Annex C

Hydrological Investigation

Annex C HYDROLOGICAL INVESTIGATION

Table of Contents

List of Tables

List of Figures

Annex C HYDROLOGICAL INVESTIGATION

C1 Hydrological Investigation Carried out in the Feasibility Study Stage (Phase II)

In succession to the hydrological investigation in the Master Plan Study stage (Phase I) in 2001, the following hydrological investigation was conducted in the Feasibility Study stage (Phase II) in 2002:

- To install one (1) streamflow gauging station (SGS) of manual type on the Kaliwa River, just upstream of the Kaliwa-Kanan confluence, in addition to the three (3) SGSs installed in the Master Plan Study stage,
- To conduct discharge measurement at the four (4) SGSs in the Agos River Basin that were installed in the Master Plan Study and Feasibility Study stages,
- To carry out the concurrent spot discharge measurement at different locations on the Kaliwa River so as to examine the water loss in limestone areas existing along the Kaliwa River,
- To conduct water sampling and laboratory tests for suspended sediment load analysis and water quality analysis on each of the Agos mainstream, Kaliwa River and Kanan River,
- To review the hydrological analysis including rainfall analysis, runoff analysis, sediment analysis and water balance analysis that was carried out in the Master Plan Study stage.

C2 Hydrological Observation and Measurement

C2.1 Installation of New Streamflow Gauges

In the Master Plan Study stage (Phase I) in 2001, three streamflow gauging stations (SGS) were installed as discussed in Part-C of Volume III. These are Agos SGS on the Agos mainstream, Kanan SGS on the Kanan River and Daraitan SGS on the Kaliwa River. In the Feasibility Study stage (Phase II) in 2002, one SGS was newly installed at Barangay Pagasangahan Proper, just upstream of the Kanan-Kaliwa confluence to observe the runoff data for the entire Kaliwa catchment that are essential for monitoring the water loss from the limestone areas in the Kaliwa River Basin from now on. The new SGS is hereinafter referred to as the Pagasangahan SGS.

The location of the Pagasangahan SGS is shown in Figure C2.1 together with the other SGSs installed in the Master Plan Study stage. The Pagasangahan SGS is of manual type equipped with staff gauges. Thus, a total of four (4) SGSs is installed in this Study as presented in the following table:

Outline of New SGSs during the Study

Station Name	Agos SGS	Kanan SGS	Daraitan SGS	Pagasangahan SGS
Time of Installation	M/P (2001)	M/P (2001)	M/P (2001)	F/S (2002)
River	Agos Mainstream	Kanan	Kaliwa	Kaliwa
Location	N 14°41'92" E 121°34'56"	N 14°42'07" E 121°31'76"	N 14°36'02" E 121°26'03"	N 14°41'32" E 121°31'69"
Start Date of water Level Measurement	May 2001	May 2001	May 2001	February 2002
Height of Staff Gauges	8 m (Right Bank)	7 m (Left Bank)	8 m (Left Bank)	5 m (Left Bank)
Automatic Water Level Recorder	Installed (Right Bank)	Installed (Left Bank)	None	None
Cable System	Installed	Installed	None	None

At the end of this Study, these gauges will be transferred to NWRB for continuation of the water level recording henceforward.

C2.2 Discharge Measurement and Sediment Sampling

(1) Discharge Measurement

Following the discharge measurements at the three (3) SGSs in the Master Plan Study stage, the discharge measurement at each of the 4 new SGSs was carried out for the period from February to June 2002 as shown below:

Total Number of Discharge Measurement Conducted in Phase I and Phase II

Station	Period of Discharge Measurement in Phase II	Total Number of Discharge Measurement in Phases I and II
Agos SGS	May 2001-Jun.2002	55
Kanan SGS	Jun. 2001-Jun. 2002	50
Daraitan SGS	May 2001-Jun. 2002	55
Pagasangahan SGS	Feb. 2002-Jun.2002	24

Based on the results of measurement, a stage-discharge rating curve (H-Q curve) was constructed for each station to convert the water level records to discharges. Due mainly to the period of field investigation works, the measurement above could not collect sufficient data for high flow period, which should be made up by the subsequent measurements. The results of the discharge measurements are shown in Table C2.1 and Figure C2.2.

(2) Sediment Sampling and Analysis

In the Feasibility Study stage, the river water samples were also taken at each of the aforesaid 4 new SGSs to be used for the suspended load analysis. The sediment sampling was carried out for the period from February to June 2002 as shown below:

Total Number of water Samples Collected in Phase I and Phase II for Suspended Load Analysis

Station	Period of Water Sampling in Phase II	Total Number of Water Samples Collected in Phase I and II
Agos SGS	May 2001 - May 2002	45
Kanan SGS	Jun.2001 – Apr. 2002	39
Daraitan SGS	May 2001 - May 2002	41
Pagasangahan SGS	Feb. 2002 - May 2002	16

The suspended loads contained in the river water samples were analyzed in a laboratory. Based on the results of the laboratory tests, a discharge-suspended sediment load rating curve was constructed for each of Agos, Kanan and Daraitan SGSs. The same for the Pagasangahan SGS could not be drawn due to the insufficient number of the data collected to date. Since most of the data had to be sampled during the comparatively low flow period, the data for high flow period are still insufficient. The results of laboratory tests for the suspended load analysis are shown in Table C2.2 and Figure C2.3.

C2.3 Spot Discharge Measurement in Kaliwa Limestone Area

The spot discharge measurement was carried out at eight (8) points on the Kaliwa River during the Feasibility Study stage. The main objective was to investigate the distribution of flows in the limestone areas along the Kaliwa River, through which the Study intended to assess the potential concern for water loss at the limestone areas. The measurements at 8 locations were made on the same day to compare the discharges at each place under a constant runoff condition. The measurement was carried out on 5 days in total during the comparatively low flow period of May to June 2002. Location of the spot discharge measurements is shown in Figure C2.4 and the result of measurements in Table C2.3.

The results of the examination on water loss in limestone areas of the Kaliwa River Basin that was made from the hydrological aspects through reflecting the results of above concurrent discharge measurements are explained in detail in Subsection 4.3.5 in Chapter IV of Volume IV.

C3 Hydrological Analysis

C3.1 Runoff Analysis

The runoff analysis to estimate the long-term runoff data at the planned dam and weir sites, which include the Agos Dam and Kaliwa Low Dam site concerned with the Feasibility Study, was carried out in the Master Plan Study stage in 2001 as explained in detail in Part-C of Volume III.

In the runoff analysis in the Master Plan stage, the Tank Model was constructed for the Kaliwa River Basin to derive the long-term runoff data for the sub-basins of thereof. While, the long-term runoff data at the Kanan-Kaliwa confluence and Agos Dam site on the Agos mainstream were derived based on those at Banugao streamflow gauging station applying the catchment area ratios. Consequently, the mean monthly discharges for 31 years in total were derived through the runoff analysis carried out in the Master Plan Study stage.

The estimated long-term mean monthly discharges at the proposed Kaliwa Low Dam site and Agos Dam site are shown in Tables C3.1 and C3.2, respectively, and summarized in the following table:

Estimated Long-Term Mean Monthly Discharges at Kaliwa Low Dam and Agos Dam Sites

(Unit: m^3/sec)

Location	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Kaliwa Low Dam Site	25.2	18.9	13.5	10.0	10.6	20.3	33.1	38.0	43.2	46.0	41.7	34.3	27.9
Agos Dam Site	155.4	104.9	75.5	47.6	42.1	51.3	74.5	88.5	92.2	161.6	221.8	244.4	113.3

The flow duration curve at each proposed damsite is shown in Figure C3.1. The minimum flow to be released from the proposed damsite downstream is planned herein at 10 % of the 80 % discharge, which is a guideline figure used in several previous studies and is adopted in this Study as a uniform criterion at the phase of the Master Plan stage. Based on this criterion, the minimum flow rates to be secured at the proposed Agos dam site and Kaliwa Low Dam site are calculated to be 1.02 m3/sec and 4.35 m3/sec, respectively.

C3.2 Flood Analysis

C3.2.1 Probable Floods at Proposed Water Resource Sites

The probable floods at the proposed Kaliwa Low Dam and Agos Dam sites were estimated from the corresponding floods at Banugao streamflow gauging station and adjusted by the drainage area ratio using the following Creager's equation:

$$q = 0.503 \times C \times A \times 0.386^{b}$$

$$b = -0.93578 \times A^{-0.048}$$

where, q : Specific flood discharge (m^3/sec/km^2)
A : Drainage area (km^2)
C : Coefficient obtained from probable floods at Banugao SGS

Estimated Probable Floods at Kaliwa Low Dam and Agos Dam Sites

Return Period	Probable Discharge (m^3/sec)	
	Kaliwa Low Dam Site	Agos Dam Site
2-year	965	1,495
5-year	1,667	2,582
10-year	2,219	3,438
20-year	2,812	4,357
50-year	3,674	5,693
100-year	4,393	6,806
200-year	5,174	8,015
1,000-year	7,256	11,241
10,000-year	10.983	17,016

C3.2.2 Probable Maximum Flood (PMF) at Agos Dam site

(1) Probable Maximum Flood (PMF) Estimated in Previous Study

In the Philippines, the unusual rainfall is generally caused by typhoons with a comparatively long duration of 2 to 3 days. According to the 1981 JICA study report on the Agos hydropower project, the recorded maximum rainfall of 2,239 mm was recorded at Baguio City between July 14 and July 17, 1911. During the unusual rainfall, the maximum 24-hour rainfall amounted to 1,168mm.

In the previous study, the unusual rainfall was transposed to the Agos dam catchment area through the depth-area-duration (DAD) analysis and storm maximization adjustment techniques applying dew points and other meteorological records in order to estimate the PMP over the Agos dam catchment. Consequently, the PMP over the Agos dam catchment area is estimated at 2,192 mm for the four (4) days. In succession, the probable maximum flood (PMF) was estimated at 17,300 m3/sec at the proposed Agos damsite with a catchment area of 867 km2 applying the PMP to the following synthetic Nakayasu's unitgraph:

Nakayasu's Unitgraph

- Peak discharge (Q_p) : $Q_p=(0.2778 \times A \times R_0)/(0.3 \times t_p + t_k)$

- Ratio of hourly discharge to peak discharge (Q/Q_p)

i) For $t=0$ to $t=t_p$; $Q/Q_p=(t/t_p)^{2.4}$

ii) For $t=t_p$ to $t=t_p + t_k$; $Q/Q_p=0.3 \times (t - t_p)/t_k$

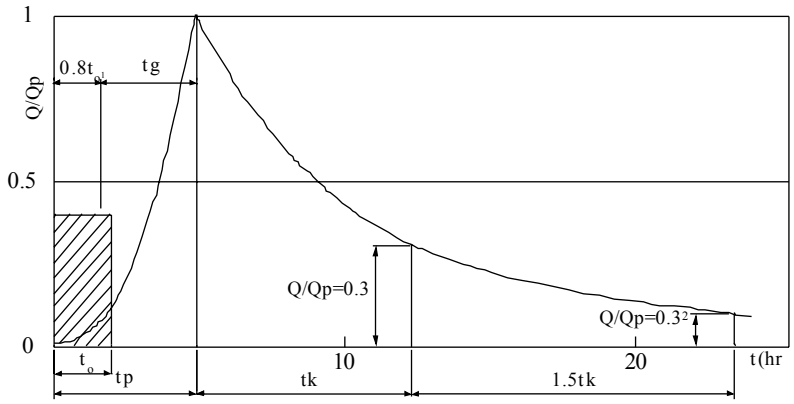
iii) For $t=t_p + t_k$ to $t=t_p+2.5 \times t_k$

$$Q/Q_p=0.3^2 \times (t - (t_p + t_k))/(1.5 + t_k)$$

iv) After $t=t_p + 2.5 \times t_p$;

$$Q/Q_p=0.3^3 \times (t - (t_p + t_k + 1.5 \times t_k))/(2.0 \times t_k)$$

Where, T : time (hour)
A: Drainage area (=867 km^2)
R_o: Unit rainfall of unit duration of 1 hour
T_k: Period in hour from the peak to the time of $Q=0.3 \times Q_p$



In the previous estimate, the base flow is assumed at 400 m3/sec, which was observed at the Banugao stream flow gauging station in the flood on November 20, 1966.

(2) Review of PMF Estimate in Previous Study

Table C3.3 shows the maximum yearly daily rainfalls recorded at Baguio City between 1970 and 2000. As seen in the Table, the recorded maximum daily rainfall is 994.6 mm in 1998 which is considerably less than the maximum daily rainfall of 1,168 mm recorded between July 14 and July 17, 1911 that was applied in the previous study to estimate the PMF at the Agos Dam site as mentioned above. Accordingly, the PMF of 17,300 estimated in the previous study is judged to have a sufficient allowance for the unusual rain storms in the Philippines.

