ATTACHMENT-I

MINUTES OF MEETING FOR INCEPTION REPORT

MINUTES OF MEETING
FOR
INCEPTION REPORT
ON
THE STUDY
ON
THE REHABILITATION OF IRRIGATION PROJECTS
IN
THE REPUBLIC OF GHANA

ACCRA, 23 OCTOBER, 1995

Mr. O.K. GYARTENG
Chief Executive
Ghana Irrigation Development Authority

Mr. KUNIO IRIE
Leader
JICA Study Team

Witnessed by

Mr. TAKEAKI SATO
Leader
Advisory Team
Japan International Cooperation Agency

1. Date : 20 October, 1995 (9 : 30 am - 12 : 00 pm)

2. Place : Conference Room at GIDA

3. Attendants : See attached list

4. Summary of Discussion :

The JICA Study Team (the Study Team) submitted twenty (20) copies of the Inception Report (the Report) to Ghana Irrigation Development Authority (GIDA) on 20 October, 1995 in accordance with the Scope of Work for the Study on the Rehabilitation of Irrigation Projects agreed upon between GIDA and Japan International Cooperation Agency (JICA) on 19 April, 1995.

The meeting was held at GIDA's conference room. Prior to the meeting, the Minutes of Meeting agreed between GIDA and the Preparatory Study Team on 19 April, 1995 were confirmed.

In the meeting, Mr. K. Irie, Leader of JICA Study Team, presented the highlights of the Inception Report. Discussions followed after the presentation with the following as conclusions:

(1) In principle, the contents of the Inception Report were accepted by GIDA.

(2) GIDA requested the Study Team that the agricultural development plan to be proposed should be worked out, putting careful attention to the sufficient maintenance period for operation and maintenance of the project facilities. The Study Team agreed to this request.

(3) GIDA requested the Study Team to study the possibility of expansion of irrigated land in the areas adjacent to the existing project sites. The Study Team agreed to make such a study within the extent economically justifiable.

(4) GIDA requested that the Steering Committee Meeting be held once a month. The Study Team agreed to this request.

(5) EIA study shall be executed for the selected priority projects in line with the latest government regulation.

(6) The proposed cropping pattern should include plan for crop diversification, taking into account the natural, social and economic conditions of the respective study projects.

(7) The weighted selection criteria which will be used for selection of priority projects should be prepared and discussed with GIDA in advance.

(8) The possibility of recovering capital cost of the Projects from the farmers should be studied.

(9) The contractor(s) for execution of any work on the agreement should be selected by bidding, except soil laboratory test.

LIST OF ATTENDANTS

Ghanaian Side

1. Ministry of Food and Agriculture

Hon. Mr. V.K. Atsu-Ahedor	Deputy Minister of MOFA (Crops)

2. Ministry of Finance

Mr. E.K. Nkansah	Representative of Ministry of Finance

3. Ghana Irrigation Development Authority

Mr. O.K. Gyarteng	Chief Executive
Mr. Kwabena Wiafe	Deputy Chief Executive (Engineering)
Mr. M.A.K. Affram	Deputy Chief Executive (Agronomy)
Mr. H.A. Torgbor	Director of Development
Mr. Yaw Yeboah	Deputy Director of Planning
Mr. S. Oduro-Konadu	Principal Agronomist
Mr. Sammy Akagbor	Principal Agronomist (Soils)
Mr. E.T. Obuobi	Chief Personnel Officer
Mr. P. Osew-Owusu	Solicitor

Japanese Side

1. Advisory Team :

Mr. Takeaki Sato	Leader
Mr. Makoto Takahashi	Coordinator

JICA Ghana Office :

Mr. Toshiharu Kai	Deputy Resident Representative

Irrigation Development Centre (IDC) :

Mr. Akira Ogawa	Colombo Plan Expert

2. JICA Study Team :

Mr. Kunio Irie	Leader
Mr. Hitoshi Shimazaki	Irrigation and Drainage System
Mr. Tadaharu Murono	Social and Farmer' Organisation
Mr. Noboru Mochizuki	Management and Agricultural Aspects
Mr. Kisaku Yamada	Agro-economic Study & Project Evaluation
Mr. Mototaka Nishi	Hydrological & Meteorological Study
Mr. Yasushi Osato	Structure Design & Cost Estimate
Mr. Yoji Mizuguchi	Pedology & Environment
Mr. Shigeya Otsuka	Coordinator

ATTACHMENT-II

MINUTES OF MEETING FOR PROGRESS REPORT-I

MINUTES OF MEETING
FOR
PROGRESS REPORT - I
ON
THE STUDY
ON
THE REHABILITATION OF IRRIGATION PROJECTS
IN
THE REPUBLIC OF GHANA

ACCRA, 22 DECEMBER, 1995

Mr. O.K. GYARTENG
Chief Executive
Ghana Irrigation Development Authority

Mr. KUNIO IRIE
Leader
JICA Study Team

1. **Date** : **22nd October, 1995 (10:00 - 13:30)**

2. **Place** : **Conference Room at GIDA**

3. **Attendants : See attached list**

4. **Summary of Discussion :**

The JICA Study Team (the Study Team) submitted twenty (20) copies of the Progress Report-I (the Report) to Ghana Irrigation Development Authority (GIDA) on 19th December, 1995 in accordance with the Scope of Work for the Study on the Rehabilitation of Irrigation Projects agreed upon between GIDA and Japan International Cooperation Agency (JICA) on 19 April, 1995.

At the meeting, Mr. K. Irie, Leader of JICA Study Team, presented the highlights of the Report, and other experts made additional explanation of their technical sections. Discussions followed after the presentation with the following as conclusions:

(1) In principle, the contents of the Report were accepted by GIDA.

(2) GIDA requested the Study Team to :

(a) Spell out the title of all tables shown in the paragraphs,
(b) Make further study on the water requirements,
(c) Make further study on possibility of increasing the reservoir capacity of Ashaiman project,
(d) Make a study on improvement of intake valve at Ashaiman reservoir,
(e) Study the maintenance method of drainage system,
(f) Make further study on fertilizer and other agro-chemicals application effects on environment,
(g) Study needs of rehabilitation and new construction of staff quarters in connection with the projects rehabilitation, and
(h) Make further study on credit facilities to farmers.

LIST OF ATTENDANTS

Ghanaian Side

1. Ghana Irrigation Development Authority :

Mr. O.K. Gyarteng	Chief Executive
Mr. Kwabena Wiafe	Deputy Chief Executive (Engineering)
Mr. M.A.K. Affram	Deputy Chief Executive (Agronomy)
Mr. H.A.Torgbor	Director of Development
Mr. D.N. Ohemeng	Acting Director of Operations
Mr. Yaw Yeboah	Deputy Director of Planning
Mr. Nana Kofi Koduah	Deputy Director of Plant
Mr. Sammy Akagbor	Deputy Director of Agriculture
Mr. Chris Bence	Agronomist

Japanese Side

1. JICA Study Team :

Mr. Kunio Irie	Leader
Mr. Hitoshi Shimazaki	Irrigation and Drainage System
Mr. Tadaharu Murono	Social and Farmer' Organisation
Dr. Noboru Mochizuki	Management and Agricultural Aspects
Mr. Kisaku Yamada	Agro-economic Study & Project Evaluation
Mr. Yasushi Osato	Structure Design & Cost Estimate
Mr. Yoji Mizuguchi	Pedology & Environment
Mr. Shigeya Otsuka	Coordinator

ATTACHMENT-III

FIELD MESUREMENT ON CYLINDER INTAKE RATE

ATTACHMENT-III

Measurement
of
Cylinder Intake Rate

1. General

The intake rate means the rate for irrigation water or rainfall infiltrated into the soil, which is expressed by mm/h. It is an important factor to determine the appropriate method, intensity and interval for irrigation for upland crops. The intake rate is generally measured by cylinder intake rate method or furrow intake rate method, which is to be selected considering the purpose of measurement. In this case, most of the projects to be studied employ the sprinkler system so that the cylinder intake rate method is selected.

2. Test Apparatus

Test apparatus for cylinder intake rate test are a fookgauge and a steel cylinder with the inner diameter of about 40 cm and the height of about 50 cm. In this test, however, a half-cut dram can is used instead of a steel cylinder.

3. Test Procedure

(1) Installation of steel cylinder

As the accuracy of the test would be affected by installation of cylinder, a cylinder (half-cut dram can) is carefully installed in the following procedure.

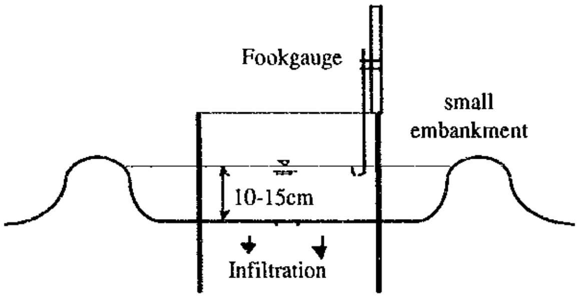
(a) Remove weeds and level the surface on the investigation point without disturbing the surface of the soil to be tested.
(b) Install the cylinder on the test point and put it horizontally.
(c) Set the timber on the cylinder and drive it gradually into the land by hammer with keeping the top of cylinder horizontal, so as to attain 20 to 30 cm of driven depth.
(d) Build a small embankment around the cylinder about 10-20 cm away.
(e) Set a fookgauge on the cylinder to measure the level of water surface.

(2) Measurement procedure

Measurement for cylinder intake rate is executed as follows.

(a) Put a vinyl sheet on soil surface in the cylinder to avoid disturbance of soil surface by pouring water.
(b) Pour water into not only the cylinder, but also the space between cylinder and small embankment until water level becomes 10-15 cm. Both water level shall be almost equal.
(c) Remove the vinyl sheet, and start measurement of water level immediately.
(d) Measure the water level at 1, 5, 10, 15, 20, 30, 40, 50, 60 min. after starting the measurement.
(e) Keep inside and outside of water level almost equal.
(f) Record the water level just before and after adding water in case additional water is poured into the cylinder.

