.0	15.5	13.6	9.7	6.1	0.4	8.4	5.2	7.4	6.5	9.3	89.3	7.4
1940	3.2	2.7	7.2	11.6	9.2	9.1	677.7	32.7	114.8	6.9	7.1	7.4	889.6	74.1
TOTAL	114.9	141.0	233.7	324.4	246.7	179.4	3,022.5	1,542.5	741.1	239.4	167.1	147.0	7,099.7	591.6
MEAN	4.8	5.9	9.7	13.5	10.3	7.5	125.9	64.3	30.9	10.0	7.0	6.1	295.8	24.7

TABLE 1-7-4
MONTHLY INFLOW AT GANHYEON (艮峴)

Unit : $m^3/sec./1,000\ km^2$

MONTH / YEAR	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	MEAN
1963	3.5	3.2	4.9	56.7	21.9	20.5	157.1	15.4	7.2	4.2	4.9	3.9	303.4	25.3
1964	3.9	86.0	80.4	127.1	12.9	7.1	153.5	91.8	41.9	7.0	4.2	3.9	619.9	51.6
1965	3.1	3.1	4.8	7.0	5.6	35.2	184.9	28.9	8.7	7.5	11.3	4.1	304.2	25.3
1966	3.1	4.8	9.2	7.5	7.1	20.0	275.3	38.4	43.0	8.4	5.9	4.0	426.7	35.6
1967	5.9	4.2	5.8	14.7	6.8	9.3	36.0	31.8	16.5	6.5	4.6	3.8	143.7	12.0
1968	3.1	3.5	6.1	6.3	5.8	8.4	164.2	109.7	20.6	12.5	5.8	4.0	350.0	29.2
1969	8.5	6.7	4.5	31.1	22.5	4.9	136.7	112.2	32.7	9.7	4.5	4.0	378.0	31.5
1970	3.6	7.9	4.2	7.5	13.4	10.7	93.2	53.2	81.0	10.9	4.6	4.9	294.9	24.6
1971	3.2	4.4	4.9	8.1	13.2	15.0	123.8	68.7	46.2	6.3	4.4	4.5	302.7	25.2
1972	3.6	5.4	13.4	15.0	10.3	3.1	38.2	169.6	46.0	7.8	8.2	4.3	324.9	27.1
TOTAL	41.5	129.0	138.2	281.0	119.5	132.2	1362.9	719.7	343.8	80.6	58.4	41.4	3448.2	287.4
MEAN	4.1	12.0	13.8	28.1	12.0	13.2	136.3	72.0	34.4	8.1	5.8	4.1	344.8	28.7

TABLE 1-7-5

MONTHLY INFLOW AT DALCHEON (達川)

Unit : $m^3/sec./1,000\ km^2$

YEAR \ MONTH	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	MEAN
1959	36.8	16.2	61.0	53.6	48.8	16.3	217.5	47.6	77.7	13.5	7.8	8.6	605.4	50.5
1960	4.7	5.9	8.4	22.6	20.8	50.4	75.4	10.1	12.8	10.5	6.7	4.7	233.0	19.4
1961	9.0	4.2	26.5	38.2	9.9	8.2	162.7	68.2	54.5	42.7	17.7	13.7	455.5	38.0
1962	3.5	5.0	14.1	15.6	9.2	10.1	94.6	33.1	93.6	17.5	6.2	2.7	305.2	25.4
1963	2.5	5.8	6.3	59.8	38.6	89.3	133.1	18.4	5.0	9.9	5.0	1.0	374.7	31.2
1964	4.5	6.8	9.6	126.0	53.7	6.7	115.8	89.1	94.5	16.7	3.9	8.3	535.6	44.6
1965	1.6	4.5	4.3	6.4	4.4	5.8	144.8	30.1	4.5	4.7	8.5	2.2	221.8	18.5
1966	2.3	5.1	23.8	12.5	8.6	15.4	46.9	55.0	35.3	8.3	4.6	3.9	221.7	18.5
1967	2.2	4.8	9.7	21.7	14.7	7.5	38.5	29.1	46.6	7.3	8.7	0.7	191.5	16.0
1968	1.6	3.9	6.5	7.0	3.9	5.2	47.5	29.1	11.2	17.0	20.0	6.0	158.9	13.2
1969	4.3	17.0	10.3	83.0	39.6	4.2	60.5	168.0	53.8	9.3	5.9	4.1	460.0	38.3
1970	0.7	5.4	3.4	11.9	10.4	12.2	105.8	55.4	114.5	26.3	6.3	6.0	368.3	29.9
1971	3.3	5.2	4.4	7.8	7.6	23.1	113.8	20.6	11.0	6.2	4.0	3.8	210.8	17.6
1972	11.6	4.1	6.8	8.4	9.5	9.7	21.3	123.6	21.0	7.3	14.7	3.9	241.9	20.2
TOTAL	88.6	83.9	195.1	474.5	279.7	264.1	1,378.2	777.4	636.0	197.2	120.0	69.6	4,574.3	381.2
MEAN	6.3	5.9	13.9	33.8	19.9	18.8	98.4	55.5	45.4	14.0	8.5	4.9	326.7	27.2

1963-1972 Year mean 24.8

TABLE 1-7-6

MONTHLY INFLOW AT PYEONGCHANG (平昌)

Unit : m^3/sec./1,000 km^2

MONTH / YEAR	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	MEAN
1960	4.0	3.4	18.0	7.4	21.7	49.6	49.2	8.6	40.1	8.3	10.3	5.0	226.5	18.9
1961	4.9	3.7	37.8	24.9	36.4	22.1	107.6	71.9	26.7	14.3	14.2	22.2	386.7	32.2
1962	3.2	7.0	4.5	17.7	5.8	12.1	2.7	88.1	74.3	7.5	7.6	4.4	234.9	19.6
1963	4.0	4.5	9.8	50.0	39.3	64.1	178.9	31.6	7.2	7.4	5.2	6.7	408.7	34.1
1964	6.9	4.5	6.8	14.5	10.9	14.8	146.2	77.8	126.6	9.3	4.9	4.0	427.2	35.6
1965	3.5	3.7	8.2	10.9	7.0	3.7	208.0	39.6	6.5	8.8	15.8	3.9	319.6	26.6
1966	22.8	24.3	30.4	10.9	10.5	23.6	210.8	33.1	64.8	11.2	11.1	3.9	457.4	38.1
1967	4.6	4.4	9.5	19.0	7.5	14.7	53.4	53.9	50.2	7.0	11.3	3.9	239.4	19.9
1968	3.2	3.9	5.0	8.4	7.0	10.6	85.0	50.3	16.9	24.3	5.7	4.6	224.9	18.7
1969	8.2	3.9	4.2	47.7	26.8	6.5	123.3	120.9	34.8	6.4	4.6	3.4	290.7	32.6
1970	3.1	8.6	8.9	5.8	35.4	17.0	81.1	54.5	115.0	13.5	4.5	5.3	352.7	29.4
1971	3.5	6.0	6.5	7.0	15.1	39.2	63.2	23.9	13.0	6.4	4.2	4.3	192.3	16.0
1972	12.8	5.9	13.4	18.2	19.6	6.9	19.5	41.0	25.7	10.3	9.6	4.0	186.9	15.6
TOTAL	84.7	83.8	163.0	242.4	243.0	284.9	1,328.9	695.2	601.8	134.7	109.0	76.5	4,047.9	337.3
MEAN	6.5	6.4	12.5	18.6	18.6	21.9	102.2	53.4	46.2	10.3	8.3	5.8	311.4	26.0

1963-1972 Year mean 26.7

TABLE 1-7-7

MONTHLY INFLOW AT SANGCHEUNG (山淸)

Unit : $m^3/sec./1,000\ km^2$

MONTH / YEAR	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	MEAN
1963	3.7	5.0	5.2	6.4	31.6	213.9	86.0	33.3	10.0	7.0	4.5	4.5	411.1	34.3
1964	5.8	20.6	23.8	58.1	12.1	16.3	92.1	11.6	75.0	7.1	4.4	3.9	330.8	27.6
1965	4.2	4.8	6.4	21.0	25.8	3.6	193.3	45.2	6.9	8.0	11.4	6.7	337.3	28.1
1966	3.3	11.9	49.1	17.1	305.8	25.1	13.4	115.0	11.8	16.3	7.8	4.3	580.9	48.4
1967	4.3	6.8	8.2	31.6	7.3	71.5	28.2	14.6	14.5	6.6	4.4	3.8	201.8	16.8
1968	3.1	5.2	10.9	9.4	16.0	12.4	65.4	103.5	12.7	26.5	6.7	4.2	276.0	23.0
1969	8.6	16.0	5.0	46.9	30.1	12.3	115.0	126.4	146.7	7.5	5.8	5.0	525.3	43.8
1970	2.9	12.1	4.4	38.3	22.7	34.4	133.6	75.7	23.5	15.4	5.9	36.7	405.6	33.8
1971	7.8	6.2	4.6	10.9	13.3	62.5	64.5	67.8	36.1	6.4	33.0	7.9	321.0	26.7
1972	20.4	4.9	49.3	18.2	27.8	10.8	136.3	71.6	21.9	8.1	33.2	8.0	410.5	34.2
TOTAL	64.1	93.5	166.9	257.9	492.5	462.8	927.8	664.7	359.1	108.9	117.1	85.0	3,800.3	316.7
MEAN	6.4	9.4	16.7	25.8	49.3	46.3	92.8	66.5	35.9	10.9	11.7	8.5	3,380.0	31.7

TABLE 1-7-8

MONTHLY INFLOW AT ANDONG (安東)