In this Study, the catchment area at the Agos Dam site is precisely measured at 860 km2 based on 1 to 50,000 scale topographic maps. Eventually, the PMF at the proposed Agos Dam site with a catchment area of 860 km2 is estimated at 17,121 m3/sec applying the same methodologies and procedures as those in the previous study as shown in Figure C3.2.

(3) PMF Adopted in this Study

The PMF at the Agos Dam site is revised to 17,100 m3/sec in this Study as mentioned above. On the other hand, the 10,000-year probable flood has been so often used as the maximum limit instead of the PMF in designing large dams in the Philippines. The 10,000-year probable flood at the Agos Dam site is derived to be about 17,000 m3/sec that almost coincides with the PMF of 17,100 m3/sec. In this Study, accordingly, it is determined to adopt the PMF of 17,100 for the design of the Agos Dam and its spillway taking the safer side design thereof.

C4 Sediment Yield

C4.1 Review of Previous Sediment Study

The sediment analysis for the Agos River Basin is available in the 1981 JICA feasibility study on Agos hydropower project, which was carried out between November 1978 and May 1980. Most of the subsequent studies assessed the sedimentation of the Agos River Basin with reference to the analysis results of the previous study.

In the previous JICA study, 36, 11 and 19 sediment samples were collected at Mahabang Lalim gauging station on the Agos River, Binugawan gauging station on the Kanan River and Nio gauging station on the Kaliwa River, respectively. Based on those data, the previous study estimated the annual sediment yield, consisting of suspended load and bed load, to be 557 m^3/km^2/year.

In the site reconnaissance conducted by helicopter in July 2000, on the other hand, it was observed that the Kaliwa flow contained much sediment, while the Kanan river water seemed comparatively transparent probably because of the smaller rainfall in that month. Further, the sediment yield of 557 m^3/km^2/year might be slightly small as compared with annual sediment yield rates estimated for the existing and proposed reservoir dam projects in Luzon Island that are shown in Table C4.1. A feasibility study on the Agos Hydropower Project (ELC, 1991) recommended to adopt a sediment yield rate of 1,000 m^3/km^2/year, although it is based on a rule-of-thumb estimate.

C4.2 Estimate of Sediment Yield

Based on the sediment sampling data collected during the field investigation period (May-Aug. 2001 and Jan.-April 2002), sediment sampling was conducted at the 4 stream gauging stations as shown in Figure C2.1. Then, the sediment yields at Agos Damsite, Kanan confluence and Kaliwa confluence were estimated as summarized below:

Estimated Sediment Yield Rates

Location	Catchment Area (km^2)	Annual Mean Discharge (m^3/sec)	Annual Sediment Yield per Year		Sediment Yield/Area/ Discharge ($m^3/km^2/m^3$/sec)
			($10^3 m^3$)	(m^3/km^2)	
Agos Dam site	860	113.3	899.5	1,046	9.23
Kanan Confluence	393	74.5	434.7	1,106	14.85
Kaliwa Confluence	465	37.4	434.4	934	24.98

As seen in the above table, the Kanan and Kaliwa River Basins are same with respect to a sediment yield per catchment area in the Agos River junction. But, the annual mean discharge of the Kaliwa River is a half that of the Kanan River. The reason of the many sediment yields in the Kaliwa River Basin was confirmed through the site reconnaissance conducted by helicopter to be much larger quantity of sediments contained in the discharge resulting from the deforestation. The monthly mean sediment yields of the Kanan and Kaliwa River Basins are shown in

Figure C4.1. A difference of the start of rainy season in Kanan and Kaliwa River basins is expressed in the monthly sediment yields in the both basins.

As far as the results of discharge and sediment rate relationship indicates, the sediment yield rate per catchment area is almost similar in the Kanan and Kaliwa River Basins, to be around 1,000 m^3/km^2/year or 0.9 to1.1 mm/year in denudation rate. Consequently, sediment yield at the Agos dam site was adopted as 1,046 m^3/km^2/year.

Owing to the limited number of sediment sampling data, the above estimate still contains uncertainties. Nevertheless, a certain extent of errors in the estimate can be absorbed by a large volume of dead storage afforded in the Agos Reservoir. Under the condition of the above estimated yield rate (1,046 m^3/km^2 /year), the horizontal sediment level after 100 years is El.86.72 m (90 million m^3). Even if the rate is double, the sediment level is El.102.69 m (180 million m^3), which is still lower than MOL El.133.0 m.

The catchment area at the Agos River mouth is 940 km^2, including the residual basin of 80 km^2 downstream from the Agos Dam. The sediment yield at the river mouth is estimated at 980,000 m^3/year, applying the same yield rate as estimated for the Agos Dam site, of which the yield from the residual basin is 83,000 m^3.

C4.3 Trap Efficiency of Reservoir

The sediment deposit volume of the reservoir is determined by sediment yield from upstream basins and trap efficiency of the reservoir. The trap efficiency was estimated using the Brune's method.

The Brune's method incorporates the average annual inflow with the capacity of the reservoir at the specified water surface elevation. The trap efficiency is determined to be the quantity of sediment that will be trapped, on average, at each capacity level of the reservoir. The relationship between reservoir sediment trap efficiency and reservoir volume/inflow is shown in Figure C4.2.

The trap efficiency and sediment trap volume for 100 years, estimated for the Agos Reservoir, are as follows:

Trap Efficiency and Trap Volume in Agos Reservoir

Item	Unit	Value
Reservoir Volume/Inflow		0.26
Catchment Area	km^2	860
Trap Efficiency	%	93.0
Sediment Yield	10^3m^3/100-year	90,000.0
Trap Volume	10^3m^3/100-year	83,700.0
Sediment to Agos Downstream	10^3m^3/100-year	6,300.0

After construction of the Agos Dam, sediment release from the Agos Reservoir is some 6,300 m^3/year. Adding the yield from the residual basin of 84,000 m^3/year, the total sediment yield at river mouth is derived to be 90,000 m^3/year.

Tables

Table C2.1 Discharge Measurement Record (1/2)

Agos SGS

Measurement Number	Date	Gauge Height (cm)	Discharge (m^3/sec)
1	May 20, 2001	88	44.54
2	May 27, 2001	89	46.17
3	May 28, 2001	68	28.34
4	May 29, 2001	75	34.65
5	May 31, 2001	70	31.36
6	Jun. 08, 2001	62	32.96
7	Jun. 09, 2001	61	28.02
8	Jun. 09, 2001	61	28.75
9	Jun. 11, 2001	58	25.04
10	Jun. 18, 2001	78	34.21
11	Jun. 21, 2001	55	24.94
12	Jun. 22, 2001	66	27.73
13	Jun. 28, 2001	100	66.60
14	Jul. 03, 2001	138	118.99
15	Jul. 04, 2001	120	83.62
16	Jul. 05, 2001	194	205.06
17	Jul. 07, 2001	140	125.70
18	Jul. 08, 2001	124	99.10
19	Jul. 11, 2001	107	61.67
20	Jul. 13, 2001	98	59.00
21	Jul. 14, 2001	99	55.66
22	Jul. 16, 2001	89	50.85
23	Jul. 17, 2001	103	62.50
24	Jul. 19, 2001	100	57.47
25	Jul. 21, 2001	100	63.73
26	Jul. 21, 2001	98	55.81
27	Jul. 22, 2001	96	47.99
28	Feb. 23, 2002	136	114.75
29	Feb. 24, 2002	124	99.05
30	Feb. 24, 2002	123	89.34
31	Feb. 26, 2002	129	103.82
32	Feb. 26, 2002	129	80.93
33	Feb. 27, 2002	119	96.24
34	Mar. 05, 2002	109	78.98
35	Mar. 06, 2002	105	77.24
36	Mar. 07, 2002	157	145.56
37	Mar. 10, 2002	124	110.67
38	Mar. 15, 2002	137	115.29
39	Mar. 16, 2002	123	102.67
40	Mar. 17, 2002	116	94.94
41	Mar. 22, 2002	90	65.80
42	Mar. 23, 2002	90	57.18
43	Mar. 24, 2002	143	127.50
44	Apr. 10, 2002	62	36.01
45	Apr. 30, 2002	97	70.43
46	May 03, 2002	85	52.52
47	May 09, 2002	76	30.54
48	May 15, 2002	59	29.98
49	May 20, 2002	78	35.18
50	May 21, 2002	75	34.09
51	May 23, 2002	61	29.79
52	May 29, 2002	56	26.92
53	May 31, 2002	53	29.02
54	Jun. 05, 2002	50	24.30
55	Jun. 08, 2002	47	21.81

Kanan SGS

Measurement Number	Date	Gauge Height (cm)	Discharge (m^3/sec)
1	Jun. 01, 2001	20	17.83
2	Jun. 06, 2001	13	15.87
3	Jun. 19, 2001	9	12.63
4	Jun. 20, 2001	7	10.20
5	Jul. 03, 2001	48	30.54
6	Jul. 07, 2001	63	39.60
7	Jul. 09, 2001	48	29.45
8	Jul. 10, 2001	42	25.34
9	Jul. 11, 2001	36	22.91
10	Jul. 12, 2001	32	21.12
11	Jul. 14, 2001	31	20.71
12	Jul. 16, 2001	25	17.64
13	Jul. 17, 2001	28	19.83
14	Jul. 18, 2001	22	16.47
15	Jul. 19, 2001	29	15.71
16	Jul. 19, 2001	32	17.57
17	Jul. 20, 2001	26	16.68
18	Jul. 21, 2001	20	17.44
19	Jul. 22, 2001	14	15.09
20	Jul. 25, 2001	20	17.54
21	Jul. 25, 2001	19	17.40
22	Jul. 26, 2001	17	16.06
23	Jul. 26, 2001	16	14.53
24	Jul. 27, 2001	35	22.80
25	Jul. 27, 2001	30	20.88
26	Feb. 15, 2002	143	135.38
27	Feb. 16, 2002	122	106.42
28	Feb. 23, 2002	90	74.28
29	Feb. 24, 2002	81	63.59
30	Feb. 25, 2002	77	59.59
31	Feb. 26, 2002	86	70.67
32	Mar. 02, 2002	61	46.64
33	Mar. 05, 2002	68	50.37
34	Mar. 07, 2002	115	100.76
35	Mar. 11, 2002	74	57.87
36	Mar. 22, 2002	44	32.62
37	Mar. 23, 2002	41	28.64
38	Mar. 24, 2002	87	66.26
39	Apr. 10, 2002	12	18.01
40	Apr. 30, 2002	55	34.39
41	May 03, 2002	43	28.90
42	May 09, 2002	23	18.96
43	May 15, 2002	12	15.77
44	May 20, 2002	18	17.18
45	May 21, 2002	13	17.21
46	May 23, 2002	6	13.75
47	May 29, 2002	0	12.30
48	May 31, 2002	-	12.51
49	Jun. 05, 2002	-	9.29
50	Jun. 07, 2002	-5	

Table C2.1 Discharge Measurement Record (2/2)

Daraitan SGS

Measurement Number	Date	Gauge Height (cm)	Discharge (m^3/sec)
1	May 18, 2001	29	3.86
2	May 22, 2001	26	3.32
3	Jun. 13, 2001	21	2.25
4	Jun. 21, 2001	21	3.39
5	Jun. 23, 2001	34	4.87
6	Jun. 24, 2001	27	3.03
7	Jun. 25, 2001	30	3.81
8	Jun. 26, 2001	41	5.70
9	Jun. 27, 2001	37	4.88
10	Jun. 28, 2001	44	7.02
11	Jun. 30, 2001	53	10.39
12	Jul. 03, 2001	79	23.76
13	Jul. 09, 2001	70	13.00
14	Jul. 10, 2001	80	20.25
15	Jul. 11, 2001	69	13.55
16	Jul. 12, 2001	64	11.39
17	Jul. 13, 2001	60	9.61
18	Jul. 14, 2001	62	11.17
19	Jul. 15, 2001	58	9.81
20	Jul. 16, 2001	54	9.36
21	Jul. 17, 2001	66	13.22
22	Jul. 18, 2001	59	9.90
23	Jul. 19, 2001	76	22.59
24	Jul. 20, 2001	116	38.61
25	Jul. 20, 2001	100	31.11
26	Jul. 24, 2001	72	14.73
27	Feb. 21, 2002	42	6.30
28	Feb. 21, 2002	42	6.76
29	Feb. 22, 2002	40	5.31
30	Feb. 22, 2002	40	5.69
31	Feb. 28, 2002	34	4.49
32	Mar. 01, 2002	34	4.03
33	Mar. 12, 2002	31	3.40
34	Mar. 13, 2002	42	5.63
35	Mar. 13, 2002	62	15.09
36	Mar. 14, 2002	44	6.46
37	Mar. 14, 2002	42	5.60
38	Mar. 18, 2002	31	3.65
39	Mar. 19, 2002	29	3.17
40	Mar. 20, 2002	28	2.87
41	Mar. 20, 2002	27	2.98
42	Mar. 21, 2002	27	2.85
43	Apr. 10, 2002	21	1.22
44	Apr. 11, 2002	21	1.26
45	Apr. 30, 2002	21	1.52
46	May 03, 2002	17	1.00
47	May 06, 2002	16	0.88
48	May 12, 2002	15	0.95
49	May 13, 2002	13	0.91
50	May 18, 2002	16	1.23
51	May 21, 2002	33	3.15
52	May 25, 2002	25	1.68
53	Jun. 01, 2002	22	1.66
54	Jun. 03, 2002	28	2.33
55	Jun. 10, 2002	22	1.64

