Table P 14 BREAKDOWN OF CONSTRUCTION COST OF HAMYANG MULTIPURPOSE DAM FOR SAMPLE DESIGN

(1978 price level)

Dam	Unit	Unit Price ($)	Hamyang Quantity	Hamyang Amount (10^3)
I CIVIL WORKS				
1. Preparatory Works				
- Access road	km	80,000	11	880
- Construction facilities	LS	-	-	2,094
Sub-total				2,974
2. Diversion Tunnel				
- Tunnel excavation	m^3	25	121,000	3,025
- Lining concrete	m^3	60	39,000	2,340
- Steel bar	ton	500	3,900	1,950
- Miscellaneous	LS	-	-	2,195
Sub-total				9,510
3. Dam				
- Excavation	m^3	3.0	210,000	630
- Embankment	m^3	7.0	2,500,000	17,500
- Foundation treatment	LS	-	-	1,813
- Miscellaneous	LS	-	-	997
Sub-total				20,940
4. Spillway				
- Excavation	m^3	4.0	460,000	1,840
- Concrete	m^3	45	41,000	1,845
- Steel bar	ton	450	1,230	554
- Miscellaneous	LS	-	-	212
Sub-total				4,450
Total				37,874
II METALWORKS				
- Diversion gate	ton	4,000	270	1,080
- Spillway gate	ton	5,200	510	2,652
- River outlet facilities	LS	-	-	520
Total				4,252

Table P 14 Continued (2)

Power Facilities	Unit	Unit Price ($)	Hamyang Quantity	Hamyang Amount ($ 10^3)
I CIVIL WORKS				
1. Preparatory Works				
- Access road	km	60,000	-	-
- Construction facilities	LS	-	-	44
Sub-total				44
2. Intake				
- Excavation	m^3	4.0	5,980	24
- Concrete	m^3	45	65	3
- Steel bar	ton	450	4	2
- Miscellaneous	LS	-	-	3
Sub-total				32
3. Intake Gate Shaft				
- Shaft excavation	m^3	25	1,331	33
- Concrete	m^3	60	554	33
- Steel bar	ton	450	33	15
- Miscellaneous	LS	-	-	16
Sub-total				97
4. Headrace Tunnel				
- Tunnel excavation	m^3	30	3,850	116
- Lining concrete	m^3	74	1,424	105
- Steel bar	ton	500	85	43
- Miscellaneous	LS	-	-	53
Sub-total				317
5. Surge Tank				
- Shaft excavation	m^3	25	600	15
- Concrete	m^3	60	187	11
- Steel bar	ton	450	11	5
- Miscellaneous	LS	-	-	6
Sub-total				37

Table P 14 Continued (3)

Power Facilities	Unit	Unit Price ($)	Hamyang Quantity	Hamyang Amount ($ 10^3)
I CIVIL WORKS (Continued)				
6. Penstock				
- Open excavation	m^3	4.0	810	3
- Concrete, block etc.	m^3	50	171	9
- Steel bar	ton	450	5	2
- Miscellaneous	LS	-	-	4
Sub-total				18
7. Power House, Substructure				
- Excavation	m^3	2.5	3,245	8
- Concrete	m^3	55	1,718	94
- Steel bar	ton	450	86	39
- Miscellaneous	LS	-	-	21
Sub-total				162
8. Power House				
- Superstructure	space volume m^3	5	816	45
9. Tailrace				
- Excavation	m^3	2.5	1,832	5
- Concrete	m^3	45	331	15
- Steel bar	ton	450	17	8
- Miscellaneous	LS	-	-	1
Sub-total				29
Total				781
II METALWORKS				
- Intake trashrack	ton	2,000	8	16
- Intake gate	ton	5,500	10	55
- Steel penstock	ton	2,000	60	120
- Tailrace gate	ton	4,500	12	54
Total				245

Table P 15 OUTLINE OF HADONG-GWANGYANG PIPELINE SYSTEM ASSOCIATED WITH JUAM DAM (MAIN STREAM PLAN)

1.	Order of Construction	1	2	3
2.	Scope	Extension of existing system	New pipeline	Extension of new pipeline
3.	Discharge Capacity (10^3 m^3/d)	300	320	320
4.	Intake Pump			
	4.1 Capacity (PS)	8,100	7,000	7,000
	4.2 Water head (m)	68	56	56
5.	Tunnel			
	5.1 Discharge capacity (10^3 m^3/d)	-	620	-
	5.2 Dimensions (D m x L km)	-	2.5 x 1.5	-
6.	Pipeline			
	6.1 Route	Sueo dam - Gwangyang	Hadong - Gwangyang	Hadong - Gwangyang
	6.2 Trunk main (D mm x L km)	1,750 x 15.4	1,800 x 17.5	1,800 x 17.5
	6.3 Primary treatment plant (10^3 m^3/d)	360	384	384
	6.4 Regulating pond (10^3 m^3/d)	70	75	75
	6.5 Distribution main (D mm x L km)	1,200 x 10	1,200 x 10	1,200 x 10

Remarks :

The facilities same as those in the second and third stages are constructed alternately in the fourth stage and onward.

Table P 16 FINANCIAL COST OF HADONG-GWANGYANG PIPELINE SYSTEM ASSOCIATED WITH THE JUAN DAM SCHEME (MAIN STREAM PLAN)

Unit: $ 10^6

Order of Construction	1	2	3
1. Investment Cost			
Intake weir	0.65	-	-
Intake & pump	4.62	3.62	3.62
Truck main	7.93	9.28	9.28
Tunnel	-	1.17	-
Primary treatment plant	2.60	2.75	2.75
Regulating pond	1.64	1.76	1.76
Distribution main	3.50	3.50	3.50
Transmission line & substation	0.50	0.87	0.38
Land compensation	0.40	0.50	0.40
Engineering fee	1.07	1.14	1.06
Contingency	4.59	4.92	4.55
Total :	27.50	29.51	27.30
2. Replacement Cost	17.6	19.2	18.5
3. O & M Cost (Full Operation)			
Fixed cost	0.48	0.48	0.44
Material cost	0.17	0.19	0.19
Energy cost	1.04	0.91	0.91
Total :	1.69	1.58	1.54

4. O & M Cost of the Yeocheon/Gwangyang existing M&I Water Supply Pipeline System (Full Operation)

Fixed cost	0.74
Material cost	0.15
Energy cost	2.14
Total :	3.03

Table P 17 OUTLINE OF M&I PIPELINE SYSTEM, ROUTE A, ASSOCIATED WITH THE JUAM DAM SCHEME (DIVERSION PLAN)

Rote A

1.	Juan Dam HWS (El. m)	114	117	120
2.	Nominal Supply Capacity (m^3/s)	11.8	13.1	15.0
3.	Diversion Tunnel			
3.1	Discharge capacity	11.8	13.1	15.0
3.2	Dimensions (D mm x L km)	2.9 x 11	3.0 x 11	3.1 x 11
3.3	Type of flow	Free	Free	Free
3.4	Energy dissipator	Intake Valve	Intake Valve	Intake Valve

4.	Regulating Reservoir (Common to the three alternative scales)	
4.1	Type	Excavated Pond
4.2	HWS	El. 70 m
4.3	LWS	El. 68 m
4.4	Active storage	120,000 m^2
4.5	Surface area	0.22 km^2
4.6	Increased discharge	-

5.	Pipeline / one line (Common to the three alternative scales)	
5.1	Trunk main	1,870 mm dia. x 33 km
5.2	Nominal capacity	320,000 m^3/d (3.7 km^3/s)
5.3	Primary treatment plant	384,000 m^3/d
5.4	Regulating pond	75,000 m^3
5.5	Distribution main	1,200 mm dia. x 10 km

Table P 18 FINANCIAL COST OF M&I PIPELINE SYSTEM, ROUTE A, ASSOCIATED WITH THE JUAM DAM SCHEME (DIVERSION PLAN)

Unit : $ 10^6

Route A

Juam Dam HWS (El. m)	114	117	120
1. Investment Cost			
1.1 Intake & diversion tunnel			
Intake, civil works	0.128	0.133	0.138
Intake, metalworks	0.240	0.260	0.280
Tunnel	8.360	8.800	9.130
Engineering fee	0.873	0.919	0.955
Contingency	1.920	2.022	2.100
Sub-total	11.521	12.135	12.603

1.2 Regulating reservoir (Common to the three alternative scales)

Excavated pond	4.557
Land compensation	0.200
Engineering fee	0.228
Contingency	0.997
Sub-total	5.982

1.3 Pipeline / one line (Common to the three alternative scales)

Construction stage	1	2 & thereafter
Trunk main	18.150	18.150
Primary treatment plant	2.753	2.753
Regulating pond	1.755	1.755
Transmission line & substation	0.350	-
Distribution main	3.500	3.500
Land compensation	0.500	0.500
Engineering fee	1.325	1.308
Contingency	5.667	5.593
Sub-total	34.000	33.559

2. Replacement Cost			
2.1 Intake & diversion tunnel	0.285	0.309	0.333
2.2 Regulating reservoir	-	-	-

2.3 Pipeline / one line (Common to the three alternative scales)

Construction stage	1	2 & onward
	26.870	26.473

3. O & M Cost			
3.1 Intake & diversion tunnel	0.058	0.061	0.063
3.2 Regulating reservoir	0.030	0.030	0.030

3.3 Pipeline / one line (Common to the three alternative scales)

Construction stage	1	2 & onward
Fixed cost	0.355	0.288
Material cost	0.188	0.188
Energy cost	-	-
Sub-total	0.543	0.476

Table P 19 OUTLINE OF M&I PIPELINE SYSTEM, ROUTE B, ASSOCIATED WITH THE JUAM DAM SCHEME (DIVERSION PLAN)

Route B

1.	Juan Dam HWS (El. m)	114	117	120
2.	Nominal Supply Capacity (m^3/S)	13.8	15.3	17.4
3.	Diversion Tunnel			
	3.1 Discharge capacity (m^3/S)	11.8	13.1	15.0
	3.2 Dimensions (D mm x L km)	2.7 x 13.5	2.8 x 13.5	2.9 x 13.5
	3.3 Type of flow	Pressure	Pressure	Pressure
	3.4 Gate	Intake & outlet	Intake & outlet	Intake & outlet
3.	Regulating Reservoir			
	4.1 Dam	Yeonggye	Yeonggye	Yeonggye
	4.2 River system	Isa	Isa	Isa
	4.3 Catchment area (km^2)	133	133	133
	4.4 Annual run-off (10^6 m^3)	120	120	120
	4.5 HWS (El. m)	89	92	95
	4.6 LWS (El. m)	60	60	60
	4.7 Drawdown (m)	29	32	35
	4.8 Active storage (10^6 m^3)	89.6	104.5	120.7
	4.9 Surface area (km^2)	4.6	5.0	5.4
	4.10 Increased discharge (m^3/S)	2.0	2.2	2.4
	4.11 Dam type -	CG	CG	CG
	4.12 Dam volume (10^3 m^3)	438	481	534
5.	Pipeline / one line (Common to the three alternative scales)			
	5.1 Trunk main	1,870 mm dia. x 26 km		
	5.2 Nominal capacity	320,000 m^3/d (3.7 m^3/S)		
	5.3 Primary treatment plant	384,000 m^3/d		
	5.4 Regulating pond	75,000 m^3		
	5.5 Distribution main	1,200 mm dia. x 10 km		

Table P 20 FINANCIAL COST OF M&I PIPELINE SYSTEM, ROUTE B, ASSOCIATED WITH THE JUAM DAM SCHEME (DIVERSION PLAN)

Unit : $ 10^6

Route B

Juam Dam HWS (El. m)	114	117	120
1. Investment Cost			
1.1 Diversion tunnel			
Tunnel, civil works	10.060	10.606	11.099
Tunnel, metalworks	0.478	0.518	0.558
Engineering fee	1.054	1.112	1.166
Contingency	2.318	2.447	2.564
Sub-total	13.910	14.684	15.387
1.2 Yeonggye dam			
Civil works	26.292	29.350	32.040
Metalworks	2.420	2.420	2.420
Relocation of ground facilities	1.211	1.356	1.500
Land compensation	4.920	5.150	5.370
Engineering fee	2.871	3.177	3.446
Contingency	7.543	8.291	8.955
Sub-total	45.257	49.744	53.731
1.3 Pipeline / one line (Common to the three alternative scales)			
Trunk main	14.300		
Primary treatment plant	2.753		
Regulating pond	1.755		
Distribution main	3.500		
Land Compensation	0.450		
Engineering fee	1.115		
Contingency	4.775		
Sub-total	28.648		
2. Replacement Cost			
2.1 Diversion tunnel	0.568	0.615	0.622
2.2 Yeonggye dam	2.875	2.875	2.875
2.3 Pipeline / one line (Common to the three alternative scales)		22.049	
3. O & M Cost			
3.1 Diversion tunnel	0.070	0.073	0.077
3.2 Yeonggye dam	0.202	0.221	0.239
3.3 Pipeline / one line (Common to the three alternative scales)			
Fixed cost		0.313	
Material cost		0.188	
Energy cost		-	
Sub-total		0.501	
4. Production Foregone			
4.1 Yeonggye dam	0.07	0.07	0.08

Table P 21 OUTLINE OF M&I PIPELINE SYSTEM, ROUTE C, ASSOCIATED WITH THE JUAM DAM SCHEME (DIVERSION PLAN)

Route C

1.	Juam Dam HWS (El. m)	114	117	120
2.	Nominal Supply Capacity (m^3/S)	11.8	13.1	15.0
3.	Diversion Tunnel			
3.1	Discharge capacity (m^3/S)	11.8	13.1	15.0
3.2	Dimensions (D mm x L km)	2.9 x 14	3.0 x 14	3.1 x 14
3.3	Type of flow	Free	Free	Free
3.4	Energy dissipator	Intake valve	Intake valve	Intake valve

4.	Regulating Reservoir (Common to the three alternative scales)	
4.1	Dam	Beolgyo
4.2	Catchment area	7.3 km^2
4.3	Annual run-off	-
4.4	HWS	El. 67 m
4.5	LWS	El. 64 m
4.6	Active storage	270,000 m^3
4.7	Dam type	Rockfill
4.8	Dam height	30 m
4.9	Dam volume	351,000 m^3

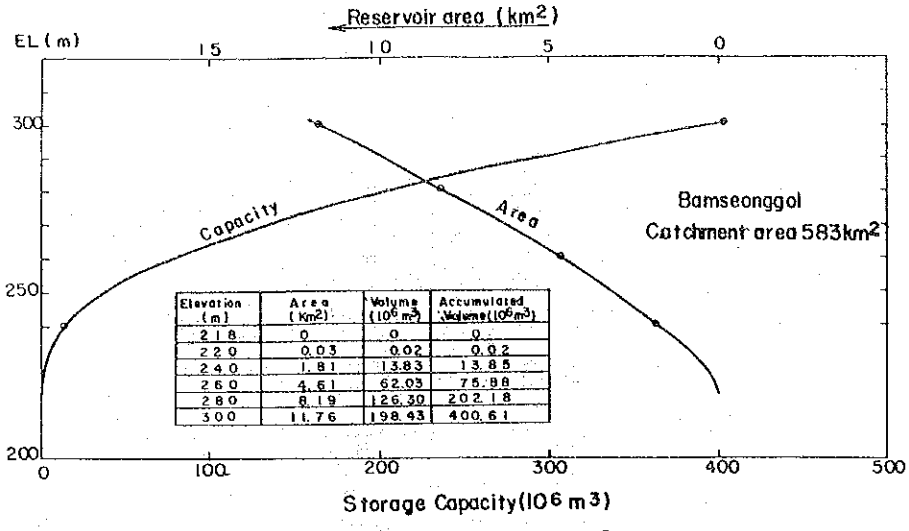
5.	Pipeline / one line (Common to the three alternative scales)	
5.1	Trunk main	1,870 mm dia. x 45 km
5.2	Nominal capacity	320,000 m^3/d (3.7 m^3/S)
5.3	Booster pump	16 m x 2,000 PS
5.4	Primary treatment plant	384,000 m^3/d
5.5	Regulating pond	75,000 m^3
5.6	Distribution main	1,200 mm dia. x 10 km

Table P 22 FINANCIAL COST OF M&I PIPELINE SYSTEM, ROUTE C, ASSOCIATED WITH THE JUAM DAM SCHEME (DIVERSION PLAN)

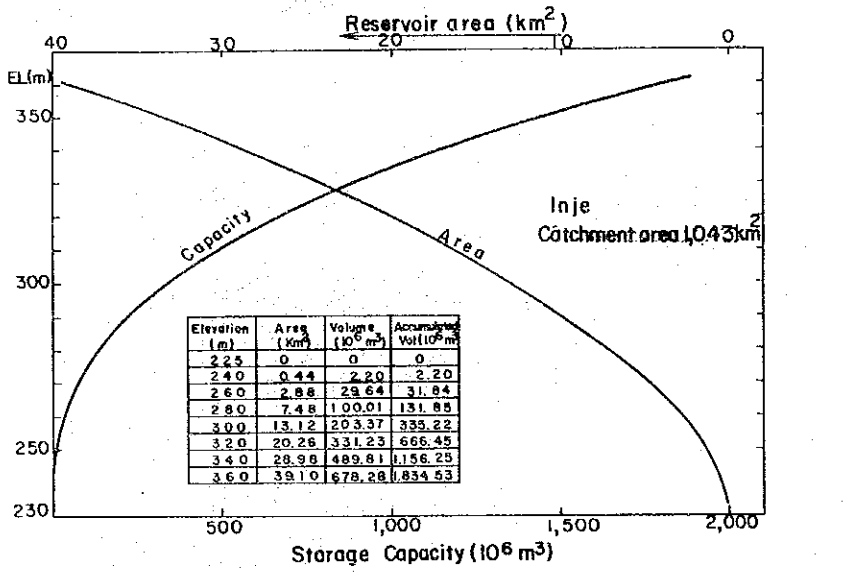
Unit : $ 10^6

Route C

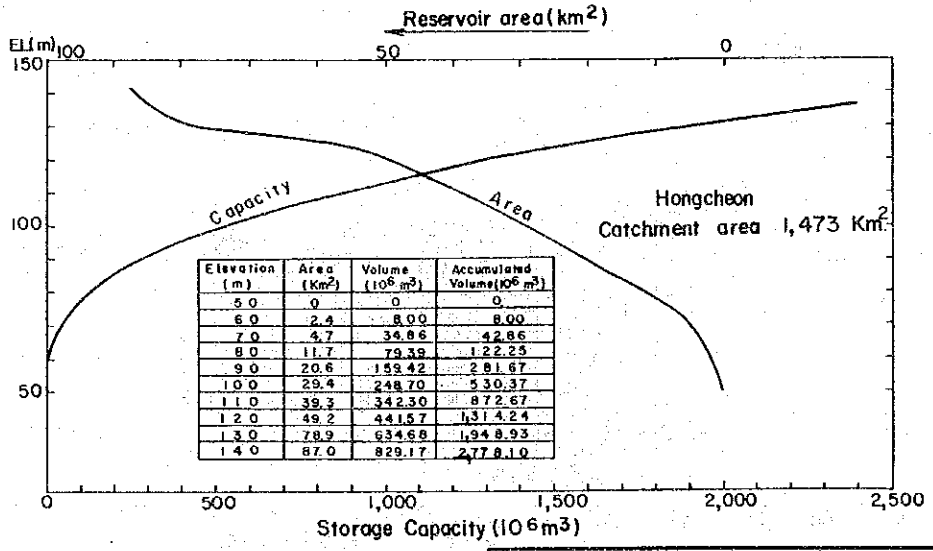
Juam Dam HWS (El. m)	114	117	120
1. Investment Cost			
1.1 Diversion tunnel			
Intake, civil works	0.128	0.133	0.138
Intake, metalworks	0.240	0.260	0.280
Tunnel	10.640	11.200	11.620
Engineering fee	1.101	1.159	1.204
Contingency	2.422	2.550	2.648
Sub-total	14.530	15.303	15.890
1.2 Beolgyo dam (Common to the three alternative scales)			
Civil works		4.914	
Metalworks		0.640	
Relocation of ground facilities		-	
Land compensation		0.500	
Engineering fee		0.555	
Contengency		1.322	
Sub-total		7.931	
1.3 Pipeline / one line (Common to the three alternative scales)			
Intake		0.500	
Trunk main		24.750	
Booster pump		1.154	
Primary treatment plant		2.753	
Regulating pond		1.755	
Transmission line & substation		0.250	
Distribution main		3.500	
Land compensation		0.800	
Engineering fee		1.733	
Contingency		7.439	
Sub-total		44.634	
2. Replacement Cost			
2.1 Diversion tunnel	0.285	0.309	0.333
2.2 Beolgyo dam	0.760	0.760	0.760
2.3 Pipeline / one line (Common to the three alternative scales)		35.168	
3. O & M Cost			
3.1 Diversion tunnel	0.073	0.076	0.079
3.2 Beolgyo dam	0.037	0.037	0.037
3.3 Pipeline / one line (Common to the three alternative scales)			
Fixed cost		0.452	
Material cost		0.188	
Energy cost		0.259	
Sub-total		0.899	
4. Production Foregone			
4.1 Beolgyo dam	-	-	-



Elevation (m)	Area (Km²)	Volume (10^6 m³)	Accumulated Volume (10^6 m³)
218	0	0	0
220	0.03	0.02	0.02
240	1.81	13.83	13.85
260	4.61	62.03	75.88
280	8.19	126.30	202.18
300	11.76	198.43	400.61



Elevation (m)	Area (Km²)	Volume (10^6 m³)	Accumulated Vol (10^6 m³)
225	0	0	0
240	0.44	2.20	2.20
260	2.88	29.64	31.84
280	7.48	100.01	131.85
300	13.12	203.37	335.22
320	20.26	331.23	666.45
340	28.98	489.81	1,156.25
360	39.10	678.28	1,834.53



Elevation (m)	Area (Km²)	Volume (10^6 m³)	Accumulated Volume (10^6 m³)
50	0	0	0
60	2.4	8.00	8.00
70	4.7	34.86	42.86
80	11.7	79.39	122.25
90	20.6	159.42	281.67
100	29.4	248.70	530.37
110	39.3	342.30	872.67
120	49.2	441.57	1,314.24
130	78.9	634.68	1,948.93
140	87.0	829.17	2,778.10