Unit : $m^3/sec./1,000\ km^2$

YEAR \ MONTH	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	MEAN
1947	7.8	3.1	3.5	3.9	25.7	37.8	51.9	18.6	30.2	5.9	7.4	4.7	195.5	16.3
1948	0.5	2.3	6.8	5.6	22.4	29.2	69.8	31.1	6.1	3.8	0.7	3.1	181.4	15.1
1949	0.7	2.9	7.5	6.3	21.2	13.9	29.5	15.1	34.8	3.1	4.4	0.5	139.9	11.7
1950	5.7	1.3	4.2	6.6	24.3	95.7	30.9	11.6	34.1	5.7	10.5	0.5	231.1	19.3
1951	0.9	1.0	4.7	8.0	28.3	4.9	20.5	21.7	17.3	13.2	8.0	4.0	132.5	11.0
1952	0.7	1.3	4.7	10.0	10.4	2.0	25.7	30.4	65.5	5.7	8.3	0.7	165.4	13.0
1953	3.5	1.0	5.4	2.4	25.2	54.1	47.2	16.7	17.1	8.7	7.1	3.3	191.7	16.0
1954	1.4	4.2	5.9	10.5	24.0	37.0	47.9	13.4	44.3	10.8	1.2	0.7	201.3	16.8
1955	0.7	1.0	6.4	5.1	8.0	24.4	44.3	41.7	14.6	2.8	5.4	0.7	155.1	12.9
1956	0.7	2.8	16.5	42.4	36.1	76.3	39.1	31.4	57.5	3.3	2.4	0.7	309.2	25.8
1957	4.5	2.6	7.5	25.6	4.0	7.8	107.5	33.5	9.7	5.9	2.0	0.7	211.3	17.6
1958	0.7	2.9	7.3	37.8	4.0	13.4	42.7	17.9	32.2	16.5	8.0	4.0	187.4	15.6
1959	0.7	6.0	10.8	13.6	26.4	13.2	44.6	23.6	30.0	3.1	6.6	2.4	181.0	15.1
1960	0.9	2.8	10.4	3.9	30.2	46.3	32.8	10.4	32.4	6.6	6.6	0.5	183.8	15.3
1961	2.4	2.3	8.7	11.9	32.3	13.6	58.0	69.3	28.7	32.8	8.3	1.2	269.5	22.4
1962	0.7	1.8	6.1	11.4	1.2	14.9	31.1	42.7	62.6	5.0	4.9	0.5	182.9	15.2
1963	1.4	1.6	1.6	50.7	30.9	114.0	8.5	48.6	4.1	0.7	0.5	0.7	263.3	21.9
1964	0.7	0.8	5.7	117.9	20.5	3.9	38.9	0.7	87.5	4.2	0.7	0.7	282.2	23.5
1965	0.7	0.8	0.7	0.7	0.7	0.7	84.4	11.8	2.0	0.7	0.5	0.5	104.2	8.7
1966	0.5	0.5	14.1	1.7	7.8	23.4	19.1	16.7	48.2	12.5	11.7	7.8	164.0	13.7
1967	0.5	8.6	0.9	15.1	9.9	5.1	38.9	8.0	25.3	7.1	9.8	9.0	138.3	11.5
1968	3.1	1.5	5.0	9.7	5.4	12.9	29.2	50.7	4.6	9.7	4.9	0.9	137.6	11.5
1969	0.7	3.4	13.2	60.7	19.8	6.6	25.7	78.0	40.0	5.9	0.7	0.7	255.4	21.3
1970	0.5	1.0	0.9	5.6	11.3	10.0	78.3	57.3	61.4	3.8	1.2	0.7	232.0	19.3
TOTAL	40.6	57.5	158.5	467.1	430.0	661.1	1,046.5	700.9	790.2	177.5	116.0	50.1	4,696.0	391.3
MEAN	1.7	2.4	6.6	19.5	17.9	27.5	43.6	29.2	32.9	7.4	4.8	2.1	145.7	16.2

TABLE 1-7-9
MONTHLY INFLOW AT YONGDAM (龍 潭)

Unit : $m^3/sec./1,000\ km^2$

MONTH / YEAR	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	MEAN
1916	5.6	5.1	3.9	35.2	7.3	221.4	93.6	78.8	84.5	8.5	5.4	3.8	553.1	46.1
1917	3.7	3.4	6.7	12.6	8.3	55.3	45.9	45.2	50.2	6.5	4.4	4.6	246.8	20.6
1918	2.7	3.7	5.7	17.6	12.6	41.5	105.0	71.7	21.4	6.5	8.9	4.0	301.3	25.1
1919	6.5	3.0	4.2	9.9	10.7	33.1	41.2	57.5	16.4	9.0	4.6	4.8	200.9	16.7
1920	10.0	5.0	7.4	10.4	5.8	3.6	143.1	34.2	28.1	6.0	5.1	6.6	265.3	22.1
1921	3.4	3.6	4.1	12.2	10.5	16.9	50.4	57.6	6.3	6.9	5.5	5.1	176.5	14.7
1922	3.1	7.3	4.2	9.3	4.9	4.6	51.6	7.0	27.4	8.9	5.7	3.8	137.8	11.5
1923	6.9	6.6	10.7	26.5	27.9	22.7	63.4	36.6	14.2	8.7	15.1	4.5	243.8	20.3
1924	2.9	11.5	4.1	14.4	7.4	14.7	119.7	8.6	18.0	8.1	6.7	4.0	220.1	18.3
1925	2.6	4.0	5.8	10.8	12.2	21.3	131.9	67.3	26.4	7.4	8.4	13.5	311.6	26.0
1926	6.2	5.0	4.6	16.4	15.3	3.2	88.1	57.2	89.4	11.1	4.5	4.5	305.5	25.5
1927	7.4	3.3	5.3	21.9	7.8	4.6	43.5	86.6	11.1	13.3	4.5	4.9	214.2	17.9
1928	6.1	4.5	7.6	16.4	5.5	9.4	14.5	11.2	62.0	7.9	9.7	5.3	160.1	13.3
1929	3.4	4.4	4.3	17.6	6.1	32.5	9.3	63.6	12.3	6.1	5.9	26.4	191.9	16.0
1930	4.0	10.2	19.2	41.7	23.0	89.1	125.4	88.5	14.4	7.7	14.5	3.6	441.3	36.8
1931	7.6	7.3	7.7	30.6	13.4	13.6	70.5	93.9	30.0	10.9	5.1	17.7	308.3	25.7
1932	3.9	4.9	4.7	16.5	8.9	4.7	7.6	62.8	7.0	6.9	4.0	6.2	138.1	11.5
1933	6.0	3.7	7.5	10.4	15.3	94.3	83.4	61.2	28.3	10.0	4.9	4.4	329.3	27.4
1934	3.1	3.9	6.1	14.2	11.8	22.0	184.6	102.2	33.0	7.2	10.9	6.4	405.4	33.8
1935	2.9	3.6	4.3	11.9	7.3	9.6	36.9	17.4	17.6	7.3	10.3	3.9	133.0	11.1
1936	2.8	3.7	3.9	25.0	6.8	21.6	48.8	202.5	76.3	6.0	5.5	11.4	414.3	34.5
1937	3.3	11.2	7.5	32.6	11.1	4.5	67.1	22.7	53.4	65.0	6.0	4.0	289.3	24.1
1938	5.5	3.8	10.3	7.0	22.4	10.7	38.0	14.7	6.3	38.6	3.9	5.4	166.6	13.9
1939	3.1	3.6	9.6	7.6	6.9	8.4	18.7	9.3	29.6	6.0	13.2	3.5	119.5	10.0
1940	13.2	5.0	3.9	15.1	6.9	33.2	110.9	43.2	24.2	11.3	6.8	12.7	276.4	23.0
TOTAL	115.9	131.3	163.3	443.8	276.0	796.5	1,793.1	1,395.5	787.8	292.7	179.5	175.0	6,550.4	545.9
MEAN	4.6	5.3	6.5	17.8	11.0	31.9	71.7	55.8	31.5	11.7	7.2	7.0	262.0	21.8

- continued -

TABLE 1-7-9

Unit : m^3/sec./1,000 km^2

MONTH / YEAR	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	MEAN
1958	12.9	6.2	5.7	24.4	16.1	1.9	126.7	89.8	96.2	6.6	16.1	11.4	414.0	34.5
1959	7.4	47.6	42.3	53.6	18.3	1.4	113.3	43.1	73.5	3.9	5.9	5.2	415.5	34.6
1960	3.1	5.0	8.2	13.6	32.7	59.5	68.5	10.8	20.2	7.5	8.0	7.9	245.0	20.4
1961	4.4	8.0	49.5	28.8	8.0	13.8	169.0	59.4	31.4	45.6	22.8	12.5	453.2	37.8
1962	6.3	8.1	7.2	7.4	3.8	2.9	24.0	27.5	75.6	8.0	10.2	5.8	186.8	15.6
1963	2.2	3.3	11.0	32.0	51.0	118.0	125.7	28.7	11.3	3.8	2.1	2.5	391.6	32.6
1964	2.0	18.5	13.9	94.7	30.3	7.8	96.7	11.1	80.4	9.5	7.3	3.2	375.4	31.3
1965	2.5	11.4	8.9	7.2	9.7	2.5	179.1	15.4	7.8	4.4	15.6	6.3	270.8	22.6
1966	3.2	13.6	64.6	12.6	20.9	15.6	71.4	36.3	31.2	15.9	16.0	8.2	309.3	25.8
1967	4.9	8.8	22.1	28.5	3.6	8.5	34.1	11.6	18.3	4.5	14.1	10.6	169.6	14.1
1968	5.9	4.4	28.1	17.3	3.4	6.7	29.0	5.7	14.9	24.6	25.8	14.9	170.7	14.2
1969	14.9	35.0	16.3	59.4	32.6	9.8	95.5	113.8	73.7	14.7	4.5	7.9	478.1	39.8
1970	2.5	9.4	6.8	17.2	9.0	12.9	99.9	45.4	79.5	12.7	10.8	8.3	304.4	25.4
1971	9.0	19.3	21.0	11.4	12.5	31.6	120.5	63.6	34.7	3.9	4.9	5.0	342.4	28.5
1972	4.2	5.5	44.7	8.4	16.1	21.4	6.0	65.0	32.1	4.9	35.7	13.5	257.5	21.5
TOTAL	75.4	204.1	350.1	396.9	268.0	314.3	1,369.4	627.2	680.8	175.5	199.8	123.2	4,784.3	398.7
MEAN	5.0	13.6	23.3	26.4	17.8	20.9	90.6	41.8	45.3	11.7	13.3	8.2	319.0	26.6