Pahasangahan SGS

Measurement Number	Date	Gauge Height (cm)	Discharge (m^3/sec)
1	Feb. 23, 2002	125	12.92
2	Feb. 24, 2002	126	11.80
3	Feb. 26, 2002	125	11.77
4	Mar. 02, 2002	120	9.70
5	Mar. 05, 2002	107	9.38
6	Mar. 07, 2002	131	13.80
7	Mar. 11, 2002	118	9.37
8	Mar. 16, 2002	125	10.71
9	Mar. 16, 2002	124	12.20
10	Mar. 22, 2002	113	8.21
11	Mar. 23, 2002	111	7.19
12	Mar. 24, 2002	146	20.48
13	Apr. 10, 2002	102	5.08
14	Apr. 30, 2002	101	3.11
15	May 03, 2002	68	3.66
16	May 09, 2002	52	2.16
17	May 15, 2002	92	2.63
18	May 20, 2002	114	8.61
19	May 21, 2002	108	6.81
20	May 23, 2002	106	5.30
21	May 29, 2002	100	3.77
22	May 31, 2002	99	4.05
23	Jun. 05, 2002	99	3.37
24	Jun. 07, 2002	100	4.20

Table C2.2 Sediment Sampling Record (1/2)

Agos SGS

No.	Date	Gauge Height (cm)	Discharge (m^3/sec)	Sedimrnt Concentration (mg/liter)	Sediment Discharge (ton/day)
1	May 20, 2001	88	44.54	0.95	3.66
2	May 27, 2001	89	46.17	3.20	12.76
3	May 28, 2001	68	28.34	6.50	15.92
4	May 29, 2001	75	34.65	1.80	5.39
5	May 31, 2001	70	31.36	1.60	4.33
6	Jun. 08, 2001	62	32.96	1.05	2.99
7	Jun. 09, 2001	61	28.02	6.25	15.13
8	Jun. 09, 2001	61	28.75	-	
9	Jun. 11, 2001	58	25.04	1.55	3.35
10	Jun. 18, 2001	78	34.21	4.20	12.42
11	Jun. 21, 2001	55	24.94	2.65	5.71
12	Jun. 22, 2001	66	27.73	4.15	9.94
13	Jun. 28, 2001	100	66.60	5.75	33.09
14	Jul. 03, 2001	138	118.99	285.55	2,935.57
15	Jul. 04, 2001	120	83.62	22.05	159.30
16	Jul. 05, 2001	194	205.06	584.00	10,346.77
17	Jul. 07, 2001	140	125.70	8.45	91.77
18	Jul. 08, 2001	124	99.10	3.80	32.54
19	Jul. 11, 2001	107	61.67	4.00	21.31
20	Jul. 13, 2001	98	59.00	1.95	9.94
21	Jul. 14, 2001	99	55.66	2.80	13.47
22	Jul. 16, 2001	89	50.85	4.05	17.79
23	Jul. 17, 2001	103	62.50	17.35	93.69
24	Jul. 19, 2001	100	57.47	21.75	107.99
25	Jul. 21, 2001	100	63.73	15.40	84.80
26	Jul. 21, 2001	98	55.81	8.15	39.30
27	Jul. 22, 2001	96	47.99	17.75	73.60
28	Feb. 23, 2002	135	114.75	2.45	24.29
29	Feb. 24, 2002	124	99.04	2.35	20.11
30	Feb. 24, 2002	123	89.34	3.50	27.02
31	Feb. 26, 2002	129	103.82	3.65	32.74
32	Feb. 26, 2002	129	80.93	4.20	29.37
33	Feb. 27, 2002	119	96.24	3.70	30.77
34	Mar. 05, 2002	109	78.97	1.05	7.16
35	Mar. 06, 2002	105	77.24	1.10	7.34
36	Mar. 07, 2002	157	145.56	4.20	52.82
37	Mar. 10, 2002	124	110.67	1.30	12.43
38	Mar. 15, 2002	137	115.29	1.30	12.95
39	Mar. 16, 2002	123	102.67	1.65	14.64
40	Mar. 17, 2002	116	94.93	1.00	8.20
41	Mar. 22, 2002	91	65.80	10.75	61.12
42	Mar. 23, 2002	90	57.17	4.55	22.47
43	Mar. 24, 2002	143	127.50	24.55	270.44
44	Apr. 30, 2002	97	36.01	6.30	19.60
45	May 03, 2002	85	52.51	2.25	10.21

Kanan SGS

No.	Date	Gauge Height (cm)	Discharge (m^3/sec)	Sedimrnt Concentration (mg/liter)	Sediment Discharge (ton/day)
1	Jun. 01, 2001	20	17.83	1.10	1.69
2	Jun. 06, 2001	13	15.87	60.80	83.39
3	Jun. 19, 2001	9	12.63	2.10	2.29
4	Jun. 20, 2001	7	10.20	2.00	1.76
5	Jul. 03, 2001	48	30.54	7.70	20.32
6	Jul. 07, 2001	63	39.60	6.50	22.24
7	Jul. 09, 2001	48	29.45	5.90	15.01
8	Jul. 10, 2001	42	25.34	2.95	6.46
9	Jul. 11, 2001	36	22.91	3.30	6.53
10	Jul. 12, 2001	32	21.12	2.80	5.11
11	Jul. 14, 2001	31	20.71	4.05	7.25
12	Jul. 16, 2001	25	17.64	245.50	374.07
13	Jul. 17, 2001	28	19.83	148.80	254.90
14	Jul. 18, 2001	22	16.47	3.80	5.41
15	Jul. 19, 2001	29	15.71	3.60	4.89
16	Jul. 19, 2001	32	17.57	2.10	3.19
17	Jul. 20, 2001	26	16.68	80.30	115.75
18	Jul. 21, 2001	20	17.44	119.60	180.18
19	Jul. 22, 2001	14	15.09	103.30	134.64
20	Jul. 25, 2001	20	17.54	3.95	5.99
21	Jul. 25, 2001	19	17.40	2.65	3.98
22	Jul. 26, 2001	17	16.06	2.40	3.33
23	Jul. 26, 2001	16	14.53	1.95	2.45
24	Jul. 27, 2001	35	22.80	302.20	595.26
25	Jul. 27, 2001	30	20.88	135.65	244.74
26	Feb. 15, 2002	143	135.38	4.20	49.13
27	Feb. 16, 2002	122	106.42	3.20	29.42
28	Feb. 23, 2002	90	74.28	2.35	15.08
29	Feb. 24, 2002	81	63.59	2.80	15.38
30	Feb. 25, 2002	77	59.59	2.90	14.93
31	Feb. 26, 2002	86	70.67	3.35	20.45
32	Mar. 02, 2002	61	46.64	1.30	5.24
33	Mar. 05, 2002	68	50.37	1.35	5.88
34	Mar. 07, 2002	115	100.76	4.05	35.26
35	Mar. 11, 2002	73	57.86	2.30	11.50
36	Mar. 22, 2002	43	32.62	2.15	6.06
37	Mar. 23, 2002	41	28.64	17.00	42.07
38	Mar. 24, 2002	87	66.26	1.65	9.45
39	Apr. 10, 2002	12	18.01	2.35	3.66

Table C2.2 Sediment Sampling Record (2/2)

Daraitan SGS

No.	Date	Gauge Height (cm)	Discharge (m^3/sec)	Sedimrnt Concentration (mg/liter)	Sediment Discharge (ton/day)
1	May 18, 2001	29	3.86	-	
2	May 22, 2001	26	3.32	100.70	28.91
3	Jun. 13, 2001	21	2.25	3.00	0.58
4	Jun. 21, 2001	21	3.39	2.20	0.65
5	Jun. 23, 2001	34	4.87	2.10	0.88
6	Jun. 24, 2001	27	3.03	4.50	1.18
7	Jun. 25, 2001	30	3.81	4.20	1.38
8	Jun. 26, 2001	41	5.70	72.30	35.63
9	Jun. 27, 2001	37	4.88	14.25	6.01
10	Jun. 28, 2001	44	7.02	20.30	12.32
11	Jun. 30, 2001	53	10.39	14.40	12.92
12	Jul. 03, 2001	79	23.76	56.45	115.86
13	Jul. 09, 2001	70	13.00	6.20	6.96
14	Jul. 10, 2001	80	20.25	25.10	43.91
15	Jul. 11, 2001	69	13.55	6.75	7.90
16	Jul. 12, 2001	64	11.39	8.30	8.17
17	Jul. 13, 2001	60	9.61	12.05	10.01
18	Jul. 14, 2001	62	11.17	7.10	6.85
19	Jul. 15, 2001	58	9.81	7.45	6.32
20	Jul. 16, 2001	54	9.36	14.90	12.05
21	Jul. 17, 2001	66	13.22	65.80	75.18
22	Jul. 18, 2001	59	9.90	6.40	5.48
23	Jul. 19, 2001	76	22.59	37.05	72.32
24	Jul. 20, 2001	116	38.61	223.25	744.82
25	Jul. 20, 2001	100	31.11	234.20	629.43
26	Jul. 24, 2001	72	14.73	54.35	69.17
27	Feb. 21, 2002	43	6.29	3.20	1.74
28	Feb. 21, 2002	42	6.26	3.40	1.84
29	Feb. 22, 2002	40	5.31	7.55	3.46
30	Feb. 22, 2002	40	5.69	4.15	2.04
31	Feb. 28, 2002	34	4.49	6.20	2.41
32	Mar. 01, 2002	34	4.03	3.75	1.31
33	Mar. 12, 2002	31	3.39	1.80	0.53
34	Mar. 13, 2002	41	5.63	5.20	2.53
35	Mar. 13, 2002	61	15.09	6.85	8.93
36	Mar. 14, 2002	44	6.46	1.80	1.00
37	Mar. 14, 2002	42	5.60	6.50	3.14
38	Mar. 18, 2002	31	3.65	5.30	1.67
39	Mar. 19, 2002	29	3.17	2.20	0.60
40	Mar. 20, 2002	27	2.97	3.15	0.81
41	May 21, 2002	27	2.85	5.60	1.38

Pagasangahan SGS

No.	Date	Gauge Height (cm)	Discharge (m^3/sec)	Sedimrnt Concentration (mg/liter)	Sediment Discharge (ton/day)
1	Feb. 23, 2002	125	12.92	4.90	5.47
2	Feb. 24, 2002	126	11.80	1.85	1.89
3	Feb. 26, 2002	125	11.76	4.50	4.57
4	Mar. 02, 2002	120	9.69	0.90	0.75
5	Mar. 05, 2002	107	6.50	2.05	1.15
6	Mar. 07, 2002	131	13.80	1.15	1.37
7	Mar. 11, 2002	118	9.37	2.10	1.70
8	Mar. 16, 2002	125	10.71	0.35	0.32
9	Mar. 16, 2002	124	12.20	0.65	0.69
10	Mar. 22, 2002	113	8.21	2.35	1.67
11	Mar. 23, 2002	111	7.19	1.00	0.62
12	Mar. 24, 2002	145	20.46	12.10	21.39
13	Apr. 10, 2002	102	5.00	2.45	1.06
14	Apr. 30, 2002	101	4.11	3.10	1.10
15	May 03, 2002	68	3.66	2.95	0.93
16	May 09, 2002	92	2.16	3.05	0.57

Table C2.3 Spot Discharge Measurement Result

(Unit : m^3/sec)

Station No.	Location	Drainage Area (km^2)	13-May	18-May	25-May	03-Jun	10-Jun
I. Lenatin River							
1	Upstream of Limestone Area	75	-	0.264	0.543	0.662	0.497
2	Downstream of Limestone Area	75	-	0.261	0.379	0.495	0.458
3	Downstream end of Lenatin River (before confluence)	131	0.129	0.264	0.502	0.574	0.448
II. Limutan River							
4	Downstream end of Limutan River (before confluence)	145	0.453	0.971	1.299	1.341	0.674
III. Kaliwa River							
(3+4)	Lenatin-Limutan Confluence (Sta.3+Sta.4)	276	0.582	1.235	1.801	1.915	1.122
5	About 2 km Downstream of Limutan/Lenatin Confluence	278	0.969	1.058	2.042	2.315	1.147
6	Before Junction of Sabalanasasin River, about 1 km Upstream of Daraitan G.S.	292	0.777	1.307	1.858	1.962	1.459
7	Daraitan G.S.	326	0.907	1.232	1.677	2.326	1.643
8	Kaliwa Low Dam No.1	335	1.667	1.879	2.171	2.486	1.965