Fig. P1 Reservoir Area and Storage Capacity Curve

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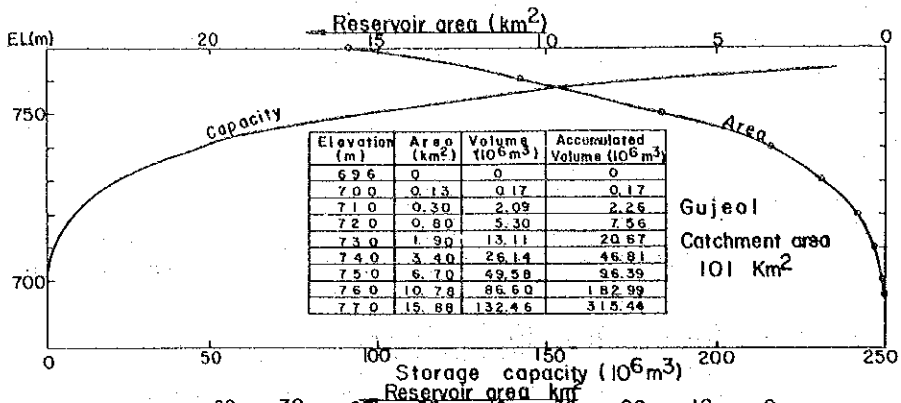
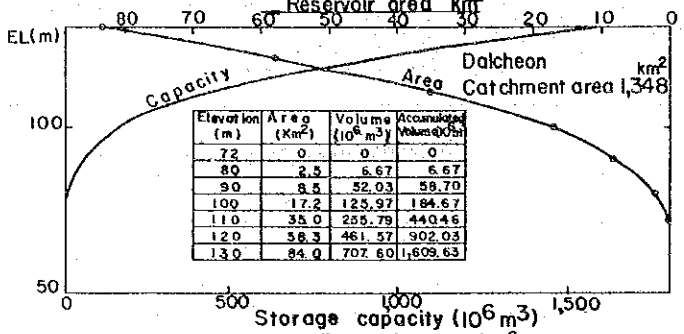
THE LONG-TERM MULTIPURPOSE DAM SCHEMES
PRELIMINARY FEASIBILITY STUDY

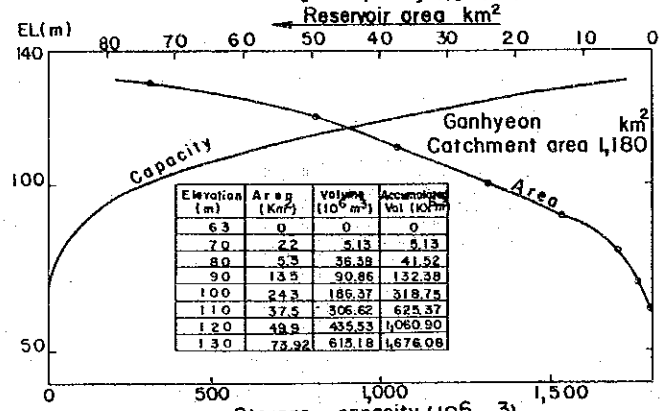
JAPAN INTERNATIONAL COOPERATION AGENCY



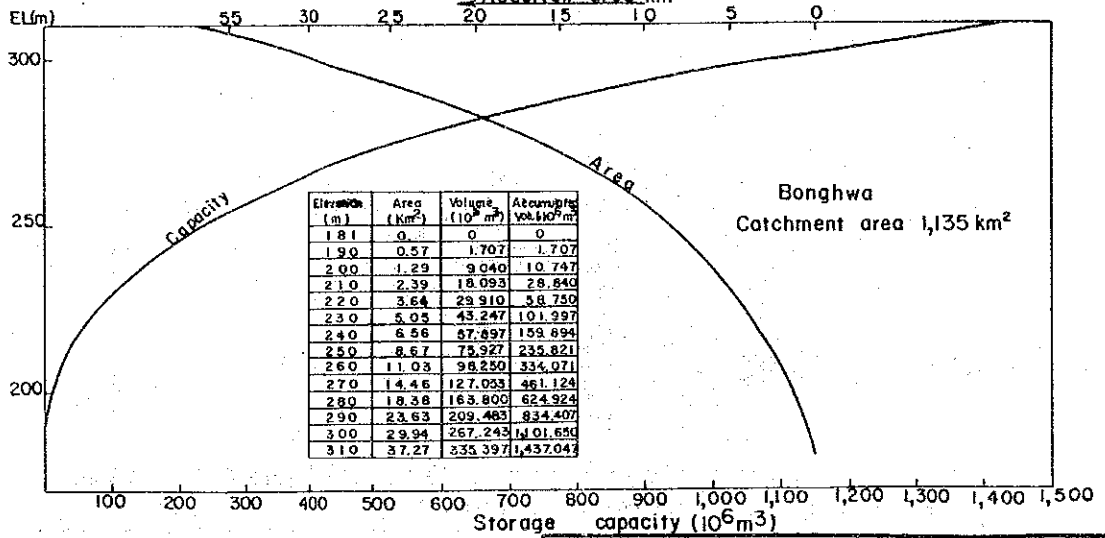
Elevation (m)	Area (km²)	Volume (10⁶m³)	Accumulated Volume (10⁶m³)
696	0	0	0
700	0.13	0.17	0.17
710	0.30	2.09	2.26
720	0.80	5.30	7.56
730	1.90	13.11	20.67
740	3.40	26.14	46.81
750	6.70	49.58	96.39
760	10.78	86.60	182.99
770	15.88	132.46	315.44



Elevation (m)	Area (Km²)	Volume (10⁶m³)	Accumulated Volume (10⁶m³)
72	0	0	0
80	2.5	6.67	6.67
90	8.5	52.03	58.70
100	17.2	125.97	184.67
110	35.0	255.79	440.46
120	56.3	461.57	902.03
130	84.9	707.60	1,609.63



Elevation (m)	Area (Km²)	Volume (10⁶m³)	Accumulated Vol (10⁶m³)
63	0	0	0
70	2.2	5.13	5.13
80	5.3	36.38	41.52
90	13.5	90.86	132.38
100	24.3	186.37	318.75
110	37.5	306.62	625.37
120	49.9	435.53	1,060.90
130	73.92	615.18	1,676.08



Elevation (m)	Area (Km²)	Volume (10⁶m³)	Accumulated Vol.(10⁶m³)
181	0.	0	0
190	0.57	1.707	1.707
200	1.29	9.040	10.747
210	2.39	18.093	28.840
220	3.64	29.910	58.750
230	5.05	43.247	101.997
240	6.56	57.897	159.894
250	8.67	75.927	235.821
260	11.03	98.250	334.071
270	14.46	127.053	461.124
280	18.38	163.800	624.924
290	23.63	209.483	834.407
300	29.94	267.243	1,101.650
310	37.27	335.397	1,437.047

Fig. P1 Continued (2)

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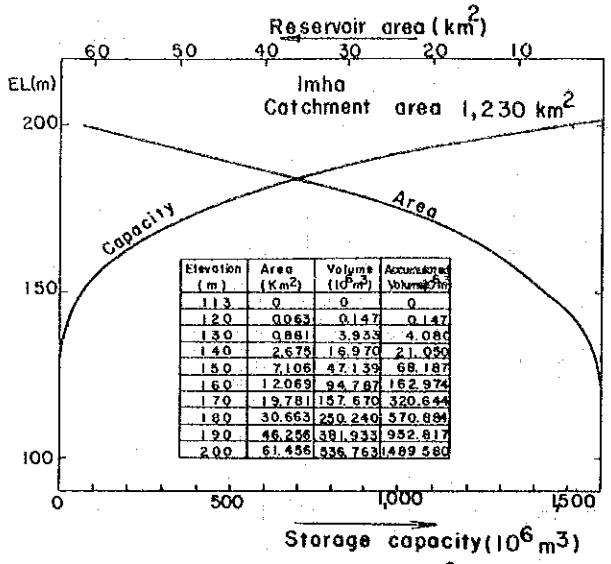
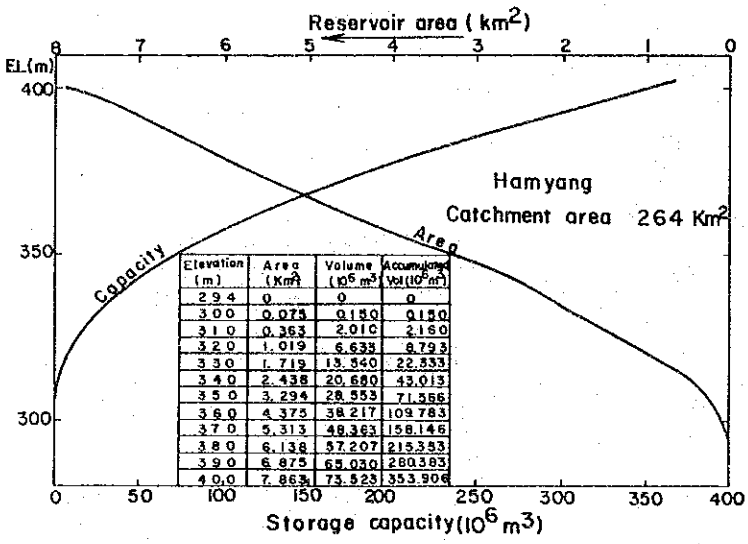
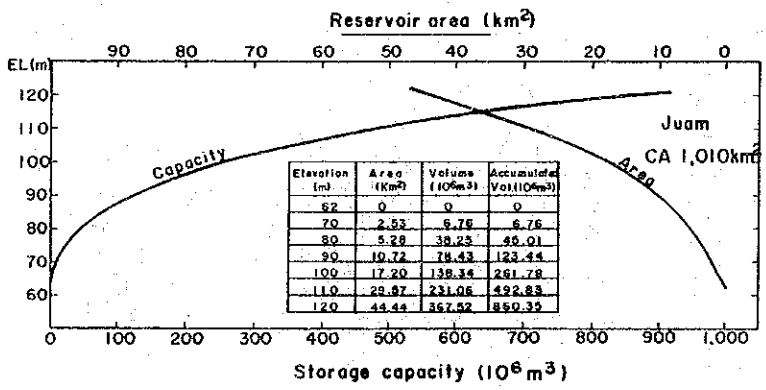


Elevation (m)	Area (Km²)	Volume (10⁶m³)	Accumulated Volume (10⁶m³)
113	0	0	0
120	0.063	0.147	0.147
130	0.881	3.933	4.080
140	2.675	16.970	21.050
150	7.106	47.139	68.187
160	12.069	94.787	162.974
170	19.781	157.670	320.644
180	30.663	250.240	570.884
190	46.256	381.933	952.817
200	61.456	536.763	1489.580



Elevation (m)	Area (Km²)	Volume (10⁶m³)	Accumulated Vol (10⁶m³)
294	0	0	0
300	0.075	0.150	0.150
310	0.363	2.010	2.160
320	1.019	6.633	8.793
330	1.719	13.540	22.333
340	2.438	20.680	43.013
350	3.294	28.553	71.566
360	4.375	38.217	109.783
370	5.313	48.363	158.146
380	6.138	57.207	215.353
390	6.875	65.030	280.383
400	7.863	73.523	353.906



Elevation (m)	Area (Km²)	Volume (10⁶m³)	Accumulated Vol (10⁶m³)
62	0	0	0
70	2.53	6.76	6.76
80	5.28	38.25	46.01
90	10.72	78.43	123.44
100	17.20	138.34	261.78
110	28.87	231.06	492.83
120	44.44	367.52	860.35

Fig. p l Continued (3)

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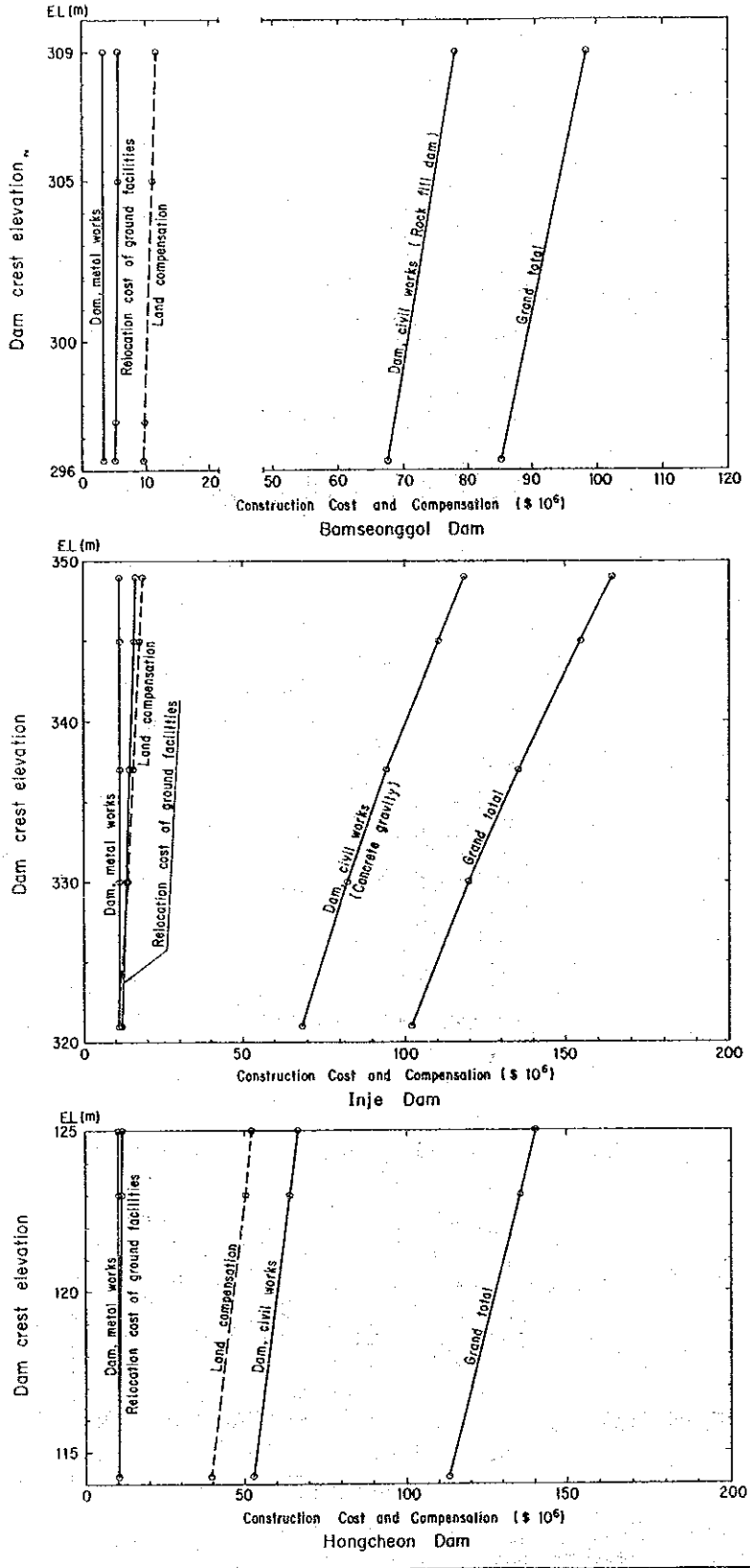

Fig. P2 Construction Cost of Dam versus Dam Crest Elevation

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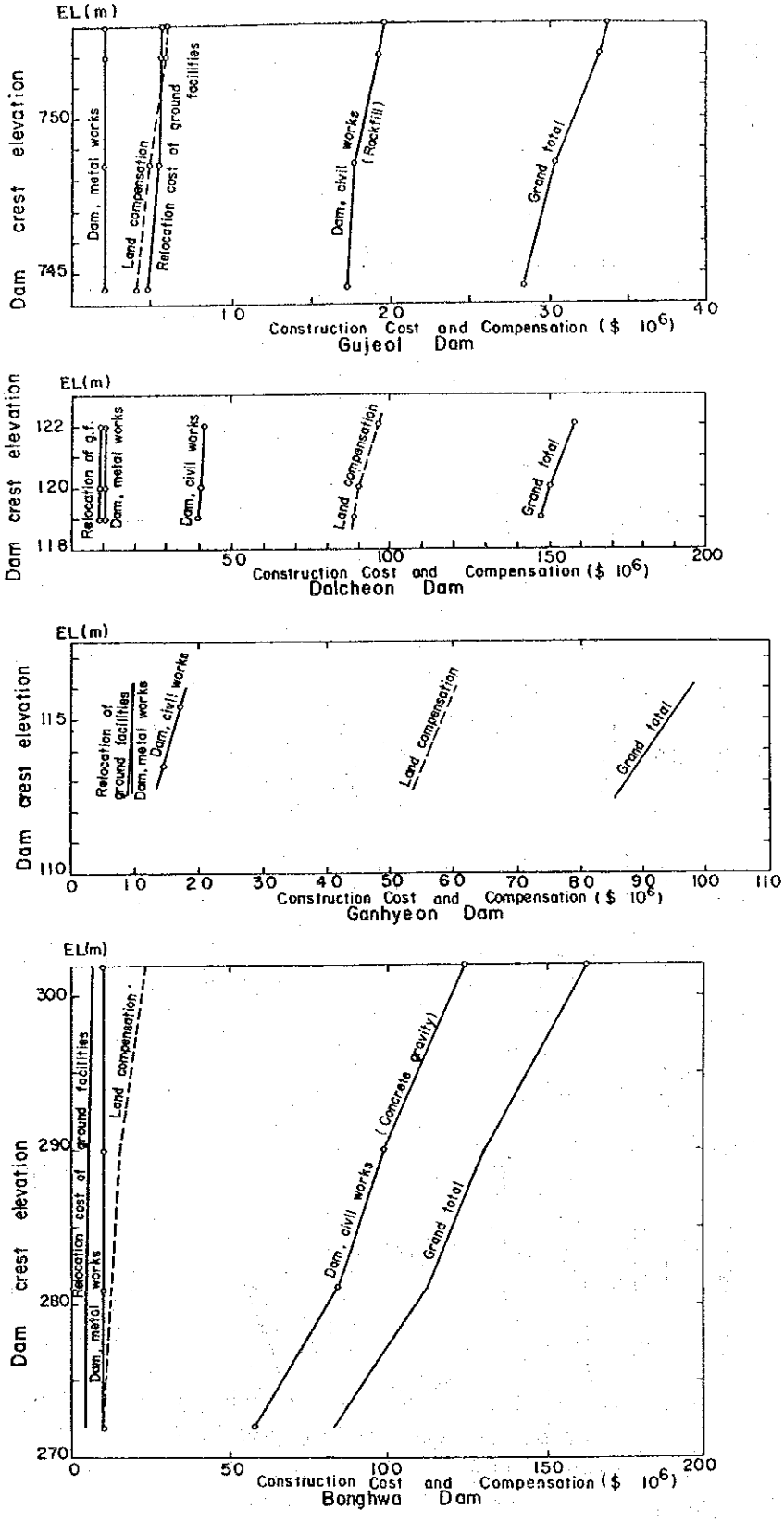

Fig. P-2 Continued (2)

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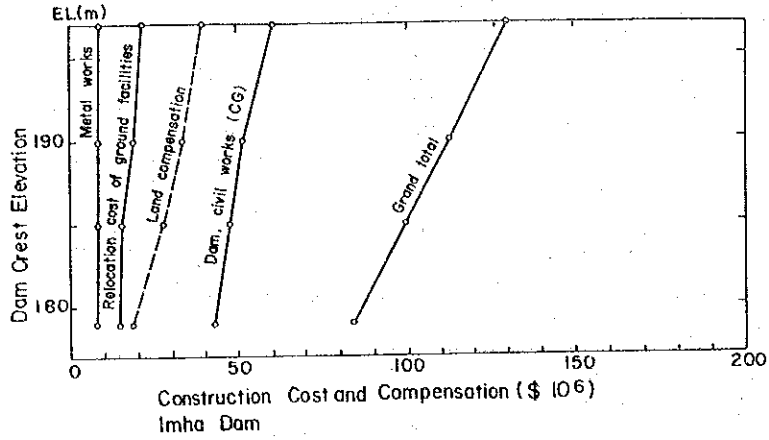

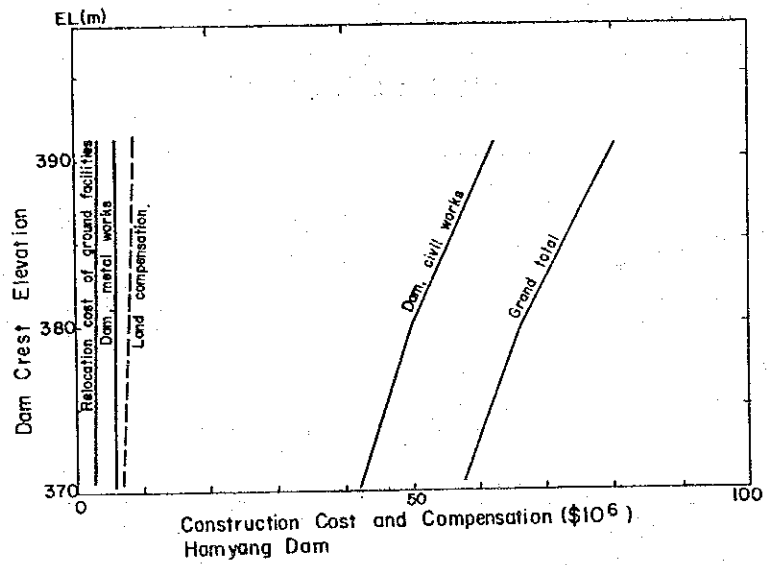

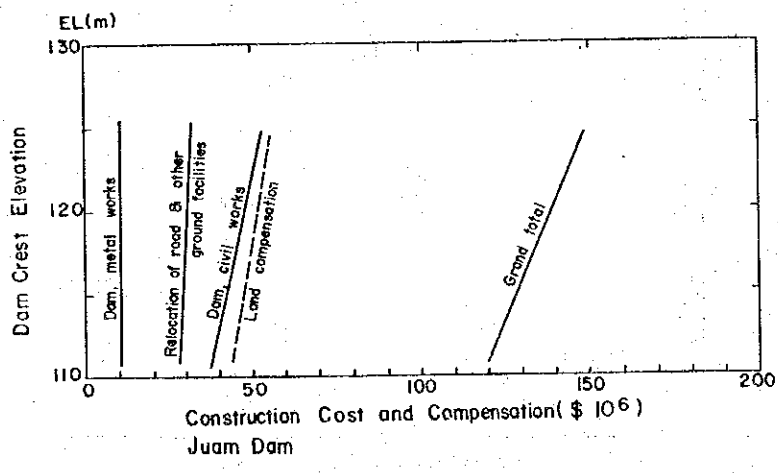

Fig. P2 Continued (3)