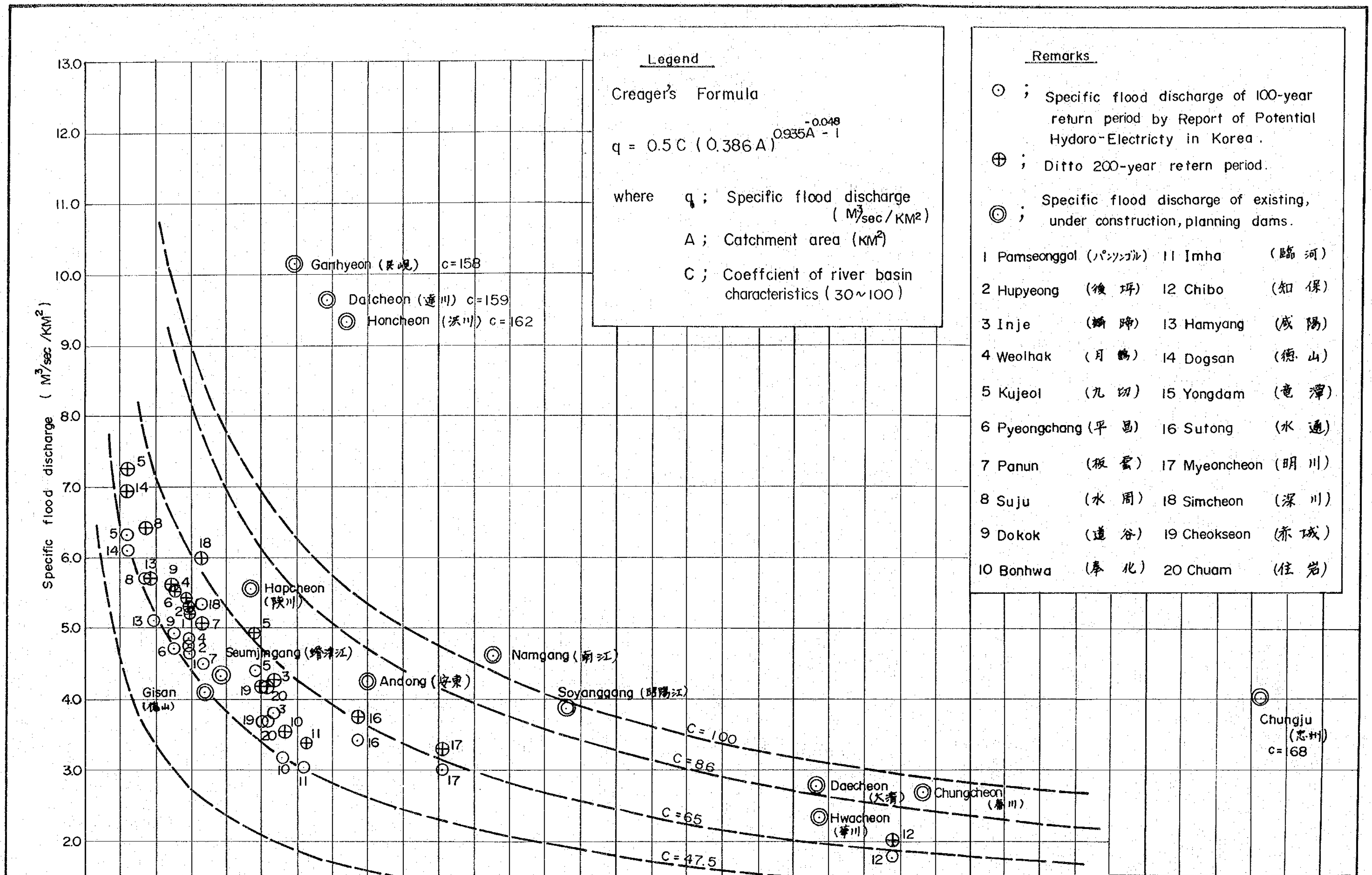
1963-1972 Year mean 25.6

TABLE 1-7-10
MONTHLY INFLOW AT JUAM (住岩)

Unit : $m^3/sec./1,000\ km^2$

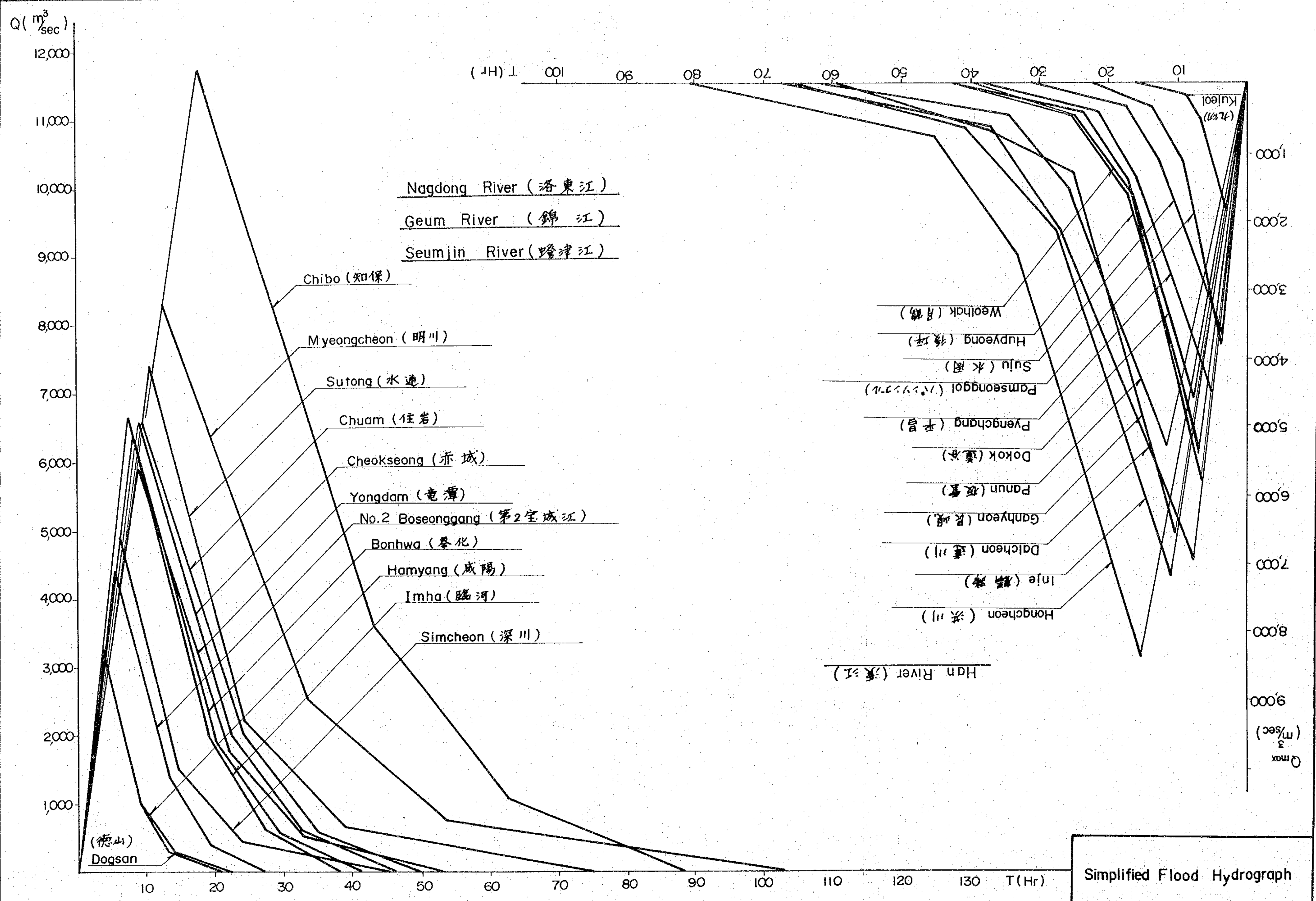
MONTH / YEAR	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	MEAN
1962	7.5	9.2	4.4	5.1	7.0	27.6	75.5	136.9	115.2	10.5	9.0	5.4	413.3	34.4
1963	3.8	4.3	10.7	55.6	44.6	231.7	147.9	25.6	11.6	8.9	5.3	5.2	560.6	46.7
1964	7.9	22.3	12.0	55.6	10.6	23.4	26.2	37.7	89.1	7.6	4.7	3.8	300.9	25.1
1965	6.4	8.2	4.5	28.0	14.3	5.5	146.5	46.3	7.4	8.4	23.4	6.5	365.4	25.4
1966	3.9	17.4	34.8	33.4	28.4	20.7	47.6	114.4	30.9	6.2	7.2	4.9	349.8	29.1
1967	4.4	4.9	16.1	33.4	6.0	63.3	44.4	7.4	14.5	7.2	25.7	5.8	233.1	19.4
1968	5.8	3.3	24.8	13.9	9.7	6.6	9.1	81.4	22.1	32.3	10.0	6.9	225.9	18.8
1969	16.4	30.1	45.1	61.2	20.8	7.4	80.7	74.5	147.9	6.4	4.2	6.6	501.3	41.8
1970	4.6	10.5	4.2	287.0	20.0	28.2	69.4	70.0	68.9	15.1	4.6	4.2	586.7	48.9
1971	14.4	8.8	6.9	11.3	13.0	1.6	82.5	64.6	46.6	6.5	5.3	4.0	265.5	22.1
1972	3.2	6.4	45.3	16.0	6.2	12.5	187.5	133.7	10.2	6.8	59.3	6.1	493.2	41.1
TOTAL	78.3	125.4	208.8	600.5	177.0	428.5	917.3	792.5	564.4	115.9	158.7	59.4	4,231.3	352.6
MEAN	7.1	11.4	18.9	54.5	16.0	38.9	83.3	72.0	51.3	10.5	14.4	5.4	384.6	32.1

1963-1972 Year mean 31.9



Design Flood Discharge on the Creager Curve

DATE FIG. 1-4-1



Simplified Flood Hydrograph

DATE | FIG. 1-5

2. HYDROPOWER

2. HYDRO POWER

2.1 Existing Facilities

The installed generating facilities in interconnected system as of June, 1977 are as follows:

Plant	Nameplate Capacity (MW)	Percentage
Hydro plant		
Conventional	619.88	12.95
Pumped-storage	90	1.88
Sub-total	709.88	14.83
Thermal plant		
Steam	3,844.3	80.33
Diesel	81.67	1.71
Gas turbine	150	3.13
Sub-total	4,075.97	85.17
Total	4,785.85	100.00

Besides the interconnected facilities above-mentioned, there are generatting facilities in islands totalling 23.9 MW. Therefore, a total capacity of generating facilities in this country is 4,809.75 MW.