Table C3.1 Estimated Mean Monthly Discharge at Kaliwa Low Damsite

(Unit : m^3/sec)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1950	32.0	27.2	25.7	17.5	13.0	13.4	11.9	9.9	20.8	37.2	35.1	45.5	24.1
1951	28.4	19.2	13.4	8.6	6.9	6.9	15.7	17.2	20.4	18.4	52.4	52.0	21.6
1952	41.5	26.5	17.4	12.8	13.1	20.5	14.3	22.0	24.5	50.3	36.2	56.1	27.9
1953	38.7	27.2	18.2	15.9	13.3	12.6	17.1	15.2	12.6	38.8	46.7	76.5	27.7
1954	49.9	41.1	44.7	25.3	18.0	16.3	14.9	14.2	12.0	16.1	19.2	29.4	25.1
1955	40.6	24.8	15.7	10.0	6.9	25.5	22.3	16.5	17.6	47.6	69.8	47.4	28.7
1956	42.3	40.6	34.3	45.2	29.3	31.6	26.7	34.9	26.5	36.0	45.3	66.0	38.2
1957	57.2	33.9	22.4	16.1	11.7	8.2	13.4	16.5	13.5	20.8	23.3	20.1	21.4
1958	38.1	36.9	21.8	14.3	9.4	8.5	14.7	25.6	18.9	34.5	34.4	21.6	23.2
1959	26.1	22.0	19.4	13.5	13.5	11.4	18.3	14.8	19.8	27.2	41.8	46.8	22.9
1960	45.4	55.0	30.3	23.3	34.6	27.0	23.4	25.3	44.0	56.0	46.7	33.9	37.1
1961	20.5	13.2	8.6	6.2	6.2	44.6	51.1	25.9	61.0	53.6	40.6	24.4	29.6
1962	16.3	11.8	8.1	5.8	5.2	13.5	77.2	64.4	71.1	40.6	28.9	19.2	30.2
1963	13.2	9.9	7.1	5.3	4.3	36.6	43.3	54.3	62.9	42.4	25.7	24.9	27.5
1964	17.4	12.4	8.4	5.9	7.5	41.5	49.1	71.7	57.6	46.3	50.9	36.3	33.7
1965	22.4	15.3	10.0	6.6	11.0	15.6	52.9	25.2	50.8	31.3	29.6	21.3	24.3
1966	14.6	10.3	7.5	5.5	42.9	16.9	17.6	18.6	65.2	44.9	56.6	41.9	28.5
1967	24.5	16.2	10.5	6.8	4.9	27.3	22.9	65.3	60.0	39.1	27.4	18.6	26.9
1968	13.2	9.3	6.5	4.8	4.0	11.0	32.6	65.2	59.1	41.2	23.9	14.8	23.8
1969	8.9	6.0	4.3	3.6	3.3	4.0	16.2	40.6	51.5	41.6	27.9	24.6	19.4
1970	16.2	10.8	6.8	4.5	3.4	6.3	18.7	15.5	89.6	80.6	60.4	38.7	29.3
1971	22.5	14.2	9.6	7.6	17.8	29.8	48.5	40.0	25.5	46.5	49.4	45.5	29.7
1972	26.7	16.6	10.2	6.7	8.2	38.6	156.3	121.4	76.1	44.1	32.3	22.2	46.6
1973	15.2	10.4	7.2	5.3	4.5	20.9	30.1	19.9	23.4	47.0	46.7	36.5	22.3
1977	14.1	11.1	7.8	5.6	4.3	6.0	29.6	50.6	59.2	32.6	39.0	23.7	23.6
1978	14.2	8.8	5.8	4.2	5.3	12.4	23.8	71.0	80.6	104.8	59.1	33.2	35.3
1984	12.5	8.9	6.0	4.4	4.6	27.3	28.0	58.8	41.1	64.6	41.9	23.3	26.8
1985	14.6	9.0	6.0	4.3	3.5	47.0	47.2	39.3	46.4	64.6	40.3	23.6	28.8
1986	15.5	9.8	6.4	4.4	7.7	10.9	40.1	61.2	62.8	68.7	57.5	32.9	31.5
1987	19.9	12.8	8.0	5.3	3.9	10.2	17.2	38.0	43.8	30.3	34.4	27.7	20.9
1988	20.5	14.3	9.5	6.1	5.7	25.5	29.6	19.4	22.2	79.8	68.7	34.4	28.0
Max	57.2	55.0	44.7	45.2	42.9	47.0	156.3	121.4	89.6	104.8	69.8	76.5	46.6
Min	8.9	6.0	4.3	3.6	3.3	4.0	11.9	9.9	12.0	16.1	19.2	14.8	19.4
Mean	25.2	18.9	13.5	10.0	10.6	20.3	33.1	38.0	43.2	46.0	41.7	34.3	27.9

Table C3.2 Estimated Mean Monthly Discharge at Agos Damsite

(Unit : m^3/sec)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1950	227.0	113.8	129.5	53.6	29.7	28.8	57.1	70.0	52.9	201.9	208.1	263.0	119.6
1951	189.7	113.3	41.1	35.2	90.2	47.1	51.7	154.1	64.6	77.9	388.4	369.7	135.2
1952	229.9	129.6	47.7	45.4	31.2	52.9	48.1	153.5	103.6	416.0	104.8	285.4	137.3
1953	169.1	180.0	52.4	53.8	26.7	53.7	32.9	100.4	50.4	174.3	182.1	392.5	122.4
1954	153.6	101.8	175.6	43.3	30.7	25.4	31.3	43.2	48.9	59.9	118.5	396.1	102.4
1955	319.5	71.0	45.0	47.9	29.6	62.2	53.7	35.8	68.4	153.1	270.4	183.4	111.7
1956	156.5	113.2	144.9	165.3	72.8	72.6	93.7	95.4	147.6	249.5	266.9	526.5	175.4
1957	243.3	76.6	39.4	30.1	20.8	22.7	37.8	78.4	59.3	84.3	101.5	70.3	72.0
1958	139.7	75.2	70.7	82.3	74.8	72.5	87.5	63.4	86.5	195.0	182.3	66.0	99.7
1959	134.8	81.4	131.1	32.1	20.3	25.3	40.0	57.5	66.9	82.5	211.4	196.8	90.0
1960	147.5	175.3	53.0	44.8	66.9	85.3	73.9	219.1	134.4	236.9	181.6	184.0	133.6
1961	187.7	148.1	113.9	74.1	96.4	73.0	61.9	58.0	107.4	188.9	277.1	112.4	124.9
1962	158.2	127.3	74.4	73.4	33.3	33.3	96.7	75.6	194.8	107.9	198.6	177.8	112.6
1963	141.5	156.5	77.5	67.2	23.6	46.1	59.1	99.2	137.1	108.2	102.3	184.2	100.2
1964	147.4	145.1	120.8	76.6	43.5	63.1	92.1	108.8	110.7	114.4	302.8	285.0	134.2
1965	185.5	108.8	67.9	29.8	25.2	26.1	65.2	55.8	69.5	137.6	214.3	293.5	106.6
1966	95.7	77.5	28.8	20.0	70.8	30.2	32.5	35.6	80.0	187.1	271.8	250.5	98.4
1967	193.0	79.3	71.3	53.1	43.0	62.5	48.8	107.8	76.0	62.0	213.4	175.4	98.8
1968	143.3	148.0	142.7	94.2	31.5	28.0	46.4	86.7	89.7	122.4	127.6	75.5	94.7
1969	78.6	35.4	41.2	26.2	14.8	12.2	35.8	55.2	66.1	67.1	107.0	287.9	69.0
1970	140.3	54.1	23.5	39.7	15.8	22.6	35.9	25.8	113.7	200.8	374.7	218.8	105.5
1971	122.8	168.0	154.2	46.8	186.1	229.4	255.7	101.0	48.7	223.5	245.1	328.3	175.8
1972	131.7	61.0	72.5	61.3	60.0	60.4	324.9	184.9	123.9	103.6	194.6	221.5	133.4
1973	86.3	99.8	51.0	40.8	38.8	55.4	60.0	39.4	50.2	176.8	302.4	387.2	115.7
1977	199.9	183.4	113.1	48.8	39.8	27.1	94.5	80.3	117.4	93.9	251.1	122.0	114.3
1978	91.1	67.7	36.6	14.6	26.0	37.5	38.9	123.3	141.4	312.2	218.3	273.0	115.0
1984	92.1	60.5	38.8	13.7	10.6	53.7	56.2	118.9	76.4	181.4	194.2	185.6	90.2
1985	93.9	55.9	35.0	13.9	7.6	94.1	98.6	75.7	101.9	183.6	197.6	204.9	96.9
1986	105.3	63.7	39.1	13.4	20.1	20.0	92.7	127.5	126.5	188.0	305.3	279.8	115.1
1987	131.0	79.1	47.5	15.3	9.6	18.6	38.4	81.4	94.5	77.4	191.9	288.6	89.4
1988	181.8	102.0	61.1	19.0	13.9	49.9	66.7	32.5	47.1	242.8	368.6	291.9	123.1
Max	319.5	183.4	175.6	165.3	186.1	229.4	324.9	219.1	194.8	416.0	388.4	526.5	175.8
Min	78.6	35.4	23.5	13.4	7.6	12.2	31.3	25.8	47.1	59.9	101.5	66.0	69.0
Mean	155.4	104.9	75.5	47.6	42.1	51.3	74.5	88.5	92.2	161.6	221.8	244.4	113.3

Table C3.3 Yearly Maximum Daily Rainfalls Recorded at Baguio

Year	Yearly Maximum Daily Rainfall Recorded at Baguio
1970	119.7
1971	379.5
1972	479.6
1973	379.7
1974	781.4
1975	163.6
1976	605.3
1977	359.1
1978	534.2
1979	285.4
1980	730.3
1981	228.8
1982	237.3
1983	208.8
1984	381.8
1985	344.5
1986	525.0
1987	333.5
1988	207.0
1989	475.8
1990	315.6
1991	760.0
1992	397.1
1993	533.6
1994	351.8
1995	223.0
1996	389.4
1997	270.2
1998	994.6
1999	433.4
2000	322.2

Data Source: PAGASA

Table C4.1 Annual Sediment Yield Estimated in Dam Projects in Luzon Island

Name of Dam	Stream	River System	Drainage Area (km^2)	Annual Sediment Yield ($m^3/km^2/year$)	Data Source
Existing Dam					
Ambuklao	Agno	Agno	617	5,337	*1
Binga	Agno	Agno	860	4,900	*2
Pantabangan	Pampanga	Pampanga	916	1,500	*3
Angat	Pampanga	Pampanga	568	4,500	*3
Magat	Cagayan	Cagayan	4,143	1,600	*3
Caliraya	Caliraya	Caliraya	92	800	*3
Proposed Dam					
Tina	Labugaon	Laoag	99	10	*3
Gosgos	Solsana	Laoag	71	10	*3
Cura	Cura	Laoag	63	10	*3
Paleiguan	Beleiguan	Ilocos	153	1,500	*3
Binongan	Binongan	Abra	377	2,000	*3
Chico IV	Chico	Cagayan	1,410	2,000	*3
Matuno	Matuno	Cagayan	593	600	*3
Casccnan	Casccnan	Cagayan	1,150	1,800	*3
Diduyon	Diduyon	Cagayan	477	1,107	*4
San Roque	Agno	Agno	1,250	6,500	*3
Balog-Balog	Bulao	Bulao	283	2,600	*3
Agos	Agos	Agos	867	557	*5