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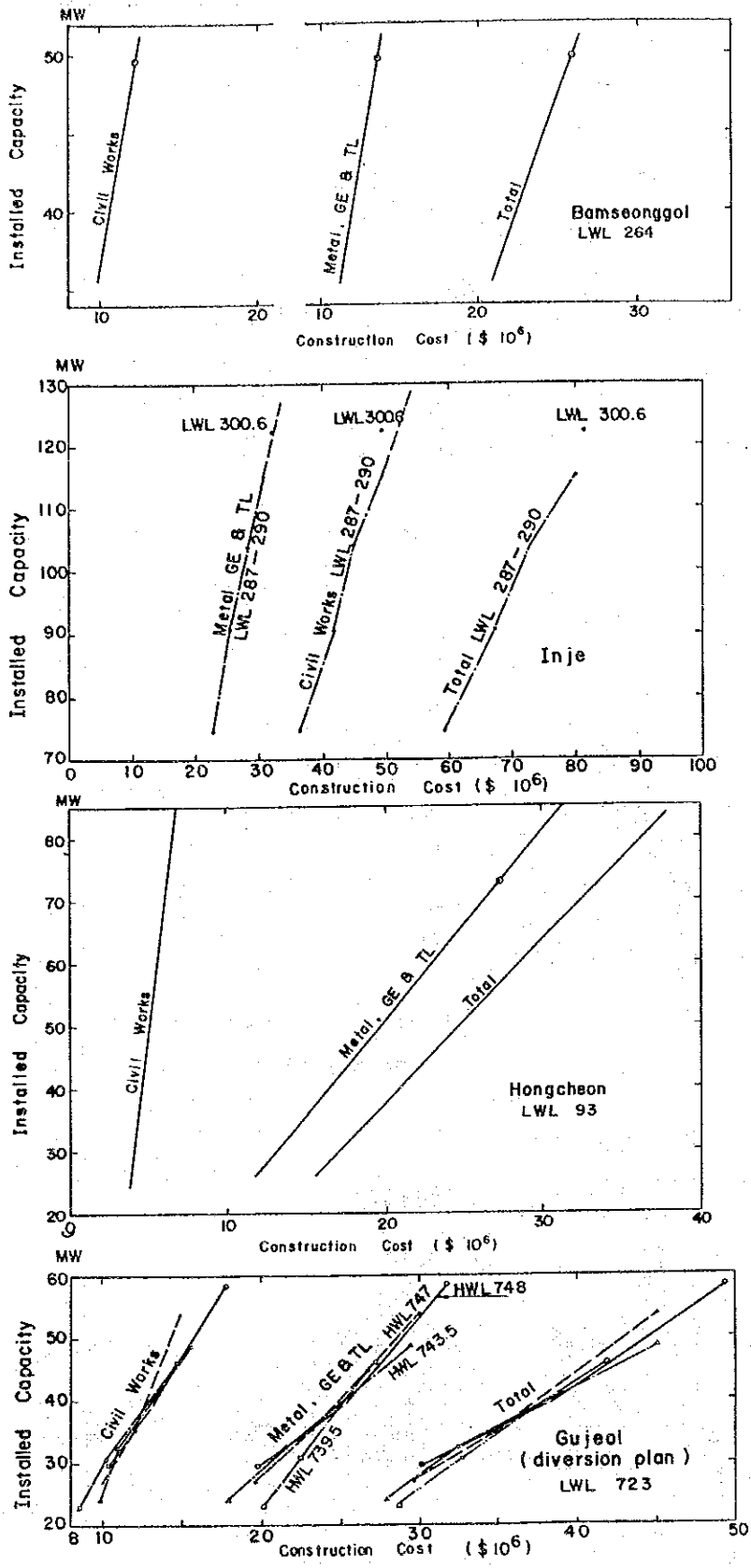

Fig. P3 Construction Cost of Power Facilities

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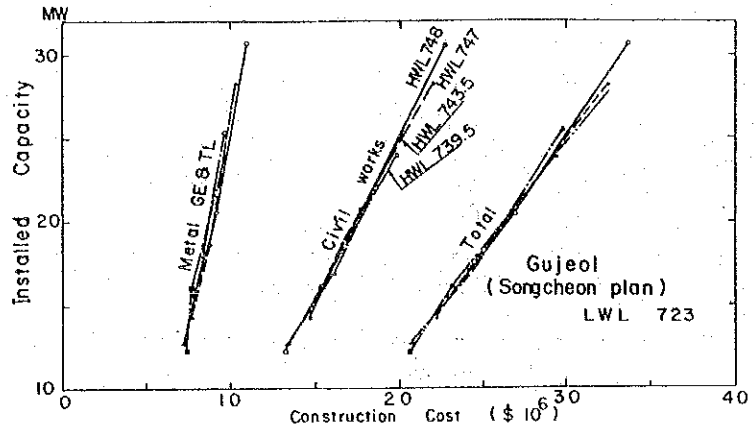

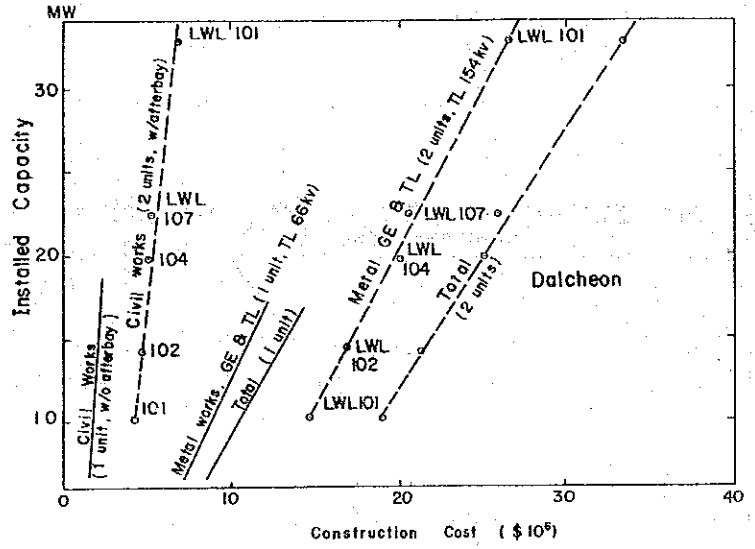

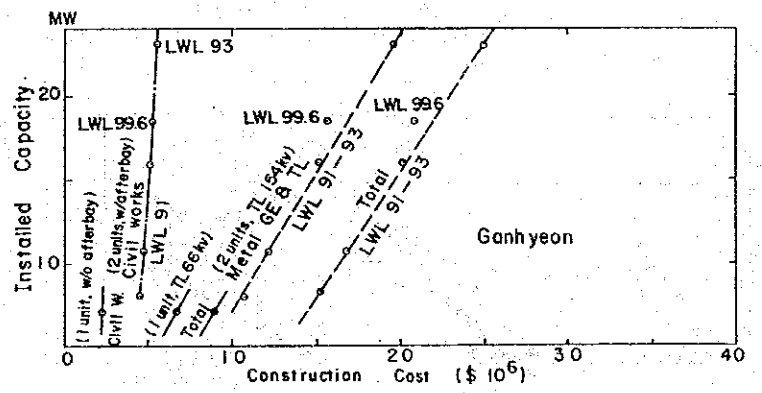

Fig. P3 Continued (2)

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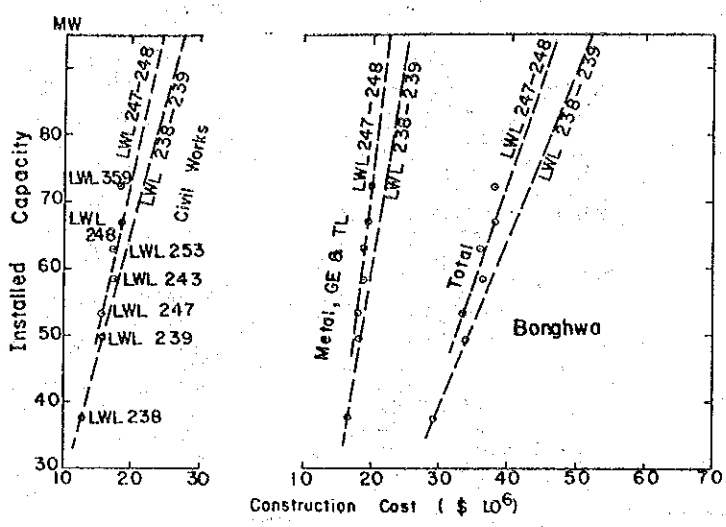

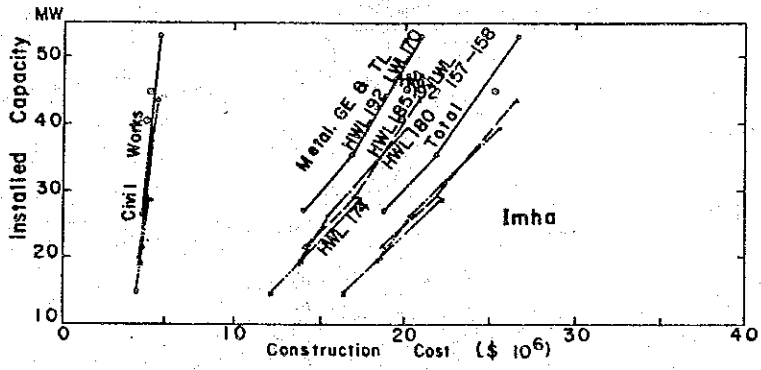

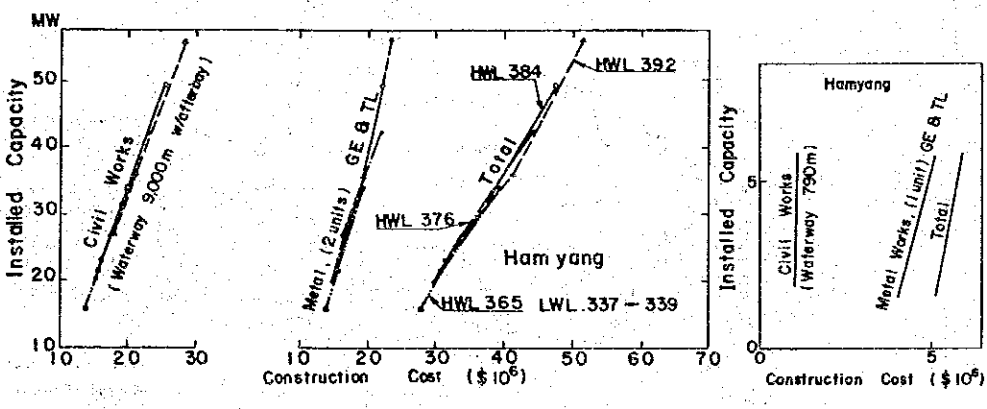

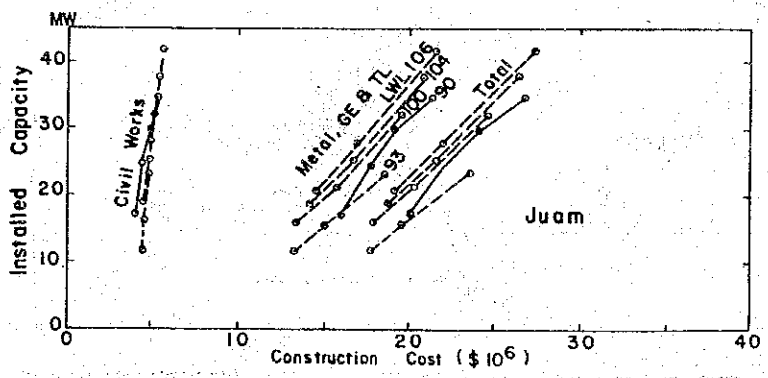

Fig P 3 Continued.(3)

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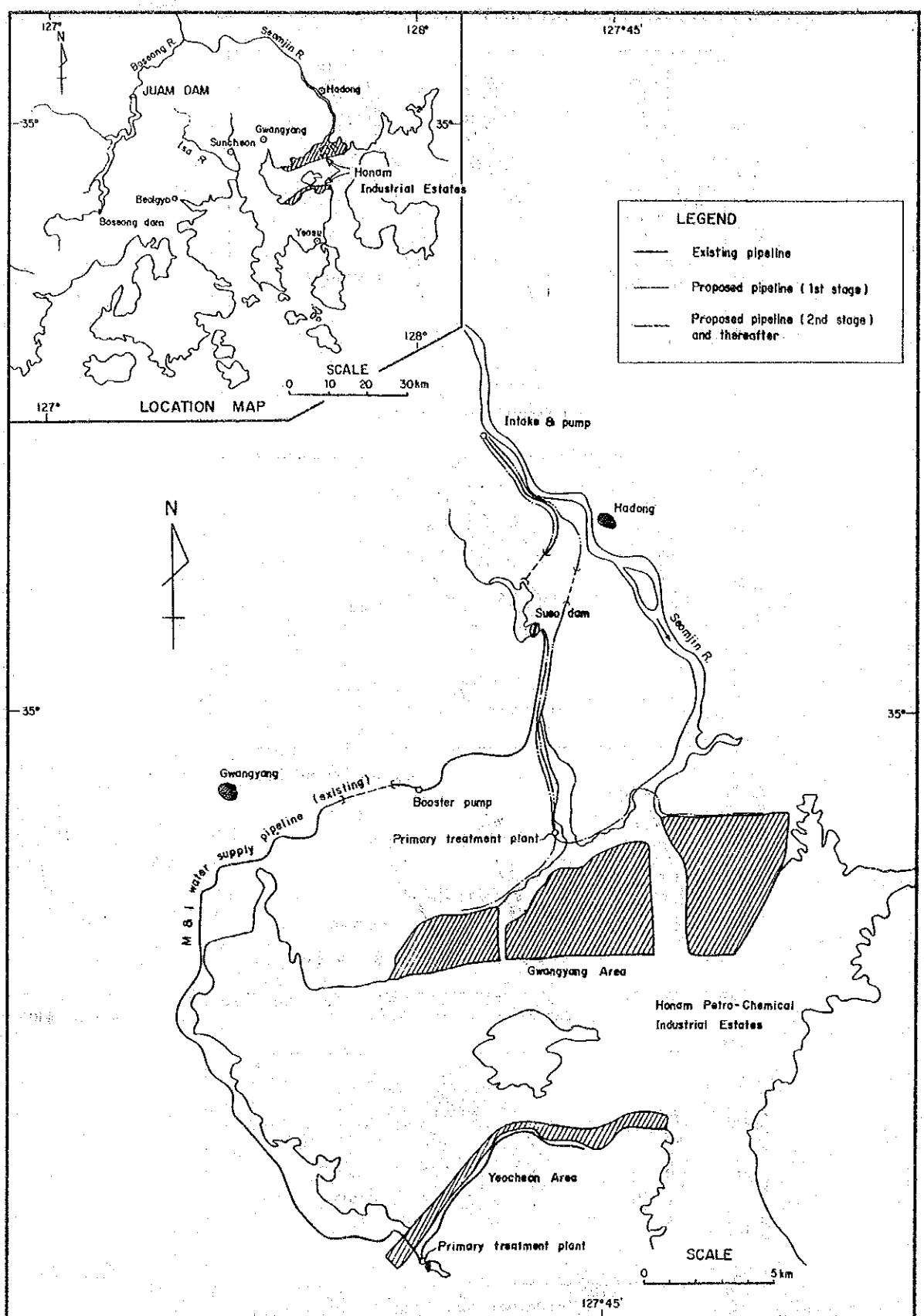

Fig. P 4 M & I Pipeline System Associated with The Juam Dam Scheme (Main Stream Plan)

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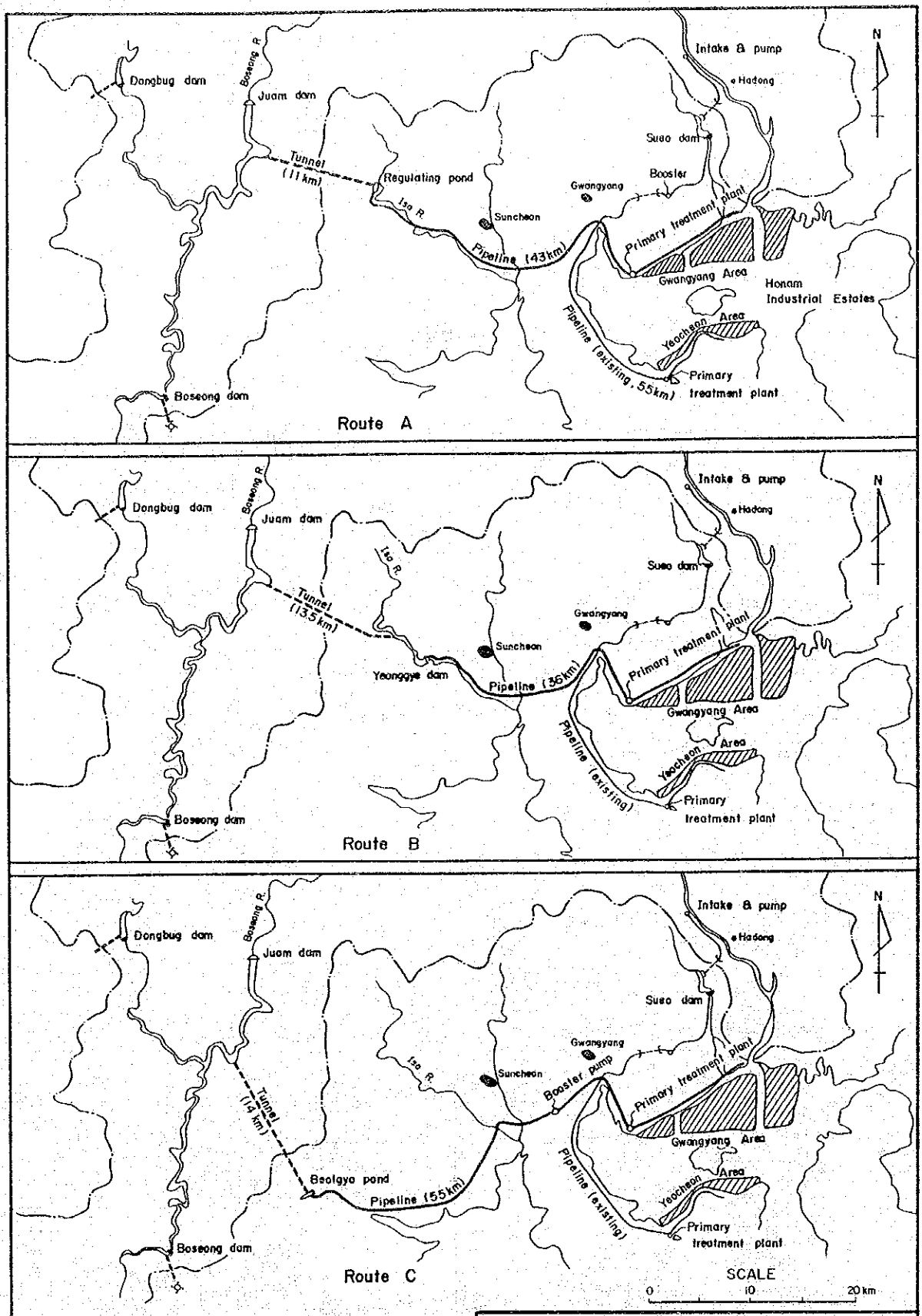

Fig. P 5 Outline of Alternative M & I Pipeline Systems Associated with the Juam Dam Scheme (Diversion plan)

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A N N E X Q

ECONOMIC ANALYSIS

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Q 1 INTRODUCTION

This ANNEX presents the results of economic analysis of the proposed dam schemes.

The optimization was made based on the net benefit maximization (B - C maximum) criteria. All the benefits and costs were converted into annual equivalents at a discount rate of 8 % for an evaluation period of 50 years of which the zero point was set at the time of completion of construction, i.e. start of operation. Neither intangible nor secondary benefits were taken into account.

The high water surface elevation of reservoir was taken as the parameter showing the alternative scale of the proposed dam. The estimated construction cost was extrapolated to some extents if necessary by means of the cost curves presented in ANNEX P.

The reservoir operations under constant draft and variable draft were studied. The 5-hour peaking operation of power station was assumed for some proposed projects and 18-hour for other proposed projects.

The economic costs and benefits were estimated based on the study results of other ANNEXes. The inclusion or exclusion of power generation purpose in each proposed scheme was tested by comparing the exclusive power facilities cost and project's power generation benefit. M&I water supply benefit was estimated based on the least-costly alternative facilities criteria. For the Juam dam scheme, the several alternative measures to supply M&I water were studied. The optimization of the flood control space for each alternative scale was made. After these procedures, the alternative scales were compared. Finally cash flow analysis was made to derive economic internal rate of return (EIRR).

Q 2 CONSTRUCTION HORIZON

The water deficit build-up curves were prepared by plotting the estimated peak water deficits at the projected years as shown in Fig. Q 1. The existing Soyanggang dam and Chungju dam supply will meet the deficit in the Han river until the year of 2008.6. It was still uncertain if the Habcheon dam or estuary barrage would be constructed next to the Andong dam. It was herein assumed that the Habcheon dam would be constructed and then additional dam will be needed in the year of 1990.1. There is no dam supplying the present deficit in the Seomjin river. The Juam dam was assumed to be constructed in 1981-1985, i.e. operation start in the year of 1986.0.

The net water supply capacity of a proposed dam was calculated deducting the natural inflow into the proposed dam at the time of peak water deficit from the regulated outlfow (draft) from the dam, if there is no dam downstream. But it was estimated as the increase in the regulated flow at the Hwacheon dam for the proposed Bamseonggol dam, the Soyanggang dam for the proposed Inje dam, the Andong dam for the proposed Bonghwa dam and the Namgang dam for the proposed Hamyang dam, respectively. No water supply was assumed for the Gujeol dam, because there would be no water deficit between the proposed damsite and the Chungju dam according to the results of water budget and significant water demand would not arise in the Gangneung area.

The estimated net water output, year of construction start, year of commission and target year of full supply are shown in Table Q 1 for varying reservoir water surface elevation of each proposed dam.

Q 3 COST ANALYSIS

The financial investment costs were taken from the results of design and cost estimate described in ANNEX P.

The economic investment costs were derived from the financial costs by deducting the transfer payment; compensation cost on land and 5 % of the other cost which was assumed to be the tax and local contractors' profit.

The disbursement of the investment cost of dam was assumed to be 12.5 % each for the first and the fifth years and 25 % each for the second to fourth years during the construction period of five years. The disbursement of the investment cost of tunnel was assumed to be 25 % each for the first and the third years and 50 % for the second year during the construction period of three years. The disbursement of the investment cost of pipeline was assumed to be 50 % each during the construction period of two years.

The metalwork, generating equipment and transmission lines were assumed to be replaced at a 30-year of economic life. Salvage value of 10 % of the replaceable items was counted.

The ratio of O & M cost to the investment cost was assumed to be 0.5 % for dam and diversion tunnel and 2.5 % for power facilities.

The cost as well as benefit were assumed to be paid or received at the end of each year.

The estimated costs of dam and power facilities of each proposed dam scheme are summarized in Tables Q 2 to Q 12.

Q 4 BENEFITS ANALYSIS

Q 4.1 M&I Water Supply Benefit

The M&I net water withdrawal building up between the year of commission of a proposed dam and its full supply target year was regarded as what to be supplied and it was called the net M&I water supply capacity of each dam scheme. The net water withdrawal in the tributary area was discounted into a half, because deficit might occur in the tributary area even after the completion of a dam. The build-up curve of net M&I water withdrawal is shown in Fig. Q 2.

M&I water supply benefit was estimated based on the cost of alternative facilities presented in ANNEX I. In accordance with the net M&I water supply capacity of a proposed dam, a least-costly alternative dam was selected among those studied in ANNEX I. If the net M&I water supply capacity of an alternative dam was a little larger or smaller than that of the proposed dam, the cost of the alternative dam was adjusted in proportion to the capacity. If the net M&I water supply capacity of a proposed dam is so large that no single alternative dam can supply it, a number of additional alternative dams were assumed to be constructed in stages until the net M&I water supply capacity of the proposed dam could be reached by the total M&I water supply capacity of the alternative dams.

The annual equivalent of cost of the alternative dams was calculated taking into account the construction sequence in accordance with the growth of water demand as shown in Table Q 13.

Q 4.2 Irrigation Benefit

The irrigation benefit arising from the agricultural land development between the year of commission and target year of full supply was taken as the irrigation benefit of a porposed dam.