Hydro plants account for 14.83 per cent of the total interconnected facilities. Table 2.1 shows the list of the existing facilities including the nameplate capacities, plant factors for the year of 1976, and the dates of commissioning.

As the characteristic mark, the power output shows a drastic reduction during the dry season as shown in Table 2.2 which mentions the concerning data for the years of 1974, 1975 and 1976. From this table, it can be known that the plant factors and load factors are so higher in a period between April and September of the wet season and lower in the remaining period during the dry season.

2.2 Development Plan

To meet the increase of peak demand and energy requirement, Korea Electric Company (KECO) has established a power development program as shown in Table 2.3. A total of about 2,300 MW in the hydro plants including conventional, pumped-storage and tidal plants is scheduled to be developed in the period upto the year of 1986 when the total capacity will reach about 19,000 MW, and percentage of the hydro plant will be about 16 per cent in the whole generating facilities. For the purpose of taking the peak loads of the system, development of these hydro plants are appropriately planned.

The plant factor and the average yearly energy of the hydro plants under construction and in future are shown in Table 2.4.

2.3 Role of Hydro Plant in the Power System

According to the statistical data, the daily load factor in week day is around 80% in an average and has been maintained in constant level for the recent several years. It is anticipated, however, that the daily load factor would decline due to the progress of industrialization and living standards, in other words, the demand for peak power would increase. Since hydro power plants are favourable to meet the peak demand and to supply clean energy, the development of hydro power plants should be promoted.

Since the power system of Korea is the sole interconnected system, except for islands, and the demand in the system is enormous compared to the expected power output at any damsite studied on this time, development of the selected and feasible multipurpose dam projects is accepted from the view of electric power.

Table 2-1 Existing Hydro Plants as of 1976 in Interconnected System

Plant Name	Nameplate Capacity (MW)	Plant Factor (1976) %	Commissioning Date
Conventional			
Hwachon #1, #2	27 x 2		May 1944
Hwachon #3	27	32.0	Nov. 1957
Hwachon #4	27		Jun. 1968
Chongpyong #1, #2	19.8 x 2	38.0	Oct. 1943
Chongpyong #3	40		Dec. 1967
Chuncheon #1, #2	28.8 x 2	31.1	Feb. 1965
Chilbo #1, #2	14.4 x 2	45.2	Apr. 1945 & Dec. 1965
Unam	2.56	44.6	-
Bosunggang #1, #2	1.625 x 2	63.2	Feb. 1937
Gaesan #1, #2	1.3 x 2	35.1	Oct. 1952
Uiam #1, #2	22.5 x 2	42.1	Nov. 1967
Namgang #1, #2	6.3 x 2	31.7	Jun. 1971
Paldang #1, #2, #3, #4	20 x 4	37.4	Dec. 1973
Soyangang #1, #2	100 x 2	24.7	Oct. 1973
Pumped-storage			
Andong	45 x 2	2.0	Sep. 1976
Total	709.88	28.7	

Table 2-2 Monthly Load Factor and Plant Factor of Existing Hydro Plant (%)

	1974		1975		1976	1977
Month	LF	PF	LF	PF	PF	PF
January	26.9	19.1	13.3	8.0		20.6
February	24.8	17.9	20.2	9.5		18.0
March	29.7	19.3	15.3	10.3		18.2
April	46.3	34.9	25.9	17.7		26.4
May	71.9	65.5	42.7	31.0		37.7
June	77.5	64.3	40.3	32.3		30.3
July	57.5	44.0	74.2	71.4		33.0
August	83.3	74.3	85.0	82.4		33.9
September	66.7	58.9	78.7	75.6	50.5	17.6
October	46.1	38.2	43.1	40.4	27.3	
November	39.5	33.2	25.0	21.9	23.7	
December	22.4	15.8	40.5	33.0	25.9	
Yearly Average	44.5	40.6	37.5	36.3	28.7	-

Notes: 1. Data for Jan.-Jul. 1976 period and Oct.-Dec. 1977 were not available.

2. Data for 1974 and 1975 do not include those for Soyangang.

Table 2-3 Power Development Program upto 1986

Year	Plant Name	Type	Nameplate Rating (MW)
1977	Yosu #2	S	300
	Yongwol, Kunsan	CC	200 x 2
	Bupyong	G	55
	Gori #1	N	595
	Ulsan	CC	220
	Incheon #3	S	325
1978	Incheon #4	S	325
	Yongwol, Kunsan	CC	100 x 2
	(Retire)		-12.5
1979	Ulsan	CC	100
	Daecheong	H	90
	Cheju #1	S	10
	Yongdong #2	S	200
	Ulsan #4	S	300
1980	Asan #1	S	300
	Chongpyong	P/S	400
	Asan #2	S	300
	Cheju #2	S	10
	Ulsan #5	S	300
1981	Ulsan #6	S	300
	New Thermal #1, #2	S (Coal fired)	200 x 2
1982	Wolsung #2	N	678.7
	Samchonpo #2	S	500
	Samrangjin	P/S	300
	(Retire)		-121.85

- continued -

Year	Plant Name	Type	Nameplate Rating (MW)
1983	New Thermal #5, #6, #7	S	500 x 3
	Gori #2	N	650
	Imgye	H	153
	Chungju	H	210
	(Retire)		-210
1984	Nuclear #5	N	700
	Habcheon	H	80
1985	New Thermal #8, #9	S	500 x 2
	Nuclear #6	N	900
	Imha	H	50
	Hongcheon	H	63
	Habcheon	P/S	400
1986	New Thermal #10, #11	S	500 x 2
	Yongdam	H	160
	Tidal plant	T	400

Note: Abbreviation for "Type of Plant" :

S : Steam
CC : Combined Cycle
H : Conventional Hydro
P/S : Pumped-storage Hydro
T : Tidal

Table 2-4 Plant Factor and Average Yearly Energy of Future Hydro Plants

Name of Plant	Installed Capacity (MW)	Average Yearly Energy (MWh)	Plant Factor (%)
Daecheong*	90	250,000	30
Imgye	153	329,000	25
Habcheon	80	183,000	26
Imha	50	74,700	17
Hongcheon	63	119,000	22
Yongdam	160	255,000	18

* Under construction

3. IRRIGATION

3. IRRIGATION

3.1 Basic Concept

Attempting long term forecast of irrigation water demand in the four major river basins in the ROK, the increase of future demand of irrigation water is considered to be basically caused by three categories as mentioned below.

Category-A : Additional water supply caused by rehabilitation of irrigation system

Category-B : Supply for newly developed area

Category-C : Additional supply for increased water requirements induced by farming improvement

As far as the basin along the main reach of the rivers is concerned, existing paddy field in the basin will be considerably well-irrigated by the existing dams and the dams under construction.

While, the most of paddy field expanding in the tributary basins still remains under partially irrigated and rainfed condition. The overall water resource development including such a tributary basins, therefore, has still enormous potentiality in the future. The conclusion of the overall development may require another detailed investigation. The required water resources for the agricultural development area under investigation have to depend on the dams proposed on the main reach of the four rivers. The development of the tributary basins cannot be taken into consideration from the view-point of project economy. After all, the future increase of water demand relevant to the Category-A will not be almost anticipated.

Recently, the production of staple crops has sharply increased and the self-sufficiency of the food has been almost attained in this country. New arable land development by land reclamation project will not be actively encouraged, since the project will not be economically justified. In this view, special attention will not be paid on the Category-B as well as Category-A.

Farming improvement, a major component of agricultural modernization will exert favourable influence on the boost and stabilization of farmers economy. Consequently, it will bring about a stabilized agricultural production which will play a predominant role in the national economy.

The farming condition on farm level has to be bettered for lifting the land and labour productivities in the agricultural sector. Firstly, the elevation of the land productivity in the paddy field will be attained by the improvement of drainage condition and water management on farm level, which will cause a remarkable increase of yield of rice. Secondary, the elevation of land productivity in the upland field will be achieved by an upland irrigation development and an introduction of new farming technology which will bring about the sharp increase of yield and the diversification of upland crops.

Agricultural mechanization, improved agricultural technology and upland crop diversification is quite requisite to attain the elevation of the land and labour productivities. The mechanization, in particular, will greatly contribute to the considerable reduce of the farming labour force and the provision of large amount of surplus labour force among the farmers concerned. The surplus labour force will cause the expansion of farming scale in the relevant basins.

Based on the above viewpoint, land consolidation and upland irrigation, relevant to the Category-C are focussed for the future development component in the basins. The increase of water demand caused by the implementation of the two development component will depend on the water resources developed at the dams proposed on the main reach of the rivers through this investigation.

3.2 Irrigation Plan

3.2.1 Proposed Area of Land Consolidation

Based on "Year Book of Agricultural and Forestry Statistics" (hereinafter called Year Book)/1, proposed area of land consolidation is estimated through the following procedure.

i) Rearrangement of the arable land area in the above "Year Book".

ii) Estimation of the arable land area along the main reaches of rivers.

iii) The arable land area on the other river basin which has already been developed by existing dams, such as Chunju Dam (Southern Han River), Namgang Dam (Nakdong River), Daecheon Dam (Geum River) and No. 1 Boseonggang Dam (Sumjin River) is included as the arable land area of proposed dam on this stage.

iv) Estimation of proposed area of land consolidation from the arable land area which is obtained in the above item i) to iii). The proposed area of land consolidation is calculated by multiplying the arable land area along the main reaches of rivers by the proposed ratio of land consolidation. The proposed ratio of land consolidation in each river basin is estimated as below based on the target area 588 thousand ha/2 (46% of arable land) of land consolidation in Korea.