Data Source

*1 : Ambuklao Rehabilitation, JICA 1988

*2 : Binga Dam Rehabilitation, JICA 1988

*3 : Study on Hydropower Project in Luzon Island, JICA 1987

*4 : Diduyon Hydroelectric Project, JICA 1980

*5 : Agos River Hydropower Project, JICA 1981

Figures

CF-1

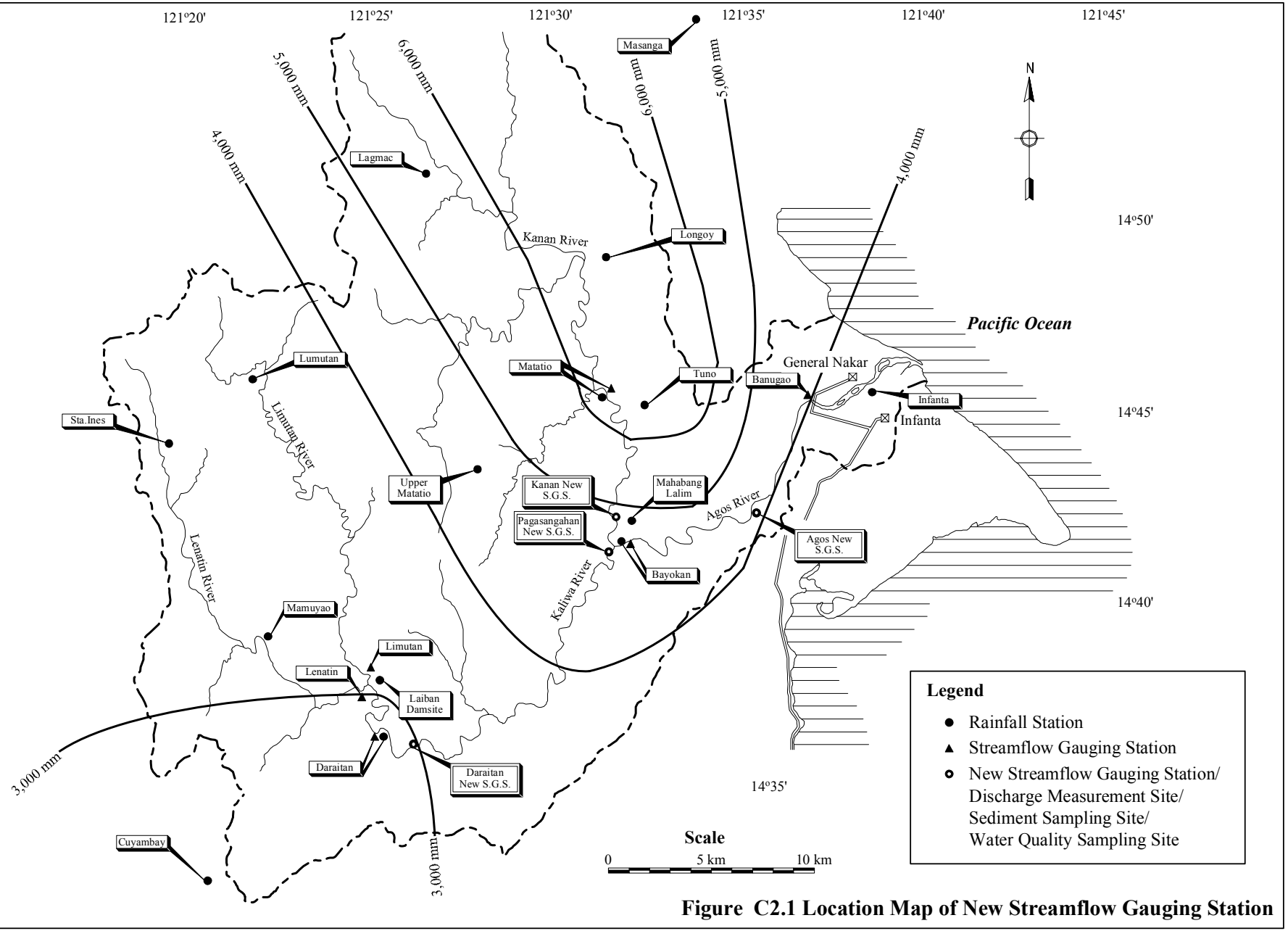
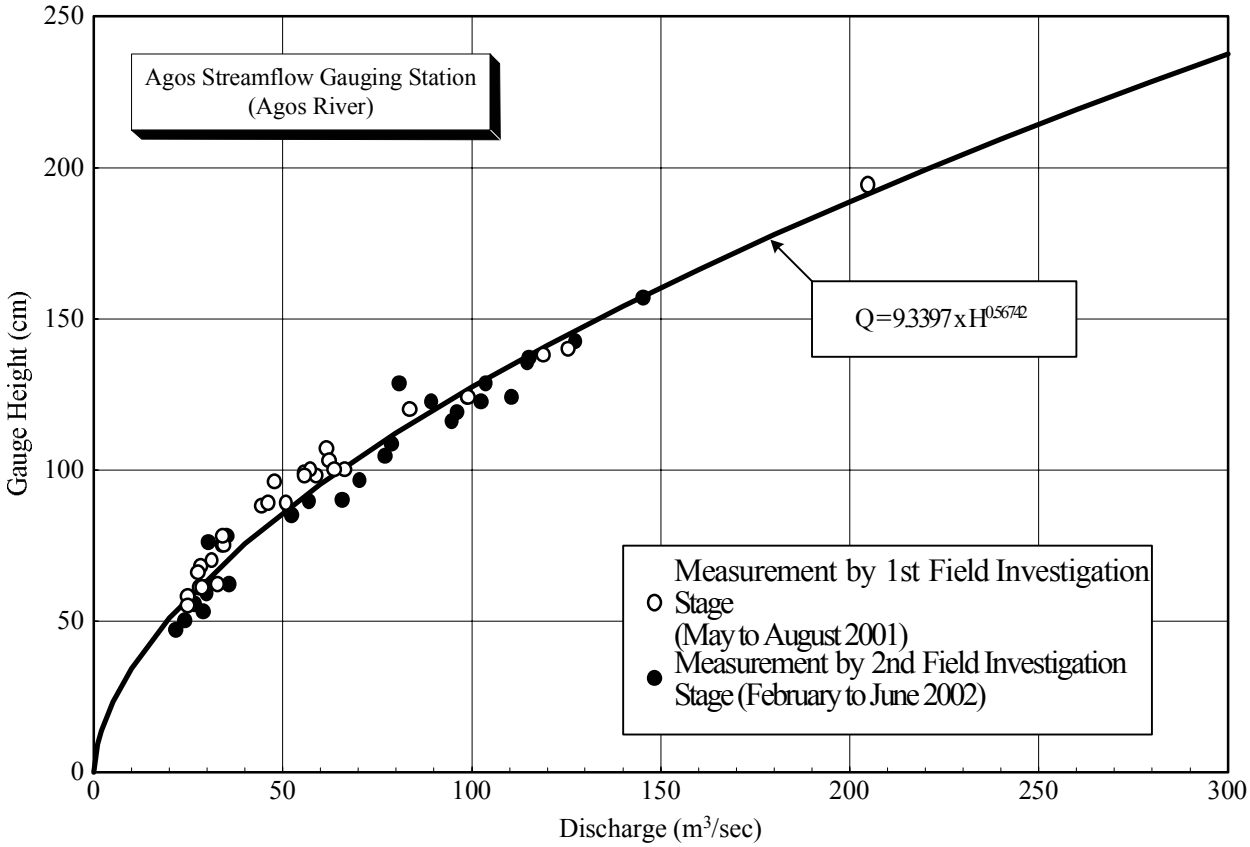


Figure C2.1 Location Map of New Streamflow Gauging Station



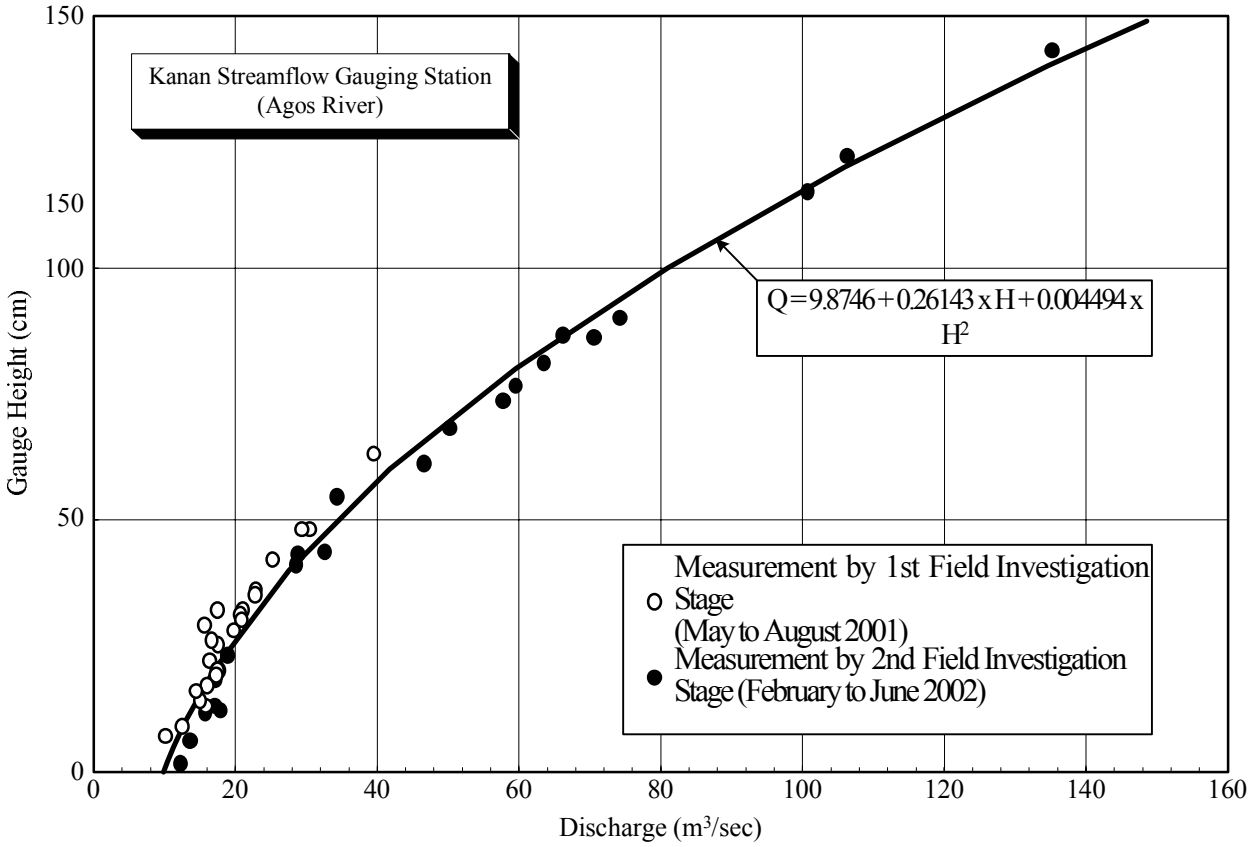
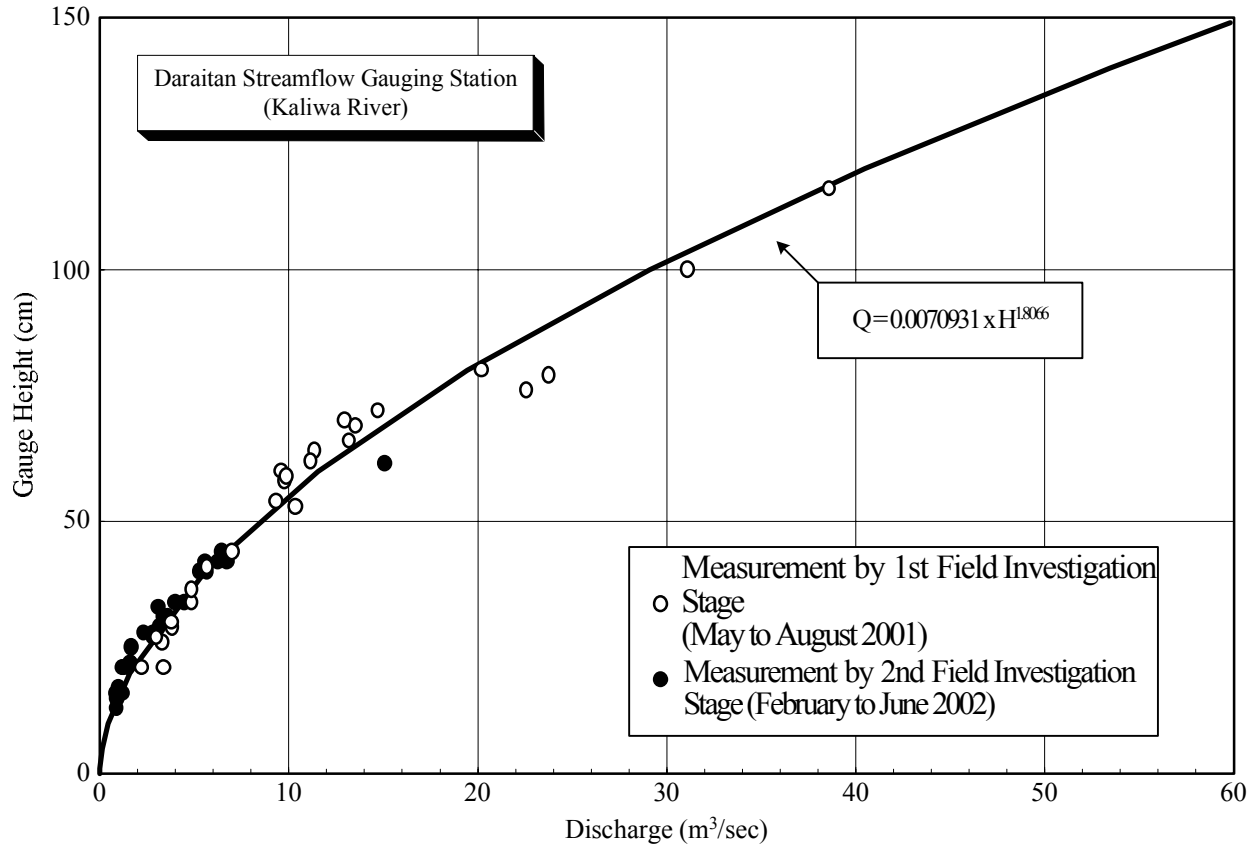