The increase in the irrigation benefit expected from a projected agricultural land development for each 5-year period was estimated in ANNEX F. The irrigation benefit build-up in each river basin was extrapolated assuming the same growth rate as in 1997-2001, if the target year of some proposed dam stretched beyond 2001.

In the case of the Seomjin river basin, water deficit was estimated on the basis of water budget analysis to have been occurring since 1977. Therefore, the irrigation benefit not realized because of the lack of water in the period of 1977-1985 was counted to arise collectively in 1986.

The irrigation benefit was assumed to be realized fully with one year delay from the start of irrigation water supply. This assumption implies a gradual growth of benefit in three years at an area.

A calculation sheet of the annual equivalent of irrigation benefit is shwon in Table Q 15.

Q 4.3 Flood Control Benefit

The flood control benefit was taken from ANNEX D. It consisted of the damage reduction and land enhancement benefit.

Q 4.4 Power Benefit

The annual equivalent of unit value of power generation was estimated to be $ 68.73/kW for the capacity value and 22.87 mills/kWh for the energy value based on the cash flow table of an alternative thermal power plant in ANNEX J.

The effective power was assumed to be an arithmetic mean of the maximum output (= installed capacity) and the minimum peaking output.

The increase in the energy production in the existing power stations was estimated assuming an average year hydrologic condition.

Q 4.5 Production Foregone

The production foregone was taken from the curves which were prepared in ANNEX O.

Q 5 TEST OF POWER GENERATION PURPOSE

The power generation was assumed only if the constant draft operation was adopted but that under the variable draft operation was left for the future detailed studies. The inclusion of power generation purpose was tested by comparing the annual equivalents of the cost of exclusive power facilities and the power benefit from which the benefit accrued from the increased energy production in the downstream power station was excluded. In the first trial assuming a 5-hour peaking operation, the power generation purpose was justified for the Bamseonggol, Inje, Hongcheon, Gujeol (diversion plant), Bonghwa and Imha dams. The second trial assuming a daily operation of 18 hours justified the power generation at the Dalcheon, Ganhyeon, and Hamyang dams. The Juam dam was not incorporated in the second trial. The results of these trials are summarized in Table Q 16.

Q 6 OPTIMIZATION OF FLOOD CONTROL SPACE

The flood control benefit, production foregone and the cost of dam where compared as the increment from those estimated for a dam having no flood control storage space. The flood control benefit of all the proposed dams except the Ganhyeon and Imha dams was found to be less than the increment production foregone and dam cost. Then a clearance of 1 m was assumed between the high water surface and flood water surface for these dams.

An optimization study of the flood control space for the Ganhyeon and Imha dams is summarized in Table Q 17. The optimum flood control space was estimated to be 2 m above the high water surface for the Ganhyeon dam. The optimum flood control space for the Imha dam was estimated to be 3 m each for high water surfaces of El. 180 m and El. 185 m and 2 m for high water surface of El. 192 m.

Q 7 M&I WATER SUPPLY BENEFIT OF THE JUAM DAM SCHEMES

Q 7.1 Assumptions

There found no possibility of M&I alternative dam for the proposed Juam dam except for the Yeonggye dam of which the net water supply capacity is far less than that of the proposed dam. It was therefore assumed that a necessary number of hypothetical M&I dams would be constructed as the alternative facilities of the Juam dam. The costs and net water supply capacity of each hypothetical dam were set to be equal to those of the Yeonggye dam and they are herein called the alternative Yeonggye dams.

The M&I water supply facilities associated with the proposed dam and with its M&I alternative dam are identical for the proposed dams except for the Juam dam, becuase the dam, proposed or alternative, if constructed, will release the regulated flow into the river channel for the intake from the downstream river channel by the water users. The costs of M&I water supply facilities, therefore, does not enter into the estimate of M&I water supply benefit, so far as the M&I water supply benefit is measured at the dam site.

The M&I water supply facilities associated with the proposed Juam dams are different from those associated with the M&I alternative dams, because the alternative dams are located out of the Seomjin river basin. To be consistent with the other proposed dams, the M&I water supply benefit of the Juam dam was calculated as the costs of the alternative dams and their associated facilities deducted by the cost of the M&I facilities associated with the proposed dam.

The destination of the M&I water supply facilities was assumed to be the Gwangyang area including Yeocheon and Gwangyang, because the projected M&I water demand in terms of the net water withdrawal is very little within the Seomjin river basin and that in the Gwangyang area is estimated the largest among those out of the basin.

A schematic sketch of the pipeline systems associated with the proposed Juam dam (main stream plan and diversion plan with Route A) and the alternative Yeonggye dams is shown in Fig. Q 3.

Q 7.2 The Yeonggye Dam and Yeonggye-Gwangyang Pipeline

The Yeonggye dam assumed as the M&I alternative dam has a net water supply capacity of 6.2 m^3/s under the variable draft operation.

The Yeonggye-Gwangyang pipeline is assumed to convey water from the Yeonggye dam to Gwangyang. It consists of two lines of pipeline each having a nominal discharge capacity of 3.1 m^3/s in relation with a Yeonggye dam and each line is constructed in accordance with the growth of demand.

The economic costs of the Yeonggye dam and a line of Yeonggye-Gwangyang pipeline were calculated as shown in Table Q 18 based on the data in ANNEX I.

Q 7.3 The Existing Yeocheon/Gwangyang Water Supply System

The existing Yeocheon/Gwangyang Water Supply System (existing pipelines) has a nominal discharge capacity of 2.9 m^3/s (250 x 10^3 m^3/d).

If the Juam dam is constructed, it will release enough water for the existing pipeline to run throughout the year.

It was assumed, based on hydrological data, that the existing pipeline will take water at an average rate of 1.8 m^3/s during dry period of 52 days but at the full capacity of 2.9 m^3/s in the other days of the year.

The O & M cost of the existing pipeline was estimated as shown in Table Q 19 for the conditions with the proposed Juam dam and with the alternative Yeonggye dam (see ANNEXes I and P).

Q 7.4 Hadong-Gwangyang Pipeline

The assumed Hadong-Gwangyang pipeline is operated at its full capacity throughout the year if the Juam dam (main stream plan) is constructed. It is operated for 210 days at its full capacity if constructed as complementary facilities with the Yeonggye-Gwangyang pipeline.

The first pipeline of the Hadong-Gwangyang pipeline will be constructed utilizing the tunnel of the existing pipeline. The tunnel capacity of 6.4 m^3/s is 3.5 m^3/s larger than the capacity of the existing pipeline. The second pipeline will consist of a tunnel and a line of pipeline. The tunnel will be utilized for the third pipeline. The fourth and fifth pipelines and onward will have the same composition as for the second and third pipelines.

The economic costs of the Hadong-Gwangyang pipeline was estimated for the conditions with the Juam dam (main stream plan) and with the alternative Yeonggye dams as shown in Table Q 20, based on the data in ANNEXes I and P.

Q 7.5 Diversion Tunnel and Diversion Pipeline

Three alignments were worked out for the M&I conveyance system of the Juam dam (diversion plan) as described in ANNEX P: Route A, B and C. Each system consists of a diversion tunnel and a pipeline between the outlet of the tunnel and Gwangyang (diversion pipeline) but Route B includes the Yeonggye dam in addition.

The nominal capacity of the diversion tunnel was determined to be the net M&I water supply capacity of the Juam dam less 2.9 m^3/s which would be released downstream of the dam under the full operation of the existing pipeline.

The economic costs of the diversion tunnel associated with the Juam dam (diversion plan) are estimated as shown in Table Q 21, based on the data in ANNEX P.

The economic costs of the diversion pipeline are shown in Table Q 22.

Q 7.6 The Yeonggye Dam Associated with the Juam Dam Diversion Plan (Route B)

Route B of the M&I water diversion system for the Juam Dam (diversion plan) includes the Yeonggye dam which will supplement the diverted water being located between the diversion tunnel and diversion pipeline.

The economic costs of the Yeonggye dam associated with the Juam dam (diversion plan), if Route B is selected, are as shown in Table Q 23.

Q 7.7 Phasing of the Alternative Dams and Their Associated Facilities

The Yeonggye alternative dams and their associated pipeline were phased out and the annual equivalents of the cost were calculated as shown in Table Q 24 in accordance with the M&I water demand build-up curve in Fig. Q 2.

As was assumed in Q 7.3, the existing pipeline can take 1.8 m^3/s any time without any alternative facilities. This value, therefore, enters in the line of the net supply capacity of the Yeonggye dam and Yeonggye-Gwangyang pipeline in the order zero of construction. In the same line for Hadong-Gwangyang pipeline entered is 2.9 m^3/s of the capacity of the existing pipeline, becuase it is utilized if available.

Q 7.8 Phasing of the M&I Water Supply Facilities Associated with the Proposed Juam Dam

The M&I facilities associated with the proposed Juam dam were phased out and the annual equivalents of costs were calculated as shown in Table Q 25 in the same way as in Table Q 24. In all studied cases, the capacity of the existing pipeline is fully utilized. It therefore enters in the line of the discharge capacity for the order zero of construction.

Q 7.9 Net M&I Benefit of the Juam Dam

The net M&I water supply capacity of the existing and proposed facilities corresponding to the target year of the Juam dam was estimated from Fig. Q 2, and the annual equivalent of costs of the alternative M&I water supply dams, their associated pipeline and pipeline associated with the Juam dam was estimated for the above-mentioned net M&I water supply capacity as shown in Table Q 26, based on the data in Tables Q 19, Q 21, Q 23, Q 24 and Q 25.

Note that the net M&I water supply capacity of the Juam dam is the above-mentioned net M&I water supply capacity less 1.8 m^3/s which can be maintained by the natural flow through the existing pipeline.

Q 8 SCALE OPTIMIZATION

The results of optimization study are summarized in Table Q 27 to Q 41, and benefit-cost curves are presented in Fig. Q 4.

The optimum high water surface of the Bamseonggol dam will be at El. 305 m. Higher dam might be better, but its reservoir will stretch to the north beyond DMZ.

The Inje dam could not be justified at a discount rate of 8 %, because its water output would hardly increase the regulated flow of the Soyanggang dam.

The Hongcheon dam was studied for the range below Hongcheon town. The Hongcheon dam was justified for both constant and variable operations and the largest size appeared to be the best.

The Gujeol dam (Diversion plan) could not be justified so far as a discount rate of 8 % was assumed. This dam should be studied if a water demand would arise in the Gangneung area.

The Dalcheon dam was studied for the range not to submerge Goesan town. The Dalcheon dam was not justified for constant draft operation but justified for variable draft operation. The largest among the compared scales was the best.

The Ganhyeon dam was not justified for constant draft operation but justified for variable draft operation. The best scale of the Ganhyeon dam was found at the maximum end of the studied range which was determined not to submerge Weonju city.

Bonghwa could not be justified with the assumed discount rate of 8 %, because it hardly increases the outflow from the Andong dam.

The optimum scale of the Imha dam was found for the high water surface at El. 192 m for constant draft operation and El. 185 m for variable draft operation.

The Hamyang dam could not be justified.

The Juam dam could be justified for both the main stream plan and diversion plan under the variable draft operation. The optimum scale of the Juam dam (diversion plan) was found with a high water surface at El. 120 m, assuming Route A, as shown in Table Q 41. The benefits and costs in Table Q 42 shows that the Juam dam (diversion plan) can also be justified for Route B and Route C.

The justified dam schemes with the optimum high water surface elevations are listed in Table Q 43.

Q 9 CASH FLOW ANALYSIS

A cash flow analysis was made for nine justified schemes which were derived from six proposed dams.

Q 9.1 Modification of Cash Flow of Alternative Facilities

The present worth of M&I water supply and power benefits were estimated to be equal to the present worth of the alternative facilities costs at a discount rate of 8 % in the benefit-cost study for the project optimization. The cash flow of the alternative facilities cost is usually head heavy, though it is related with the build-up of the project output to some extents. The benefit will increase in accordance with the increase in the project output which is utilized by the users, if it should be measured by the utility of the output. With these considerations, the following two assumptions were introduced:

(1) The project output has a certain unit value, which is constant throughout the evaluation period.

(2) The alternative facilities have an internal rate of return of 8 %.

The cash flow of M&I alternative facilities cost was converted to a cash flow of M&I water supply benefit based on the above-mentioned assumptions as shown in Table Q 49. The unit value of water supplied for the M&I water purpose is listed in Table Q 50. The basic data employed are summarized in Tables Q 44 to Q 48.

The power benefit is the annual equivalent of cost of alternative thermal plant at a discount rate of 8 % under the above-mentioned assumptions; $ 68.73 kW and 22.87 mills/kWh.

Q 9.2 Economic Internal Rate of Return

The cash flow tables for the nine dam schemes were prepared as shown in Table Q 51, based on all the assumptions and results of study described in the preceding chapters.

The values of economic internal rate of return (EIRR) were calculated based on the cash flow tables for the following cases:

A : Normal

B : Benefit 10 % reduction

C : Cost 20 % increase

D : Benefit 1 year delay

E : B + C

F : B + C + D

The results are presented in Table Q 52 and also are illustrated in Fig. Q 5.

Table Q 1 TARGET YEAR OF FULL WATER SUPPLY

Proposed Dam Scheme /1		High Water Surface (El. m)	Net Water Supply Capacity (m^3/s)	Construction Start	Year of Commission	Target Year
Bamseonggol	(C)	292.5	7.7	2003.6	2008.6	2010.0
		300	9.5	2003.6	2008.6	2010.3
		305	10.0	2003.6	2008.6	2010.4
Inje	(C)	315	1.6	2003.6	2008.6	2008.9
		324.5	2.8	2003.6	2008.6	2009.1
		332.6	3.8	2003.6	2008.6	2009.3
Hongcheon	(C)	110	10.7	2003.6	2008.6	2010.5
		115	14.5	2003.6	2008.6	2011.2
		120	18.1	2003.6	2008.6	2011.8
Chongcheon	(V)	110	79.4	2003.6	2008.6	2022.6
		115	86.3	2003.6	2008.6	2023.9
		120	93.0	2003.6	2008.6	2025.0
Gujeol	(C)	743.5	-	1981.0	1986.0	1986.0
		747	-	1981.0	1986.0	1986.0
		748	-	1981.0	1986.0	1986.0
Dalcheon	(C)	109	5.4	2003.6	2008.6	2009.6
		114	12.0	2003.6	2008.6	2010.7
		117	14.4	2003.6	2008.6	2011.1
Dalcheon	(V)	109	61.5	2003.6	2008.6	2019.5
		114	76.5	2003.6	2008.6	2022.1
		117	81.3	2003.6	2008.6	2023.0
Ganhyeon	(C)	103.5	7.9	2003.6	2008.6	2010.0
		108.5	10.9	2003.6	2008.6	2010.5
		111.4	12.9	2003.6	2008.6	2010.9
Ganheyon	(V)	103.5	64.5	2003.6	2008.6	2020.0
		108.5	75.5	2003.6	2008.6	2022.0
		111.4	79.7	2003.6	2008.6	2022.7

Remarks: /1 C: Constant draft operation
V: Variable draft operation

Table Q 1 Continued (2)

Proposed Dam Scheme /1		High Water Surface (El. m)	Net Water Supply Capacity (m^3/s)	Construction Start	Year of Commission	Target Year
Bonghwa	(C)	267	1.4	1985.1	1990.1	1990.5
		276	3.0	1985.1	1990.1	1991.1
		285	4.0	1985.1	1990.1	1991.6
Imha	(C)	180	11.9	1985.1	1990.1	1995.5
		185	13.7	1985.1	1990.1	1996.5
		192	15.6	1985.1	1990.1	1997.4
Imha	(V)	180	19.2	1985.1	1990.1	1999.3
		185	22.0	1985.1	1990.1	2000.7
		192	24.2	1985.1	1990.1	2001.9
Hamyang	(C)	376	2.8	1985.1	1990.1	1991.0
		384	3.7	1985.1	1990.1	1991.3
		392	4.6	1985.1	1990.1	1991.9
Juam Main Stream	(V)					
		108	25.5	1981.0	1986.0	2006.8
		111	27.2	1981.0	1986.0	2009.7
		114	28.7	1981.0	1986.0	2012.3
		117	30.3	1981.0	1986.0	2015.2
		120	32.7	1981.0	1986.0	2019.3
Juam Diversion	(V)					
		114	21.2	1981.0	1986.0	1999.2
		117	22.5	1981.0	1986.0	2001.6
		120	24.4	1981.0	1986.0	2005.1

Remarks: /1 C: Constant draft operation
V: Variable draft operation

Table Q 2 BAMSEONGGOL DAM COST

High Water Surface	El. m	292.5	300	305
1 Dam Cost				
Dam type		——— Rockfill ———		
Flood water surface	El. m	293.5	301	306
Dam crest	El. m	296.5	304	309
Financial Investment Cost				
Civil work	$ 10^6	67.96	73.96	77.96
Metalwork	$ 10^6	3.41	3.41	3.41
Compensation: Land	$ 10^6	9.66	10.87	11.74
: Ground facilities	$ 10^6	5.04	5.47	5.58
Total	$ 10^6	86.07	93.71	98.69
Economic Investment Cost				
Civil work	$ 10^6	64.56	70.26	74.06
Metalwork	$ 10^6	3.24	3.24	3.24
Ground facilities	$ 10^6	4.79	5.20	5.30
Total	$ 10^6	72.59	78.70	82.60
Annual Equivalent of Cost				
Investment	$ 10^6	6.95	7.54	7.91
Replacement	$ 10^6	0.03	0.03	0.03
O & M	$ 10^6	0.34	0.37	0.39
Total	$ 10^6	7.32	7.94	8.33
2 Power Facilities Cost				
Installed Capacity	MW	37.4	46.5	49.7
Financial Investment Cost				
Civil work	$ 10^6	10.4	11.8	12.3
Metal & generating equipment	$ 10^6	11.6	13.0	13.6
Total	$ 10^6	22.0	24.8	25.9
Economic Investment Cost				
Civil work	$ 10^6	9.9	11.2	11.7
Metal & generating equipment	$ 10^6	11.0	12.4	12.9
Total	$ 10^6	20.9	23.6	24.6
Annual Equivalent of Cost				
Investment	$ 10^6	2.0	2.3	2.4
Replacement	$ 10^6	0.1	0.1	0.1
O & M	$ 10^6	0.5	0.6	0.6
Total	$ 10^6	2.6	3.0	3.1

Table Q 3 INJE DAM COST

High Water Surface	El. m	315	324.5	332.6
1 Dam Cost				
Dam type		———Concrete Gravity———		
Flood water surface	El. m	316	325.5	333.6
Dam crest	El. m	318	327.5	335.6
Financial Investment Cost				
Civil work	$ 10^6	64.36	78.63	92.30
Metalwork	$ 10^6	11.09	11.11	11.12
Compensation: Land	$ 10^6	9.28	12.84	15.54
: Ground facilities	$ 10^6	11.28	12.80	13.97
Total	$ 10^6	96.01	115.38	132.93
Economic Investment Cost				
Civil work	$ 10^6	61.14	74.70	87.69
Metalwork	$ 10^6	10.54	10.55	10.56
Ground facilities	$ 10^6	10.72	12.16	13.27
Total	$ 10^6	82.40	97.41	111.52
Annual Equivalent of Cost				
Investment	$ 10^6	7.89	9.33	10.68
Replacement	$ 10^6	0.09	0.09	0.09
O & M	$ 10^6	0.36	0.43	0.49
Total	$ 10^6	8.34	9.85	11.26
2 Power Facilities Cost				
Installed Capacity	MW	75.0	93.8	105.5
Financial Investment Cost				
Civil work	$ 10^6	36.5	42.4	45.3
Metal & generating equipment	$ 10^6	23.1	26.1	28.7
Total	$ 10^6	59.6	68.5	74.0
Economic Investment Cost				
Civil work	$ 10^6	34.7	40.3	43.0
Metal & generating equipment	$ 10^6	21.9	24.8	27.3
Total	$ 10^6	56.6	65.1	70.3
Annual Equivalent of Cost				
Investment	$ 10^6	5.4	6.2	6.7
Replacement	$ 10^6	0.2	0.2	0.2
O & M	$ 10^6	1.4	1.6	1.8
Total	$ 10^6	7.0	8.0	8.7

Table Q 4 HONGCHEON DAM COST

High Water Surface	El. m	110	115	120
1 Dam Cost				
Dam type		---Concrete Gravity---		
Flood water surface	El. m	111	116	121
Dam crest	El. m	113	118	123
Financial Investment Cost				
Civil work	$ 10^6	51.18	57.63	64.16
Metalwork	$ 10^6	10.17	10.17	10.17
Compensation: Land	$ 10^6	38.16	44.28	50.16
: Ground facilities	$ 10^6	10.42	10.78	11.28
Total	$ 10^6	109.93	122.86	135.77
Economic Investment Cost				
Civil work	$ 10^6	48.68	54.75	60.95
Metalwork	$ 10^6	9.66	9.66	9.66
Ground facilities	$ 10^6	9.90	10.24	10.72
Total	$ 10^6	68.18	74.65	81.33
Annual Equivalent of Cost				
Investment	$ 10^6	6.53	7.15	7.79
Replacement	$ 10^6	0.09	0.09	0.09
O & M	$ 10^6	0.29	0.32	0.35
Total	$ 10^6	6.91	7.56	8.23
2 Power Facilities Cost				
Installed Capacity	MW	51.6	62.1	72.9
Financial Investment Cost				
Civil work	$ 10^6	5.4	5.8	6.3
Metal & generating equipment	$ 10^6	19.9	23.6	27.4
Total	$ 10^6	25.3	29.4	33.7
Economic Investment Cost				
Civil work	$ 10^6	5.1	5.5	6.0
Metal & generating equipment	$ 10^6	18.9	22.4	26.0
Total	$ 10^6	24.0	27.9	32.0
Annual Equivalent of Cost				
Investment	$ 10^6	2.3	2.7	3.1
Replacement	$ 10^6	0.2	0.2	0.3
O & M	$ 10^6	0.6	0.7	0.8
Total	$ 10^6	3.1	3.6	4.2

Table Q 5 GUJEOL DAM COST

High Water Surface	El. m	743.5	747	748
1 Dam Cost				
Dam type			-Rockfill-	
Flood water surface	El. m	744.5	748	749
Dam crest	El. m	747.5	751	752
Financial Investment Cost				
Civil work	$ 10^6	17.58	18.88	19.36
Metalwork	$ 10^6	2.08	2.08	2.08
Compensation: Land	$ 10^6	4.70	5.64	5.90
: Ground facilities	$ 10^6	5.34	5.64	5.70
Total	$ 10^6	29.70	32.24	33.04
Economic Investment Cost				
Civil work	$ 10^6	16.70	17.94	18.39
Metalwork	$ 10^6	1.98	1.98	1.98
Ground facilities	$ 10^6	5.07	5.36	5.42
Total	$ 10^6	23.75	25.28	25.79
Annual Equivalent of Cost				
Investment	$ 10^6	2.28	2.42	2.47
Replacement	$ 10^6	0.02	0.02	0.02
O & M	$ 10^6	0.09	0.10	0.10
Total	$ 10^6	2.39	2.54	2.59
2 Power Facilities Cost				
Installed Capacity	MW	40.2	46.2	48.4
Financial Investment Cost				
Civil work	$ 10^6	13.2	13.7	15.4
Metal & generating equipment	$ 10^6	25.2	27.1	28.3
Total	$ 10^6	38.4	40.8	43.7
Economic Investment Cost				
Civil work	$ 10^6	12.5	13.0	14.6
Metal & generating equipment	$ 10^6	24.0	25.8	26.9
Total	$ 10^6	36.5	38.8	41.5
Annual Equivalent of Cost				
Investment	$ 10^6	3.5	3.7	4.0
Replacement	$ 10^6	0.2	0.2	0.2
O & M	$ 10^6	0.9	1.0	1.0
Total	$ 10^6	4.6	4.9	5.2