Northern Han River and Sumjin River	40%
Southern Han River	60%
Nakdong River (Namgang)	70%
Nakdong River and Geum River	80%

The proposed area of land consolidation is shown in Table-3.1.

/1 Published by Ministry of Agriculture and Forestry in 1976.

/2 Refer to Korean Agricultural Present and Future
– Part I Current Korean Agriculture Situation and Prospects –

3.2.2 Proposed Area of Upland Irrigation

Upland irrigation area along the main reach of river is estimated from the proposed ratio of upland irrigation. The proposed ratio of upland irrigation is estimated as shown below based on the topographic condition.

Han River and Geum River	20%
Nakdong River	25%
Sumjin River	5%

In upland irrigation, selection of crops is made based on "Year Book". Especially, perenial crops such as fruits are selected as main crops from profitability and high potential demand.

The proposed area of upland irrigation is shown in Table-3.17.

3.2.3 Irrigation Water Requirement

(1) Water requirement for land consolidation

After completion of land consolidation, the following additional water requirement will be occured.

i) Additional water requirement by improvement of drainage system

ii) Additional water requirement by improvement of irrigation system

On the basis of experiences in Japan and relevent references in Korea, additional water requirements are estimated as shown in Table-3.3.

(2) Water requirement for upland irrigation

The soils in proposed upland irrigation area are derived from clay and/or clay loam of Quaternary period alluvium.

Irrigation method is carried out using the portable pressure sprinkler. The amount of water is estimated 50 mm with 5 days irrigation interval. Monthly irrigation water requirement is estimated as shown in Table-3.4. from experience in Japan.

Table-3.5 shows the cropping intensity.

Water requirement for upland irrigation is shown in Table-3.6.

3.3 Benefit Estimation

3.3.1 General

The following benefit will be expected by the land improvement projects.

i) Prevention of the drought damage and/or the flood damage by the improvement of irrigation and drainage facilities.

ii) Increasing of yield by the soil dressing and the improvement of irrigation system.

iii) Introduction of improved variety or newly crops by the land reclamation and upland irrigation development.

iv) Introduction of secondary cropping by the drainage improvement.

On the other side, farming improvement by the modern agricultural mechanization will exert favourable influence on the boost and stabilization of farmers economy.

3.3.2 Benefit by Land Consolidation

Annual benefit is estimated by the following formula.

Annual benefit = Annual Income by additional paddy production + Additional annual income by reduce of farming labor force - Annual expenses

Additional paddy production by the land consolidation is shown in Table-3.7. The data relevant to the reduce of the farming labor force is shown in Table-3.9. Annual income by additional paddy production is shown in Table-3.10. Additional annual income by the reduce of the farming labor force is shown in Table-3.11. Table-3.13 shows the construction cost of land consolidation. Estimated benefit by land consolidation is shown in Table-3.12.

3.3.3 Benefit by Upland Irrigation

Annual benefit is estimated by the following formula.

Annual benefit = Annual income by upland crops production - Annual expenses

Yields of crops are shown in Table-3.8. Annual income by upland crops production is shown in Table-3.14. Construction cost of upland irrigation is shown in Table-3.16. Estimated benefit by upland irrigation is shown in Table-3.15.

3.3.4 Annual Benefit

The annual irrigation benefit derived from the development of the long-term multi-purpose dams are summarized in Table-3.18. As a result, the justifiable expenditure for irrigation sector of the multi-purpose dam is estimated for each basin as follows;

Han river basin	W18 - 20/m3
Nakdon river basin	W23 - 26/m3
Geum river basin	W26/m3
Sumjin river basin	W22 - 23/m3

Table-3.1 Proposed Land Consolidation

Proposed Dam Site	Existing Irrigated Area (1)	Proposed Ratio of Land Consolidation (2)	Proposed Area of Land Consolidation (3) = (1) x (2)
Han River	177,400 ha	%	ha
1-32 Bamseonggol	29,600	40	11,840
2-23 Hupyeon	29,900	"	11,960
3-22 Inje	29,900	"	11,960
4-30 Weolhak	30,100	"	12,040
5-A3 Hongcheon	27,400	"	10,960
6-3 Gujeol	41,000	60	24,600
7-9 Pyeongchang	41,500	"	24,900
8-10 Panun	40,800	"	24,480
9-13 Suju	41,300	"	24,780
10-12 Dogok	41,300	"	24,780
11-A1 Dalcheon	35,600	"	21,360
12-A2 Ganhyeon	35,400	"	21,240
Nakdong River	279,300 1)		
13-35 Bonghwa	43,400	80	34,720
14-43 Imha	43,900	"	35,120
15-36 Chibo	42,000	"	33,600
16-51 Hamyang	29,600	70	20,720
17-53 Dogsam	28,600	"	20,720
Geum River	192,900 2)		
18-62 Yongdam	69,200 3)	80	55,360
19-63 Sutong	69,000 3)	"	55,200
20-64 Myeongcheon	68,900 3)	"	55,120
21-69 Simcheon	68,900 3)	"	55,120
Sumjin River	65,600		
22-77 Jeokseong	5,700	40	2,280
23-82 Juam	3,800	"	1,520
24 No. 2 Boseonggang	5,900 4)	60	3,540

Source: Yearbook of Agriculture and Forestry Statistics, 1976, MOAF.

Notes:
1) Includes 46,300 ha of Nam river basin.
2) Includes 38,100 ha of Mangyeong river basin.
3) Includes 19,500 ha of Mangyeong river basin.
4) Includes 1,100 ha of Rakuwu River basin.

Table-3.2 Present Land Use: (1975)

Item	Area (ha)	Ratio (%)		Land Consolidation Area
Total	9,875,769	100		
Cultivated Land	2,239,692	23	100	263,323
Paddy Field	1,276,599	13	57	
Upland	963,093	10	43	
Forest	6,639,579	67		
Other	996,498	10		

Source: Yearbook of Agriculture and Forestry Statistics, 1976, MOAF.

Table-3.3 Proposed Irrigation Water Requirement

(Unit: mm/year)

River System	Present Irrigation Water Requirement (1)	Proposed Irrigation Water Requirement after Completion of Land Consolidation		
		Additional Water Requirement by Improvement of Drainage (2)	Additional Water Requirement by Improvement of Irrigation System (3)	Proposed Irrigation Water Requirement (4)=(1)+(2)+(3)
Han River (Nothern)	1,102	220	55	1,380
(Southern)	1,027	205	51	1,285
Nakdong River	1,256	251	63	1,570
Namkang	1,019	204	51	1,275
Geum River	1,035	207	52	1,295
Sumjin River	1,281	256	64	1,600

Notes: 1) Additional water requirement by improvement of drainage is estimated at 20% of present water requirement.

2) Additional water requirement by improvement of irrigation system is estimated at 5% of present water requirement.

3) Sources of present water requirement are as follows:

Han River System : Reconnaissance Report water Resources Han River Basin, 1971.

Nakdong River System: Nakdong River Basin Development Project Feasibility Study, 1976.

Geum River System : Report on the Geum River Basin Overall Development Project, 1972.

Sumjin River System : River Investigation Book, 1974.

Table-3.4 Monthly Irrigation Water Requirement

(Unit: mm/day)

Month / Crops	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Vegetables	1.5	2.0	2.0	2.5	2.5	3.0	4.0	5.0	3.0	2.0	2.0	1.5
Fruits	1.5	1.5	2.0	2.5	3.0	4.0	5.0	6.0	5.0	2.0	1.5	1.5

Table-3.5 Cropping Intensity in River System

(Unit: %)

River System / Crop items	Han River	Nakdong River	Geum River	Sumjin River
Vegetables	79	59	59	87
Fruits	21	41	41	13

Source: Yearbook of Agriculture and Forestry Statistics, 1976, MOAF.

Table-3.6 Proposed Irrigation Water Requirement for Upland Crops

Item \ River System	Han River	Nakdong River	Geum River	Sumjin River
Consumption use (mm/year)	974	1,001	1,001	963
Effective rainfall (mm/year)	672	605	676	605
Irrigation efficiency (%)	75	75	75	75
Irrigation water requirement (mm/year)	367	528	433	477

Notes: 1) Effective rainfall is estimated using the monthly effective rainfall ratio obtained in Chungju Multipurpose Project Feasibility Report, 1976.

2) irrigation efficiency = water-application efficiency x water-conveyance efficiency x water - management efficiency

Table-3.7 Proposed Yield of Paddy Rice

(kg/10a)

River-system	Classification of DO	Present yield	Yield after completion of irrigation system	Yield after completion of land consolidation	Increased yield
		(1)	(2)	(3) = 1.15x(2)	(4) = (3) - (2)
Han River	Gyeonggi-do Gangweon-do	337	421	484	63
Nakdong River	Gyeongsang-bug " -nam	360	450	518	68
Geum River	Chungcheong-bug " -nam	361	451	519	68
Sumjin River	Jeonla-bug " -nam	345	431	496	65
Average	-	354	443	509	66

Notes: 1) Present yield is obtained in "Average Year Production of Food" yearbook of A.F.S., 1976.

2) Additional yield after completion of land consolidation is estimated at 15% of yield after completion of irrigation system.

Table-3.8 Increased Unit Yield of Upland Crops

Crop	Unit-Production	Increased Yield Ratio	Increased Yield	Unit Price	Net Income Rate	Increased Income
	kg/10a	%	kg/10a	W/kg	%	W/10a
White potato	1,281	10	128	68	69	6,005
Sweet potato	2,065	15	310	66	71	14,526
Corn	173	20	35	48	70	1,176
Sorghum	74	"	15	95	70	997
Peanut	81	10	8	376	65	1,955
Radish	1,281	"	128	52	75	4,992
Carrot	897	"	90	110	67	6,633
Red-peper	161	"	16	1,586	65	16,494
Garlic	517	"	52	356	65	12,032
Green onion	1,295	15	194	79	61	9,348
Onion	2,262	"	339	85	68	19,594
Cucumber	1,308	20	262	87	65	14,816
Sweet melon	1,245	"	249	110	70	19,173
Water melon	1,908	"	382	92	72	25,303
Eggplant	1,224	"	245	80	67	13,132
Tomato	1,962	"	392	94	64	23,582
Chinese cabbage	1,228	15	184	58	70	7,470
Cabbage	2,169	"	325	60	69	13,455
Spinach	1,017	"	153	113	67	11,583
Apple	890	"	134	189	75	18,994
Pear	543	"	81	177	66	9,462
Grape	662	"	99	171	73	12,358
Peach	679	"	102	512	80	41,779
Orange	729	"	109	438	80	38,193

Note: 1) Unit production and unit price are shown in yearbook of A.F.S., 1976, MOAF.