Apparatus of Cylinder Intake Rate Test



4. Test Result and Analysis

The test results are plotted on a full logarithm paper with the time on a horizontal axis and accumulated intake on a vertical axis. As the plotted points are almost on a straight line, a relation between cylinder intake rate and the accumulated intake is expressed with the following equation:

$$Dc = CT^{n} \text{ (mm)}$$
$$Ic = 60CnT^{n-1} \text{ (mm/h)}$$

Where,
D: Accumulated intake amount within T minutes after starting the test
C: Accumulated intake when T=1 minute
n: Gradient

The basic intake rate I_B which is defined as the 10% of the rate of decrease in intake rate, is expressed by the following equation.

$$I_B = 60Cn\{600(1-n)\}^{n-1} \text{ (mm/h)}$$

Test results for 8 Projects are given in the next page. In addition, the sample analysis and calculation of the test result is attached hereto.

Project	Test	Texture of Surface Soil	Accumulated Intake Dc (mm)	Cylinder Intake Rate Ic (mm/h)	Basic Intake Rate IB (mm/h)
Ashaiman		Loamy Sand	$Dc=5.71T^{0.54}$	$Ic=186T^{-0.46}$	14.3
Weija	A	Course Sand	$Dc=4.43T^{0.50}$	$Ic=131T^{-0.51}$	7.3
	B	Course sand	$Dc=2.03T^{0.58}$	$Ic=71T^{-0.42}$	6.9
Kpando-Torkor	A	Loam with Gravel	$Dc=12.05T^{0.68}$	$Ic=489T^{-0.32}$	89.3
	B	Sandy Loam	$Dc=2.03T^{0.71}$	$Ic=86T^{-0.29}$	19.3
Mankessim	A	Silty Clay	$Dc=13.80T^{0.94}$	$Ic=780T^{-0.06}$	635.0
	B	Sandy Loam	$Dc=6.92T^{0.69}$	$Ic=288T^{-0.31}$	58.4
Akumadan	A	Clay Loam with Gravel	$Dc=9.57T^{0.83}$	$Ic=477T^{-0.17}$	218.6
	B	Clay Loam with Gravel	$Dc=8.20T^{0.92}$	$Ic=454T^{-0.08}$	338.2
Tanoso	A	Sandy Loam	$Dc=3.03T^{0.76}$	$Ic=138T^{-0.24}$	42.8
	B	Sandy Loam	$Dc=2.01T^{0.78}$	$Ic=94T^{-0.22}$	32.4
	C	Sandy Soil	$Dc=2.07T^{0.77}$	$Ic=95T^{-0.23}$	30.7
Bontanga	A	Clay Loam	$Dc=2.05T^{0.40}$	$Ic=49T^{-0.60}$	1.4
	B	Clay Loam	$Dc=12.05T^{0.68}$	$Ic=489T^{-0.32}$	20.8
Subinja	A	Sandy Soil	$Dc=0.96T^{0.72}$	$Ic=42T^{-0.28}$	9.9
	B	Sandy Soil	$Dc=1.88T^{0.71}$	$Ic=80T^{-0.29}$	17.7

Sample Analysis and Calculation of Cylinder Intake Rate Test

Date: 1995/11/28
Weather: Clear
Place: Near left embankment of Left Main Canal
Soil Type: Loamy Sand
Cylinder Diameter: 0.580m

Time		Accumulated Time.	Time Interval	Reading of Gauge	Decrease in Water Level	Accumulated Decreased Water Level
(hr.)	(min.)	(min.)	(min.)	(mm)	(mm)	(mm)
14	34	0	0	118.5	0.0	0.0
14	35	1	1	113.0	5.5	5.5
14	39	5	4	105.0	8.0	13.5
14	44	10	5	98.0	7.0	20.5
14	49	15	5	92.0	6.0	26.5
14	54	20	5	88.0	4.0	30.5
15	04	30	10	81.5	6.5	37.0
15	23	40	10	77.0	4.5	41.5
15	33	50	10	72.5	4.5	46.0
15	43	60	10	68.5	4.0	50.0

From the measurement results mentioned above, the accumulated intake Dc is expressed by:

$Dc=CT^{n}$

$\log_{10}Dc=\log_{10}C+n\log_{10}T$

To calculate $\log_{10}C$ and **n**, a least square method is adopted. In case the graph between **x** and **y** shows straight line, it is expressed by the following equation:

$y = a+bx$

The above **a** and **b** are obtained using a least square method.

$[y]=aN+b[x]$

$[xy]=a[x]+b[x^2]$

[ ] is a mark for expressing the total amount, such as
$[x]=x_1+x_2+..+x_i, [y]=y_1+y_2+..+y_i, [xy]=x_1y_1+x_2y_2+..+x_iy_i$, $[x^2]=x_1^2+x_2^2+..+x_i^2$.
Where, **N** is the number of data.

Namely,
$a=\{[x^2][y^2]-[x][y]\}/\{[x][xy]\}$
$b=\{N[xy]-[x][y]\}/\{N[x^2]-[x]^2\}$

In this test, $x=\log_{10}T$, $y=\log_{10}Dc$, $a=\log_{10}C$, $b=n$.

N	T(min.)	Dc (mm)	$\log_{10}T$	$\log_{10}Dc$	$(\log_{10}T)^2$	$\log_{10}T \times \log_{10}Dc$
1	1	5.5	0.00	0.74	0.00	0.00
2	5	13.5	0.70	1.13	0.49	0.79
3	10	20.5	1.00	1.31	1.00	1.31
4	15	26.5	1.18	1.42	1.38	1.67
5	20	30.5	1.30	1.48	1.69	1.93
6	30	37.0	1.48	1.57	2.18	2.32
7	40	41.5	1.60	1.62	2.57	2.59
8	50	46.0	1.70	1.66	2.89	2.82
9	60	50.0	1.78	1.70	3.16	3.02
Total			10.73	12.64	15.36	16.46

In this case, **N=9**.

Thus,

$\log_{10}C = \{[\log_{10}T]2][\log_{10}Dc]-[\log_{10}T][\log_{10}T \times \log_{10}Dc]\}$

$/\{N[(\log_{10}T)^2]-[\log_{10}T]^2\}$

$= (15.36 \times 12.64 - 10.73 \times 16.46)/(9 \times 15.36 - 10.73^2) = 0.757$

$C = 5.71$

$n = \{N[\log_{10}T \times \log_{10}Dc]-[\log_{10}T][\log_{10}Dc]\}/\{(\log_{10}T)^2]-[\log_{10}T]^2\}$

$= (9 \times 16.46 - 10.73 \times 12.64)/(9 \times 15.36 - 10.73^2) = 0.54$

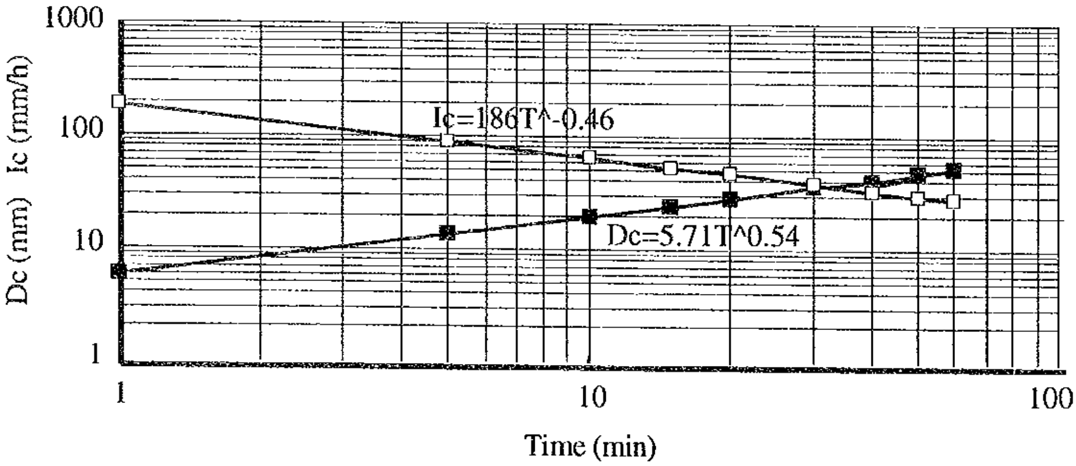
From this calculation results,

Accumulated intake : $Dc = 5.71T^{0.54}$ (mm)

Cylinder intake rate : $Ic = 60 \times 0.54 \times 5.71 \times T^{(0.54-1)} = 186T^{-0.46}$ (mm/h)

Basic intake rate : $I_B = 60 \times 5.71 \times 0.54 \times \{600 \times (1-0.54)\}^{0.54-1} = 14.3$ (mm/h)

The equations obtained above are shown in the following full logarithm paper.



ATTACHMENT-IV

FIELD MESUREMENT ON CANAL SEEPAGE RATE

ATTACHMENT-IV

Field Measurement
on
Canal Seepage Rate

1. General

Measurement of canal seepage rate was executed to grasp the present canal condition, and also to obtain the basic data for rehabilitation plan of the Projects. The results are compiled in a form of the unit of litter/sec/1,000 m2 of wetted perimeter for easy analysis and application to other canals.

2. Test Apparatus

Test apparatus for the measurement of canal seepage consists of dial gauge, float and its supports

3. Test Procedure

(1) Installation of test apparatus

(a) Install the supports with a dial gauge approximately on the mid-point of total length of the tested canal.
(b) Set the dial gauge on the support bar and place the float on the surface of the water attached to the tip of dial gauge.
(c) Check the upstream and the downstream ends of the canal completely with clay soil to create pond in the canal.

(2) Measurement procedure

(a) Start reading a dial gauge every 5 minutes to record the decrease in water level, immediately After installing the apparatus.
(b) Measure water depth and surface width with tape at several points of tested canal at 5-20 meters interval just before and after commencement of measurement.
(c) Continue the measurement until constant of gauge variation, say at least 2 hours.

4. Test Result and Analysis

Relation between time lapse and decrease of water level drawn on the section paper shows that a decrease rate in water level at the initial stage is high, and as the time has passed, it becomes lower. The decrease rate approaches to a certain constant value DR after a few hours, which can be easily estimated from the graph.

With an assumption that the seepage loss is in proportion to the area of wetted perimeter, it is estimated using the following equation.

$$Cs = D_R \times L \times W_S \times (1{,}000/A_P) \ (\text{liter/sec./}1{,}000\text{m}^2)$$

Where,

- Cs : Canal seepage
- DR : Decreasing rate of water level
- L : Tested canal length (m)
- Ws : Width of water surface (m)

A_P : Area of wetted perimeter of tested canal (m^2)

Test results for 4 projects are given below, and the sample analysis and calculation of the test is shown hereinafter.