Table Q 6 DALCHEON DAM COST

High Water Surface	El. m	109	114	117
1 Dam Cost				
Dam type		----Concrete Gravity----		
Flood water surface	El. m	110	115	118
Dam crest	El. m	112	117	120
Financial Investment Cost				
Civil work	$ 10^6	24.76	38.15	40.18
Metalwork	$ 10^6	10.66	10.66	10.66
Compensation: Land	$ 10^6	60.60	79.80	90.00
: Ground facilities	$ 10^6	6.84	8.04	8.76
Total	$ 10^6	112.86	136.65	149.60
Economic Investment Cost				
Civil work	$ 10^6	33.02	36.24	38.17
Metalwork	$ 10^6	10.13	10.13	10.13
Ground facilities	$ 10^6	6.50	7.64	8.32
Total	$ 10^6	49.65	54.01	56.62
Annual Equivalent of Cost				
Investment	$ 10^6	4.76	5.17	5.42
Replacement	$ 10^6	0.09	0.09	0.09
O & M	$ 10^6	0.22	0.23	0.24
Total	$ 10^6	5.07	5.49	5.75
2 Power Facilities Cost				
Installed Capacity	MW	5.0	7.9	9.2
Financial Investment Cost				
Civil work	$ 10^6	1.3	1.5	1.6
Metal & generating equipment	$ 10^6	6.4	7.8	8.4
Total	$ 10^6	7.7	9.3	10.0
Economic Investment Cost				
Civil work	$ 10^6	1.2	1.4	1.5
Metal & generating equipment	$ 10^6	6.1	7.4	8.0
Total	$ 10^6	7.3	8.8	9.5
Annual Equivalent of Cost				
Investment	$ 10^6	0.7	0.8	0.9
Replacement	$ 10^6	0.1	0.1	0.1
O & M	$ 10^6	0.2	0.2	0.2
Total	$ 10^6	1.0	1.1	1.2

Table Q 7 GANHYEON DAM COST

High Water Surface	El. m	103.5	108.5	111.4
1 Dam Cost				
Dam type		---Concrete Gravity---		
Flood water surface	El. m	105.5	110.5	113.4
Dam crest	El. m	107.5	112.5	115.4
Financial Investment Cost				
Civil work	$ 10^6	6.85	13.30	17.05
Metalwork	$ 10^6	9.77	9.77	9.77
Compensation: Land	$ 10^6	45.48	53.76	58.56
: Ground facilities	$ 10^6	8.60	9.23	9.60
Total	$ 10^6	70.70	86.06	94.98
Economic Investment Cost				
Civil work	$ 10^6	6.51	12.04	16.20
Metalwork	$ 10^6	9.28	9.28	9.28
Ground facilities	$ 10^6	8.17	8.77	9.12
Total	$ 10^6	23.96	30.69	34.60
Annual Equivalent of Cost				
Investment	$ 10^6	2.30	2.94	3.31
Replacement	$ 10^6	0.08	0.08	0.08
O & M	$ 10^6	0.08	0.11	0.13
Total	$ 10^6	2.46	3.13	3.52
2 Power Facilities Cost				
Installed Capacity	MW	4.6	6.0	6.9
Financial Investment Cost				
Civil work	$ 10^6	1.9	2.1	2.2
Metal & generating equipment	$ 10^6	5.3	6.2	6.7
Total	$ 10^6	7.2	8.3	8.9
Economic Investment Cost				
Civil work	$ 10^6	1.8	2.0	2.1
Metal & generating equipment	$ 10^6	5.0	5.9	6.4
Total	$ 10^6	6.8	7.9	8.5
Annual Equivalent of Cost				
Investment	$ 10^6	0.7	0.8	0.8
Replacement	$ 10^6	0.0	0.1	0.1
O & M	$ 10^6	0.2	0.2	0.2
Total	$ 10^6	0.9	1.1	1.1

Table Q 8 BONGHWA DAM COST

High Water Surface	El. m	267	276	285
1 Dam Cost				
Dam type		---Concrete Gravity---		
Flood water surface	El. m	268	277	286
Dam crest	El. m	270	279	288
Financial Investment Cost				
Civil work	$ 10^6	51.63	77.83	95.12
Metalwork	$ 10^6	10.17	10.34	10.42
Compensation: Land	$ 10^6	9.74	12.54	15.36
: Ground facilities	$ 10^6	4.40	4.63	5.05
Total	$ 10^6	75.94	105.33	125.95
Economic Investment Cost				
Civil work	$ 10^6	49.05	73.93	90.36
Metalwork	$ 10^6	9.66	9.82	9.90
Ground facilities	$ 10^6	4.18	4.40	4.80
Total	$ 10^6	62.89	88.15	105.06
Annual Equivalent of Cost				
Investment	$ 10^6	6.02	8.44	10.06
Replacement	$ 10^6	0.09	0.09	0.09
O & M	$ 10^6	0.29	0.42	0.50
Total	$ 10^6	6.40	8.95	10.65
2 Power Facilities Cost				
Installed Capacity	MW	40.2	49.2	58.0
Financial Investment Cost				
Civil work	$ 10^6	13.4	15.7	18.1
Metal & generating equipment	$ 10^6	16.8	18.1	19.4
Total	$ 10^6	30.2	33.8	37.5
Economic Investment Cost				
Civil work	$ 10^6	12.7	14.9	17.2
Metal & generating equipment	$ 10^6	16.0	17.2	18.4
Total	$ 10^6	28.7	32.1	35.6
Annual Equivalent of Cost				
Investment	$ 10^6	2.7	3.1	3.4
Replacement	$ 10^6	0.1	0.2	0.2
O & M	$ 10^6	0.7	0.8	0.9
Total	$ 10^6	3.5	4.1	4.5

Table Q 9 IMHA DAM COST

High Water Surface	El. m	180	185	192
1 Dam Cost				
Dam type		——Concrete Gravity———		
Flood water surface	El. m	183	188	194
Dam crest	El. m	185	190	196
Financial Investment Cost				
Civil work	$ 10^6	47.77	51.64	59.40
Metalwork	$ 10^6	8.72	8.74	8.80
Compensation: Land	$ 10^6	27.66	33.96	38.38
: Ground facilities	$ 10^6	15.24	18.60	21.00
Total	$ 10^6	99.39	112.94	127.58
Economic Investment Cost				
Civil work	$ 10^6	45.38	49.06	56.43
Metal work	$ 10^6	8.28	8.30	8.36
Ground facilities	$ 10^6	14.48	17.67	19.95
Total	$ 10^6	68.14	75.03	84.74
Annual Equivalent of Cost				
Investment	$ 10^6	6.53	7.19	8.12
Replacement	$ 10^6	0.07	0.07	0.08
O & M	$ 10^6	0.27	0.29	0.32
Total	$ 10^6	6.87	7.55	8.52
2 Power Facilities Cost				
Installed Capacity	MW	34.7	40.5	47.6
Financial Investment Cost				
Civil work	$ 10^6	4.7	5.0	5.3
Metal & generating equipment	$ 10^6	18.8	19.8	22.0
Total	$ 10^6	23.5	24.8	27.3
Economic Investment Cost				
Civil work	$ 10^6	4.5	4.8	5.0
Metal & generating equipment	$ 10^6	17.8	18.8	20.9
Total	$ 10^6	22.3	23.6	25.9
Annual Equivalent of Cost				
Investment	$ 10^6	2.1	2.3	2.5
Replacement	$ 10^6	0.2	0.2	0.2
O & M	$ 10^6	0.6	0.6	0.6
Total	$ 10^6	2.9	3.1	3.3

Table Q 10 HAMYANG DAM COST

High Water Surface	El. m	376	384	392
1 Dam Cost				
Dam type		------Rockfill------		
Flood water surface	El. m	377	385	393
Dam crest	El. m	380	388	396
Financial Investment Cost				
Civil work	E 10^6	49.99	59.19	68.40
Metalwork	$ 10^6	5.84	5.93	6.02
Compensation: Land	$ 10^6	7.80	8.45	9.06
: Ground facilities	$ 10^6	2.86	3.10	3.34
Total	$ 10^6	66.49	76.67	86.82
Economic Investment Cost				
Civil work	$ 10^6	47.49	56.23	64.98
Metalwork	$ 10^6	5.55	5.63	5.72
Ground facilities	$ 10^6	2.72	2.95	3.17
Total	$ 10^6	55.76	64.81	73.87
Annual Equivalent of Cost				
Investment	$ 10^6	5.34	6.21	7.08
Replacement	$ 10^6	0.05	0.05	0.05
O & M	$ 10^6	0.27	0.31	0.35
Total	$ 10^6	5.66	6.57	7.48
2 Power Facilities Cost				
Installed Capacity	MW	2.8	3.6	4.0
Financial Investment Cost				
Civil work	$ 10^6	1.04	1.08	1.10
Metal & generating equipment	$ 10^6	4.34	4.58	4.70
Total	$ 10^6	5.38	5.66	5.80
Economic Investment Cost				
Civil work	$ 10^6	0.99	1.03	1.05
Metal & generating equipment	$ 10^6	4.12	4.35	4.46
Total	$ 10^6	5.11	5.38	5.51
Annual Equivalent of Cost				
Investment	$ 10^6	0.49	0.52	0.53
Replacement	$ 10^6	0.04	0.04	0.04
O & M	$ 10^6	0.13	0.13	0.14
Total	$ 10^6	0.66	0.69	0.71

Table Q 11 JUAM (MAIN STREAM) DAM COST

High Water Surface	El. m	108	111	114	117	120
1 Dam Cost						
Dam type		Concrete Gravity				
Flood water surface	El. m	109	112	115	118	121
Dam crest	El. m	111	114	117	120	123
Financial Investment Cost						
Civil work	$ 10^6	27.77	41.05	44.40	47.59	50.94
Metalwork	$ 10^6	10.21	10.21	10.50	10.21	10.21
Compensation:						
Land	$ 10^6	42.84	46.08	48.80	51.60	54.00
Ground facilities	$ 10^6	28.11	28.74	29.50	30.00	30.84
Total	$ 10^6	118.93	126.08	133.20	139.40	145.99
Economic Investment Cost						
Civil work	$ 10^6	35.88	39.00	42.18	45.21	48.39
Metalwork	$ 10^6	9.70	9.70	9.70	9.70	9.70
Ground facilities	$ 10^6	26.70	27.30	28.03	28.50	29.30
Total	$ 10^6	72.28	76.00	79.91	83.41	87.39
Annual Equivalent of Cost						
Investment	$ 10^6	6.92	7.28	7.66	7.99	8.37
Replacement	$ 10^6	0.09	0.09	0.09	0.09	0.09
O & M	$ 10^6	0.23	0.24	0.26	0.27	0.29
Total	$ 10^6	7.24	7.61	8.01	8.35	8.75

Table Q 12 JUAM (DIVERSION) DAM COST

High Water Surface	El. m	114	117	120
1 Dam Cost				
Dam type		--- Concrete Gravity ---		
Flood water surface	El. m	115	118	121
Dam crest	El. m	117	120	123
Financial Investment Cost				
Civil work	$ 10^6	44.40	47.59	50.94
Metalwork	$ 10^6	10.50	10.21	10.21
Compensation: Land	$ 10^6	48.80	51.60	54.00
: Ground facilities	$ 10^6	29.50	30.00	30.84
Total	$ 10^6	133.20	139.40	145.99
Economic Investment Cost				
Civil work	$ 10^6	42.18	45.21	48.39
Mealwork	$ 10^6	9.70	9.70	9.70
Ground facilities	$ 10^6	28.03	28.50	29.30
Total	$ 10^6	79.91	83.41	87.39
Annual Equivalent of Cost				
Investment	$ 10^6	7.66	7.99	8.37
Replacement	$ 10^6	0.09	0.09	0.09
O & M	$ 10^6	0.26	0.27	0.29
Total	$ 10^6	8.01	8.35	8.75

Table Q 13 ANNUAL EQUIVALENT OF COST OF ALTERNATIVE DAMS FOR M&I WATER SUPPLY

1. The Han River Basin

Unit: $ 10^6

Name of Alternative Dam	Gwangju I	Janghoweon	Gwangju II	Weonsong B	Yeoju
1. Output (m^3/s)	14.4	17.1	7.4	44.4	8.2
Economic Investment Cost					
2. Civil work	21.28	18.43	27.59	42.48	30.62
3. Metal work	7.02	8.15	5.24	30.25	32.45
4. Ground facilities	----- Included in (2) -----				
5. Total	28.30	26.58	32.83	72.73	63.07
Capitalized Cost					
6. Investment	33.14	31.13	38.44	85.17	73.85
7. Replacement	0.73	0.84	0.54	3.13	3.36
8. Total	33.87	31.97	39.98	88.30	77.21
Annual Equivalent of Cost Single Stage Construction					
9. Year of commission	2008.6	2008.6	2008.6	2008.6	2008.6
10. Investment	2.77	2.61	3.18	7.21	6.31
11. OM & production foregone	1.90	3.42	0.98	5.34	3.77
12. Annual equivalent (10 + 11)	4.67	6.03	4.16	12.55	10.08
Annual Equivalent of Cost Stage Construction					
13. Year of commission	2008.6	2011.2	2014.3	2015.6	2023.6
14. Annual equivalent	4.67	4.94	2.68	7.32	3.18

Table Q 13 Continued (2)

2. The Nagdong River Basin

Unit: $ 10^6

Name of Alternative Dam	Mungyeong	Gimcheon	Goryeong
1. Output (m^3/s)	10.2	4.3	19.2
Economic Investment Cost			
2. Civil work	34.71	39.68	47.46
3. Metal work	7.85	5.92	8.81
4. Ground facilities	---- Included in (2) ----		
5. Total	42.56	45.60	56.27
Capitalized Cost			
6. Investment	49.84	53.40	65.89
7. Replacement	0.81	0.61	0.91
8. Total	50.65	54.01	66.80
Annual Equivalent of Cost Single Stage Construction			
9. Year of commission	1990.1	1990.1	1990.1
10. Investment	4.14	4.41	5.46
11. OM & production foregone	0.71	0.30	2.22
12. Annual equivalent (10 + 11)	4.85	4.71	7.68
Annual Equivalent of Cost Stage Construction			
13. Year of commission	1990.1	1990.1	1990.1
14. Annual equivalent	4.85	4.71	7.68

Table Q 14 ANNUAL EQUIVALENT OF M&I WATER SUPPLY BENEFIT

Han River Basin

Unit: $ 10^6

Name of Alternative Dams		Gwangju I	Jongho-weon	Gwangju II	Weonsong B	Yeonju	Total
1. Output	(m^3/s)	14.1	17.1	7.4	44.4	8.2	
2. Accumulation of (1)	(m^3/s)	14.4	31.5	38.9	83.3	91.5	
3. Capitalized Cost	($\$ 10^6$)	4.67	6.03	4.16	12.55	10.08	
4. Annual Equivalent of Cost							
4.1 Year of commission		2008.6	2011.2	2014.3	2015.6	2023.6	
4.2 Annual equivalent of cost	($\$ 10^6$)	4.67	4.94	2.68	7.32	3.18	

Proposed Dam Scheme	HWS (El. m)	Net Water Supply Capacity (m^3/s)					
Bamseonggol	292.5	7.5			4.23		4.23
	300	9.3			5.23		5.23
	305	9.8			5.51		5.51
Inje	315	1.6			0.87		0.87
	324.5	2.7			1.54		1.54
	332.6	3.7			2.09		2.09
Hongcheon (C)	110	10.5		3.71			3.71
	115	14.4		5.08			5.08
	120	17.7		6.26			6.26
Hongcheon (V)	110	77.6	4.67	4.94	2.68	6.38	- 18.67
	115	84.8	4.67	4.94	2.68	7.32	0.58 20.19
	120	90.9	4.67	4.94	2.68	7.32	2.95 22.56
Dalcheon (C)	109	5.3	1.72				1.72
	114	11.6	3.77				3.77
	117	13.9	4.49				4.49
Dalcheon (V)	109	60.4	4.67	4.94	2.68	3.54	15.83
	114	74.8	4.67	4.94	2.68	5.92	18.21
	117	79.8	4.67	4.94	2.68	6.74	19.03
Ganhyeon (C)	103	7.8	2.52				2.52
	108.5	10.5	3.41				3.41
	111.4	12.8	4.13				4.13
Ganhyeon (V)	103.5	63.2	4.67	4.94	2.68	4.01	16.30
	108.5	74.3	4.67	4.94	2.68	5.84	18.13
	111.4	78.2	4.67	4.94	2.68	6.48	18.77

Nagdong River Basin

Name of Alternative Dams		Mungyeong	Gimcheon	Goreyeong	Total
1. Output	(m^3/s)	10.2	4.3	19.2	
2. Accumulation of (1)	(m^3/s)	10.2	14.5	-	
3. Annual Equivalent of Cost					
3.1 1st stage construction		4.85	4.71	7.68	

	(El. m)	(m^3/s)				
Bonghwa	267	0.6		0.66		0.66
	276	1.5		1.64		1.64
	285	2.3		2.52		2.52
Imha (C)	180	8.4	3.99			3.99
	185	9.9	4.71			4.71
	192	11.3	5.37			5.37
Imha (V)	180	14.3			5.72	5.72
	185	15.8			6.32	6.32
	192	18.3			7.26	7.26
Hamyang	376	1.4		1.53		1.53
	384			1.97		1.97
	392	2.7		2.96		2.96

Table Q 15 CALCULATION OF ANNUAL EQUIVALENT OF IRRIGATION BENEFIT

Unit: $ 10^3

(1) No.	(2) Year	(3) Reduced PWAF	(4) Benefit annual increase	(5) Capitalized (4)	(6) Accumulated (5)	(7) Annual equivalent
Han River						
1	2008.6	10.450	153	1,599	1,599	131
2	2009.6	9.656	153	1,477	3,076	251
3	2010.6	8.921	153	1,365	4,441	363
4	2011.6	8.241	153	1,261	5,702	466
5	2012.6	7.610	153	1,164	6,866	561
6-11	2013.6					
	-2018.6	34.813	153	5,326	12,192	997
12	2019.6	4.329	153	662	12,854	1,051
13	2020.6	3.989	153	610	13,464	1,101
14	2021.6	3.674	153	562	14,026	1,147
15	2022.6	3.382	153	517	14,543	1,189
16	2023.6	3.111	153	476	15,019	1,228
17	2024.6	2.861	153	438	15,457	1,264
18	2025.6	2.629	153	402	15,859	1,296
Nagdong River						
1	1990.1	10.450	407.5	4,258	4,258	348
2	1991.1	9.656	404.7	3,908	8,166	667
3	1992.1	8.921	379.3	3,384	11,550	944
4	1993.1	8.241	379.3	3,126	14,676	1,199
5	1994.1	7.610	379.3	2,886	17,562	1,435
6	1995.1	7.027	379.3	2,665	20,227	1,653
7	1996.1	6.486	379.2	2,459	22,686	1,853
8	1997.1	5.986	378.7	2,267	24,953	2,039
9	1998.1	5.523	378.7	2,092	27,045	2,210
10	1999.1	5.094	378.7	1,929	28,974	2,367
11	2000.1	4.697	378.7	1,779	30,753	2,513
12	2001.1	4.329	378.7	1,639	32,392	2,646
13	2002.1	3.989	378.7	1,511	33,903	2,770

Remarks; (3) : Present worth of an annuity factor of 50 years less that of (1) + 1 years,
(4) : Increase in annual irrigation benefit,
(5) : (3) x (4),
(7) : (6) x capital recovery factor

Table Q 15 Continued (2)

Unit: $ 10^3

(1) No.	(2) Year	(3) Reduced FWAF	(4) Benefit annual increase	(5) Capitalized (4)	(6) Accumulated (5)	(7) Annual equivalent
Seomjin River						
1	1986	10.450	516.9	5,402	5,402	442
2-6	1987 -1991	41.455	53.8	2,230	7,632	624
7-11	1992 -1996	27.786	58.1	1,614	9,246	756
12-14	1997 -1999	11.992	54.1	649	9,895	809
15	2000	3.382	54.1	183	10,078	824
16	2001	3.111	54.1	168	10,246	838
17	2002	2.861	54.1	155	10,401	850
18	2003	2.629	54.1	142	10,543	862
19	2004	2.415	54.1	131	10,674	873
20	2005	2.216	54.1	120	10,794	882
21	2006	2.032	54.1	110	10,904	891
22	2007	1.862	54.1	101	11,005	900
23	2008	1.704	54.1	92	11,097	907
24	2009	1.558	54.1	84	11,181	914
25	2010	1.423	54.1	77	11,258	920
26	2011	1.298	54.1	70	11,328	926
27	2012	1.182	54.1	64	11,392	931
28	2013	1.075	54.1	58	11,450	936
29	2014	0.975	54.1	53	11,503	940
30	2015	0.883	54.1	48	11,551	944
31	2016	0.798	54.1	43	11,594	948
32	2017	0.719	54.1	39	11,633	951
33	2018	0.646	54.1	35	11,668	954
34	2019	0.578	54.1	31	11,699	956
35	2020	0.516	54.1	28	11,727	959

Remarks; (3) : Present worth of an annuity factor of 50 years less that of (1) + 1 years,
(4) : Increase in annual irrigation benefit,
(5) : (3) x (4),
(7) : (6) x capital recovery factor.