2) Increase yield-ratio and net income rate are based on data in Japan, 1976.

Table-3.9 Labor Hours for Paddy Cultivation

(Unit: hr/ha)

Item	Present (1)		Planning (2)		(3) = (2)-(1)	
	Man Power	/1 Machinery	Man Power	/2 Machinery	Man Power	Machinery
Seed preparation	5		3		- 2	
Nursery bed preparation	75	5	72	0.2	- 3	- 4.8
Paddy field preparation	210	40	15	15.0	- 195	- 25.0
Transplanting	300	10	250	2.5	- 50	- 7.5
Weeding and application of checmicals	200	10	80	0.8	- 120	- 9.2
Fertilization	20		20			
Water control	150		50		- 100	
Harvesting and conveyance	440	20)	22	10.0	- 498	- 50.0
Threshing and treatment	80	40)				
Drying of unhulled rice, regulating and marketing	85	30	35	30.0	- 50	
Total	1,565	155	547	58.5	-1,018	- 96.5

Notes: /1 : Cultivator, power sprayer and power threshing huller.

/2 : Tractor, cultivator, speed sprayer and automatic combine.

Source: "Farming data in Japan" Labor Hours by Type of Work., A.F.S., 1976.

Table-3.10 Annual Income per ha by Paddy Production

Items	Increased yield (1)	Unit price (2)	Net income rate (3)	Increased income (4) = (1)x(2)x(3)	Additional income by decreasing of labor hours (5)	Annual income (6) = (4)+(5)
	ton/ha	W/ton	%	W	W	W
Han River System	0.63	268,500	70	118,408	90,935	209,943
Nakdong, Geum Ri.	0.68	"	"	127,806	"	218,741
Sumjin Ri.	0.65	"	"	122,167	"	213,102

Notes: 1) Unit prices is estimated assuming the government's purchasing price in 1977.

2) Net income rate is applied to the same one in Japan.

3) Additional income by decreasing of labor hours is shown in the following table-11.

Table-3.11 Additional Income by Decreasing of Labor Hours

(Unit: per ha)

Items	Power	Working hour	Evaluated amount
(1) Present	Man power	1,565 hr.	313,000 W
	Machinery	155	75,175
(2) Planning	Man power	547	109,400
	Machinery	58.5	187,840
(3) = (2)-(1)	Man power	- 1,018	- 203,600
	Machinery	- 96.5	112,665
	Income		- 90,935

Notes: 1) Working hour is 10 hr. per day.

2) Faming cost is assumed in 200 W/ha.

3) Machinery cost = depreciation cost + management cost + operation cost.

(Small-sized machinery - 485 W/hr.
(
(Medium-sized machinery -3,200 W/hr.

Table-3.12 Annual Benefit per ha by Paddy Production

River system	Annual income	Annual expenses		Annual benefit
		Construction cost	Operation and maintenance cost	
Han River System	209,343 W	141,620 W	7,000 W	60,723 W
Nakdong, Geum Ri.	218,741	"	"	70,121
Sumjin Ri.	213,102	"	"	64,482

Note: Construction cost is shown in the following table-13.

Table-3.13 Construction Cost of Land Consolidation

(per ha)

Item	Quantity	Unit Cost	Construction Cost
Land grading	2,400 m^3	305 W	732,000 W
Farm roads	140 m	1,228	171,920
Irrigation canals	140 m	3,621	506,940
Drainage canals	90 m	3,388	304,920
Underdrainage etc.			30,000
Surveys and tests			240,000
Others			14,220
Total			2,000,000

Notes: 1) Construction cost is estimated based on the following conditions.

Project area : ill-drained paddy field mean gradient - 1/300

farmland block - 100^m x 30^m

Land grading : bulldozer execution

Farm road : 4 - 6^m in width, gravel pavement

Irrigation canal : reinforced concrete canal and V-type ditch

Drainage canal : earth and precast concrete block lining canal

2) Uniform annual capital recovery cost
= $2,000,000^W$ x 0.07081 = $141,620^W$

Capital recovery factor $= \frac{i(1+i)^n}{(1+i)^n - 1}$

$$= \frac{0.055(1 + 0.055)^{28}}{(1 + 0.055)^{28} - 1}$$

$= 0.07081$

where i ; interest rate = 0.055

n ; durable period = 28 years

Table-3.14 Annual Income per ha by Production of Upland Crops

River system	Increased income	Upland area	Annual income
	$\times 10^6$W	ha	W/ha
Han River system	2,386.86	13,700	174,223
Nakdong Ri. system	4,449.61	17,600	252,818
Geum Ri. system	2,295.07	9,800	234,190
Sumjin Ri. system	866.06	3,570	242,593
Total	9,897.60	44,670	221,571

Note: Increased income and upland area are shown in Table 17.

Table-3.15 Annual Benefit per ha by Production of Upland Crops

River system	Annual income	Annual expense	Annual benefit
Han River system	174,223 W	127,280 W	46,943 W
Nakdong Ri. system	252,818	"	125,538
Geum Ri. system	234,190	"	106,910
Sumjin Ri system	242,593	"	115,313
Average	221,571	"	94,291

Note: Annual expense is obtained from the following Table-16.

Table-3.16 Construction Cost of Upland Irrigation Project

(Unit: per 10a)

Item	Construction cost
Diversion facility	64,000 W
Distributing facility	64,000
Sprinkler, etc.	32,000
Total	160,000

Notes: 1) Project area is irrigated by using the portable pressure sprinkler.

2) Annual expense = uniform annual capital recovery cost
+ maintenance and management cost
= 1,600,000 (0.07455 + 0.005)
= 127,280 W/ha

where ; capital recovery factor

$$= \frac{0.055\ (1 + 0.055)^{25}}{(1 + 0.055)^{25} - 1} = 0.07455$$

interest rate = 0.055

durable period = 25 years

annual operation and maintenance cost is estimated at 0.5% of the construction cost.

Table-3.17-1 Increased Yield and Income by Production of Upland Corp

Han River system

Item	Cropping area	Unit increased yield	Increased yield	Unit increased income	Increased income
	ha	kg/10a	T/M	W/10a	$x10^6$W
White potato	2,400	128	3,072	6,005	144.12
Sweet potato	900	310	2,790	14,526	130.73
Corn	5,600	35	1,960	1,176	65.85
Sorghum	500	15	75	997	4.98
Peanut	500	8	40	1,955	9.77
Radish	–	128	–	4,992	–
Carrot	–	90	–	6,633	–
Red peper	2,100	16	336	16,494	346.37
Galic	600	52	312	12,032	72.19
Green onion	500	194	970	9,348	46.74
Onion	–	339	–	19,594	–
Cucumber	1,500	262	3,930	14,816	222.24
Sweet melon	700	249	1,743	19,173	134.21
Water melon	300	382	1,146	25,303	75.90
Eggplant	300	245	735	13,132	39.39
Tomato	400	392	1,568	23,582	94.32
Chinese cabbage	5,400	184	9,936	7,470	403.38
Cabbage	200	325	650	13,455	26.91
Spinach	200	153	306	11,583	23.16
Apple	700	134	938	18,994	132.95
Pear	1,200	81	972	9,462	113.54
Grape	400	99	396	12,358	49.43
Peach	600	102	612	41,779	250.67
Orange	–	109	–	38,193	–
Total					2,386.86

Table-3.17-2 Increased Yield and Income by Production of Upland Corp

Nakdong River system

Item	Cropping area	Unit increased yield	Increased yield	Unit increased income	Increased income
	ha	kg/10a	T/M	W/10a	$x10^6$W
White potato	4,500	128	5,760	6,005	270.22
Sweet potato	5,200	310	16,120	14,526	755.35
Corn	-	35	-	1,176	-
Sorghum	-	15	-	997	-
Peanut	800	8	64	1,955	15.64
Radish	-	128	-	4,992	-
Carrot	100	90	90	6,633	6.63
Red peper	3,800	16	608	16,494	626.77
Galic	1,200	52	624	12,032	144.38
Green onion	700	194	1,358	9,348	65.43
Onion	600	339	2,034	19,594	117.56
Cucumber	500	262	1,310	14,816	74.08
Sweet melon	700	249	1,743	19,173	134.21
Water melon	1,200	382	4,584	25,303	303.63
Eggplant	200	245	490	13,132	26.26
Tomato	600	392	2,352	23,582	141.49
Chinese cabbage	3,200	184	5,888	7,470	239.04
Cabbage	500	325	1,625	13,455	67.27
Spinach	400	153	612	11,583	46.33
Apple	5,000	134	6,700	18,994	949.70
Pear	600	81	486	9,462	56.77
Grape	1,000	99	990	12,358	123.58
Peach	500	102	510	41,779	208.89
Orange	200	109	218	38,193	76.38
Total					4,449.61

Table-3.17-3 Increased Yield and Income by Production of Upland Crop

Geum River system

Item	Cropping area	Unit increased yield	Increased yield	Unit increased income	Increased income
	ha	kg/10a	T/M	W/10a	$x10^6$W
White potato	-	128	-	6,005	-
Sweet potato	1,800	310	5,580	14,526	261.46
Corn	700	35	245	1,176	8.23
Sorghum	400	15	60	997	3.98
Peanut	200	8	16	1,955	3.91
Radish	-	128	-	4,992	-
Carrot	-	90	-	6,633	-
Red peper	3,300	16	528	16,494	544.30
Galic	1,200	52	624	12,032	144.38
Green onion	300	194	582	9,348	28.04
Onion	100	339	339	19,594	19.59
Cucumber	400	262	1,048	14,816	59.26
Sweet melon	500	249	1,245	19,173	95.86
Water melon	300	382	1,146	25,303	75.90
Eggplant	200	245	490	13,132	26.26
Tomato	100	392	392	23,582	23.58
Chinese cabbage	2,000	184	3,680	7,470	149.40
Cabbage	50	325	163	13,455	6.72
Spinach	50	153	77	11,583	5.79
Apple	2,300	134	3,082	18,994	436.86
Pear	500	81	405	9,462	47.31
Grape	500	99	495	12,358	61.79
Peach	700	102	714	41,779	292.45
Orange	-	109	-	38,193	-
Total					2,295.07