Project	Place	Date	DR (mm/5min.)	DR (mm/sec.)	Canal Length (m)	Width of Water Surface (m)	Area of Perimeter (m^2)	Seepage Rate (l/sec./1,000m^2)
Ashaiman	Left Bank Main Canal	1995/11/28	0.10	0.00033	115.65	1.06	180.85	0.23
Afife	Lateral Canal	1995/11/17	1.60	0.00533	305.50	1.22	431.35	4.61
Okyereko	Right Bank Main Canal	1995/12/4	1.00	0.00333	85.00	0.80	107.63	2.11
Bontanga	Right Bank Lateral Canal No.2	1995/11/7	0.40	0.00133	25.46	0.79	29.03	0.92
Bontanga	Right Bank Lateral Canal No.1	1995/11/8	0.40	0.00133	33.26	0.68	35.59	0.85

Sample Analysis and Calculation of Canal Seepage Rate

Measurement Place : Okyereko Irrigation Project

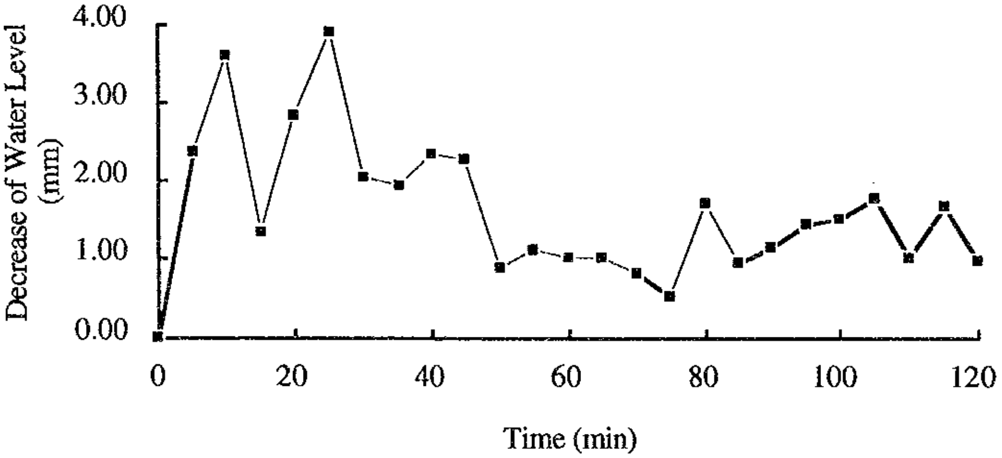
Date:	1995/12/4
Weather:	Clear
Place:	Right bank of Main canal
Canal type:	Precast concrete block lining
Test length:	85.00m

Measurement Time		Accumulated Time	Time Interval	Reading of Gauge		Decrease in Water Level
(hr)	(min.)	(min.)	(min.)	(mm)		(mm)
13	58	0	0	25.00		0.00
14	03	5	5	22.64		2.36
14	08	10	5	19.06		3.58
14	13	15	5	17.71		1.35
14	18	20	5	14.88		2.83
14	23	25	5	11.00		3.88
14	28	30	5	8.95		2.05
14	33	35	5	7.02		1.93
14	38	40	5	4.70		2.32
14	43	45	5	2.43	17.57	2.27
14	48	50	5		16.70	0.87
14	53	55	5		15.58	1.12
14	58	60	5		14.57	1.01
15	03	65	5		13.57	1.00
15	08	70	5		12.76	0.81
15	13	75	5		12.25	0.51
15	18	80	5		10.56	1.69
15	23	85	5		9.62	0.94
15	28	90	5		8.47	1.15
15	33	95	5		7.03	1.44
15	38	100	5		5.53	1.50
15	43	105	5		3.76	1.77
15	48	110	5		2.74	1.02
15	53	115	5		1.07	1.67
15	58	120	5		0.08	0.99

At the same time, width, and depth of water surface just before and after measurement were measured shown as below.

Point	Width of Water Surface		Water Depth		Wetted Perimeter		Area of Wetted Perimeter	
	(m)	(m)	(m)	(m)	(m)	(m)	(m^2)	(m^2)
	13:58	15:58	13:58	15:58	13:58	15:58	13:58	15:58
1	1.10	1.00	0.33	0.30	1.12	1.04	22.33	20.77
2	1.10	1.00	0.32	0.28	1.09	0.99	21.81	19.73
3	0.98	0.90	0.34	0.30	1.14	1.04	22.85	20.77
4	1.04	0.97	0.34	0.29	1.14	1.01	22.85	20.25
5	0.99	0.90	0.34	0.30	1.14	1.04	22.85	20.77
6	0.90	0.81	0.36	0.31	1.19	1.06	5.97	5.32
Average	0.87	0.80	0.29	0.25	0.98	0.88	118.66	107.63

Relation of time lapse and decrease of water level is shown in following figure. From this figure, it is apparent that the decreasing rate in water level (DR) approaches to a constant value of 1.00 mm/5min., that is 0.00333mm/sec.



From the above test results, canal seepage rate is expressed by the following equation.

Canal seepage rate Cs=0.00333 x 85.00 x 0.80 x (1,000/107.63)
=2.11 (l/sec./1,000m^2)

ANNEX-B

METEOROLOGY AND HYDROLOGY

ANNEX - B

METEOROLOGY AND HYDROLOGY

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ANNEX - B METEOROLOGY AND HYDROLOGY

1. METEOROLOGY

The analysis of meteorological data is required mainly for the purpose of preparing the basis for irrigation planning and drainage improvement in connection with the projects rehabilitation. The data on rainfall, temperature, relative humidity, sunshine hours and evaporation are the prerequisite for the study on irrigation water requirements and drainage requirements as well. With this view, the analysis and study of meteorological data are made in this Annex.

1.1 Climate

The climate in Ghana is characeterised by distinct wet and dry seasons. The mean annual temperature ranges from 26°C near the coast to 29°C in the north with daily variations of 4° - 5°C on an average. In the south, relative humidity exceeds 90% during night time and early morning, but during daytime along the coast it drops on average to 75 % on the southwest and 65 % on the southeast with variation of about 15 % between seasons. Lowest humidity occurs between December and February. In the north, night humidity averages 95 % and drops to about 70 % during daytime between April and October. Annual evaporation ranges from 1,650 mm to 1980 mm in the Savannah areas, while in the wetter areas it is between 1,370 mm and 1,650 mm. Generally, the climate varies with the agro-ecological zones, and the climatic characteristic in each zone is summarised as follows (refer to Figures B-1 and B-2):

The mean annual rainfall in the Transitional Zone ranges from 1,240 mm at Wenchi (1961-94 average) to 1,410 mm at Koforidua (1963-94 average) normally in two seasons between April and October with about 200 to 220 rain days. Potential evaporation is between 1,400 mm and 1,650 mm per year and exceeds rainfall in the five dry months. The vegetation is mainly secondary forests mixed with scrub which are affected by bush fires during the dry months. During the dry months short term crops cannot be grown without irrigation. There exists only Kpando-Torkor project in this zone.

The mean annual rainfall in the Coastal Savannah Zone varies from 700 mm at Tema (1961-94 average) in the coast to 1,260 mm at Aburi (1961-94 average) inland. The rainfall distribution is bimodel, giving a major period between March and June and minor season between September and November. During the 6 to 7 rainy months, rainfall normally exceeds potential evaporation in only about two months. Irrigation could be valuable for crops in this zone. Ashaiman, Aveyime, Mankessim and Okyereko projects are located in this zone.

1.2 Observation Station and Data

Meteorological observation is being carried out by the synoptic stations under the management of Meteorological Department and also by climatological stations (including agro-meteorological stations and rainfall stations) which are managed by other government institutes, agricultural experimental stations and various projects.

There are 20 synoptic stations in Ghana. Meteorological data such as rainfall, temperature, relative humidity, wind speed, and sunshine hours are available from these stations for long period. The reliability of the records is also high. Out of 20 stations, four (4) stations are located relatively near to the priority projects. They are Tema, Saltpond, Ho, and Akuse stations. The data required for the feasibility study are therefore collected from these stations (refer to Figure B-1 and Table B-1).

There exist more than 700 climatological stations in the whole of Ghana, which observe rainfall in the main. However, some of them are not working well, and observation period is also short in general. In addition, the reliability of the records available from these stations is not so high. Therefore, careful attention should be paid, when the data from these stations are used for the study.

1.3 Data related to Projects

The meteorological data used for the study on each of the five (5) priority projects are collected as follows, taking into account the reliability and observation period of available data :

(1) Ashaiman Project

A synoptic station exists in Tema which is located at about 5 km south from Ashaiman project. The data from this station such as rainfall, temperature, relative humidity and wind speed are used for the project study. Because data of sunshine hours are not available at this station, those observed at Accra synoptic station are used.

The Irrigation Development Centre (IDC) located at this project is being carried out the observation of rainfall, temperature, relative humidity, pan evaporation and radiation since 1991. The observation period is still short, but the reliability is high. Then, rainfall data from this Centre are used for river runoff analysis, and evaporation data are used for water balance study as well as for estimate of irrigation water requirements.

(2) Aveyime Project

Two (2) meteorological stations, Akuse synoptic station and Akasti climatological station, are located near the project, and Akuse station is located more near to the project than Akasti. In addition, not much difference is recognised in the data recorded at both stations. Then, the data such as temperature, relative humidity, sunshine hours and wind speed available from Akuse station are used for the study. As for rainfall data, a 10-year series of daily data are available from Aveyime rainfall station and are used for the study.

(3) Kpando-Torkor Project

Ho synoptic station is located at about 50 km south of the project, and this is only the nearest one to the project. Then, the data such as temperature, relative humidity, sunshine hours and wind speed recorded at this station are used for the study. A 10-year series of daily rainfall data available from Kpando rainfall station is used for the study.

(4) Makessim Project

A synoptic station exists in Saltpond which is located at about 10 km south-west from the project. All meteorological data available from this station are used for the project study.