Table Q 16 JUSTIFICATION OF POWER PURPOSE

Dam Scheme/1	HWS (El. m)	Installed capacity (MW)	Annual Equivalents		
			Benefit	Cost	B-C
Bamseonggol (C)	292.5	37.4	4.29	2.60	1.69
	300	46.5	5.01	3.00	2.01
	305	49.7	5.25	3.10	2.15
Inje (C)	315	75.0	8.62	7.00	1.62
	324.5	93.8	10.16	8.00	2.16
	332.6	105.5	11.12	8.70	2.42
Hongcheon (C)	110	51.6	5.92	3.10	2.82
	115	62.1	6.75	3.60	3.15
	120	72.9	7.57	4.20	3.37
Gujeol (C)	743.5	40.2	4.84	4.60	0.24
	747	46.2	5.36	4.90	0.46
	748	48.4	5.56	5.20	0.36
Dalcheon (C)/2	109	5.0	1.47	1.00	0.47
	114	7.9	1.90	1.10	0.80
	117	9.2	2.10	1.20	0.90
Ganhyeon (C)/2	103.5	4.6	1.21	0.90	0.31
	108.5	6.0	1.44	1.10	0.34
	111.4	6.9	1.58	1.10	0.48
Banghwa (C)	267	40.2	4.65	3.50	1.15
	276	49.2	5.35	4.10	1.25
	285	58.0	6.03	4.50	1.53
Imha (C)	180	34.7	3.84	2.90	0.94
	185	40.5	4.29	3.10	1.19
	192	47.6	4.82	3.30	1.52
Hamyang (C)/2	376	2.8	0.72	0.66	0.06
	384	3.6	0.85	0.69	0.16
	392	4.0	0.91	0.71	0.20

Remarks; /1 ; C: Constant draft operation

/2 ; 18-hour operation assumed; other than /2 5-hour operation assumed

Table Q 17 FLOOD CONTROL SPACE OPTIMIZATION

Flood Water Surface (El. m)	Flood Control Space (10^6 m^3)	Flood Control Benefit ($ 10^6)	Production Foregone ($ 10^6)	Dam Cost ($ 10^6)	B - C ($ 10^6)
Ganhyeon HWS El. 103.5 m					
104.5	25	0.41	-0.11	0.13	0.17
105.5	59	0.75	-0.17	0.26	0.32
106.5	90	0.89	-0.24	0.39	0.26
Ganhyeon HWS El. 108.5 m					
109.5	35	0.57	-0.05	0.13	0.39
110.5	78	0.84	-0.10	0.26	0.48
111.5	115	0.98	-0.13	0.39	0.46
Ganhyeon HWS El. 111.4 m					
112.4	40	0.62	-0.04	0.13	0.45
113.4	92	0.90	-0.08	0.26	0.56
114.4	130	1.03	-0.13	0.39	0.51
Imha HWS El. 180 m					
182	60	1.53	-0.13	0.27	1.13
183	97	1.74	-0.15	0.40	1.19
184	130	1.86	-0.17	0.53	1.16
Imha HWS El. 185 m					
187	70	1.62	-0.04	0.26	1.32
188	114	1.82	-0.07	0.39	1.36
189	155	1.91	-0.08	0.55	1.29
Imha HWS El. 192 m					
193	50	1.41	-0.02	0.16	1.24
194	100	1.78	-0.04	0.31	1.44
195	151	1.90	-0.05	0.46	1.39

Table Q 18 ECONOMIC COSTS OF ALTERNATIVE YEONGGYE DAM AND YEONGGYE-GWANGYANG PIPELINE

Unit: $ 10^6

	Yeonggye Dam	Yeonggye-Gwangyang Pipeline
1. Net Water Supply/Discharge Capacity (m^3/s)	6.2	3.1
2. Capital Cost		
Investment cost	37.96	24.73
Replacement cost	2.74	19.28
3. Annual Cost		
O & M cost	0.18	0.42
Production foregone	0.07	
Total	0.25	0.42
4. Capitalized Cost		
Investment cost	44.45	25.72
Replacement cost	0.31	1.99
Total	44.76	27.71
5. Annual Equivalent of Cost		
Capital cost	3.67	2.27
Annual cost	0.25	0.42
Total	3.92	2.69

Table Q 19 ECONOMIC O & M COSTS OF EXISTING PIPELINE

Unit: $ 10^6

As Associated with:-	Proposed Dam	Alternative Dam
Discharge Capacity (m^3/s)	2.9	2.9
Fixed Cost	0.74	0.74
Material Cost	0.15	0.14
Energy Cost	2.14	2.02
Total	3.03	2.90

Table Q 20 ECONOMIC COSTS OF HADONG-GWANGYANG PIPELINE

Unit : $ 10^6

Order of Construction	1	Even	Odd
1. Discharge Capacity (m^3/s)	3.5	3.7	3.7
2. Capital Cost			
Investment cost	26.12	28.04	25.93
Replacement cost	16.71	18.21	17.61
3. Annual Cost			
- As associated with proposed dam	1.69	1.58	1.54
- As associated with alternative dam	1.17	1.12	1.08
4. Capitalized Cost			
Investment cost	27.16	29.16	26.97
Replacement cost	1.73	1.88	1.82
Total :	28.89	31.04	28.79
5. Annual Equivalent of Cost			
- As associated with proposed dam			
Capital cost	2.37	2.55	2.36
Annual cost	1.69	1.58	1.54
Total :	4.06	4.13	3.90
- As associated with alternative dam			
Capital cost	2.37	2.55	2.36
Annual cost	1.17	1.12	1.08
Total :	3.54	3.67	3.44

Remarks : First pipeline is constructed utilizing the tunnel of the existing pipeline. The pipeline of even number includes a tunnel with a capacity of 7.4 m^3/s.
The pipeline of odd number utilizes the tunnel of the pipeline of even number.

Table Q 21 ECONOMIC COSTS OF DIVERSION TUNNEL ASSOCIATED WITH THE JUAM DAM (DIVERSION PLAN)

Unit: $ 10^6

	Route A			Route B			Route C		
HWS (El. m)	114	117	120	114	117	120	114	117	120
1. Net Supply Capacity (m^3/s)	11.8	13.1	15.0	11.8	13.1	15.0	11.8	13.1	15.0
2. Capital Cost									
Investment cost	16.30	17.22	17.66	13.22	13.95	14.62	20.77	21.50	22.00
Replacement cost	0.27	0.30	0.32	0.54	0.59	0.63	0.99	1.02	1.04
3. Annual Cost									
O & M cost	0.08	0.09	0.09	0.07	0.07	0.07	0.10	0.11	0.11
4. Capitalized Cost									
Investment cost	17.99	18.62	19.10	14.30	15.09	15.81	22.46	23.25	23.86
Replacement cost	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total :	18.00	18.63	19.11	14.31	15.10	15.82	22.47	23.26	23.87
5. Annual Equivalent of Cost									
Capital cost	1.48	1.53	1.57	1.18	1.25	1.31	1.86	1.92	1.97
Annual cost	0.08	0.09	0.09	0.07	0.07	0.07	0.10	0.11	0.11
Total :	1.56	1.62	1.66	1.25	1.32	1.38	1.96	2.03	2.08

Remarks : For the details of alternative routes, see ANNEX P.

Table Q 22 ECONOMIC COST OF DIVERSION PIPELINE ASSOCIATED WITH THE JUAM DAM (DIVERSION PLAN)

Unit: $ 10^6

	Route	Ā	A	B	C
	Order of Construction	1	2 onward	Each	Each
1.	Net discharge Capacity (m^3/s)	3.7	3.7	3.7	3.7
2.	Capital Cost				
	Investment cost	32.30	31.88	27.21	42.40
	Replacement cost	25.52	25.15	20.94	33.41
3.	Annual Cost				
	O & M cost	0.54	0.48	0.50	0.90
4.	Capitalized Cost				
	Investment cost	33.59	33.16	28.31	44.10
	Replacement cost	2.64	2.60	2.16	3.45
	Total	36.23	35.76	30.47	47.55
5.	Annual Equivalent of Cost				
	Capital cost	2.97	2.93	2.50	3.90
	Annual cost	0.54	0.48	0.50	0.90
	Total	3.51	3.41	3.00	4.80

Remarks; The first pipeline of Route A includes the power transmission line and substation.

Table 23 ECONOMIC COSTS OF YEONGGYE DAM ASSOCIATED WITH THE JUAM DAM DIVERSION PLAN (ROUTE B)

Unit: $ 10^6

	HWS (El. m)	114	117	120
1.	Net M&I Water Supply Capacity (m^3/s)	2.0	2.2	2.4
2.	Capital Cost			
	Investment cost	37.90	41.39	44.92
	Replacement cost	2.74	2.74	2.74
3.	Annual Cost			
	O & M cost	0.19	0.21	0.23
	Production foregone	0.07	0.07	0.08
	Total	0.26	0.28	0.31
4.	Capitalized Cost			
	Investment cost	44.38	48.47	52.60
	Replacement cost	0.32	0.32	0.32
	Total	44.70	48.79	52.92
5.	Annual Equivalent of Cost			
	Capital cost	3.66	3.99	4.33
	Annual cost	0.26	0.28	0.31
	Total	3.92	4.27	4.64

Table Q 24 YEAR OF COMMISSION AND ANNUAL EQUIVALENT OF COST OF M&I ALTERNATIVE DAMS AND THEIR ASSOCIATED FACILITIES

Order of Construction		0	1	2	3	4	5	6	7	8
1. Yeonggye Dams										
Capacity	(m^3/s)	1.8	6.2	6.2	6.2	6.2				
Acc. capacity	(m^3/s)	1.8	8.0	14.2	20.4	26.6				
Year of commission		-	1986.0	1987.5	1998.3	2009.7				
Capital cost	($\$ 10^6$)	-	3.67	3.26	1.41	0.59				
Annual cost	($\$ 10^6$)	-	0.25	0.22	0.09	0.04				
Total annual eqv't	($\$ 10^6$)	-	3.92	3.48	1.50	0.63				
Acc. of the above	($\$ 10^6$)	-	3.92	7.40	8.90	9.53				
2. Yeonggye-Gwangyang Pipeline										
Capacity	(m^3/s)	1.8	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Acc. capacity	(m^3/s)	1.8	4.9	8.0	11.1	14.2	17.3	20.4	23.5	26.6
Year of commission		-	1986.0	1986.0	1987.5	1992.6	1998.3	2004.0	2009.7	2015.4
Capital cost	($\$ 10^6$)	-	2.27	2.27	2.02	1.37	0.87	0.57	0.37	0.24
Annual cost	($\$ 10^6$)	-	0.42	0.42	0.37	0.25	0.16	0.10	0.06	0.04
Total annual eqv't	($\$ 10^6$)	-	2.69	2.69	2.39	1.69	1.03	0.67	0.43	0.26
Acc. of the above	($\$ 10^6$)	-	2.69	5.38	7.77	9.39	10.42	11.09	11.52	11.80
3. Hadong-Gwangyang Pipeline										
Capacity	(m^3/s)	2.9	3.5	3.7	3.7	3.7	3.7	3.7	3.7	
Acc. capacity	(m^3/s)	2.9	6.4	10.1	13.8	17.5	21.2	24.9	28.6	
Year of commission		-	1986.0	1986.0	1990.7	1997.5	2004.3	2011.1	2018.0	
Capital cost	($\$ 10^6$)	-	2.37	2.55	1.65	1.06	0.58	0.37	0.21	
Annual cost	($\$ 10^6$)	-	1.17	1.12	0.75	0.45	0.25	0.14	0.07	
Total annual eqv't	($\$ 10^6$)	-	3.54	3.67	2.40	1.51	0.83	0.51	0.28	
Acc. of the above	($\$ 10^6$)	-	3.54	7.21	9.61	11.12	11.95	12.46	12.74	

Table Q 25 YEAR OF COMMISSION AND ANNUAL EQUIVALENT OF COST OF M&I WATER SUPPLY FACILITIES ASSOCIATED WITH THE JUAM DAM

Order of Construction		0	1	2	3	4	5	6	7
1. Hadong-Gwangyang Pipeline									
Capacity	(m^3/s)	2.9	3.5	3.7	3.7	3.7	3.7	3.7	3.7
Acc. capacity	(m^3/s)	2.9	6.4	10.1	13.8	17.5	21.2	24.9	28.6
Year of commission		-	1986.0	1986.0	1990.7	1997.5	2004.3	2011.1	2018.0
Capital cost	($ 10^6)	-	2.37	2.55	1.65	1.06	0.58	0.37	0.21
Annual cost	($ 10^6)	-	1.69	1.58	1.07	0.63	0.35	0.20	0.10
Total annual eqv't	($ 10^6)	-	4.06	4.13	2.72	1.69	0.93	0.57	0.31
Acc. of the above	($ 10^6)	-	4.06	8.19	10.91	12.60	13.53	14.10	14.41
2. Diversion Pipeline Route A									
Capacity	(m^3/s)	2.9	3.7	3.7	3.7	3.7	3.7		
Acc. capacity	(m^3/s)	2.9	6.6	10.3	14.0	17.7	21.4		
Year of commission		-	1986.0	1986.0	1991.1	1997.9	2004.7		
Capital cost	($ 10^6)	-	2.97	2.93	1.98	1.18	0.70		
Annual cost	($ 10^6)	-	0.54	0.48	0.32	0.19	0.11		
Total annual eqv't	($ 10^6)	-	3.51	3.41	2.30	1.37	0.81		
Acc. of the above	($ 10^6)	-	3.51	6.92	9.22	10.59	11.40		
3. Diversion Pipeline Route B (HWS El. 120 m)									
Capacity	(m^3/s)	2.9	3.7	3.7	3.7	3.7	3.7	3.7	
Acc. capacity	(m^3/s)	2.9	6.6	10.3	14.0	17.7	21.4	25.1	
Year of commission		-	1986.0	1986.0	1987.3	1993.5	2000.3	2007.1	
Capital cost	($ 10^6)	-	2.50	2.50	2.26	1.40	0.83	0.49	
Annual cost	($ 10^6)	-	0.50	0.50	0.45	0.28	0.16	0.09	
Total annual eqv't	($ 10^6)	-	3.00	3.00	2.71	1.68	0.99	0.58	
Acc. of the above	($ 10^6)	-	3.00	6.00	8.71	10.39	11.38	11.96	
4. Diversion Pipeline Route C									
Capacity	(m^3/s)	2.9	3.7	3.7	3.7	3.7	3.7		
Acc. capacity	(m^3/s)	2.9	6.6	10.3	14.0	17.7	21.4		
Year of commission		-	1986.0	1986.0	1991.1	1997.9	2004.7		
Capital cost	($ 10^6)	-	3.90	3.90	2.64	1.56	0.93		
Annual cost	($ 10^6)	-	0.90	0.90	0.60	0.35	0.20		
Total annual eqv't	($ 10^6)	-	4.80	4.80	3.24	1.91	1.13		
Acc. of the above	($ 10^6)	-	4.80	9.60	12.84	14.75	15.88		

Table Q 26 NET M&I WATER SUPPLY CAPACITY TO BE SUPPLIED FROM EXISTING AND PROPOSED FACILITIES AND ESTIMATED ANNUAL EQUIVALENT OF M&I WATER SUPPLY BENEFIT OF JUAM DAM

MAIN STREAM PLAN — Unit: $ 10^6

HWS (El. m)	108	111	114	117	120
Target Year	2006.8	2009.7	2012.3	2015.2	2019.3
Net M&I Water Supply Capacity(m^3/s)	18.8	20.4	21.8	23.4	25.6
1. Alternative Facilities Costs					
1.1 Yeonggye dam	8.52	8.90	9.04	9.21	9.42
1.2 Yeonggye-Gwanggang pipeline	10.76	11.10	11.30	11.52	11.72
1.3 Hadong-Gwangyang pipeline	11.41	11.77	12.03	12.25	12.51
1.4 Existing pipeline	2.90	2.90	2.90	2.90	2.90
Total	33.59	34.67	35.27	35.88	36.55
2. Project Associated Facilities Cost					
2.1 Hodong-Gwangyang pipeline	12.92	13.32	13.62	13.87	14.16
2.2 Existing pipeline	3.03	3.03	3.03	3.03	3.03
Total	15.95	16.35	16.65	16.90	17.19
3. Annual Equivalent of M&I Benefit					
1-2	17.64	18.32	18.62	18.98	19.36

DIVERSION PLAN

Route		A		B	C
HWS (El. m)	114	117	120	120	120
Target Year	1999.2	2001.6	2005.1	2009.5	2005.1
Net M&I Water Supply Capacity(m^3/s)	14.7	16.0	17.9	20.3	17.9
1. Alternative Facilities Costs					
1.1 Yeonggye dam	7.52	7.84	8.29	8.90	8.29
1.2 Yeonggye-Gwangyang pipeleine	9.58	9.99	10.54	11.03	10.54
1.3 Hadong-Gwangyang pipeline	9.98	10.51	11.21	11.76	11.21
1.4 Existing pipeline	2.90	2.90	2.90	2.90	2.90
Total	29.98	31.24	32.94	34.59	32.94
2. Project Associated Facilities Cost					
2.1 Diversion tunnel	1.56	1.62	1.66	1.38	2.08
2.2 Yeonggye dam	-	-	-	4.64	-
2.3 Diversion pipeline	9.48	9.96	10.64	11.09	14.81
2.4 Existing pipeline	3.03	3.03	3.03	3.03	3.03
Total	14.07	14.61	15.33	20.14	19.92
3. Annual Equivalent of M&I Benefit					
1-2	15.91	16.63	17.61	14.45	13.02

Table Q 27 SCALE COMPARISON
BAMSEONGGOL DAM (C)

High Water Surface	El. m	292.5	300	305
Flood water surface	El. m	293.5	301	306
Low water surface	El. m	264	264	264
Active Storage	10^6 m^3	210	303	368
Flood control space	10^6 m^3	10.7	13.4	15.6
Draft	10^6 m^3	324	387	403
Net water supply	m^3/s	7.7	9.5	10.0
Available for down stream power	10^6 m^3	162	200	210
Maximum discharge	m^3/s	49.4	59.0	61.4
Rated water head	m	90.2	93.9	96.4
Installed capacity	MW	37.4	46.5	49.7
Firm peak output	MW	28.9	33.8	34.7
Effective power	MW	33.2	40.2	42.2
Annual energy output	GWh	87.7	98.2	102.6
Down stream water head	m	138.4	138.4	138.4
Down stream energy increase	GWh	52.3	64.5	67.9
Total energy	GWh	140.0	162.7	170.5
Annual Benefit				
M&I	$ 10^6	4.23	5.23	5.51
Irrigation	$ 10^6	0.30	0.33	0.34
Flood control	$ 10^6	0.07	0.08	0.08
Power	$ 10^6	5.48	6.48	6.80
Production foregone	$ 10^6	-0.58	-0.65	-0.70
Total	$ 10^6	9.50	11.47	12.03
Annual Cost				
Dam	$ 10^6	7.32	7.94	8.33
Power facilities	$ 10^6	2.60	3.00	3.10
Total	$ 10^6	9.92	10.94	11.43
B - C	$ 10^6	-0.42	0.53	0.60

Remarks ; DMZ approximately at El. 305 m

Table Q 28 SCALE COMPARISON
INJE DAM (C)

High Water Surface	El. m	315	324.5	332.6
Flood water surface	El. m	316	325.5	333.6
Low water surface	El. m	287	288	289.8
Active Storage	10^6 m^3	376	565	753
Flood control space	$10^6 m^3$	19.3	20.0	23.8
Draft	$10^6 m^3$	558	665	715
Net water supply	m^3/s	1.6	2.8	3.8
Available for down stream power	10^6 m^3	46	81	110
Maximum discharge	m^3/s	85.0	101.3	109.0
Rated water head	m	105.0	110.2	115.2
Installed capacity	MW	75.0	93.8	105.5
Firm peak output	MW	60.5	71.6	77.5
Effective power	MW	67.8	82.7	91.5
Annual energy output	GWh	173.3	195.7	211.3
Down stream water head	m	145.6	145.6	145.6
Down stream energy increase /1	GWh	14.3	24.9	33.9
Total energy	GWh	187.6	220.6	245.2
Annual Benefit				
M&I	$ 10^6	0.87	1.54	2.09
Irrigation	$ 10^6	0.17	0.19	0.22
Flood control	$ 10^6	0.08	0.08	0.08
Power	$ 10^6	8.95	10.73	11.90
Production foregone	$ 10^6	-0.74	-0.85	-0.93
Total	$ 10^6	9.33	11.69	13.36
Annual Cost				
Dam	$ 10^6	8.34	9.85	11.26
Power facilities	$ 10^6	7.00	8.00	8.70
Total	$ 10^6	15.34	17.85	19.96
B - C	$ 10^6	-6.01	-6.16	-6.60

Remarks ; /1 : Available water except Soyanggang dam reservoir was reduced.

Table Q 29 SCALE COMPARISON
HONGCHEON DAM (C)

High Water Surface	El. m	110	115	120
Flood water surface	El. m	111	116	121
Low water surface	El. m	93	93	93
Active Storage	10^6 m^3	513	720	954
Flood control space	10^6 m^3	38.0	44.7	52.3
Draft	10^6 m^3	832	951	1,065
Net water supply	m^3/s	10.7	14.5	18.1
Available for down stream power	10^6 m^3	271	351	427
Maximum discharge	m^3/s	126.7	145.0	162.2
Rated water head	m	48.5	51.0	53.5
Installed capacity	MW	51.6	62.1	72.9
Firm peak output	MW	38.6	43.1	47.1
Effective power	MW	45.1	52.6	60.0
Annual energy output	GWh	123.5	137.0	150.8
Down stream water head	m	35.0	35.0	35.0
Down stream energy increase	GWh	22.1	28.7	34.9
Total energy	GWh	145.6	165.7	185.7
Annual Benefit				
M&I	$ 10^6	3.71	5.08	6.26
Irrigation	$ 10^6	0.35	0.43	0.49
Flood control	$ 10^6	0.29	0.31	0.32
Power	$ 10^6	6.43	7.41	8.37
Production foregone	$ 10^6	-1.48	-1.67	-1.87
Total	$ 10	9.30	11.56	13.57
Annual Cost				
Dam	$ 10^6	6.91	7.56	8.22
Power facilities	$ 10^6	3.10	3.60	4.20
Total	$ 10^6	10.01	11.16	12.42
B - C	$ 10^6	-0.71	0.40	1.15

Remarks ; Hongcheon town approximately at El. 125 m.

Table Q 30 SCALE COMPARISON
HONGCHEON DAM (V)

High Water Surface	El. m	110	115	120
Flood water surface	El. m	111	116	121
Low water surface	El. m	93	93	93
Active Storage	10^6 m^3	513	720	954
Flood control space	10^6 m^3	38.0	44.7	52.3
Draft	10^6 m^3	794	909	1,064
Net water supply	m^3/s	79.4	86.3	93.0
Available for down stream power	10^6 m^3	265	303	355
Maximum discharge	m^3/s	-	-	-
Rated water head	m	-	-	-
Installed capacity	MW	-	-	-
Firm peak output	MW	-	-	-
Effective power	MW	-	-	-
Annual energy output	GWh	-	-	-
Down stream water head	m	35.0	35.0	35.0
Down stream energy increase	GWh	21.6	24.7	29.0
Total energy	GWh	21.6	24.7	29.0
Annual Benefit				
M&I	$ 10^6	18.67	20.19	22.56
Irrigation	$ 10^6	1.19	1.24	1.28
Flood control	$ 10^6	0.29	0.31	0.32
Power	$ 10^6	-	-	-
Production foregone	$ 10^6	-1.48	-1.67	-1.87
Total	$ 10^6	18.67	20.06	22.29
Annual Cost				
Dam	$ 10^6	6.91	7.56	8.22
Power facilities	$ 10^6	-	-	-
Total	$ 10^6	6.91	7.56	8.22
B - C	$ 10^6	11.76	12.50	14.07

Remarks : Hongcheon town approximately at El. 125m

Table Q 31 SCALE COMPARISON
GUJEOL DAM (C)

High Water Surface	El. m	743.5	747	748
Flood water surface	El. m	744.5	748	749
Low water surface	El. m	723	723	723
Active Storage	10^6 m^3	50.3	67.1	73.2
Flood control space	10^6 m^3	4.5	5.8	6.2
Draft	10^6 m^3	52.3	59.9	62.7
Net water supply	m^3/s	-	-	-
Available for down stream power	10^6 m^3	-	-	-
Maximum discharge	m^3/s	7.97	9.12	9.55
Rated water head	m	601.2	603.0	603.5
Installed capacity	MW	40.2	46.2	48.4
Firm peak output	MW	39.2	44.8	46.9
Effective power	MW	39.7	45.5	47.7
Annual energy output	GWh	92.1	97.7	99.8
Down stream water head	m	-	-	-
Down stream energy increase	GWh	-	-	-
Total energy	GWh	92.1	97.7	99.8
Annual Benefit				
M&I	$ 10^6	-	-	-
Irrigation	$ 10^6	-	-	-
Flood control	$ 10^6	0.04	0.05	0.05
Power	$ 10^6	4.84	5.36	5.56
Production foregone	$ 10^6	-0.01	-0.01	-0.01
Total	$ 10^6	4.87	5.40	5.60
Annual Cost				
Dam	$ 10^6	2.39	2.54	2.59
Power facilities	$ 10^6	4.60	4.90	5.20
Total	$ 10^6	6.99	7.44	7.79
B - C	$ 10^6	-2.12	-2.04	-2.19

Remarks ; Seoul-Gangneung highway approximately at El. 750 m.