Table-3.17-4 Increased Yield and Income by Production of Upland Crop

Sumjin River system

Item	Cropping area	Unit increased yield	Increased yield	Unit increased income	Increased income
	ha	kg/10a	T/M	W/10a	$x10^6$W
White potato	400	128	512	6,005	24.02
Sweet potato	2,400	310	7,440	14,526	348.62
Corn	-	35	-	1,176	-
Sorghum	-	15	-	997	-
Peanut	-	8	-	1,955	-
Radish	950	128	1,216	4,992	47.42
Carrot	50	90	45	6,633	3.31
Red peper	600	16	96	16,494	98.96
Galic	200	52	104	12,032	24.06
Green onion	100	194	194	9,348	9.34
Onion	100	339	339	19,594	19.59
Cucumber	100	262	262	14,816	14.81
Sweet melon	100	249	249	19,173	19.17
Water melon	100	382	382	25,303	25.30
Eggplant	100	245	245	13,132	13.13
Tomato	100	392	392	23,582	23.58
Chinese cabbage	800	184	1,472	7,470	59.76
Cabbage	50	325	163	13,455	6.72
Spinach	50	153	77	11,583	5.79
Apple	50	134	67	18,994	9.49
Pear	100	81	81	9,462	9.46
Grape	100	99	99	12,358	12.35
Peach	200	102	102	41,779	83.55
Orange	20	109	22	38,193	7.63
Total					866.06

Table-3.18 Annual Benefit of Irrigation Water Utilization Scheme in Long-term Multi-purpose Dam Project

River system	Proposed dam site		Benefit area (ha)		Water depend on dam x $10^6 m^3$			Annual benefit x $10^6 W$			(9) = (8)/(5)
	No.	Dam site	Paddy field	Up-land	Paddy field	Up-land	Total	Paddy field	Up-land	Total	
			(1)	(2)	(3)	(4)	(5)=(3)+(4)	(6)	(7)	(8)=(6)+(7)	W/m^3
Han River (North)	1 - 32	Bamseonggol	11,840	8,080	32.68	29.65	62.33	718.96	379.29	1,098.25	17.6
	2 - 23	Hupyeon	11,960	8,220	33.01	30.17	63.18	726.24	385.87	1,112.11	"
	3 - 22	I.je	"	"	"	"	"	"	"	"	"
	4 - 30	Weolhak	12,040	"	33.23	"	63.40	731.10	"	1,116.97	"
	5 - A3	Hongcheon	10,960	7,540	30.25	27.67	57.92	665.52	353.95	1,019.47	"
(South)	6 - 3	Gujeol	24,600	9,590	63.22	35.20	98.42	1,493.78	450.18	1,943.96	19.8
	7 - 9	Pyeongchang	24,900	"	63.99	"	99.19	1,512.00	"	1,962.18	"
	8 - 10	Panun	24,480	9,450	62.91	34.68	97.59	1,486.49	443.61	1,930.10	"
	9 - 13	Suju	24,780	9,590	63.68	35.20	98.88	1,504.71	450.18	1,954.89	"
	10 - 12	Dogck	"	"	"	"	"	"	"	"	"
	11 - A1	Dalcheon	21,360	8,220	54.90	30.17	85.07	1,297.04	385.87	1,682.91	"
	12 - A2	Ganhyeon	21,240	"	54.59	"	84.76	1,289.75	"	1,675.62	"
Nakdong River	13 - 35	Bonghwa	34,720	13,900	109.02	73.39	182.41	2,434.60	1,744.97	4,179.57	22.9
	14 - 43	Imha	35,120	14,080	110.28	74.34	184.62	2,462.64	1,767.57	4,230.21	"
	15 - 36	Chibo	33,600	13,380	105.50	70.65	176.15	2,356.06	1,679.69	4,035.75	"
	16	Hamyang	20,720	5,280	52.84	27.88	80.72	1,452.90	662.84	2,115.74	26.2
	17 - 53	Dogsan	20,020	5,100	51.05	26.93	77.98	1,403.82	640.24	2,044.06	"
Geum River	18 - 62	Yongdam	55,360	9,800	143.38	42.43	185.81	3,881.89	1,047.71	4,929.60	26.5
	19 - 63	Sutong	55,200	9,600	142.97	41.57	184.54	3,870.67	1,026.33	4,897.00	"
	20 - 64	Myeongcheon	55,120	9,310	142.76	40.31	183.07	3,865.06	995.33	4,860.39	"
	21 - 69	Simcheon	"	"	"	"	"	"	"	"	"
Sumjin River	22 - 77	Jeokseong	2,280	2,860	7.30	13.64	20.94	147.01	329.79	476.80	22.8
	23 - 82	Juam	1,520	1,790	4.86	8.54	13.40	98.01	206.41	304.42	22.7
	24	No. 2 Boseonggang	3,540	2,140	11.33	10.21	21.54	228.26	246.76	475.02	22.1

4. FLOOD CONTROL

4. FLOOD CONTROL

4.1 Outline

Effects of flood control of a dam are determined by characteristics of rainfall and the resulted flow discharge at the time of a flood; design flood discharge and operational schemes of the dam; hydraulic characteristics of the river in the downstream of the dam; and topographical conditions of the surrounding areas of the dam.

Therefore, in the study of effects of flood control resulted from construction of a dam, such preliminary studies as the hydraulic and hydrological survey and analyses, operational schemes of the dam group, land utilization of the downstream areas, and a mechanical nature of a flood damage may have to be studied as an indispensable preliminaries.

The group of twenty-four dams for the subject of this study, stretched over four major river systems, and hydrological and social conditions of the project areas are different from each other.

On the other hand, for the purpose to determine construction priority of the twenty-four dams, it is advisable to evaluate flood control effects of the dams in question on an equal basis, and to clarify the relations between flood control projects of the rivers and the respective dams on the rivers.

So, in the first stage survey, the evaluation of effects of the flood control is rather limited to the results of field reconnaissance and available data collection taking time limits into consideration.

Further details of the effects of flood control are up for the proposed second stage survey and the ones subsequent to.

4.2 Flood Damage

A flood damage shows a steady decrease with the progress in river improvement works and flood control facilities, but, on the other hand, it shows a bigger and more frequent damage due to changes in types of land utilization in inundation areas, namely, an increase in damage potentials, and a discharge increase caused by development of natural lands. Taking the above-mentioned study items into consideration, a review of the flood damage of the last 10 years were made.

4.2.1 National Flood Damage

Table 4.1 shows a flood damage for 10 years between 1967 and 1976. The ratio between the average 10-year damage and the Gross National Product is 0.45%. Especially in 1969, the ratio jumped up to 1.4% due to a frequent occurrence of floods in countrywide scale, followed by the ratio of 1.0% in 1970 and 1972.

Table 4.1 Flood Damage and GNP (1967 - 1976)

Year	GNP (B)	Flood Damage (A)	(A)/(B)
	Won 1-billion	Won 1-million	(%)
1967	1,269.95	484	0.04
68	1,598.04	5,431	0.34
69	2,081.52	29,541	1.42
70	2,589.26	20,394	0.79
71	3,151.55	11,005	0.35
72	3,860.00	34,109	0.88
73	4,901.63	5,495	0.11
74	6,747.07	23,243	0.34
75	9,080.33	8,863	0.10
76	12,108.78	14,109	0.12
Average	4,738.81	15,267.4	0.449

Note: GNP and flood damage are shown in the figures of each year.

Refer to: "General Survey of Disasters"

Flood damage by cities and prefectures, shows Gyeongsangnam-Do as the heaviest and Jeonlanam-Do, Gangweon-Do and Chungchongnam-Do to follow.

Flood damage in urban areas are heavy. Though Seoul and Pusan takes about 10% of the total damage of the all cities and prefectures, it can be understood that the intensity of damage is quite high taking the magnitude of the areas of the two cities into consideration.

Since Seoul and Pusan are the economic, social and cultural centers of the country, the adoption of flood control measures to protect the two cities are matters of urgent importance. A fact supporting the above-mentioned importance can be seen in statistics of disasters of the past years. In the statistics since 1916, show a tendency of steady increases in inundation areas and death toll in recent years.

Table 4.2 Flood Damage by Cities and Prefectures (1967 - 1976)

Flood Damage, unit in million Won (price level in 1976)

Name	Total (1967 - 1976)	Average	%
Seoul	5,350	535	1.6
Pusan	5,151	515	1.6
Gyeonggi-Do	31,145	3,115	9.6
Gangweon-Do	39,507	3,951	12.2
Chungcheongbug-Do	17,727	1,773	5.5
Chungcheongnam-Do	31,872	3,187	9.8
Jeonlabuk-Do	18,038	1,804	5.5
Jeonlanam-Do	56,614	5,661	17.4
Gyeongsangbug-Do	30,327	3,033	9.3
Gyeongsannam-Do	76,830	7,683	23.7
Cheju island	9,629	963	2.9
Others	2,905	581	0.9
Total	325,096	32,510	100

Refer to "General Survey of Disasters"

Table 4.3 Comparison between Inundation Areas and Death Toll in Flood Damage Statistics

Period	1916 - 1930 (15-year)	1931 - 1944 (14-year)	1958 - 1971 (14-year)
Deaths	261	227	271
Inundation, ha	60,553	100,438	119,192

Refer to "General Survey of Disasters"

4.2.2 Details and Characteristics of Flood Damage by Catchment Basins

Amounts of flood damage in the past 10 years by the catchment basins of the Han, Naktong, Geum and Seumjin Rivers are shown in Table 4.4.