Figure C2.2 Stage-Discharge Rating Curve (H-Q Curve) (1/2)



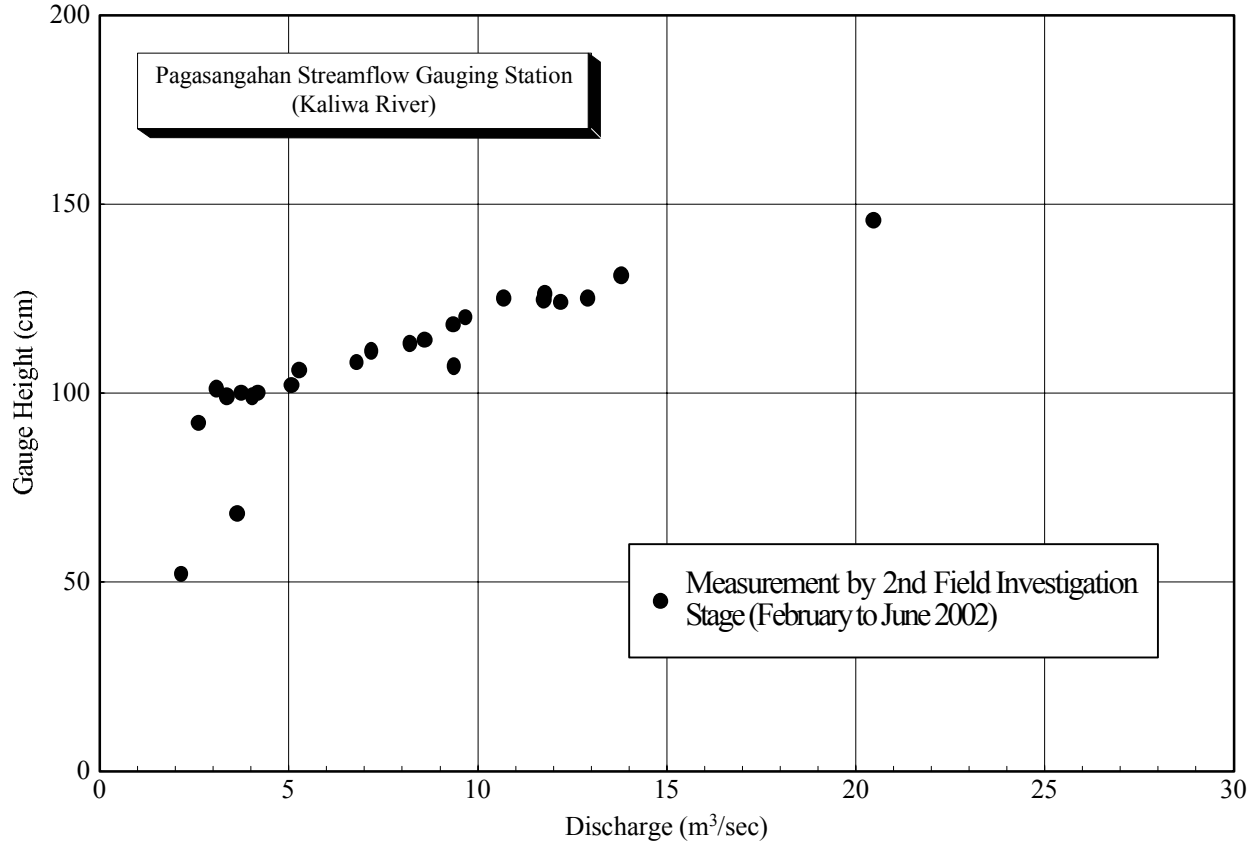
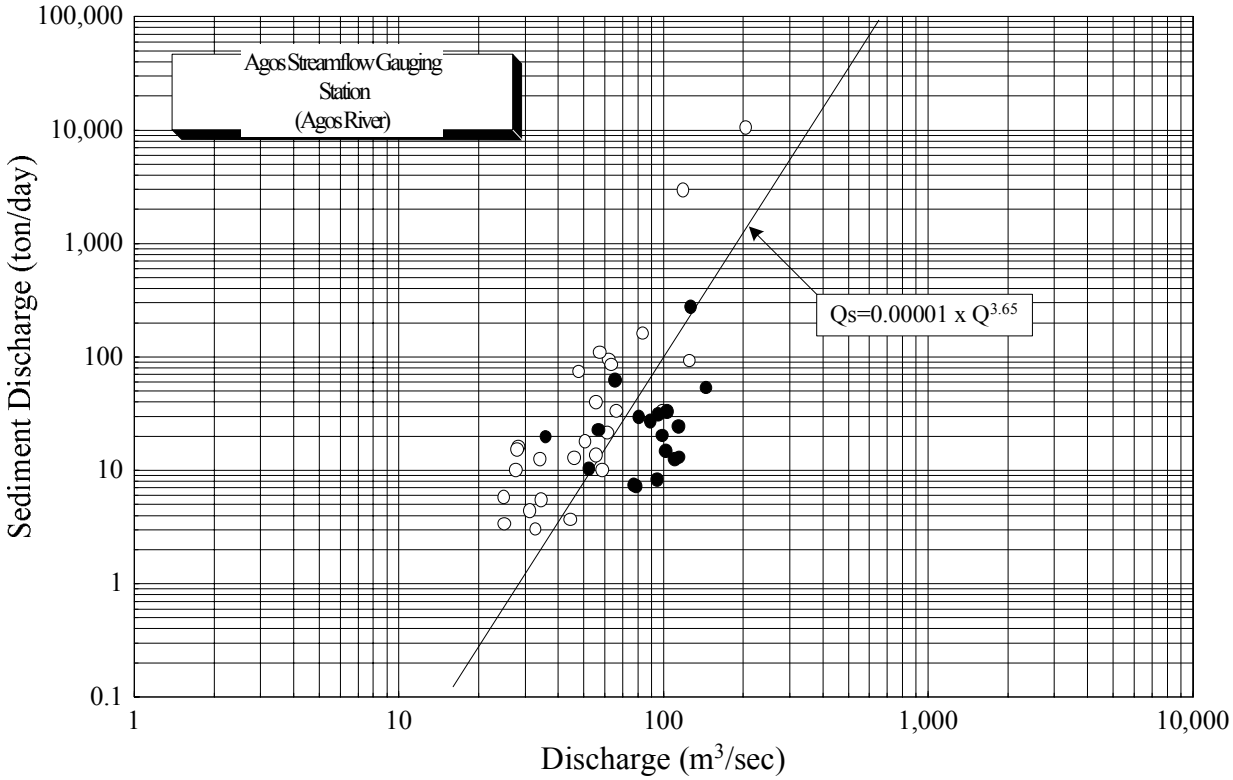
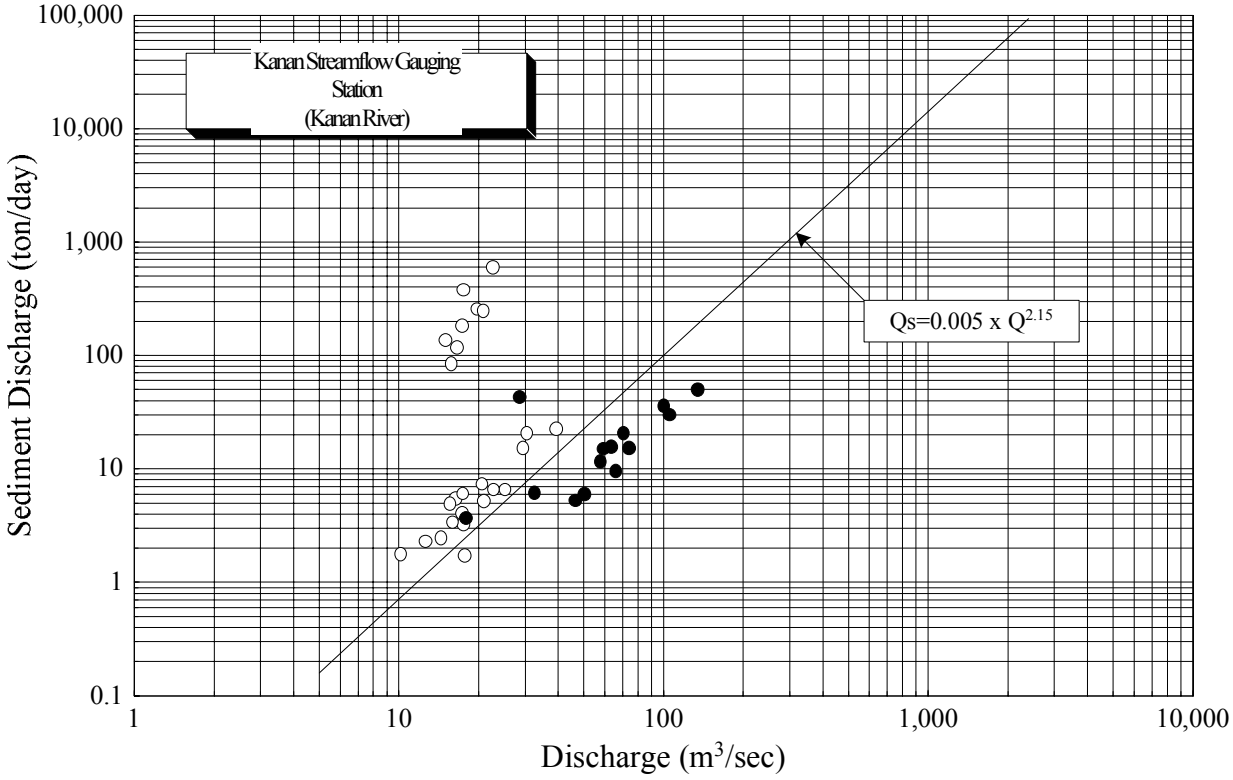


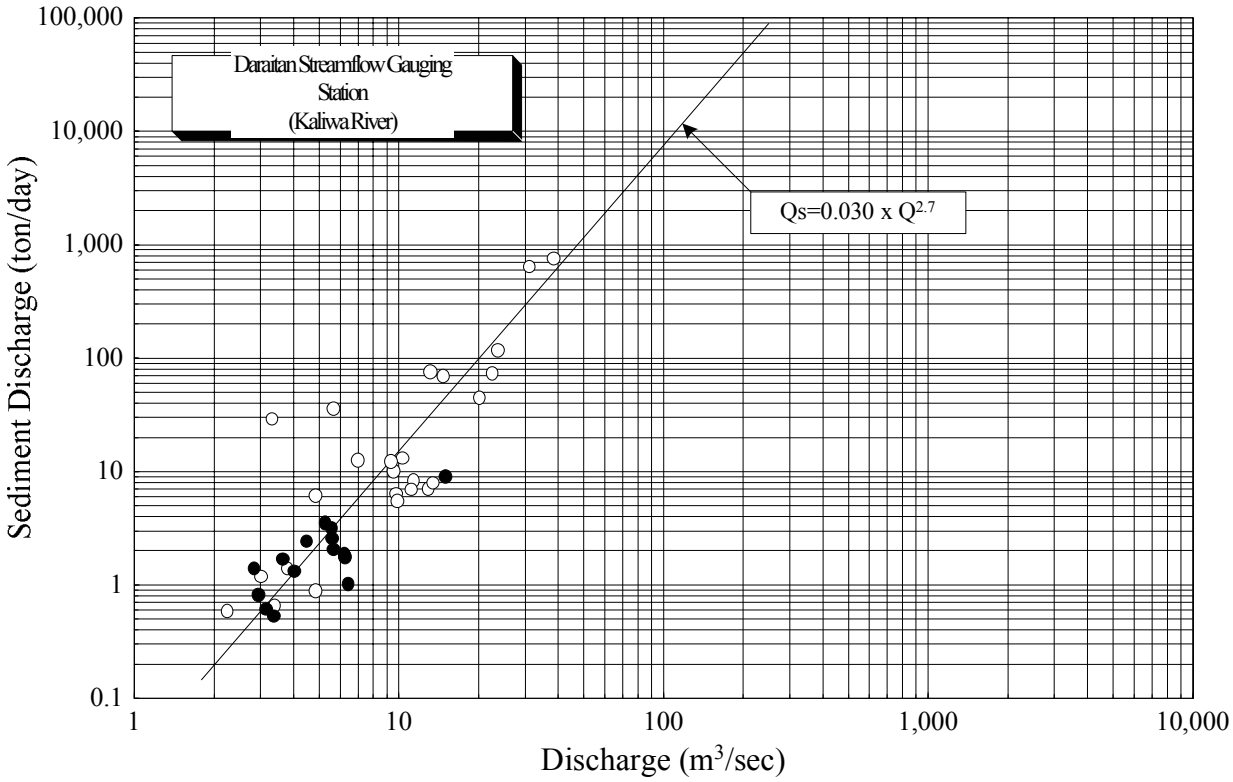
Figure C2.2 Stage-Discharge Rating Curve (H-Q Curve) (2/2)