(5) Okyereko Project

The meteorological data available from Saltpond synoptic station, which is located at about 45 km west from this project, are used for the study of this project. As for the rainfall data, a 15-year series of monthly data are available from the project rainfall station. But daily rainfall data, which are required for estimate of irrigation/drainage requirements and water balance study, are not available at this project station. On the other hand, comparison of rainfall data recorded at Saltpond and project site is made, and shows a close relationship in rainfall pattern between two stations. Then, the daily rainfall at the project site is estimated by using such a relationship, and is used for the project study.

The meteorological data collected for the projects study are summarised in Tables B-2 and B-3.

1.4 Rainfall Analysis

(1) Rainfall Tendency

It is said that tendency of arid climate continues since 1983 when the whole of Ghana has had serious droughts. On the basis of rainfall records collected from the synoptic stations located near the projects, analysis of annual rainfall with 2-year return period at each station is made as shown below :

Project	Rainfall Station	Climatic Zone	Rainfall with 2-year Period (mm) 1960 - 79 (1)	1980 - Latest (2)	Ratio (2)/(1)
Ashaiman	Tema	Coastal Savannah	773	588	76%
Aveyime	Akuse	Coastal Savannah	1,175	1,155	98%
Kpando-Torkor	Ho	Transitional Zone	1,359	1,286	95%
Mankessim	Saltpond	Coastal Savannah	1,100	906	82%
Okyereko	Saltpond	Coastal Savannah	1,100	906	82%

The analysis shows that a significant difference of annual rainfall between the period of 1960-1979 and that of 1980 to date is not recognised in the Transitional Zone. On the other hand, there is a tendency that rainfall is decreasing in recent 15 years at the stations located in the Coastal Savannah Zone where Ashaiman, Aveyime, Makessim and Okyereko projects are located. This means the decrease in water resources that can be used for the water projects such as domestic water supply schemes as well as irrigation projects.

(2) Rainfall Intensity

In order to estimate the drainage requirements for respective projects, probability analysis of the maximum daily rainfall and the maximum 3-day continuous rainfall is made on the basis of more than 10-year series of daily rainfall data. Table B-4 shows the result of analysis which is summarised as follows :

Project	Observation Site	Data Period	Probable Rainfall (mm) Max.Daily Rainfall 2 yrs	5 yrs	10 yrs	Max. 3-Day Conti. Rainfall 2 yrs	5 yrs	10 yrs
Ashaiman	Tema	1976 - 95	72.4	94.4	108.5	87.6	111.9	128.0
Aveyime	Aveyime	1980 - 95	70.4	92.6	109.6	91.5	127.3	156.1
Kpando-Torkor	Kpando	1976 - 95	76.9	116.8	152.9	105.7	152.0	187.5
Mankessim	Saltpond	1976 - 95	93.5	120.5	135.4	121.0	152.3	171.4
Okyereko	Saltpond	1976 - 95	93.5	120.5	135.4	121.0	152.3	171.4

In addition, the maximum hourly rainfall intensity is determined through the probability analysis, using the following formula :

$Rt = R_{24} / 24 \times (24 / t)^n$

where, Rt : (t) hours average rainfall intensity (mm/hour)
R_{24} : One day maximum rainfall (mm/day)
n : Coefficient estimated by the method shown in " Maximum Rainfall Intensity Duration Requirements in Ghana"

Ashaiman and Weija (Accra)	0.852
Kpando-Torkor (Ho)	0.870
Aveyime (Akuse)	0.870
Mankessim and Okyereko (Saltpond)	0.899

The rainfall intensity with 10-year return period at each project site is estimated as shown below. Relatively high rainfall intensity is indicated in Kpando-Torkor, Mankessim and Okyereko projects.

Project	Observation Site	R24 (mm)	10-Year Return Period Rainfall Intensity (mm/hr) 1 hr	2 hrs	3 hrs	4 hrs	6 hrs	12 hrs
Ashaiman	Tema	108.5	67.8	37.6	26.6	20.8	14.7	8.2
Aveyime	Aveyime	109.6	72.5	39.7	27.9	21.7	15.3	8.3
Kpando-Torkor	Kpando	152.9	101.2	55.3	33.9	30.3	21.3	11.6
Makessim	Saltpond	135.4	98.2	52.7	36.6	28.2	19.6	11.6
Okyereko	Saltpond	135.4	98.2	52.7	36.6	28.2	19.6	11.6

2. HYDROLOGY

The analysis of hydrological data is made for the purpose of preparing information required for the water balance study in order to clarify water shortage problem in some of the priority projects as well as for preparation of the most optimum rehabilitation plan of each priority project. Such an analysis is also required for the study on drainage problem caused by floods from the rivers located adjacent to the projects. The results of the analysis are as follows:

2.1 River System

Ghana has five (5) main river basin, namely the Volta, Pra, Tano, Ankobra and the Coastal basins. The Volta river system is the dominant river basin which includes neighbouring countries such as Cote d'Ivoire, Togo and Burkina Faso. It occupies about 70 % of the country. The Volta basin is composed of big rivers such as White Volta, Black Volta, Ochi, Pru and so on. The second largest basin is the Pra basin which occupies 12 % of the country, and followed by the Coastal basin, the Tano basin and the Ankobra basin. These basins occupy about 7 %, 6% and 3 % of the total country area, respectively. All of rivers in Ghana flow into the Gulf of Guinea (refer to Figure B-1).

The whole country is generally classified as a lowland with the greater part less than 300 m above sea level, and none of the ridges exceeding 1,000 m in elevation. However, there is a mountainous area running from Koforidua to Wenchi, a distance of about 260 km, which constitutes a drain divide separating the Volta river basin from other river basins.

Most of the rivers have very gentle slopes and winding courses. In general, hydrological conditions of the river basins give moderate floods. Occasionally, however, very serious floods occur in some part of the country owing to drainage problem such as influence of back water of the main drains or sea. In addition, low or null discharge is observed in most small rivers in the dry season.

The water sources of the priority projects are as follows :

Project	River Basin	Water Source	Catchment Area (km^2)	Type of Reservoir
Ashaiman	Coastal	Gyorwulu River	82.4	Dam
Aveyime	Volta	Volta River	-	River
Kpando-Torkor	Volta	Volta Lake	-	Dam
Mankessim	Coastal, Ochi-Amis	Aprapon River	57.3	Dam
Okyereko	Coastal, Ayensu	Okyereko River	17.6	Dam
		Ayensu River	1,659.0	Weir *

* means supplemental water source for Okyereko project.

2.2 Hydrological Observation and Data

The Architectural and Engineering Service Corporation (AESC) has a hydrological section which observes river discharge and/or water level in the main river basins of Ghana. Some of the main river basins such as Tano, Ayensu and Ochi-Amisa basins, which are related to Okyereko and Mankessim projects, have hydrological observation stations, and available records are collected for the study.

Since Ashaiman project is carrying out the daily observation of water level of the reservoir from the year 1992, such data are also collected for the study. The runoff into the reservoir is estimated for water balance study on the basis of the data on water level record of the reservoir, rainfall, evaporation and intake records .

As for Aveyime project, water level fluctuation of the Volta river is examined by installing a staff gage at the existing pumping site. In addition, water level records at the Kpong dam tail side located upstream from Aveyime are also collected for the study.

Since the water level of the Volta lake fluctuates throughout the year, water level records of the lake are collected from the Volt River Authority (VRA) for the study of Kpando-Torkor project.

These hydrological data are as follows : These data are fully used for the study of available amount of water for irrigation use, rehabilitation plan of the existing project facilities, etc.

Project	Item	Location of Observation	Data Period	Source
Ashaiman	Reservoir water level	Ashaiman	1992 - 96	IDC
	Rainfall (daily)	ditto	ditto	ditto
	Pan evaporation (daily)	ditto	ditto	ditto
	Intake discharge	ditto	ditto	ditto
Aveyime	Water level of Volta river	Aveyime	1995 - 96	Project
	ditto	Kpong dam	1981 - 96	VRA
Kpando-Torkor	Water level of Volta lake	Akosonbo	1976 - 96	VRA
Mankessim	Discharge of Ochi river	Mankessim	1956 - 91	AESC
Okyereko	Discharge of Ayensu river	Okyereko	1962 - 91	AESC

2.3 Potential Water Source

(1) Ashaiman Project

Since IDC at Ashaiman project carries out meteo-hydrological observation such as rainfall, water level fluctuation of the reservoir, pan evaporation and amount of water released from the reservoir, the runoff into the reservoir is estimated through water balance study under the present project condition, using these daily data. The following equation is used for the water balance study :

$$Qdf = Qin - Qout - Qep - Qol$$

where,
- Qdf : Daily difference of storage, which is calculated based on water level records of the reservoir (m^3)
- Qin : Runoff into reservoir (m^3)
- Qout : Amount of water released from reservoir for irrigation (m^3)
- Qep : Evaporation (m^3)
- Qol : Other losses (m^3)

The result of the runoff study is shown in Table B-5 and is summarised as follows : The study shows that average runoff ratio is estimated at 6.8 %, which is very small as compared with those in other river basins.

Period	Rainfall (mm)	(mm)	Runoff (%)	(MCM)	Intake (MCM)	Evaporation (MCM)
Feb. to Dec. 1994	673.7	28.9	4.3	2.380	0.540	1.246
Jan. to Dec. 1995	902.5	90.0	10.0	7.414	0.343	1.795
Jan. to Jun. 1996	602.8	29.7	4.9	2.447	0.189	1.373
Total	2,179.0	148.6	6.8	12.241	1.071	4.416

Such a small runoff ratio may be due to the hydrological conditions such as topography, soils and vegetation in the chatchment area. In fact, water level records show that the dam becomes rarely full. This is the main cause of high water shortage in this project. In addition, high evaporation rate, about 2,000 mm per year from the dam water surface, and shallow effective water depth of the reservoir may accelerate the water shortage problem.

(2) Aveyime Project

As shown in Figgure B-3, water released from the Akosonbo dam is stored in the Kpong dam once, and then the water is released again from the Kpong dam under the supervision of the VRA. The water released from the Kpong dam and the inflow from the downstream basin become the water source for Aveyime project.

The amount of water released from the Kpong dam can be estimated from the relationship between the water level records and the rating curve. The minimum release is estimated at about 200 m^3/sec, which corresponds to the discharge with 10-year non exceedence return period (refer to Table B-6). The water available for Aveyime project with about 100 ha of irrigable area is enough for its rehabilitation.