Table Q 32 SCALE COMPARISON
DALCHEON DAM (C)

High Water Surface	El. m	109	114	117
Flood water surface	El. m	110	115	118
Low water surface	El. m	101	101	101
Active Storage	10^6 m^3	200	390	540
Flood control space	10^6 m^3	31.9	44.1	53.2
Draft	10^6 m^3	454	662	737
Net water supply	m^3/s	5.4	12.0	14.4
Available for down stream power	10^6 m^3	43	153	197
Maximum discharge	m^3/s	19.2	27.9	31.1
Rated water head	m	31.2	33.7	35.2
Installed capacity	MW	5.0	7.9	9.2
Firm peak output	MW	4.1	5.7	6.2
Effective power	MW	4.6	6.8	7.7
Annual energy output	GWh	50.5	62.7	68.5
Down stream water head	m	11.5	11.5	11.5
Down stream energy increase	GWh	1.2	4.1	5.3
Total energy	GWh	51.7	66.8	73.8
Annual Benefit				
M&I	$ 10^6	1.72	3.77	4.49
Irrigation	$ 10^6	0.25	0.37	0.42
Flood control	$ 10^6	0.60	0.68	0.71
Power	$ 10^6	1.50	2.00	2.22
Production foregone	$ 10^6	-2.67	-3.26	-3.62
Total	$ 10^6	1.40	3.56	4.22
Annual Cost				
Dam	$ 10^6	5.07	5.49	5.75
Power facilities	$ 10^6	1.00	1.10	1.20
Total	$ 10^6	6.07	6.59	6.95
B - C	$ 10^6	-4.67	-3.03	-2.73

Remarks ; Goesan town approximately at El. 117 m.

Table Q 33 SCALE COMPARISON
DALCHEON DAM (V)

High Water Surface	El. m	109	114	117
Flood water surface	El. m	110	115	118
Low water surface	El. m	101	101	101
Active Storage	10^6 m^3	200	390	540
Flood control space	10^6 m^3	31.9	44.1	53.2
Draft	10^6 m^3	415	618	696
Net water supply	m^3/s	61.5	76.5	81.3
Available for down stream power	10^6 m^3	138	206	180
Maximum discharge	m^3/s	-	-	-
Rated water head	m	-	-	-
Installed capacity	MW	-	-	-
Firm peak output	MW	-	-	-
Effective power	MW	-	-	-
Annual energy output	GWh	-	-	-
Down stream water head	m	11.5	11.5	11.5
Down stream energy increase	GWh	3.7	5.5	4.8
Total energy	GWh	3.7	5.5	4.8
Annual Benefit				
M&I	$ 10^6	15.83	18.21	19.03
Irrigation	$ 10^6	1.05	1.17	1.21
Flood control	$ 10^6	0.60	0.68	0.71
Power	$ 10^6	-	-	-
Production foregone	$ 10^6	-2.67	-3.26	-3.62
Total	$ 10^6	14.81	16.80	17.33
Annual Cost				
Dam	$ 10^6	5.07	5.49	5.75
Power facilities	$ 10^6	-	-	-
Total	$ 10^6	5.07	5.49	5.75
B - C	$ 10^6	9.74	11.31	11.58

Remarks ; Goesan town approximately at El. 117 m.

Table Q 34 SCALE COMPARISON
GANHYEON DAM (C)

High Water Surface	El. m	103.5	108.5	111.4
Flood water surface	El. m	105.5	110.5	113.4
Low water surface	El. m	91	91	91
Active Storage	10^6 m^3	265	425	540
Flood control space	10^6 m^3	58.9	78.2	91.7
Draft	10^6 m^3	545	639	702
Net water supply	m^3/s	7.9	10.9	12.9
Available for down stream power	10^6 m^3	57	104	136
Maximum discharge	m^3/s	23.0	27.0	29.7
Rated water head	m	23.8	26.4	27.8
Installed capacity	MW	4.6	6.0	6.9
Firm peak output	MW	2.9	3.3	3.5
Effective power	MW	3.8	4.7	5.2
Annual energy output	GWh	41.4	48.8	53.4
Down stream water head	m	11.5	11.5	11.5
Down stream energy increase	GWh	1.5	2.8	3.6
Total energy	GWh	42.9	51.6	57.0
Annual Benefit				
M&I	$ 10^6	2.52	3.41	4.13
Irrigation	$ 10^6	0.30	0.35	0.39
Flood control	$ 10^6	0.75	0.84	0.90
Power	$ 10^6	1.24	1.50	1.66
Production foregone	$ 10^6	-2.43	-2.69	-2.80
Total	$ 10^6	2.38	3.41	4.28
Annual Cost				
Dam	$ 10^6	2.46	3.13	3.52
Power facilities	$ 10^6	0.90	1.10	1.10
Total	$ 10^6	3.36	4.23	4.62
B - C	$ 10^6	-0.98	-0.82	-0.34

Remarks ; Weonju City at approximately El. 115 m.

Table Q 35 SCALE COMPARISON
GANHYEON DAM (V)

High Water Surface	El. m	103.5	108.4	111.4
Flood water surface	El. m	105.5	110.4	113.4
Low water surface	El. m	91	91	91
Active Storage	10^6 m^3	265	425	540
Flood control space	10^6 m^3	58.9	78.2	91.7
Draft	10^6 m^3	432	597	666
Net water supply	m^3/s	64.5	75.5	79.7
Available for down stream power	10^6 m^3	144	199	222
Maximum discharge	m^3/s	-	-	-
Rated water head	m	-	-	-
Installed capacity	MW	-	-	-
Firm peak output	MW	-	-	-
Effective power	MW	-	-	-
Annual energy output	GWh	-	-	-
Down stream water head	m	11.5	11.5	11.5
Down stream energy increase	GWh	3.9	5.3	6.0
Total energy	GWh	3.9	5.3	6.0
Annual Benefit				
M&I	$ 10^6	16.30	18.13	18.77
Irrigation	$ 10^6	1.07	1.16	1.19
Flood control	$ 10^6	0.75	0.84	0.70
Power	$ 10^6	-	-	-
Production foregone	$ 10^6	-2.43	-2.69	-2.80
Total	$ 10^6	15.69	17.44	18.06
Annual Cost				
Dam	$ 10^6	2.46	3.13	3.52
Power facilities	$ 10^6	-	-	-
Total	$ 10^6	2.46	3.13	3.52
B - C	$ 10^6	13.23	14.31	14.54

Remarks ; Weonju City at approximately El. 115 m.

Table Q 36 SCALE COMPARISON
BONGHWA DAM (C)

High Water Surface	El. m	267	276	285
Flood water surface	El. m	268	277	286
Low water surface	El. m	238	238	238
Active Storage	10^6 m^3	269	406	573
Flood control space	10^6 m^3	13.3	17.0	21.5
Draft	10^6 m^3	410	473	529
Net water supply	m^3/s	1.4	3.0	4.0
Available for down stream power	10^6 m^3	18	45	67
Maximum discharge	m^4/s	62.40	72.00	80.64
Rated water head	m	76.8	81.3	85.8
Installed capacity	MW	40.2	49.2	58.0
Firm peak output	MW	29.4	33.0	35.9
Effective power	MW	34.8	41.1	47.0
Annual energy output	GWh	99.0	110.8	122.5
Down stream water head	m	57.0	57.0	57.0
Down stream energy increase	GWh	2.4	6.0	8.9
Total energy	GWh	101.4	116.8	131.4
Annual Benefit				
M&I	$ 10^6	0.66	1.64	2.52
Irrigation	$ 10^6	0.48	0.67	0.81
Flood control	$ 10^6	0.09	0.10	0.11
Power	$ 10^6	4.71	5.49	6.24
Production foregone	$ 10^6	-0.27	-0.33	-0.41
Total	$ 10^6	5.67	7.57	9.27
Annual Cost				
Dam	$ 10^6	6.40	8.95	10.65
Power facilities	$ 10^6	3.50	4.10	4.50
Total	$ 10^6	9.90	13.05	15.15
B - C	$ 10^6	-4.23	-5.48	-5.88

Remarks ; Topographic limit of water surface at approximately El. 301 m.

Table Q 37 SCALE COMPARISON
IMHA DAM (C)

High Water Surface	El. m	180	185	192
Flood water surface	El. m	183	188	194
Low water surface	El. m	158	158	158
Active Storage	10^6 m^3	438	583	920
Flood control space	10^6 m^3	96.8	113.6	100.0
Draft	10^6 m^3	491	548	608
Net water supply	m^3/s	11.9	13.7	15.6
Available for down stream power	10^6 m^3	-	-	-
Maximum discharge	m^3/s	74.88	83.52	92.64
Rated water head	m	55.2	57.7	61.2
Installed capacity	MW	34.7	40.5	47.6
Firm peak output	MW	24.9	27.2	29.2
Effective power	MW	29.8	33.9	38.4
Annual energy output	GWh	78.3	85.7	95.2
Down stream water head	m	-	-	-
Down stream energy increase	GWh	-	-	-
Total energy	GWh	78.3	85.7	95.2
Annual Benefit				
M&I	$ 10^6	3.99	4.71	5.37
Irrigation	$ 10^6	1.73	1.93	2.09
Flood control	$ 10^6	1.74	1.82	1.78
Power	$ 10^6	3.84	4.29	4.82
Production foregone	$ 10^6	-0.84	-0.95	-1.05
Total	$ 10^6	10.46	11.80	13.01
Annual Cost				
Dam	$ 10^6	6.87	7.55	8.52
Power facilities	$ 10^6	2.90	3.10	3.30
Total	$ 10^6	9.77	10.65	11.82
B - C	$ 10^6	0.69	1.15	1.19

Remarks ; Topographic limit of water surface at approximately El. 195 m.

Table Q 38 SCALE COMPARISON
IMHA DAM (V)

High Water Surface	El. m	180	185	192
Flood water surface	El. m	183	188	194
Low water surface	El. m	158	158	158
Active Storage	10^6 m^3	438	583	920
Flood control space	10^6 m^3	96.8	113.6	100.0
Draft	10^6 m^3	475	542	593
Net water supply	m^3/s	19.2	22.0	24.2
Available for down stream power	10^6 m^3	-	-	-
Maximum discharge	m^3/s	-	-	-
Rated water head	m	-	-	-
Installed capacity	MW	-	-	-
Firm peak output	MW	-	-	-
Effective power	MW	-	-	-
Annual energy output	GWh	-	-	-
Down stream water head	m	-	-	-
Down stream energy increase	GWh	-	-	-
Total energy	GWh	-	-	-
Annual Benefit				
M&I	$ 10^6	5.72	6.32	7.26
Irrigation	$ 10^6	2.40	2.59	2.75
Flood control	$ 10^6	1.74	1.82	1.78
Power	$ 10^6	-	-	-
Production foregone	$ 10^6	-0.84	-0.95	-1.05
Total	$ 10^6	9.02	9.78	10.74
Annual Cost				
Dam	$ 10^6	6.87	7.55	8.52
Power facilities	$ 10^6	-	-	-
Total	$ 10^6	6.87	7.55	8.52
B - C	$ 10^6	2.15	2.23	2.22

Remarks ; Topographic limit of water surface at approximately El. 195 m.

Table Q 39 SCALE COMPARISON
HAMYANG DAM (C)

High Water Surface	El. m	376	384	392
Flood water surface	El. m	377	385	393
Low water surface	El. m	338	339	339
Active Storage	10^6 m^3	151	201	251
Flood control space	10^6 m^3	5.3	6.4	7.7
Draft	10^6 m^3	180	208	209
Net water supply	m^3/s	2.8	3.7	4.6
Available for down stream power	10^6 m^3	59	78	97
Maximum discharge	m^3/s	7.41	8.59	8.65
Rated water head	m	46.0	50.5	54.5
Installed capacity	MW	2.8	3.6	4.0
Firm peak output	MW	2.0	2.1	2.0
Effective power	MW	2.4	2.9	3.0
Annual energy output	GWh	24.5	28.5	30.8
Down stream water head	m	10.1	10.1	10.1
Down stream energy increase	GWh	1.4	1.8	2.3
Total energy	GWh	25.9	30.3	33.1
Annual Benefit				
M&I	$ 10^6	1.53	1.97	2.96
Irrigation	$ 10^6	0.64	0.72	0.89
Flood control	$ 10^6	0.04	0.05	0.05
Power	$ 10^6	0.75	0.89	0.91
Production foregone	$ 10^6	-0.28	-0.30	-0.32
Total	$ 10^6	2.68	3.33	4.49
Annual Cost				
Dam	$ 10^6	5.66	6.57	7.48
Power facilities	$ 10^6	0.66	0.69	0.71
Total	$ 10^6	6.32	7.26	8.19
B - C	$ 10^6	-3.64	-3.93	-3.70

Table Q 40 SCALE COMPARISON
JUAM MAIN STREAM (V)

High Water Surface	El. m	108	111	114	117	120
Flood water surface	El. m	109	112	115	118	121
Low water surface	El. m	85	85	85	85	85
Active Storage	10^6 m^3	355	448	530	630	780
Flood control space	10^6 m^3	25.0	30.0	35.8	41.3	47.6
Draft	10^6 m^3	377	417	454	495	554
Net water supply	m^3/s	25.5	27.2	28.7	30.3	32.7
Available for down stream power	10^6 m^3	-	-	-	-	-
Maximum discharge	m^3/s	-	-	-	-	-
Rated water head	m	-	-	-	-	-
Installed capacity	MW	-	-	-	-	-
Firm peak output	MW	-	-	-	-	-
Effective power	MW	-	-	-	-	-
Annual energy output	GWh	-	-	-	-	-
Down stream water head	m	-	-	-	-	-
Down stream energy increase	GWh	-	-	-	-	-
Total energy	GWh	-	-	-	-	-
Annual Benefit						
M&I	$ 10^6	17.64	18.32	18.62	18.98	19.36
Irrigation	$ 10^6	0.90	0.92	0.93	0.95	0.96
Flood control	$ 10^6	0.11	0.14	0.16	0.18	0.21
Power	$ 10^6	-	-	-	-	-
Production foregone	$ 10^6	-1.48	-1.57	-1.67	-1.76	-1.88
Total	$ 10^6	17.17	17.81	18.04	18.35	18.65
Annual Cost						
Dam	$ 10^6	7.24	7.61	8.01	8.35	8.75
Power facilities	$ 10^6	-	-	-	-	-
Total	$ 10^6	7.24	7.61	8.01	8.35	8.75
B - C	$ 10^6	9.93	10.20	10.03	10.00	9.90

Table Q 41 SCALE COMPARISON
JUAM DIVERSION (V)

High Water Surface	El. m	114	117	120
Flood water surface	El. m	115	118	121
Low water surface	El. m	85	85	85
Active Storage	10^6 m^3	530	630	780
Flood control space	10^6 m^3	35.8	41.3	47.6
Draft	10^6 m^3	372	413	473
Net water supply	m^3/s	21.2	22.5	24.4
Available for down stream power	10^6 m^3	-	-	-
Maximum discharge	m^3/s	-	-	-
Rated water head	m	-	-	-
Installed capacity	MW	-	-	-
Firm peak output	MW	-	-	-
Effective power	MW	-	-	-
Annual energy output	GWh	-	-	-
Down stream water head	m	-	-	-
Down stream energy increase	GWh	-	-	-
Total energy	GWh	-	-	-
Annual Benefit				
M&I	$ 10^6	15.91	16.63	17.61
Irrigation	$ 10^6	0.81	0.85	0.88
Flood control	$ 10^6	0.16	0.18	0.21
Power	$ 10^6	-	-	-
Production foregone	$ 10^6	-1.67	-1.76	-1.88
Total	$ 10^6	15.21	15.90	16.82
Annual Cost				
Dam	$ 10^6	8.01	8.35	8.75
Power facilities	$ 10^6	-	-	-
Total	$ 10^6	8.01	8.35	8.75
B - C	$ 10^6	7.20	7.55	8.07

Table Q 42 COMPARISON OF DIVERSION ROUTES
(JUAM DIVERSION DAM SCHEME)

Unit: $ 10^6

		Route A	Route B	Route C
High Water Surface (El. m)		120	120	120
Annual Benefit				
M&I	$\$10^6$	17.61	14.45	13.02
Irrigation	$\$10^6$	0.88	0.88	0.88
Flood control	$\$10^6$	0.21	0.21	0.21
Production foregone	$\$10^6$	-1.88	-1.88	-1.88
Total	$\$10^6$	16.82	13.66	12.23
Annual Cost				
Dam	$\$10^6$	8.75	8.75	8.75
B-C	$\$10^6$	8.07	4.91	3.48

Table Q 43 JUSTIFIED DAM SCHEMES

Name of Dam Plan	Operation Method	HWS (El. m)
1. Bamseonggol	C	305
2. Hongcheon	C	120
3. Hongcheon	V	120
4. Dalcheon	V	117
5. Ganhyeon	V	111.4
6. Imha	C	192
7. Hongcheon	V	185
8. Juam Main Stream	V	111
9. Juam Diversion	V	120

Remarks: C : Constant draft operation

V : Variable draft operation

Table Q 44 ALTERNATIVE FACILITIES COST OF M&I WATER SUPPLY IN THE HAN AND NAGDONG RIVER BASINS

Unit: $ 10^6$

(Net Water Supply Capacity)	Bamseonggol (C) (9.81 m^3/s)	Hongcheon (C) (17.74 m^3/s)
1. Name of Alternative Dam	Gwangju (II)	Janghoweon
1.1 Net supply capacity (m^3/s)	9.81	17.74
1.2 Accumulation of 1.1 (m^3/s)	9.81	17.74
2. Construction Start	2003.6	2003.6
3. Investment Cost	43.52	27.57
3.1 Civil work	(36.57)	(19.12)
3.2 Metal work	(6.95)	(8.45)
4. Replacement Cost	6.26	7.61
5. Annual Cost	1.30	3.55

(Net Water Supply Capacity)	Hongcheon (V) (90.92 m^3/s)				
1. Name of Alternative Dam	Gwangju (I)	Jang-howeon	Gwangju (II)	Weosong (B)	Yeoju
1.1 Net supply capacity (m^3/s)	14.40	17.10	7.40	44.40	7.62
1.2 Accumulation of 1.1 (m^3/s)	14.40	31.50	38.90	83.30	90.92
2. Construction Start	2003.6	2006.2	2009.3	2010.6	2018.6
3. Investment Cost	28.30	26.58	32.83	72.73	58.61
3.1 Civil work	(21.28)	(18.43)	(27.59)	(42.48)	(28.45)
3.2 Metal work	(7.02)	(8.15)	(5.24)	(30.25)	(30.16)
4. Replacement Cost	6.32	7.34	4.72	27.23	27.14
5. Annual Cost	1.90	3.42	0.98	5.34	3.50

Remarks : C : Constant draft operation
V : Variable draft operation

Table Q 44 Continued (2)

Unit: $ 10^6

(Net Water Supply Capacity)	Dalcheon (V) ($79.83\ m^3/s$)			
1. Name of Alternative Dam	Gwangju (I)	Jang-howeon	Gwangju (II)	Weonson (B)
1.1 Net supply capacity (m^3/s)	14.40	17.10	7.40	40.93
1.2 Accumulation of 1.1 (m^3/s)	14.40	31.50	38.90	79.83
2. Construction Start	2003.6	2006.2	2009.3	2010.6
3. Investment Cost	28.30	26.58	32.83	67.05
3.1 Civil work	(21.28)	(18.43)	(27.59)	(39.16)
3.2 Metal work	(7.02)	(8.15)	(5.24)	(27.89)
4. Replacement Cost	6.32	7.34	4.72	25.10
5. Annual Cost	1.90	3.42	0.98	4.92

(Net Water Supply Capacity)	Ganhyeon (V) ($78.17\ m^3/s$)			
1. Name of Alternative Dam	Gwangju (I)	Jang-howeon	Gwangju (II)	Weonson (B)
1.1 Net supply capacity (m^3/s)	14.40	17.10	7.40	39.27
1.2 Accumulation of 1.1 (m^3/s)	14.40	31.50	38.90	78.17
2. Construction Start	2003.6	2006.2	2009.3	2010.6
3. Investment Cost	28.30	26.58	32.83	64.33
3.1 Civil work	(21.28)	(18.43)	(27.59)	(37.58)
3.2 Metal work	(7.02)	(8.15)	(5.24)	(26.75)
4. Replacement Cost	6.32	7.34	4.72	24.08
5. Annual Cost	1.90	3.42	0.98	4.72

Table Q 44 Continued (3)

Unit: $ 10^6

(Net Water Supply Capacity)	Imha (C) (11.30 m^3/s)	Imha (V) (15.8 m^3/s)
1. Name of Alternative Dam	Mungyeong	Goryeong
1.1 Net supply capacity (m^3/s)	11.30	15.80
1.2 Accumulation of 1.1 (m^3/s)	11.30	15.80
2. Construction Start	1985.1	1985.1
3. Investment Cost	47.15	46.31
3.1 Civil work	(38.45)	(39.06)
3.2 Metal work	(8.70)	(7.25)
4. Replacement Cost	7.83	6.53
5. Annual Cost	0.79	1.83

Table Q 45 ALTERNATIVE FACILITIES COST OF JUAM DAM (MAIN STREAM PLAN) FOR M&I WATER SUPPLY

Unit: $ 10^6

Order of Construction	Alternative Yeonggye Dam 1	2	3
1. Net Supply Capacity (m^3/s)	6.2	6.2	6.2
2. Accumulation of 1 (m^3/s)	6.2	12.4	18.6
3. Construction Start	1981.0	1982.5	1993.3
4. Investment Cost	37.96	37.96	37.96
4.1 Civil works	(34.92)	(34.92)	(34.86)
4.2 Metalworks	(3.04)	(3.04)	(3.04)
5. Replacement Cost	2.74	2.74	2.74
6. Annual Cost	0.25	0.25	0.25