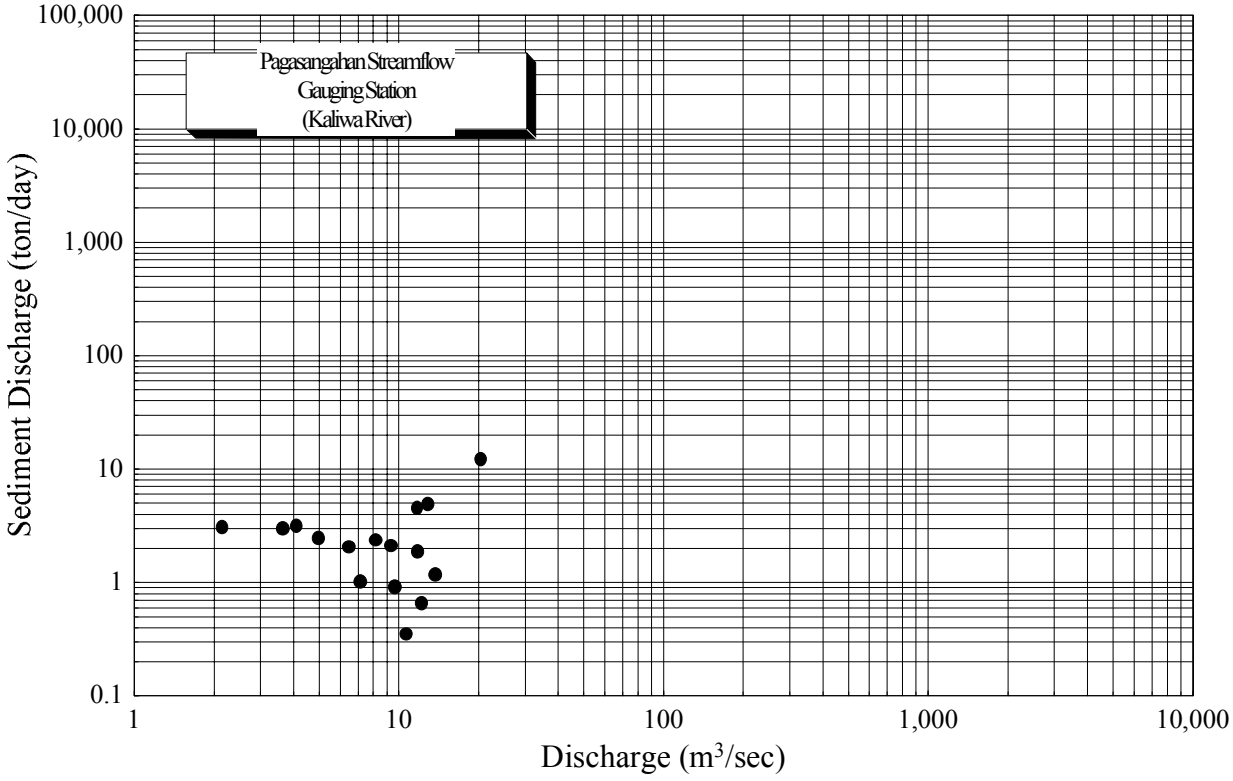




Remarks ;
- ○ Measurement by 1st Field Investigation Stage (May to August 2001)
- ● Measurement by 2nd Field Investigation Stage (February to June 2002)

Figure C2.3 Sediment Sampling Record and Discharge-Sediment Rating Curve (1/2)





Remarks ;
- ○ Measurement by 1st Field Investigation Stage (May to August 2001)
- ● Measurement by 2nd Field Investigation Stage (February to June 2002)

Figure C2.3 Sediment Sampling Record and Discharge-Sediment Rating Curve (2/2)

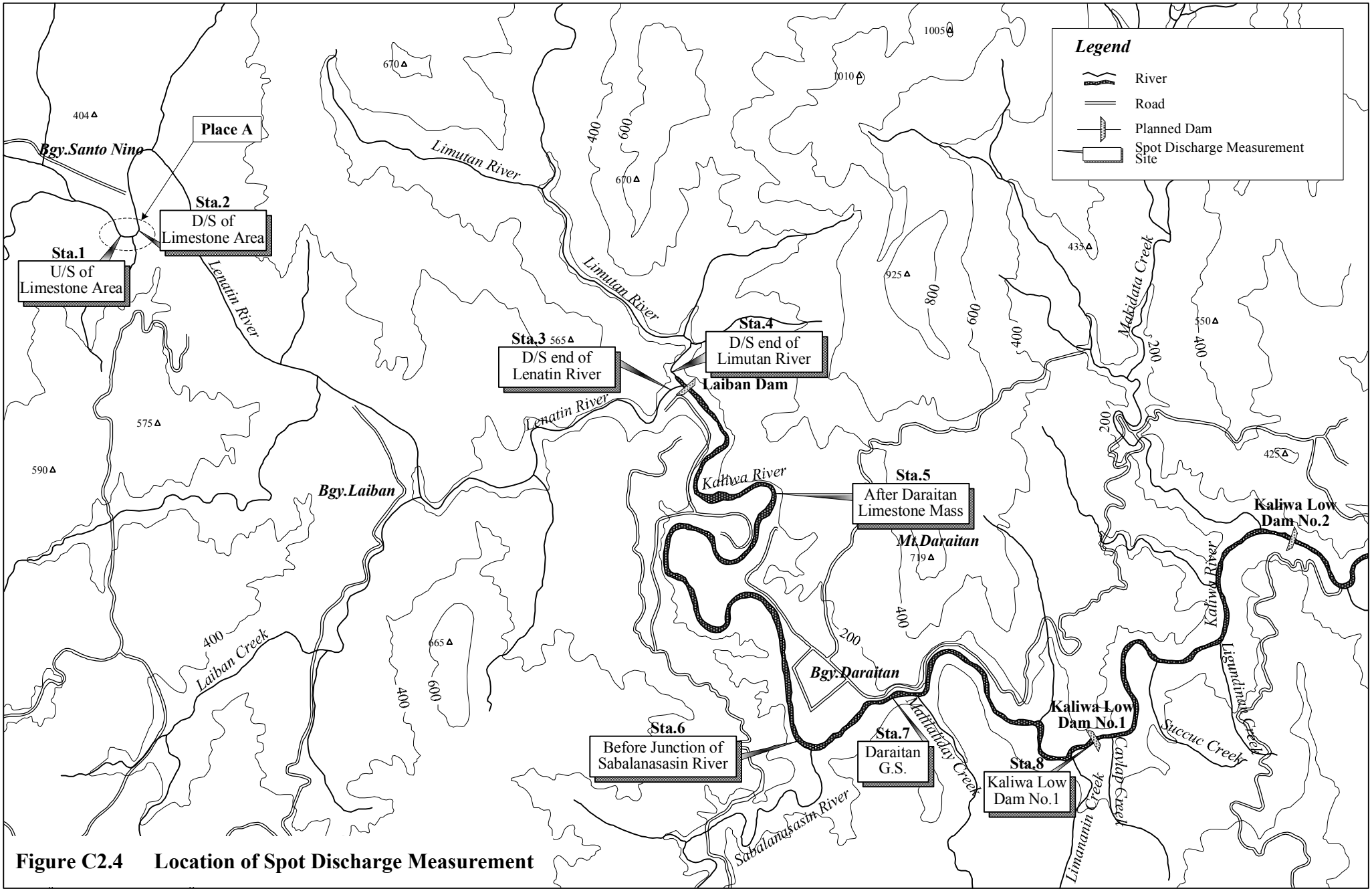
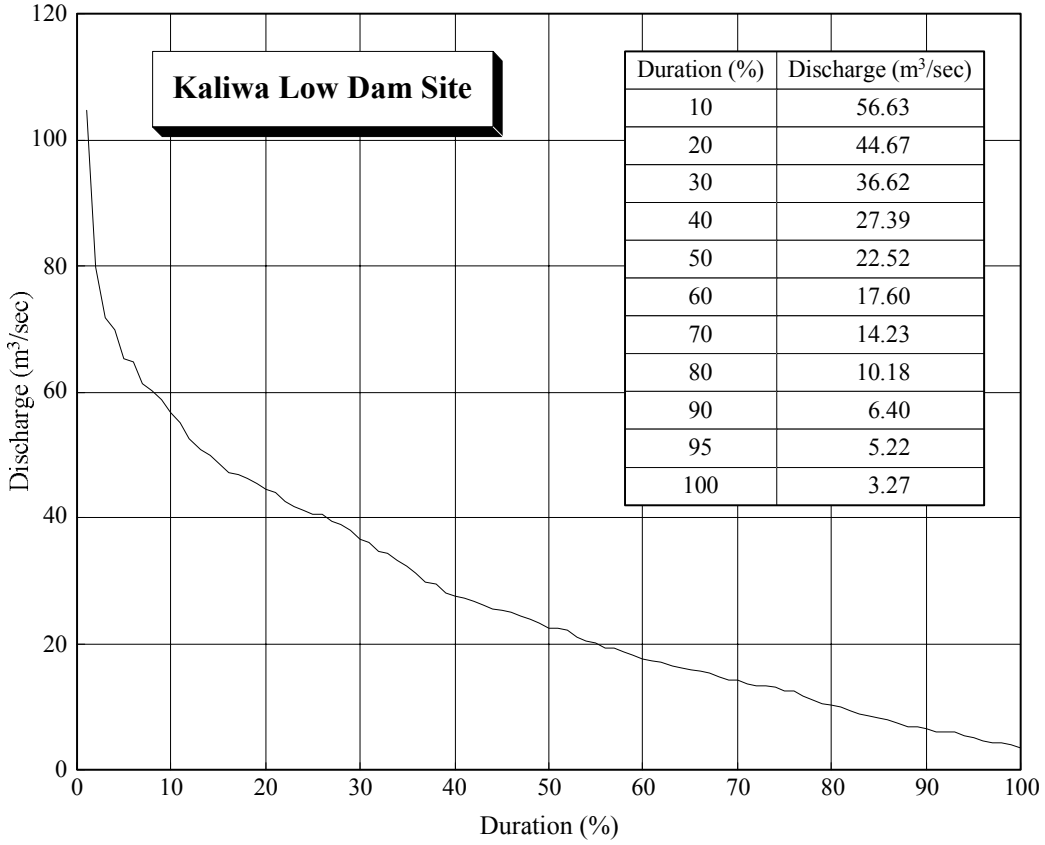
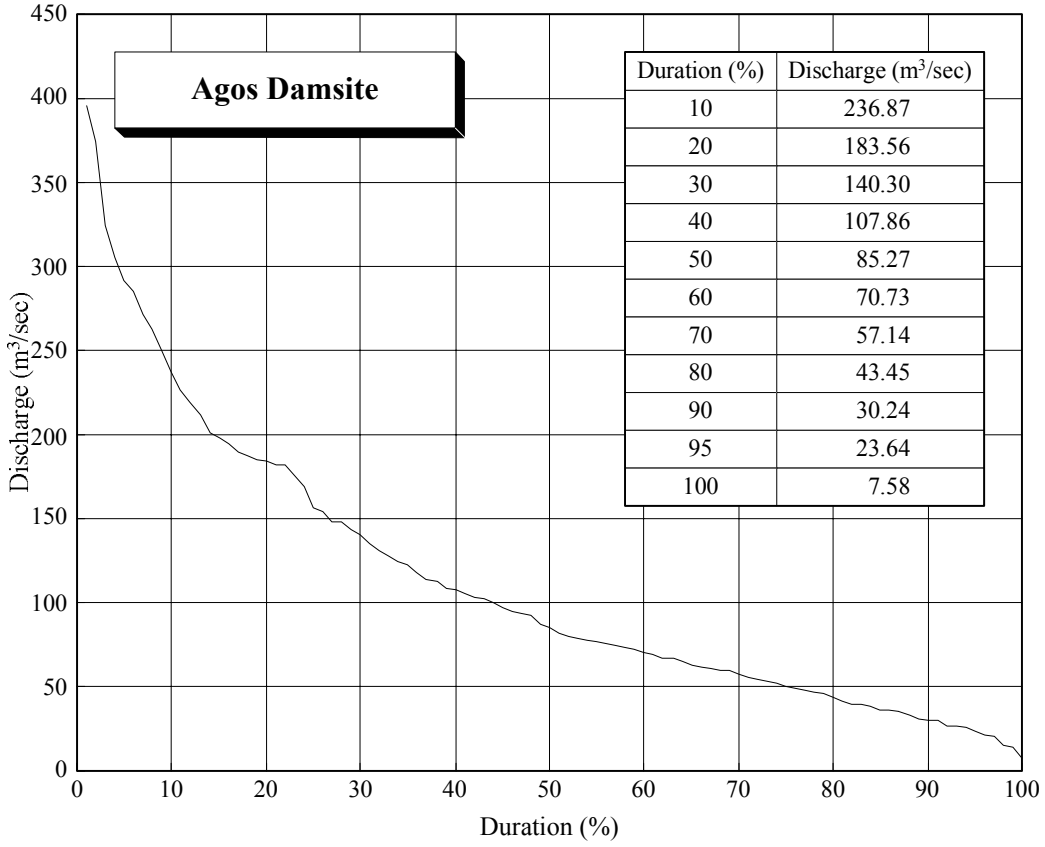