The water level at the tail side of Kpong dam and at Aveyime pump site during the period from Nov. 1995 to Jun. 1996 is shown in Fig. B-4. The water level at the Kpong Dam tail side is about 3.70 m ASL for the observation period which links to the upper operating water level at the dam. For the same observation period, the water level at Aveyime is 1.70 m ASL. Therefore, maximum water level at the Aveyime pump site might be estimated as 1.70 m ASL. Taking into consideration safety for the pump facilities, the fluctuation of the Volta river at Aveyime pump site is estimated from 0 m ASL to 2 m ASL.

(3) Kpando-Torkor Project

The water source of this project is the Volta lake. Its capacity is up to 150,000 million cubic meter (MCM). Although the lake water is used for electric power generation, available water in the lake is sufficient for irrigation use in this project area.

The water level of the lake fluctuates from season to season. On the other hand, irrigation water for this project is lifted from the lake at pump stations to be constructed in the lake shore. This means that the study on water level fluctuation in the lake is required for design of pump stations. Then, the water level records of the lake are collected from the VRA and are shown in Figgure B-5. The water level of the lake is managed by the VRA so as to be within the upper-lower water level regulation, 8 m fluctuation in height.

(4) Mankessim Project

This project has a reservoir constructed on the Aprapon river which is a tributary of the Ochi-Amisa main river, and serious water shortage problem does not occur at present, because irrigated land is very small, about 20 ha, as compared with the storage capacity of the reservoir. The chatchment area of the reservoir is estimated at 57.3 km^2. Since the Aprapon is not perennial one, in addition, the reservoir becomes full only once a 10-year approximately.

According to the discharge records of the Ochi-Amisa river, it becomes null, when drought year comes. In this case, the water released from the Mankessim reservoir is used not only for irrigation but also for domestic purpose in the downstream areas. It is therefore that consideration should be paid for domestic use of water, when water balance study is made.

(5) Okyereko Project

Since the water source of this project is the existing Okyereko reservoir fed by rainfall only, the irrigated area is severely restricted at present. In fact, the irrigated area in the past five (5) years from 1991 to 1995 ranges from 7.3 ha to 31 ha and averages 21.6 ha. In addition, water balance study shows that irrigable area with 80 % dependability would only be 11 ha, out of 111 ha of potential irrigable area. GIDA has a plan to provide supplemental water source by installing pumps on the Ayensu river located near the project. Then, the study of an alternative plan is made so as to include new pump station in the proposed rehabilitation works of the project.

For the study on the plan, analysis of discharge records in the Ayensu river is required, and the estimated discharges of the Ayensu on monthly basis are obtained (see Table B-9). The following is a summary of the estimated discharges :

Unit : m3/sec.

Return Period	Jan.	Feb.	Mar.	Apri.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
2 years	0.52	0.32	0.42	0.84	2.01	16.18	10.37	5.46	3.97	6.04	3.69	2.03
5 yeras	0.23	0.11	0.11	0.37	0.59	10.03	4.06	1.67	1.2	2.77	1.85	1.24
10 years	0.12	0.01	0.06	0.23	0.33	7.78	2.59	0.98	0.72	1.72	1.18	0.91

Design of the pumps required for supply of necessary amount of water to the Okyereko reservoir is made on the basis of the estimated discharges and irrigation water requirements for this project. In this case, consideration should be paid for release of city water supply to Winneba which is estimated at 1 (one) million gallons per day. As a result, pumps could be operated during the period from June to November in a year.

2.4 River Runoff Study

River runoff study is required to estimate available amount of water for irrigation through water balance study for Ashaiman, Mankessim and Okyereko projects whose water source is reservoir. Since the river discharge records related to the projects are not sufficient in terms of observation period and number of gauging stations, the study is made using the rainfall data.

As mentioned in Sub-chapter 2.3, the water balance study is made under the present project condition of Ashaiman, using daily data on rainfall, water level fluctuation in the reservoir, pan evaporation and amount of water released from the reservoir. This water balance study at Ashaiman gives useful information for river runoff study at Mankessim and Okyereko for which the tank model method is applied. The model is composed of four (4) tanks combined vertically , and each tank has two (2) types of outlets, one for runoff and the other for percolation. At first, rainfall is stored in the upper tank, which is divided into runoff and percolation through each outlet by multiplying with coefficients which vary depending on water depth. Finally, runoff is estimated as total water volume passing through the runoff outlets of the four tanks (refer to Figure B-6).

The coefficient to be applied to the tank model is determined using the daily rainfall data at Ashaiman and runoff into the reservoir obtained from the water balance study. Using such input data as daily rainfall and the estimated runoff, calibration of the tank model method is made, and the calibration results are shown in Figure B-7.

The runoff study is made for 10 years from 1985 to 94, using rainfall data at Mankessim and Okyereko and the above tank model method. The results of the study are given in Tables B-10 to B-13 and Figures B-8 to B-10, and are summarised as follows : The results are fully used for water balance study to prepare the most optimum rehabilitation plan for Ashaiman, Mankessim and Okyereko projects.

Project	Rainfall (mm/year)	Runoff (mm/year)	Runoff Coefficient (%)
Ashaiman	610.6	26.728	4.38
Mankessim	885.7	49.319	5.57
Okyereko	778.1	36.784	4.73

2.4 Flood Discharge

The drainage problem caused by floods from the rivers located adjacent to the project is seen in Mankessim and Okyereko projects. The flood discharge analysis in the Ochi-Amisa river in Mankessim and the Ayensu river in Okyereko is made for the study of the drainage problem in both projects. In addition, the analysis is also required for facility design of pump station to be constructed on the Ayensu river for Okyereko project. As for Ashaiman project, the analysis is necessary for facility design of the drainage canal. Therefore, the flood discharge analysis in Gyorwulu river in Ashaiman is also made.

Discharge observation at both rivers is being carried out by AESC. However, the observation period of daily data is too short to make the frequency analysis. Then, the method applied for flood discharge analysis is as follows :

a) Unit graph method is applied for the analysis.
b) Rainfall data are used for the analysis.
c) Unit graph is made by using the Sato formula which is a function of flood concentration time.
d) The flood concentration time is calculated by the Kraven formula.
e) Design rainfall is calculated from three consecutive days rainfall and/or one day rainfall observed at Saltpond for Okyereko and Mankessim, at Tema for Ashaiman.
f) Effective rainfall is estimated using the observation data at the Ochi-Amisa river.

The results of the analysis are summarised in the following table, and shown in Figures B-11 to B-17 for details. In addition, comparative study of the Unit Graph method with the Rational formula is made in order to confirm the reliability of this flood analysis.

For Ochi-Amisa River (Catchment Area : 1,217km^2)

Return Period	3-Day Rainfall (mm)	Flood Discharge (m^3/sec)
2-year	121.0	130
5-year	152.3	200
10-year	171.4	230
25-year	194.0	330
50-year	210.0	360

For Ayensu River (Catchment Area : 1,659km^2)

Return Period	3-Day Rainfall (mm)	Flood Discharge (m^3/sec)
2-year	121.0	145
5-year	152.3	220
10-year	171.4	255
25-year	194.0	370
50-year	210.0	400

For Ayensu River (Catchment Area : 1,659km^2)

Return Period	1-Day Rainfall (mm)	Flood Discharge (m^3/sec)
2-year	93.5	119
5-year	120.5	196
10-year	135.4	228
25-year	152.0	257
50-year	163.1	295

For Gyorwulu River (Catchment Area : 82.4km^2)

Return Period	1-Day Rainfall (mm)	Flood Discharge (m^3/sec)
2-year	72.4	44
5-year	94.4	57
10-year	108.5	66

TABLES

Table B-1 List of Rainfall Station

Station No.	Station Name	Data Period		Station Type	Latitude	Longitude	Elevation
		Start Date	End Date				(m)
23014TEM	Tema	1956-06-01	Conti.	Synoptic	05-37 N	000-00 E	14.0
	Ashaiman (IDC)	1992-01-01	Conti.	Agromet.	05-41 N	000-03 W	30.0
23016ACC	Accra	1952-01-01	Conti.	Synoptic	05-36 N	000-10 W	67.7
07003AKU	Akuse	1912-04-01	Conti.	Synoptic	06-06 N	000-07 E	17.4
07034AVE	Aveyime	1963-10-01	Conti.	Agromet.	06-02 N	000-22 E	6.1
07017HO	Ho	1921-06-01	Conti.	Synoptic	06-36 N	000-28 E	157.6
07017KPA	Kpando	1958-01-01	Conti.	Climate	07-00 N	000-17 E	213.3
23022SAL	Saltpond	1944-01-01	Conti.	Synoptic	05-12 N	001-04 E	43.9
07012NYN	Nyankpala	1952-10-01	Conti.	Agromet.	09-24 N	000-58 W	182.8
	Okyereko	1978-01-01	Conti.	Agromet.	05-24 N	000-36 W	30.0

Table B-2 Monthly Meteorological Values (1/2)

Project : Ashaiman

Item	Station	Period	Unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Tot./Ave.
Rainfall	Tema	1961-94	(mm)	7.3	24.0	48.8	89.6	129.0	178.6	57.8	18.5	49.9	57.4	21.4	16.0	698.2
	Tema	1985-94	(mm)	4.1	21.4	32.7	69.5	132.9	108.5	37.8	15.0	55.9	57.9	15.3	24.4	575.5
	Ashaiman	1992-96	(mm)	3.7	7.6	78.2	75.8	130.6	124.7	57.7	19.0	37.2	59.2	30.9	4.7	629.2
Max. Temperature	Tema	1961-90	(℃)	30.4	30.9	31.0	31.0	30.5	28.8	27.3	26.7	27.5	29.2	30.5	30.5	29.5
	Ashaiman	1991-95	(℃)	31.7	31.6	31.8	31.4	30.5	28.3	26.8	27.4	28.5	29.9	31.2	31.3	30.0
Min. Temperature	Tema	1961-90	(℃)	24.0	24.8	25.0	25.0	24.6	23.7	22.9	22.2	22.7	23.4	24.2	24.0	23.9
	Ashaiman	1991-95	(℃)	22.4	24.1	24.4	25.0	24.3	22.9	22.2	22.2	22.7	22.9	23.4	23.1	23.3
Mean Temperature	Tema	1961-90	(℃)	27.2	27.9	28.1	28.0	27.5	26.2	25.0	24.7	25.1	26.4	27.3	27.3	26.7
	Ashaiman	1991-95	(℃)	24.8	26.0	26.3	26.5	25.9	24.6	23.6	23.5	23.9	24.7	25.3	25.2	25.0
Rel. Humidity	Tema	1965-90	(%)	79	82	82	82	83	86	88	88	87	84	83	81	84
Sunshine Hours	Accra	1961-90	(hours)	6.8	6.9	6.9	7.0	6.9	5.1	4.7	4.9	5.9	7.5	7.9	6.9	6.5
Wind Velocity	Tema	1965-90	(m/s)	2.6	3.1	3.1	2.9	2.8	2.4	2.9	3.1	3.4	3.2	2.8	2.4	2.9
	Ashaiman	1991-95	(m/s)	1.8	2.2	2.4	2.2	2.3	1.9	2.7	2.6	2.5	2.2	1.7	1.6	2.2
A-pan Evaporation	Ashaiman	1991-96	(mm)	172.2	194.2	215.6	180.5	159.6	115.5	111.7	126.6	141.8	168.6	156.0	143.7	1885.7