Order of Construction	Alternative Yeonggye-Gwangyang Pipeline 1 & 2	3	4	5	6
1. Capacity (m^3/s)	6.2	3.1	3.1	3.1	3.1
2. Accumulation of 1 (m^3/s)	6.2	9.3	12.4	15.5	18.6
3. Construction Start	1984.0	1985.5	1990.6	1996.3	2002.2
4. Investment Cost	49.46	24.73	24.73	24.73	24.65
4.1 Civil works	(6.62)	(3.31)	(3.31)	(3.31)	(3.30)
4.2 Metalworks	(42.84)	(21.42)	(21.42)	(21.42)	(21.35)
5. Replacement Cost	38.56	19.28	19.28	19.28	19.22
6. Annual Cost	0.84	0.42	0.42	0.42	0.42

Table Q 45 Continued (2)

Unit: $ 10^6

Order of Construction	Handong-Gwangyang Pipeline 1	2	3	4	5
1. Capacity (m^3/s)	3.5	3.7	3.7	3.7	2.9
2. Accumulation of 1 (m^3/s)	3.5	7.2	10.9	14.6	17.5
3. Construction Start	1984.0	1984.0	1988.7	1995.5	2002.3
4. Investment Cost	26.12	28.04	25.93	28.04	20.32
4.1 Civil works	(7.55)	(7.81)	(6.36)	(7.81)	(4.98)
4.2 Metalworks	(18.57)	(20.23)	(19.57)	(20.23)	(15.34)
5. Replacement Cost	16.71	18.21	17.61	18.21	13.80
6. Annual Cost	1.17	1.12	1.08	1.12	0.85

O & M Cost of Existing Pipeline

1. Fixed Cost	0.625
2. Material Cost	0.145
3. Energy Cost	2.131
Total :	2.901

Table Q 46 ASSOCIATED FACILITIES COST OF JUAM DAM (MAIN STREAM PLAN) FOR M&I WATER SUPPLY

Unit: 10^6

Order of Construction	Handong-Gwangyang Pipeline 1	2	3	4	5
1. Capacity (m^3/s)	3.5	3.7	3.7	3.7	2.9
2. Accumulation of 1 (m^3/s)	3.5	7.2	10.9	14.6	17.5
3. Construction Start	1984.0	1984.0	1988.7	1995.5	2002.3
4. Investment Cost	26.12	28.04	25.93	28.04	20.32
4.1 Civil works	(7.55)	(7.81)	(6.36)	(7.81)	(4.98)
4.2 Metalworks	(18.57)	(20.23)	(19.57)	(20.23)	(15.34)
5. Replacement Cost	16.71	18.21	17.61	18.21	13.80
6. Annual Cost	1.69	1.58	1.54	1.58	0.85

O & M Cost of Existing Pipeline

1. Fixed Cost	0.625
2. Material Cost	0.145
3. Energy Cost	2.257
Total :	3.027

Table Q 47 ALTERNATIVE FACILITIES COST OF JUAM DAM (DIVERSION PLAN) FOR M&I WATER SUPPLY

Unit: $ 10^6

Order of Construction	Alternative Yeonggye Dam 1	2	3
1. Net Supply Capacity (m^3/s)	6.2	6.2	3.7
2. Accumulation of 1 (m^3/s)	6.2	12.4	16.10
3. Construction Start	1981.0	1982.5	1993.3
4. Investment Cost	37.96	37.96	22.65
4.1 Civil works	(34.92)	(34.92)	(20.84)
4.2 Metalworks	(3.04)	(3.04)	(1.81)
5. Replacement Cost	2.74	2.74	1.63
6. Annual Cost	0.25	0.25	0.15

Order of Construction	Alternative Yeonggye-Gwangyang Pipeline 1 & 2	3	4	5	6
1. Capacity (m^3/s)	6.2	3.1	3.1	3.1	0.6
2. Accumulation of 1 (m^3/s)	6.2	9.3	12.4	15.5	16.1
3. Construction Start	1984.0	1985.5	1990.6	1996.3	2002.0
4. Investment Cost	49.46	24.73	24.73	24.73	4.79
4.1 Civil works	(6.62)	(3.31)	(3.31)	(3.31)	(0.64)
4.2 Metalworks	(42.84)	(21.42)	(21.42)	(21.42)	(4.15)
5. Replacement Cost	38.56	19.28	19.28	19.28	3.73
6. Annual Cost	0.84	0.42	0.42	0.42	0.08

Table Q 47 Continued (2)

Unit: $ 10^6

Order of Construction	Handong-Gwangyang Pipeline 1	2	3	4	5
1. Capacity (m^3/s)	3.5	3.7	3.7	3.7	0.4
2. Accumulation of 1 (m^3/s)	3.5	7.2	10.9	14.6	15.0
3. Construction Start	1984.0	1984.0	1988.7	1995.5	2002.3
4. Investment Cost	26.12	28.04	25.93	28.04	2.80
4.1 Civil works	(7.55)	(7.81)	(6.36)	(7.81)	(0.69)
4.2 Metalworks	(18.57)	(20.23)	(19.57)	(20.23)	(2.11)
5. Replacement Cost	16.71	18.21	17.61	18.21	1.90
6. Annual Cost	1.17	1.12	1.08	1.12	1.08

O & M Cost of Existing Pipeline

1. Fixed Cost	0.625
2. Material Cost	0.145
3. Energy Cost	2.131
Total :	2.901

Table Q 48 ASSOCIATED FACILITIES COST OF JUAM DAM (DIVERSION PLAN) FOR M&I WATER SUPPLY

Unit: $ 10^6

Order of Construction	Diversion Pipeline 1	2	3	4	5
1. Capacity (m^3/s)	3.7	3.7	3.7	3.7	0.2
2. Accumulation of 1 (m^3/s)	3.7	7.4	11.1	14.8	15.0
3. Construction Start	1984.0	1984.0	1988.1	1995.9	2002.7
4. Investment Cost	32.30	31.88	31.88	31.88	1.72
4.1 Civil works	(3.94)	(3.94)	(3.94)	(3.94)	(0.21)
4.2 Metalworks	(28.36)	(27.94)	(27.94)	(27.94)	(1.51)
5. Replacement Cost	25.52	25.15	25.15	25.15	1.36
6. Annual Cost	0.54	0.48	0.48	0.48	0.03

Diversion Tunnel Route A	
1. Capacity (m^3/s)	15.0
2. Construction Start	1983.0
3. Investment Cost	17.66
3.1 Civil works	(17.31)
3.2 Metalworks	(0.35)
4. Replacement Cost	0.32
5. Annual Cost	0.09

O & M Cost of Existing Pipeline	
1. Fixed Cost	0.626
2. Material Cost	0.145
3. Energy Cost	2.257
Total :	3.027

Table Q 49 CONVERSION OF M&I ALTERNATIVE FACILITIES COST TO M&I BENEFIT

Year in Order	Bamseonggol (C)			Dalcheon (V)			Ganhyeon (V)		
	M&I Alternative Cost /1 ($ 10^6)	Net Water Supply /2 (m^3/s)	M&I Benefit /3 ($ 10^6)	M&I Alternative Cost ($ 10^6)	Net Water Supply (m^3/s)	M&I Benefit ($ 10^6)	M&I Alternative Cost ($ 10^6)	Net Water Supply (m^3/s)	M&I Benefit ($ 10^6)
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
1	5.44	-	-	3.54	-	-	3.54	-	-
2	10.88	-	-	7.08	-	-	7.08	-	-
3	10.88	-	-	7.08	-	-	7.08	-	-
4	10.88	-	-	10.40	-	-	10.40	-	-
5	5.44	-	-	10.19	-	-	10.19	-	-
6	1.30	5.54	3.25	8.58	5.54	2.13	8.55	5.54	2.12
7	1.30	9.81	5.76	12.65	11.09	4.25	12.65	11.09	4.24
8	1.30	9.81	5.76	21.81	16.63	6.38	21.47	16.63	6.36
9	.	.	.	30.29	22.18	8.51	29.61	22.18	8.48
10	.	.	.	30.29	27.72	10.63	29.61	27.72	10.59
11	.	.	.	26.18	33.26	12.76	25.50	33.26	12.71
12	.	.	.	14.68	38.81	14.89	14.34	38.81	14.83
13	.	.	.	11.22	44.35	17.01	11.02	44.35	16.95
14	.	.	.	.	49.90	19.14	11.02	49.90	19.07
15	.	.	.	.	55.44	21.27	.	55.44	21.19
16	.	.	.	.	60.98	23.40	.	60.98	23.31
17	.	.	.	.	66.53	25.52	.	66.53	25.43
18	ditto	.	.	.	72.07	27.65	.	72.07	27.54
19	.	.	.	ditto	77.62	29.78	ditto	77.62	29.67
20	.	.	.	.	79.83	30.63	.	78.17	29.88
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30	1.30	.	.	11.22	.	.	11.02	.	.
31	2.08	.	.	12.01	.	.	11.81	.	.
32	2.87	ditto	ditto	12.80	.	.	12.60	.	.
33	2.87	.	.	12.80	.	.	12.60	.	.
34	2.87	.	.	13.72	.	.	13.52	.	.
35	2.08	.	.	13.85	.	.	13.65	.	.
36	1.30	.	.	13.06	.	.	12.86	.	.
37	1.30	.	.	13.65	ditto	ditto	13.45	ditto	ditto
38	.	.	.	16.46	.	.	16.13	.	.
39	.	.	.	18.68	.	.	18.22	.	.
40	.	.	.	18.68	.	.	18.22	.	.
41	.	.	.	18.09	.	.	17.63	.	.
42	ditto	.	.	14.36	.	.	14.03	.	.
43	.	.	.	11.22	.	.	11.02	.	.
44	.	.	.	.	.	.	.	.	.
45	.	.	.	.	.	.	.	.	.
46	.	.	.	ditto	.	.	ditto	.	.
47	.	.	.	.	.	.	.	.	.
48	.	.	.	.	.	.	.	.	.
49	.	.	.	.	.	.	.	.	.
50	1.30	9.81	5.76	11.22	79.83	30.63	11.02	78.17	29.88
T.P.W. /4	45.91	78.15 /5	45.89	155.41	405.08	155.41	153.15	400.71	153.16

/1 : See Table Q 44

/2 : Annual increase of net water supply ; 5.544 m^3/s/year (Han basin)

/3 : M&I benefit is calculated as follows.

$$(3) = \frac{\text{T.P.W. of (1)}}{\text{T.P.W. of (2)}} \times (2)$$

/4 : Total Present Worth (Discount rate ; 8 %)

/5 : Total present worth in column (2) is calculated assuming the unit value of net water supply is \$ 1/m^3/s.

Table Q 49 Continued (2)

Year in Order	Hongcheon (C) M&I Alternative Cost ($ 10^6) (1)	Hongcheon (C) Net Water Supply (m^3/s) (2)	Hongcheon (C) M&I Benefit ($ 10^6) (3)	Hongcheon (V) M&I Alternative Cost ($ 10^6) (1)	Hongcheon (V) Net Water Supply (m^3/s) (2)	Hongcheon (V) M&I Benefit ($ 10^6) (3)	Imha (C) M&I Alternative Cost ($ 10^6) (1)	Imha (C) Net Water Supply (m^3/s) (2)	Imha (C) M&I Benefit ($ 10^6) (3)
1	3.45	-	-	3.54	-	-	5.89	-	-
2	6.89	-	-	7.08	-	-	11.79	-	-
3	6.89	-	-	7.08	-	-	11.79	-	-
4	6.89	-	-	10.40	-	-	11.79	-	-
5	3.45	-	-	10.19	-	-	5.89	-	-
6	3.55	5.54	2.14	8.55	5.54	2.36	0.79	1.51	0.92
7	3.55	11.09	4.29	12.65	11.09	4.72	.	3.07	1.87
8	3.55	16.63	6.43	22.52	16.63	7.08	.	4.63	2.82
9	.	17.74	6.86	31.71	22.18	9.44	.	6.19	3.78
10	.	17.74	6.86	31.71	27.72	11.80	.	7.75	4.73
11	.	.	.	27.60	33.26	14.16	.	9.31	5.68
12	.	.	.	15.39	38.81	16.52	.	10.85	6.62
13	.	.	.	11.64	44.35	18.88	.	11.30	6.89
14	.	.	.	11.64	49.90	21.24	.	.	.
15	.	.	.	11.64	55.44	23.60	.	.	.
16	.	.	.	18.97	60.98	25.96	.	.	.
17	.	.	.	26.29	66.53	28.32	ditto	.	.
18	ditto	.	.	26.29	72.07	30.68	.	.	.
19	.	.	.	26.29	77.62	33.05	.	.	.
20	.	.	.	18.97	83.16	35.40	.	.	.
21	.	.	.	15.14	88.70	37.76	.	.	.
22	.	.	.	15.14	90.92	38.71	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	ditto	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
30	3.55	.	.	15.14	.	.	0.79	.	.
31	4.50	.	.	15.93	.	.	1.77	.	.
32	5.45	.	.	16.72	.	.	2.75	.	.
33	5.45	ditto	ditto	16.72	.	.	2.75	ditto	ditto
34	5.45	.	.	17.64	.	.	2.75	.	.
35	4.50	.	.	17.77	.	.	1.77	.	.
36	3.55	.	.	16.98	.	.	0.79	.	.
37	3.55	.	.	17.57	ditto	ditto	.	.	.
38	.	.	.	20.64	.	.	.	.	.
39	.	.	.	23.13	.	.	.	.	.
40	.	.	.	23.13	.	.	.	.	.
41	.	.	.	22.54	.	.	.	.	.
42	.	.	.	18.54	.	.	.	.	.
43	.	.	.	15.14	.	.	ditto	.	.
44	ditto	.	.	15.14	.	.	.	.	.
45	.	.	.	15.14	.	.	.	.	.
46	.	.	.	18.53	.	.	.	.	.
47	.	.	.	21.93	.	.	.	.	.
48	.	.	.	21.93	.	.	.	.	.
49	.	.	.	21.93	.	.	.	.	.
50	3.55	17.74	6.86	18.53	90.92	38.71	0.79	11.30	6.89
T.P.W.	51.84	134.02	51.83	183.98	432.14	183.97	44.73	73.31	44.71

/1 : Annual increase of net water supply of Nagdong basin is as follows.

1991 - 1995 : 1.560 m^3/s/year
After 1996 : 1.544 m^3/s/year

Table Q 49 Continued (3)

Year in Order	Imha (V)			Juam (V) : Main Stream					
	M&I Alternative Cost ($ 10^6)	Net Water Supply (m^3/s)	M&I Benefit ($ 10^6)	M&I Alternative Cost: Dam ($ 10^6)	M&I Alternative Cost: Associated ($ 10^6)	Project Associated ($ 10^6)	(1)+(2)-(3) ($ 10^6)	Net Water Supply /1 (m^3/s)	M&I Benefit /2 ($ 10^6)
	(1)	(2)	(3)	(1)	(2)	(3)	(4)	(5)	(6)
1	5.79	-	-	4.75	-	-	4.75	-	-
2	11.58	-	-	14.24	-	-	14.24	-	-
3	11.58	-	-	18.98	-	-	18.98	-	-
4	11.58	-	-	18.98	51.81	27.08	43.71	-	-
5	5.79	-	-	14.24	64.18	27.08	51.34	-	-
6	1.83	1.51	0.86	5.00	18.40	6.30	17.10	0.64	1.76
7	.	3.07	1.74	0.50	6.45	6.30	0.65	1.29	3.55
8	.	4.63	2.63	0.50	19.42	19.27	0.65	1.93	5.31
9	.	6.19	3.52	0.50	19.42	19.27	0.65	2.58	7.09
10	.	7.75	4.40	0.50	19.90	7.84	12.56	3.22	8.85
11	.	9.31	5.29	0.50	19.90	7.84	12.56	3.76	10.34
12	.	10.85	6.16	0.50	7.95	7.84	0.61	4.30	11.82
13	.	12.40	7.04	5.25	7.95	7.84	5.36	4.84	13.31
14	.	13.94	7.92	9.99	7.95	7.84	10.01	5.38	14.79
15	.	15.49	8.80	9.99	21.97	21.86	10.01	5.92	16.28
16	.	15.80	8.98	9.99	34.34	21.86	22.47	6.46	17.76
17	.	.	.	5.25	21.44	9.42	17.27	7.00	19.25
18	.	.	.	0.75	9.49	9.42	0.82	7.55	20.76
19	ditto	.	.	0.75	9.49	9.42	0.82	8.09	22.24
20	.	.	.	.	9.49	9.42	0.82	8.63	23.73
21	.	.	.	.	9.49	9.42	0.82	9.17	25.21
22	.	.	.	.	32.02	19.58	13.19	9.71	26.70
23	.	.	.	.	32.02	19.58	13.19	10.26	28.21
24	.	.	.	ditto	10.76	10.63	0.88	10.80	29.70
25	.	.	.	.	.	.	.	11.34	31.18
26	.	.	.	.	.	.	.	11.88	32.66
27	.	.	.	.	ditto	ditto	ditto	12.42	34.15
28	.	.	.	.	.	.	.	12.97	35.66
29	.	.	.	.	.	.	.	13.51	37.15
30	1.83	.	.	0.75	10.76	10.63	0.88	14.51	39.90
31	2.65	.	.	1.09	10.76	10.63	1.22	14.59	40.12
32	3.46	ditto	ditto	1.78	10.76	10.63	1.91	15.13	41.60
33	3.46	.	.	2.13	10.76	10.63	2.26	15.68	43.11
34	3.46	.	.	2.13	47.50	28.09	21.54	16.22	44.60
35	2.65	.	.	1.78	57.14	28.09	30.83	16.76	46.08
36	1.83	.	.	1.09	20.40	10.63	10.86	17.30	47.57
37	.	.	.	0.75	10.76	10.63	0.88	17.84	49.05
38	.	.	.	0.75	19.57	19.44	0.88	18.39	50.56
39	.	.	.	0.75	19.57	19.44	0.88	18.60	51.14
40	.	.	.	0.75	20.40	10.63	10.52	.	.
41	.	.	.	0.75	20.40	10.63	10.52	.	.
42	.	.	.	0.75	10.76	10.63	0.88	.	.
43	ditto	.	.	1.09	10.76	10.63	1.22	.	.
44	.	.	.	1.44	10.76	10.63	1.57	.	.
45	.	.	.	1.44	19.87	19.74	1.57	ditto	ditto
46	.	.	.	1.44	29.51	19.74	11.21	.	.
47	.	.	.	1.09	20.40	10.63	10.86	.	.
48	.	.	.	0.75	10.76	10.63	0.88	.	.
49	.	.	.	0.75	10.76	10.63	0.88	.	.
50	1.83	15.80	8.98	0.75	10.76	10.63	0.88	18.60	51.14
T.P.W.	52.53	92.47	52.54	75.58	215.70	136.59	154.69	56.26	154.69

/1 : Annual increase of net water supply of Seomjin basin is as follows.

1986 - 1990 : 0.644 m^3/s/year
1991 - 1995 : 0.540 m^3/s/year
After 1996 : 0.542 m^3/s/year

/2 : $(6) = \frac{\text{T.P.W. of (4)}}{\text{T.P.W. of (5)}} \times (5)$

Table Q 49 Continued (4)

Juam (V) : Diversion

Year in Order	M&I Alternative Cost Dam ($ 10^6) (1)	M&I Alternative Cost Associated ($ 10^6) (2)	Project Associated Cost ($ 10^6) (3)	(1)+(2)-(3) ($ 10^6) (4)	Net Water Supply (m^3/s) (5)	M&I Benefit ($ 10^6) (6)
1	4.75	-	-	4.75	-	-
2	14.24	-	-	14.24	-	-
3	18.98	-	4.42	14.56	-	-
4	18.98	51.81	40.92	29.87	-	-
5	14.24	64.18	36.51	41.91	-	-
6	5.00	18.40	4.14	19.26	0.64	1.70
7	0.50	6.45	4.14	2.81	1.29	3.44
8	0.50	19.42	22.81	-2.89	1.93	5.14
9	0.50	19.42	22.81	-2.89	2.58	6.87
10	0.50	19.90	4.62	15.78	3.22	8.58
11	0.50	19.90	4.62	15.78	3.76	10.02
12	0.50	7.95	4.62	3.83	4.30	11.45
13	3.33	7.95	4.62	6.66	4.84	12.89
14	6.16	7.95	4.62	9.49	5.38	14.33
15	6.16	21.97	20.56	7.57	5.92	15.77
16	6.16	34.34	20.56	19.94	6.46	17.21
17	3.33	21.44	5.10	19.67	7.00	18.65
18	0.65	9.49	5.10	5.04	7.55	20.11
19	.	9.49	5.10	5.04	8.09	21.55
20	.	9.49	5.10	5.04	8.63	22.99
21	.	9.49	5.10	5.04	9.17	24.43
22	.	13.29	5.96	7.98	9.71	25.87
23	.	13.29	5.96	7.98	10.26	27.33
24	ditto	9.69	5.13	5.21	10.80	28.77
25	.	.	.	.	11.34	30.21
26	.	.	.	.	11.88	31.65
27	.	.	.	ditto	12.42	33.08
28	.	ditto	ditto	.	12.97	34.55
29	.	.	.	.	13.51	35.99
30	0.65	.	.	5.21	14.05	37.43
31	0.99	.	.	5.55	14.59	38.86
32	1.68	9.69	5.13	6.24	15.13	40.30
33	2.03	9.69	5.21	6.51	15.68	41.77
34	2.03	46.43	30.63	17.83	16.10	42.89
35	1.68	56.07	30.55	27.20	.	.
36	0.99	19.33	5.13	15.19	.	.
37	0.65	9.69	5.13	5.21	.	.
38	0.65	18.50	17.71	1.44	.	.
39	0.65	18.50	17.71	1.44	.	.
40	0.65	19.33	5.13	14.85	.	.
41	0.65	19.33	.	14.85	.	.
42	0.65	9.69	.	5.21	.	.
43	0.85	9.69	.	5.41	ditto	ditto
44	1.06	9.69	.	5.62	.	.
45	1.06	18.80	ditto	14.73	.	.
46	1.06	28.44	.	24.37	.	.
47	0.85	19.33	.	15.05	.	.
48	0.65	9.69	.	5.21	.	.
49	0.65	9.69	.	5.21	.	.
50	0.65	9.69	5.13	5.21	16.10	42.89
T.P.W.	70.38	206.51	130.78	146.11	54.85	146.11

Table Q 50 UNIT VALUE OF M&I WATER

	Net Water Supply Capacity (m^3/s)	Unit Value ($mill/m^3$)
Bamseonggol (C)	9.81	18.6
Dalcheon (V)	79.83	12.2
Ganhyeon (V)	78.17	12.1
Hongcheon (C)	17.74	12.3
Hongcheon (V)	90.92	13.5
Imha (C)	11.30	19.4
Imha (V)	15.80	18.0
Juam (V) : Main Stream	18.60	87.3
M&I Alternative		
- Dam		42.7
- Associated		121.7
Project Associated		-77.1
Juam (V) : Diversion	16.10	84.6
M&I Alternative		
- Dam		40.7
- Associated		119.5
Project Associated		-75.7

Remarks :

C : Constant draft operation

V : Variable draft operation