Figure C2.4 Location of Spot Discharge Measurement



Duration (%)	Discharge (m^3/sec)
10	56.63
20	44.67
30	36.62
40	27.39
50	22.52
60	17.60
70	14.23
80	10.18
90	6.40
95	5.22
100	3.27



Duration (%)	Discharge (m^3/sec)
10	236.87
20	183.56
30	140.30
40	107.86
50	85.27
60	70.73
70	57.14
80	43.45
90	30.24
95	23.64
100	7.58

Figure C3.1 Flow Duration Curve at Proposed Damsite

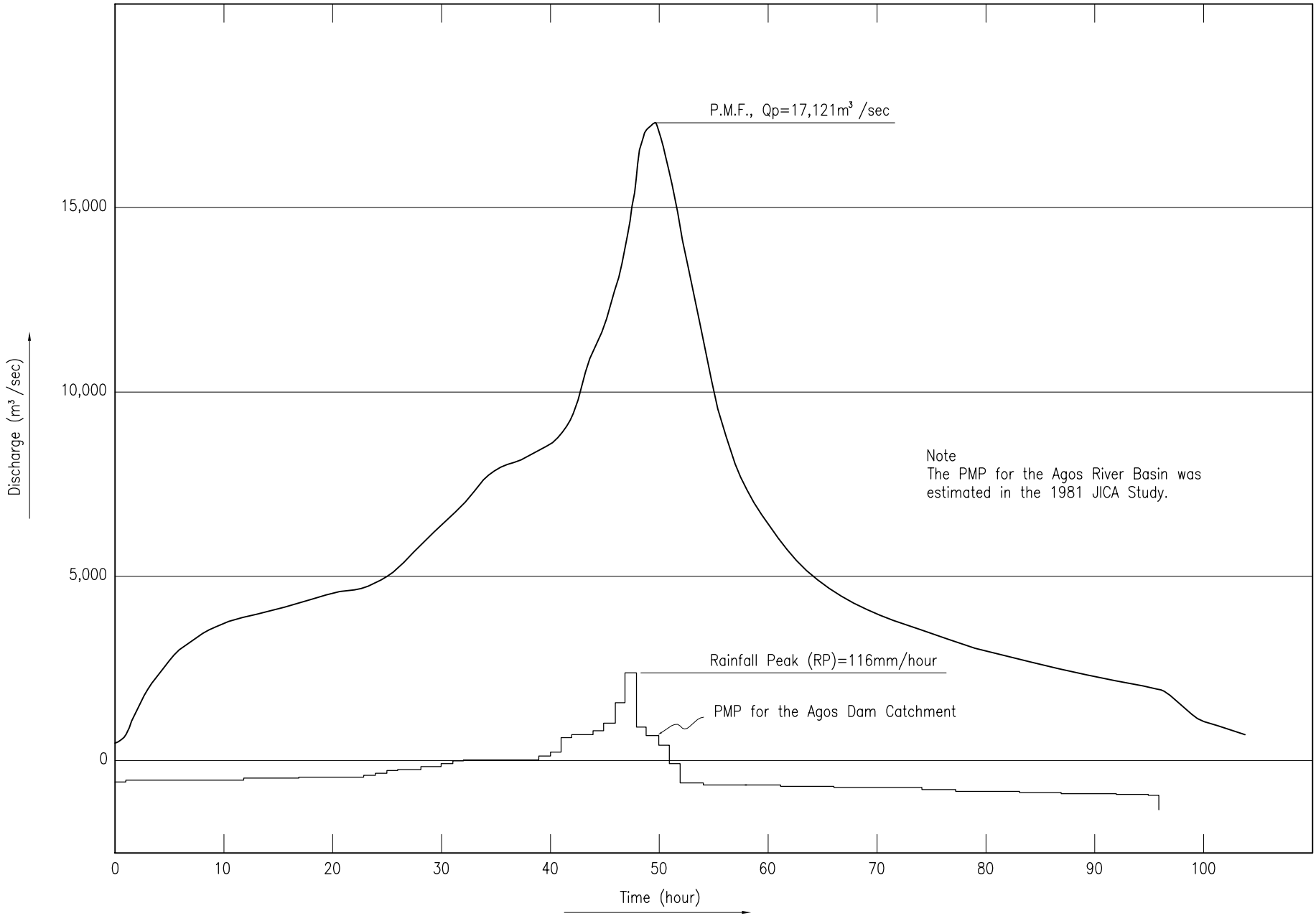


Figure C3.2 Hydrograph of Probable Maximum Flood (PMF) at Agos Dam Site

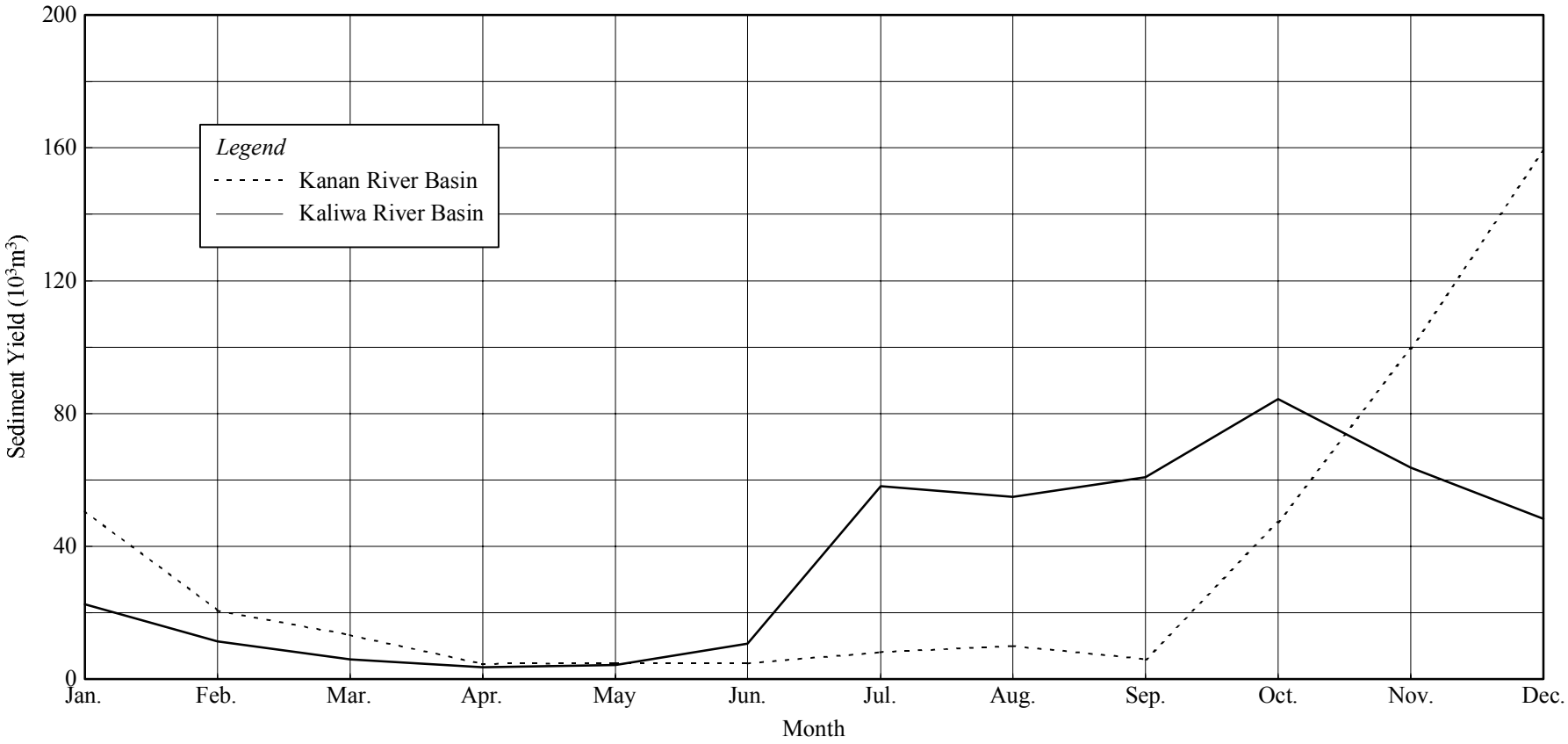


Figure C4.1 Monthly Sediment Discharge Pattern at Kanan and Kaliwa River Basins

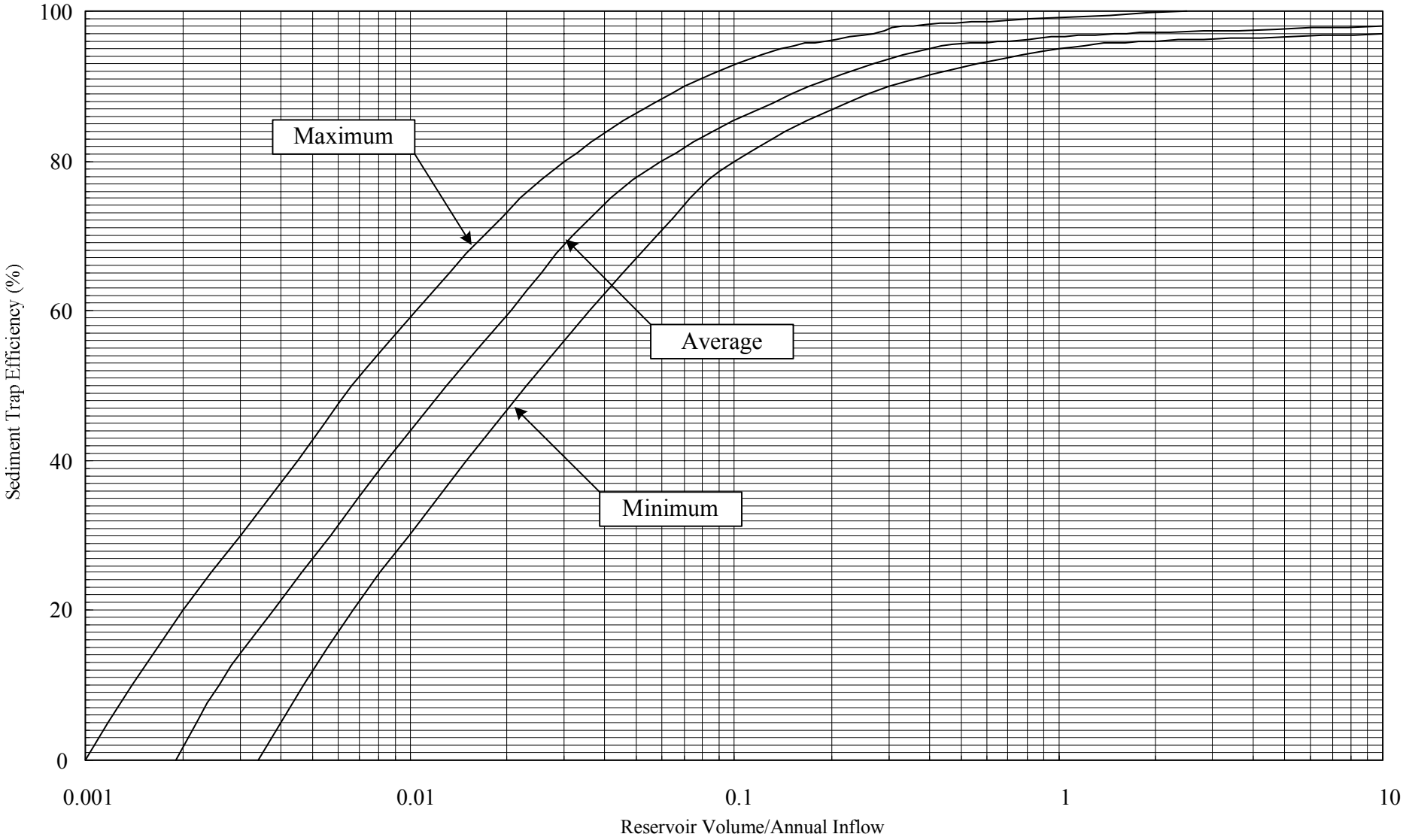


Figure C4.2 Sediment Trap Efficiency in Reservoir