Project : Aveyime

Item	Station	Period	Unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Tot./Ave.
Rainfall	Akuse	1960-90	(mm)	14.0	52.1	92.6	128.9	149.9	204.7	91.5	54.6	141.8	132.0	82.1	25.7	1169.7
	Akuse	1981-90	(mm)	3.4	34.3	85.2	99.2	138.0	168.6	81.3	55.8	131.5	123.7	59.7	31.7	1012.4
	Aveyime	1982-96	(mm)	4.0	35.5	95.6	127.3	149.4	133.3	92.6	32.8	92.0	120.1	53.0	16.7	952.4
Max. Temperature	Akuse	1961-90	(℃)	34.0	35.2	34.9	34.1	33.0	31.0	30.0	30.3	31.3	32.2	33.1	32.8	32.7
Min. Temperature	Akuse	1961-90	(℃)	21.5	23.4	23.9	23.8	23.3	22.5	22.0	21.8	21.9	21.9	21.9	21.3	22.4
Mean Temperature	Akuse	1961-90	(℃)	27.8	29.3	29.4	29.0	28.2	26.8	26.0	26.1	26.6	27.1	27.5	27.1	27.5
Rel. Humidity	Akuse	1961-90	(%)	69	70	73	76	80	84	82	80	81	82	80	75	77
Sunshine Hours	Akuse	1961-90	(hours)	6.5	6.8	6.7	6.7	6.8	5.1	4.5	4.5	5.0	6.8	7.5	6.8	6.1
Wind Velocity	Akuse	1961-90	(m/s)	0.9	1.3	1.4	1.2	1.0	1.0	1.4	1.5	1.2	0.9	0.8	0.7	1.1

Project : Kpando-Torkor

Item	Station	Period	Unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Tot./Ave.
Rainfall	Ho	1961-90	(mm)	24.0	64.6	117.9	127.2	180.6	201.5	137.3	96.2	142.1	163.7	51.9	35.0	1342.1
	Ho	1981-90	(mm)	14.5	58.5	130.6	111.4	166.2	167.2	151.4	108.2	132.2	161.7	51.0	27.1	1279.9
	Kpando	1985-94	(mm)	4.5	21.5	54.2	109.5	122.7	166.8	222.6	177.4	199.3	140.6	46.6	18.9	1284.7
Max. Temperature	Ho	1961-90	(℃)	33.8	34.8	34.0	33.1	32.0	29.9	28.8	29.0	30.0	31.3	32.9	32.8	31.9
Min. Temperature	Ho	1961-90	(℃)	22.1	23.1	23.3	23.4	23.0	22.2	21.6	21.3	21.5	21.9	22.4	22.1	22.3
Mean Temperature	Ho	1961-90	(℃)	27.9	29.0	28.7	28.2	27.5	26.1	25.2	25.2	25.8	26.6	27.7	27.4	27.1
Rel. Humidity	Ho	1961-90	(%)	65	68	73	77	80	85	85	84	83	82	76	70	77
Sunshine Hours	Ho	1961-90	(hours)	7.0	7.1	7.0	7.3	7.5	5.9	4.6	4.2	4.9	7.1	8.3	7.1	6.5
Wind Velocity	Ho	1961-90	(m/s)	0.8	0.8	0.9	0.9	0.8	0.9	0.9	0.9	0.9	0.8	0.7	0.7	0.8
A-pan Evaporation	Ho	4 years	(mm)	191.2	196.9	187.0	170.0	161.2	128.3	97.1	102.3	114.0	143.6	151.0	158.1	1800.8

Table B-2 Monthly Meteorological Values (2/2)

Project : Okeyereko, Mankessim

Item	Station	Period	Unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Tot./Ave.
Rainfall	Saltpond	1961-94	(mm)	15.9	24.7	58.2	99.4	207.2	284.9	74.3	36.1	56.9	90.0	55.7	21.5	1024.7
	Saltpond	1985-94	(mm)	17.3	17.7	69.0	65.8	202.6	194.9	54.2	25.5	85.2	102.1	38.6	22.0	894.9
	Okeyereko	1985-94	(mm)	17.1	26.5	52.5	49.5	171.3	164.9	55.1	58.6	64.1	81.7	39.4	22.1	803.0
Max. Temperature	Saltpond	1961-90	(℃)	30.6	31.3	31.3	31.2	30.3	28.5	27.2	26.6	27.4	29.2	30.8	30.6	29.6
Min. Temperature	Saltpond	1961-90	(℃)	22.9	23.8	23.9	23.9	23.6	23.1	22.5	21.9	22.2	22.8	23.0	22.9	23.0
Mean Temperature	Saltpond	1961-90	(℃)	26.8	27.6	27.6	27.6	27.0	25.8	24.9	24.3	24.8	26.0	26.9	26.8	26.3
Rel. Humidity	Saltpond	1961-90	(%)	83	84	84	84	86	88	89	90	89	87	85	84	86
Sunshine Hours	Saltpond	27 years	(hours)	7.0	7.3	7.2	7.0	6.9	5.0	4.8	4.6	5.4	7.3	8.2	7.2	6.5
Wind Velocity	Saltpond	21 years	(m/s)	1.5	1.8	1.8	1.7	1.7	1.8	1.6	1.5	1.7	2.0	1.6	1.3	1.7
A-pan Evaporation	Saltpond	7 years	(mm)	115.2	133.8	163.4	160.3	155.4	128.0	119.6	115.1	139.5	166.5	170.5	129.7	1697.1

Table B-3 Monthly Rainfall Data (1/8)

Project : Ashaiman
Station No. : 23014TEM
Station Name : Tema

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1961	16.8	1.3	76.5	121.2	139.7	398.0	50.0	0.0	112.5	17.0	12.2	15.0	960.2
62	31.0	26.2	55.4	32.0	235.2	530.9	26.7	8.6	1.8	94.7	22.4	29.7	1,094.6
63	13.0	17.3	34.8	124.2	170.9	169.7	97.5	48.3	77.7	76.5	43.2	11.4	884.5
64	0.0	4.1	79.0	159.8	108.5	169.9	0.3	0.3	0.5	5.3	0.0	0.5	528.2
65	10.4	84.1	2.5	160.0	78.0	244.3	120.6	35.6	20.1	66.0	8.6	16.8	847.0
66	1.5	23.1	78.5	99.8	97.0	63.0	51.8	0.5	14.2	66.5	0.0	0.0	495.9
67	36.8	0.0	57.7	102.9	114.6	234.4	7.4	1.3	33.3	17.8	48.8	18.8	673.8
68	39.9	80.0	24.6	61.2	105.9	294.6	469.9	98.8	238.3	183.1	94.0	30.2	1,720.5
69	21.6	5.6	88.4	65.3	78.2	186.7	23.1	7.9	36.3	56.9	79.5	0.3	649.8
1970	19.3	68.1	49.0	66.8	217.2	121.7	13.7	7.4	16.5	81.3	26.2	3.0	690.2
71	0.0	61.7	59.9	89.9	48.8	415.0	83.8	29.0	65.8	2.0	6.4	40.6	902.9
72	0.0	68.8	39.4	233.4	105.7	239.0	1.5	4.1	23.6	53.6	30.5	23.1	822.7
73	0.0	2.3	140.5	49.3	87.9	309.6	54.6	50.5	65.3	60.5	0.0	30.5	851.0
74	11.7	0.0	94.0	59.2	178.8	231.4	95.0	17.3	110.0	45.2	0.0	30.7	873.3
75	0.0	57.2	122.7	96.5	156.2	114.6	75.9	2.5	17.8	44.7	9.1	0.0	697.2
76	0.0	33.9	40.5	209.0	68.3	140.2	1.0	17.6	4.3	30.3	14.0	0.0	559.1
77	0.5	19.8	2.5	72.8	82.0	20.3	11.3	25.2	1.3	84.8	8.9	0.0	329.4
78	2.6	7.4	7.9	86.1	155.3	56.2	13.5	1.3	10.3	36.1	0.0	2.0	378.7
79	0.0	0.0	61.6	59.5	136.2	274.8	37.2	20.4	27.9	169.5	82.6	0.0	869.7
1980	0.0	0.0	66.7	59.5	136.2	274.8	37.2	23.2	28.4	169.5	82.6	0.0	878.1
81	1.5	0.0	40.2	58.0	132.7	206.6	141.0	26.0	68.0	35.9	9.4	1.1	720.4
82	0.8	8.9	104.1	93.5	108.9	288.9	87.2	0.8	0.5	48.0	0.0	0.0	741.6
83	0.3	0.0	1.8	42.4	83.9	154.8	0.0	47.3	0.0	0.0	0.0	0.0	330.5
84	0.0	0.0	17.3	50.5	99.2	48.0	50.3	20.4	79.9	48.9	15.1	31.7	461.3
85	0.3	8.1	57.3	14.0	171.7	94.0	8.6	46.3	23.9	98.2	21.1	0.0	543.5
86	0.0	47.3	28.6	27.9	85.5	63.4	0.8	0.0	5.3	73.2	6.1	29.9	368.0
87	24.0	5.2	42.6	45.5	106.4	3.4	21.2	57.4	297.9	75.7	0.0	14.0	693.3
88	0.0	90.1	52.2	77.3	99.4	172.2	44.8	1.8	72.9	52.4	1.1	65.8	730.0
89	0.0	0.0	17.3	142.2	93.4	169.6	65.0	9.6	15.7	99.5	30.6	0.0	642.9
1990	1.4	16.0	5.5	79.1	114.8	112.3	13.1	0.1	39.2	31.5	18.9	111.0	542.9
91	5.7	17.3	4.7	175.1	189.6	81.0	189.3	12.9	23.3	59.1	0.1	0.0	758.1
92	0.0	0.0	35.7	35.0	254.3	80.0	24.5	1.6	4.6	16.3	5.9	0.0	457.9
93	0.0	5.9	49.3	61.0	86.7	154.1	7.2	13.2	61.5	0.0	54.9	23.3	517.1
94	9.3	23.7	34.0	37.5	127.4	155.1	3.7	7.0	14.8	73.5	14.7	0.4	501.1
95	0.0	0.2	165.1	97.3	135.8	252.0	140.2	10.9	1.1	4.5	32.1	55.8	895.0
Ave.	7.1	22.4	52.5	87.0	125.4	186.4	59.1	18.7	46.1	59.4	22.3	16.7	703.2
Max.	39.9	90.1	165.1	233.4	254.3	530.9	469.9	98.8	297.9	183.1	94.0	111.0	
Min.	0.0	0.0	1.8	14.0	48.8	3.4	0.0	0.0	0.0	0.0	0.0	0.0	