As far as the conditions in the recent 10 years, the amount of flood damage in the above-mentioned 4 major river systems takes up about 50% of the national total, and nearly 70% of which are of the basins of Han and Naktong Rivers.

By river systems, Han river is the heaviest in the damage amount followed by Naktong, Geum, Seumjin rivers in order of the damage, and by inundation areas by floods, Naktong river is the widest followed by Geum, Han and Seumjin rivers.

Table 4.4 Amount of Damage by Rivers

Year	Whole country		Han		Naktong		Geum		Seumjin	
	Total Damage 10^6Won	Inundation Area 10^3ha	T. Damage 10^6Won	I. Area 10^3ha	T. Damage 10^6Won	I. Area 10^3ha	T. Damage 10^6Won	I. Area 10^3ha	T. Damage 10^6Won	I. Area 10^3ha
1967	1,715	1.7	806	0.4	256	0.2	126	*	6	-
68	16,748	52.4	1,110	4.0	5,653	29.9	252	0.2	675	2.4
69	85,332	155.1	5,217	8.5	17,351	40.8	8,074	20.9	3,432	4.5
70	53,963	144.5	3,965	6.3	10,208	56.1	2,378	6.2	2,205	3.7
71	26,813	71.9	848	2.0	1,289	3.3	11,186	19.2	424	1.5
72	72,901	166.2	41,900	36.4	6,339	43.3	1,240	4.9	690	4.1
73	10,982	24.4	176	0.2	2,025	8.3	194	*	798	3.5
74	32,679	113.7	119	0.7	4,906	33.0	2,822	9.9	1,301	1.7
75	9,854	86.2	2,602	3.6	1,906	5.8	636	8.4	1,640	11.9
76	14,109	28.3	5,655	5.7	737	4.4	220	0.5	273	1.0
Total:	325,096	844.4	62,398	67.8	50,668	225.1	27,128	70.4	11,444	34.3
Average:	32,510	84.4	6,240	6.8	5,067	22.5	2,713	7.0	1,144	3.8

Note: 1976 price level, * less than 100 ha

In intensity of damage by inundation per unit area is the highest in Han River and the lowest in Naktong River.

Flood damage components are listed below, and it can be said that characteristics of flood damage by river basins are clearly shown.

Table 4.5 Annual Average Flood Damage Components by River Systems (1967 - 1976)

Type of Damage	Whole country		Han		Naktong		Geum		Seumjin	
	Damage	%	Damage	%	Damage	%	Damage	%	Damage	%
Death	211.9	-	7.1	-	26.9	-	11.7	-	2.5	-
Dwelling	2,277.9	7	883.2	14	227.9	4	91.3	3	39.6	3
Farmland	2,798.4	8	757.9	12	443.9	9	273.1	10	86.3	8
Public Facilities	11,237.8	35	2,515.3	41	1,853.0	36	776.4	29	404.6	35
Farm Products	13,649.3	42	1,827.5	29	2,410.5	48	1,519.6	56	590.8	52
Others	2,546.2	8	255.9	4	131.5	3	52.4	2	22.9	2
Total	32,509.6	100	6,239.8	100	5,066.8	100	2,712.8	100	1,144.4	100

Note: 1. Price level in 1976

2. In Million Won

3. % - Ratio to the Total

In damage to public facilities, the Han River is the heaviest, and one to dwellings of the river basin is relatively heavier compared with other basins. It is considered that this is because the type of damage is relatively urban nature. More than 60% of damage from floods is somehow connected to agriculture in the catchment basins of Naktong, Geum and Seumjin Rivers, while a heavy death toll is observed in the basins of the Naktong and Geum Rivers.

4.3 Flood Control Project, Past and Present

4.3.1 Development of Flood Control Project

An idea of river improvement scheme of an entire river system, as a part of a flood control project, came on the scene in only about 1910s. A survey of catchment basins, topographical and hydrological survey of the more important areas of the basins began with 1915 as drastic counter measures against frequent and repeated flood damage. In 1924, river survey of 11 major rivers, the Han River as the first of all, were reached completion, and improvement programs of the respective rivers were mapped out. In early and mid. 1920s, the country met frequent floods all over the areas, and the flood of July 18, 1925 was in country wide scale as well as record breaking. Because of this, time was getting ripe for the earliest completion of the river improvements, and the works were started according to the urgency of sections in the neighbourhood of the urban areas. In the course of the development, the river improvement projects mentioned above are divided into 3 terms according to the nature of the works. Major items in the respective terms are the diversion channel project of Nam River in the "First Term" (1945 - 1950), the long term flood control project and the establishment of basis of the continued flood control project in the "Second Term" (1953 - 1960), and the 5-year flood control project came to a fuller realization in the "Third Term" (1961 - 1971).

Recently; an increased population and concentration of assets in urban areas especially in Seoul invite a higher damage potential and an increase of flood damage in urban areas.

The background of flood prevention measures in the respective river basins are generally as below.

(1) Han River

a. Seoul, the metropolis and center of political, economical and social activities, where concentration of population and accumulation of assets are observed, is located in the downstream of the river. The flood prevention effects in the Seoul-Incheon industrial zone are believed high.

b. In the recent years, a bigger flood damage in the downstream of Seoul was reported.

c. In the river systems represented by the South Han and North Han, flood prevention facilities on the South Han are relatively scarce.

d. A frequent flood damage is observed in the basin of the South Han River.

(2) Naktong River

a. Because of the topographical limitations, suitable construction sites for larger scale flood control facilities are comparatively scarce.

b. About 50% of the total flood damage is somehow related to agriculture.

c. Since the soils along the left bank area of the basin of the main river is granite in formation, thus a higher rate of flush sediment is observed caused by devastation of the basin. This is causing a rise of the river bed and an increase of a flood damage.

d. There are extensive farmlands as the result of land development of the river. The area suffers a considerable inundation damage because the low capacity of the inland water drainage.

e. In recent years there are changes in land utilization in mid-stream areas, a new industrial zone (Gumi zone) is one of the example.

f. A number of flood control dams may have to be constructed on the river due to the configuration of the catchment basin and the alignment of the river channel.

(3) Geum River

a. The forest pattern along the river is rather poor hence a shorter flood discharge.

b. Most of the damage is concentrated in the downstream areas. Since the Daecheong Dam, under construction, is located in the mid-stream of the main river, it is expected to produce considerable effects on the flood control.

c. A damage caused by inland water is relatively high.

(4) Seumjin River

a. The catchment basin is consisted of 73% of mountainous area and 13.9% arable land.

b. Population is the lowest of the four major river basins. It is a low development area.

c. Areas suffering frequent flood damage can be seen even up to the mid- and downstream areas especially concentrated in the downstream of the No. 2 Boseonggang Dam.

4.3.2 Existing River Improvements of the Rivers

The river improvement works are divided into three categories by river systems direct central supervision, local and provisional. In 1977, out of the total length, 20,600 km, of the proposed improvement sections, so far 5,932 km (28.8%) are already improved. By river systems, improvements are in progress along the Geum River 72.8% in the local supervision section, the Naktong River 65.0% in the direct central supervision section, however, the progress of the improvements in Han River and Seumjin River are relatively left behind.

Table 4.6 The Progress of the River Improvements

River System	Class	River Length km	Proposed Improvement Section Length km	Improved Section Length km	%
	Total	30,290.3	20,600.0	5,932.1	28.8
Whole country	D	2,258.3	2,448.7	1,332.1	54.4
	L	2,321.2	3,130.4	1,254.3	40.0
	P	25,710.8	15,020.9	3,345.8	22.3
Han	D	542.0	517.3	168.9	32.7
	L	929.0	872.5	247.4	28.4
	P	3,946.3	2,435.3	619.1	25.4
Naktong	D	683.4	718.4	467.0	65.0
	L	396.6	888.9	208.9	23.5
	P	6,193.4	3,448.7	703.8	20.4
Geum	D	450.4	375.6	208.4	55.5
	L	407.2	364.5	265.3	72.8
	P	2,472.7	1,512.9	483.0	31.9
Seumjin	D	189.6	226.9	87.1	38.4
	L	113.9	122.2	18.1	14.8
	P	2,485.4	1,466.3	163.7	11.2

(as of 1977)

Note D : Direct Central Supervision

L : Local Supervision

P : Provisional

4.3.3 Flood Control Factors of the Dams of Existing, under Construction and Proposed

The existing conditions of flood control dams by river basins are summaried in Table 4.7.

The flood control capacity of the existing dams is 13.6% of the gross storage capacity. In the case of the Han River, it is 19.3% a little higher than the average. Equivalent precipitation (= V/A) is 76.4mm in national average. In any case, it is under 100mm except Soyangang dam on North Han River.

Accordings to the above view, number and storage capacity of the existing dams are far too small, and this is why construction of more flood control dams are waited for.

Table 4.7 Existing Conditions of Flood Control Dams by River Basin

	Dams	River Systems	(1) Gross Storage (x10 cum)	(2) Flood Control Capacity (x10 cum)	Depth (m)	(3) Flood Discharge Inflow (cms)	(4) Flood Discharge Outflow (cms)W	(5)=(3)-(4) Control Discharge (cms)	(6)=(2)/(5) Capacity Req'd for 1cum/s Control (m^3/cms)	(7) Catchment Basin (km^2)	(8)=(2)/(7) Equivalent Precipitation (mm)
Existing	Soyang	North Han	2,800	500	4.5	10,500	5,500	5,000	100,000	2,703	185
	Sumjin	Seumjin	466	32		3,268	1,868	1,400	22,860	763	42
	Namgang	Naktong's tributary	136	42		10,570	2,000 (D.V.5400)	3,110	13.50	2,285	18
	Andong	Naktong	1,248	110	2.5	5,000	3,400	1,600	93.750	1,588	69
Uner Construction	Daechong	Geum	1,490	250	3.3	10,700	3,500	7,200	71,430	4,134	60
	Yeongcheon	Naktong's tributary	98	10							
Proposed	Chungju	South Han	2,900	600		26,700	20,400	6,300	95,238	6,648	90
	Hapchon	Naktong's tributary	794	80		3,405	340	3,065	19,575	925	86