Table B-3 Monthly Rainfall Data (2/8)

Project : Ashaiman
Station No. :
Station Name : Ashaiman (IDC)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1992	0.0	0.0	106.2	62.2	150.5	40.3	32.2	4.6	22.1	25.2	4.3	14.1	461.7
93	4.5	2.1	4.8	46.5	106.3	142.4	1.8	18.0	69.2	59.8	34.0	4.5	493.9
94	14.0	4.3	76.8	9.5	136.4	201.1	3.5	14.1	52.4	95.9	32.0	0.0	640.0
95	0.0	4.5	154.9	144.0	89.7	177.1	193.2	39.3	5.1	55.7	53.3	0.1	916.9
96	0.0	27.0	48.5	117.0	170.1	62.4							
Ave.	3.7	7.6	78.2	75.8	130.6	124.7	57.7	19.0	37.2	59.2	30.9	4.7	629.2
Max.	14.0	27.0	154.9	144.0	170.1	201.1	193.2	39.3	69.2	95.9	53.3	14.1	
Min.	0.0	0.0	4.8	9.5	89.7	40.3	1.8	4.6	5.1	25.2	4.3	0.0	

Table B-3 Monthly Rainfall Data (3/8)

Project : Aveyime
Station No. : 07003AKU
Station Name : Akuse

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1960	8.4	23.6	128.0	107.4	76.7	263.9	42.2	49.8	191.8	142.5	80.0	36.1	1,150.4
61	19.8	0.5	58.9	158.2	27.7	240.3	140.2	0.3	164.3	146.1	101.1	8.1	1,065.5
62	30.0	48.8	18.9	235.0	227.1	286.0	128.8	64.5	31.5	101.3	90.9	49.5	1,312.3
63	18.3	76.5	77.2	212.3	277.6	244.9	87.6	108.2	150.4	63.2	132.1	2.8	1,451.1
64	10.7	0.0	79.8	186.4	73.6	302.8	42.2	11.9	16.3	62.0	64.5	13.7	863.9
65	12.2	53.1	126.0	207.5	95.8	364.0	144.8	31.0	148.6	105.7	99.3	45.5	1,433.5
66	62.2	0.5	103.1	77.2	149.9	246.6	167.1	35.6	233.9	146.3	58.4	47.8	1,328.6
67	9.1	51.3	167.4	94.5	182.4	329.2	51.3	10.7	232.9	77.2	96.0	28.2	1,330.2
68	2.8	89.4	71.1	337.1	182.1	252.5	284.5	222.5	260.1	178.1	67.1	14.0	1,961.3
69	82.3	19.6	47.5	76.5	143.8	331.5	105.2	63.8	24.4	259.3	90.7	49.0	1,293.6
1970	46.0	104.4	53.1	87.1	392.2	82.6	44.2	3.6	77.0	104.6	182.1	0.0	1,176.9
71	0.5	51.3	84.1	79.8	48.5	96.5	62.7	57.4	156.5	199.4	28.4	9.9	875.0
72	0.0	127.0	93.3	196.6	180.1	259.3	49.5	2.5	45.7	94.7	162.6	45.2	1,256.5
73	0.0	35.6	50.8	118.9	135.1	204.2	30.7	66.0	200.7	179.6	95.3	30.0	1,146.9
74	15.7	49.5	190.2	30.0	164.8	206.5	126.7	41.7	214.6	130.0	43.9	16.3	1,229.9
75	0.0	12.4	126.2	149.9	141.2	191.3	152.9	6.9	69.9	137.9	134.1	6.1	1,128.8
76	44.2	73.1	98.5	121.7	75.4	110.7	3.1	133.5	51.7	156.7	31.5	38.4	938.5
77	21.9	76.9	0.8	30.2	71.8	73.7	11.2	1.0	143.0	88.7	37.6	6.4	563.2
78	2.8	192.9	119.3	269.4	131.3	120.2	2.8	13.5	62.1	192.2	59.6	3.3	1,169.4
79	0.0	93.4	155.5	30.0	139.4	185.4	158.0	44.0	186.8	46.5	93.2	3.8	1,136.0
1980	0.3	39.6	75.6	67.5	198.6	63.2	95.4	111.6	276.7	109.8	116.4	0.0	1,154.7
81	5.1	83.5	54.4	52.3	147.2	320.4	98.7	48.9	189.4	113.4	130.0	7.4	1,250.7
82	8.4	75.8	85.8	123.4	101.8	209.3	57.2	75.2	12.0	111.8	31.3	42.7	934.7
83	0.0	0.0	0.0	87.4	41.4	225.0	12.5	0.0	66.8	85.0	12.8	41.1	572.0
84	2.8	7.9	165.0	108.0	259.3	113.5	135.2	98.8	174.2	139.6	37.2	40.3	1,281.8
85	0.0	30.0	83.1	56.4	121.1	120.3	202.3	63.6	151.5	224.4	38.5	0.0	1,091.2
86	0.8	57.4	123.1	102.3	220.5	79.9	42.0	22.9	113.4	94.5	31.2	0.0	888.0
87	1.3	4.1	117.4	84.4	82.1	60.9	38.6	139.0	187.9	87.6	67.0	12.7	883.0
88	0.3	26.2	49.2	145.4	145.3	174.3	57.8	54.6	122.1	123.0	64.6	44.7	1,007.5
89	0.0	0.3	102.0	116.1	143.5	241.3	117.1	53.5	197.4	164.1	125.3	43.1	1,303.7
1990	15.0	58.2	71.9	116.6	118.2	140.8	51.7	1.3	100.0	93.7	59.1	85.2	911.7
Ave.	14.0	52.1	92.6	128.9	149.9	204.7	91.5	54.6	141.8	132.0	82.1	25.7	1,169.7
Max.	82.3	192.9	190.2	337.1	392.2	364.0	284.5	222.5	276.7	259.3	182.1	85.2	
Min.	0.0	0.0	0.0	30.0	27.7	60.9	2.8	0.0	12.0	46.5	12.8	0.0	

Table B-3 Monthly Rainfall Data (4/8)

Project : Aveyime
Station No. : 07034AVE
Station Name : Aveyime

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1980	0.0	38.6	57.2	99.5	221.3	87.1	22.3	41.7	65.4	101.4	198.9	9.4	942.8
81	2.3	81.8	44.5	32.0	125.0	191.9	47.8	46.6	122.1	67.7	55.0	13.5	830.2
82	2.1	65.5	91.3	100.6	72.0	206.9	63.1	8.4	1.0	101.4	62.5	0.0	774.8
83													
84	0.0	3.8	83.1	66.8	274.8	88.7	199.4	39.2	67.1	140.2	39.1	49.8	1,052.0
85	0.0	2.3	145.4	64.8	158.4	112.3	119.3	28.0	50.6	147.4	49.0	0.0	877.5
86	0.0	61.5	183.2	111.3	119.6	0.0	15.3	2.6	81.5	112.8	35.6	0.0	723.4
87	3.1	6.6	159.8	68.4	166.4	33.3	56.3	169.1	78.3	85.9	2.6	24.6	854.4
88	0.0	68.6	91.8	113.8	154.2	166.6	22.9	8.7	170.9	94.7	86.4	0.0	978.6
89	0.0	19.1	28.9	128.8	75.7	216.3	111.0	20.4	215.3	113.9	48.3	18.3	996.0
1990	0.0	11.5	84.8	128.3	118.4	176.8	131.1	9.2	110.7	73.3	41.0	76.1	961.2
91	17.0	14.2	26.7	206.5	171.9	82.1	154.6	5.2	35.2	167.1	24.1	0.5	905.1
92													
93													
94	0.0	53.8	36.1	43.3	157.3	72.2	26.9	24.7	116.3	124.7	148.3	0.0	803.6
95	0.0	0.3	109.3	309.6	101.8	311.2	118.2	45.2	85.4	159.8	46.3	14.5	1,301.6
96	26.3	118.6	107.3	185.5	221.9								
Ave.	3.6	39.0	89.2	118.5	152.8	134.3	83.7	34.5	92.3	114.6	64.4	15.9	942.9
Max.	26.3	118.6	183.2	309.6	274.8	311.2	199.4	169.1	215.3	167.1	198.9	76.1	
Min.	0.0	0.3	26.7	32.0	72.0	0.0	15.3	2.6	1.0	67.7	2.6	0.0	

Table B-3 Monthly Rainfall Data (5/8)

Project : Kpando-Torkor
Station No. : 07017HO
Station Name : Ho

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1961	8.1	10.2	80.3	136.9	196.9	289.3	165.6	23.6	91.9	128.0	83.3	70.1	1,284.2
62	32.8	16.3	40.9	159.8	376.2	374.4	179.8	87.1	24.4	179.1	57.4	22.4	1,550.6
63	96.5	112.0	144.0	163.0	78.2	162.8	425.7	226.1	235.5	312.9	56.9	40.4	2,054.0
64	50.0	29.5	134.4	110.5	289.6	302.5	207.3	15.2	97.5	60.5	45.7	28.4	1,371.1
65	20.6	98.6	282.7	251.0	207.3	267.7	83.3	146.1	157.7	97.0	32.8	26.2	1,671.0
66	23.1	31.0	106.2	83.6	190.2	152.9	132.8	155.4	112.0	103.9	105.4	61.5	1,258.0
67	0.5	20.6	173.0	180.8	105.9	309.9	56.6	77.7	161.5	51.4	37.8	26.2	1,201.9
68	114.3	98.8	99.3	86.6	97.5	315.5	261.4	241.0	254.3	205.7	37.8	9.9	1,822.1
69	0.3	121.2	75.4	72.6	225.0	298.7	133.1	69.9	101.6	245.4	28.4	91.7	1,463.3
1970	15.5	24.4	164.8	133.9	219.5	91.4	58.4	6.4	193.5	233.7	36.1	0.0	1,177.6
71	40.9	58.4	147.6	150.1	153.7	137.9	127.0	153.7	223.8	55.1	29.5	79.8	1,357.5
72	19.1	72.6	108.5	185.2	183.6	141.2	52.6	32.8	51.3	162.3	52.1	97.5	1,158.8
73	6.4	28.2	62.5	101.6	141.5	282.4	71.1	169.7	245.6	134.9	6.4	90.9	1,341.2
74	44.7	17.5	103.9	86.6	197.6	274.3	140.7	76.2	313.7	106.4	15.5	9.7	1,386.8
75	0.0	68.1	120.4	179.1	133.9	195.6	156.5	21.1	123.2	182.1	108.7	6.9	1,295.6
76	3.6	198.9	97.8	80.0	96.6	220.3	39.6	29.6	98.1	204.4	109.4	70.2	1,248.5
77	1.1	33.0	14.0	108.0	155.7	51.5	49.0	42.7	80.8	196.1	14.8	20.2	766.9
78	15.2	102.5	128.6	164.8	136.8	194.2	8.2	51.9	116.8	186.3	77.5	27.2	1,210.0
79	68.3	34.9	122.5	43.8	341.9	193.8	142.4	67.8	125.3	178.5	95.9	0.0	1,415.1
1980	14.1	177.2	24.1	224.0	228.2	117.0	114.2	110.1	134.1	269.4	16.9	0.0	1,429.3
81	39.4	46.9	121.9	73.4	278.6	89.5	101.8	105.0	120.4	319.8	50.0	0.0	1,346.7
82	43.4	137.2	104.0	51.4	93.4	179.7	99.1	87.6	47.5	230.1	30.7	37.1	1,141.2
83	0.0	9.1	20.3	132.0	147.9	155.3	139.0	19.4	163.4	143.8	49.0	31.0	1,010.2
84	0.0	35.3	265.1	6.9	158.4	180.9	189.4	205.5	87.0	154.8	53.3	0.0	1,336.6
85	16.0	6.9	111.7	90.7	126.9	129.5	283.6	179.2	123.6	136.9	130.6	2.8	1,338.4
86	2.1	212.7	100.2	125.7	186.8	117.3	200.6	21.0	62.1	154.1	45.5	0.0	1,228.1
87	8.5	17.1	155.9	119.3	247.5	134.1	110.9	254.1	206.3	124.6	23.0	7.7	1,409.0
88	21.4	77.5	187.8	174.1	148.6	223.1	134.7	40.3	166.3	83.6	44.7	80.1	1,382.2
89	0.0	5.8	215.8	115.4	150.7	346.4	140.2	148.5	142.2	121.3	43.6	8.6	1,438.5
1990	14.6	36.5	23.1	224.7	123.4	115.8	115.1	21.1	203.0	147.9	39.1	103.4	1,167.7
Ave.	24.0	64.6	117.9	127.2	180.6	201.5	137.3	96.2	142.1	163.7	51.9	35.0	1,342.1
Max.	114.3	212.7	282.7	251.0	376.2	374.4	425.7	254.1	313.7	319.8	130.6	103.4	
Min.	0.0	5.8	14.0	6.9	78.2	51.5	8.2	6.4	24.4	51.4	6.4	0.0	

Table B-3 Monthly Rainfall Data (6/8)

Project : Kpando-Torkor
Station No. : 07017KPA
Station Name : Kpando

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1976	1.0	51.1	115.9	121.9	185.5	153.9	150.4	55.3	177.8	283.3	112.1	2.8	1,411.0
77	59.8	6.3	14.5	63.2	100.3	113.8	28.2	26.7	138.7	147.4	0.0	3.3	702.2
78	31.0	61.9	127.4	122.7	133.9	98.4	97.2	57.4	145.5	91.5	116.6	5.3	1,088.8
79	44.4	35.3	73.6	85.3	225.0	174.9	300.0	139.6	218.8	192.3	54.3	9.1	1,552.6
1980	0.0	21.9	70.8	81.3	151.0	108.8	133.1		219.6	197.9	68.4	16.0	
81	14.2		53.3	83.6	148.0	144.5	244.6	216.1	109.2	129.6	9.1		
82	0.0	7.5	38.1	59.3	124.9	246.9	69.8	98.7	47.3	70.8	34.0	5.6	802.9
83	0.0	5.3	53.3	94.9	120.2	163.4	43.4	36.8	140.4	72.9	24.6	59.9	815.1
84	0.0	3.6	172.4	344.4	89.4	128.0	197.1	146.9	65.1	0.0	24.6	59.9	1,231.4
85	25.9	33.3	66.7	124.2	21.4	185.0	289.1	188.4	306.1	51.9	101.0	12.9	1,405.9
86	0.0	17.4	24.4	159.3	155.7	165.4	128.3	42.4	149.7	156.4	20.2	12.9	1,032.1
87	0.0	45.8	77.9	76.1	77.8	164.1	103.7	305.0	207.5	108.8	23.1	9.2	1,199.0
88	0.0	2.8	63.2	66.9	113.4	116.2	350.5	57.7	257.2	97.9	29.4	17.7	1,172.9
89	0.0	56.6	58.7	0.0	99.7	250.5	192.6	278.1	176.4	165.7	3.4	20.1	1,301.8
1990	10.1	4.4	16.2	213.9	117.8	204.1	412.2	88.0	179.4	181.9	37.8	50.5	1,516.3
91	0.0	40.4	57.6	130.2	217.3	114.3	312.8	120.6	134.2	174.3	50.1	25.6	1,377.4
92	0.0	0.0	45.2	106.5	240.2	101.1	181.3	102.6	215.6	111.5	55.5	13.4	1,172.9
93	0.0	3.1	61.0	111.1	85.3	194.7	171.7	141.9	141.7	210.2	110.8	26.8	1,258.3
94	9.3	11.6	70.9	107.1	98.7	172.3	83.3	449.7	224.8	147.6	34.7	0.0	1,410.0
95	0.0	50.8	104.0	129.6	197.6	210.7	209.4	243.4	182.4	136.4	30.7	18.7	1,513.7
Ave.	9.8	24.2	68.3	114.1	135.2	160.6	184.9	147.1	171.9	136.4	47.0	19.5	1,218.8
Max.	59.8	61.9	172.4	344.4	240.2	250.5	412.2	449.7	306.1	283.3	116.6	59.9	
Min.	0.0	0.0	14.5	0.0	21.4	98.4	28.2	26.7	47.3	0.0	0.0	0.0	

Table B-3 Monthly Rainfall Data (7/8)

Project : Mankessim
Station No. : 23022SAL
Station Name : Saltpond

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1961	31.5	8.6	54.9	104.4	414.3	430.5	73.4	1.0	10.7	1.5	70.6	8.1	1,209.5
62	73.9	14.5	32.0	19.6	185.7	839.9	18.3	24.9	38.3	177.0	179.3	54.1	1,657.5
63	37.6	10.7	11.9	197.6	120.9	319.5	392.6	62.2	20.8	68.6	159.5	8.4	1,410.3
64	27.4	26.4	20.6	239.0	247.9	626.1	11.9	16.5	16.0	0.3	10.4	1.5	1,244.0
65	0.0	32.3	24.6	254.0	190.2	248.9	65.0	27.4	36.6	53.9	106.2	37.1	1,076.2
66	6.6	3.3	80.8	129.3	204.9	74.2	200.4	51.6	17.8	31.7	53.9	26.9	881.4
67	20.8	6.6	47.2	89.9	211.8	552.7	5.3	13.5	78.7	13.2	58.7	3.3	1,101.7
68	44.7	56.6	29.7	72.4	132.1	258.8	369.0	167.9	122.2	159.5	80.8	0.0	1,493.7
69	1.5	11.7	82.0	17.5	188.9	342.1	52.8	11.9	23.1	231.1	37.6	74.4	1,074.6
1970	13.2	11.2	48.8	101.3	323.1	225.0	15.2	10.9	10.4	94.7	34.3	10.2	898.3
71	25.4	12.2	44.5	170.9	73.4	546.1	117.9	23.6	16.0	0.0	20.8	12.9	1,063.7
72	0.0	69.6	122.9	154.9	55.4	294.4	19.8	9.1	24.6	48.5	33.5	51.1	883.8
73	1.3	12.7	137.4	72.1	219.7	393.7	78.2	92.7	91.2	105.9	1.3	51.3	1,257.5
74	11.4	61.0	80.0	99.1	260.9	668.5	75.9	80.8	217.9	58.9	5.1	34.3	1,653.8
75	0.0	52.1	81.5	52.3	170.9	231.6	57.9	15.0	4.3	33.0	102.4	4.1	805.1
76	0.0	121.9	59.2	177.1	98.2	85.7	7.0	77.8	4.3	16.3	99.0	5.7	752.2
77	21.9	42.0	21.6	142.5	99.7	199.2	8.1	13.2	10.1	44.9	12.2	0.3	615.7
78	1.4	11.2	10.0	151.6	155.8	105.1	38.4	4.5	21.1	48.1	83.6	18.6	649.4
79	0.0	41.1	65.9	124.9	197.8	378.0	74.3	113.0	74.8	311.3	94.0	3.5	1,478.6
1980	0.4	12.5	90.8	55.6	354.9	133.7	113.9	43.4	60.0	156.7	124.9	0.8	1,147.6
81	4.9	7.4	66.5	27.3	387.6	256.1	33.3	31.0	88.6	79.3	32.2	65.3	1,079.5
82	10.3	35.5	69.4	154.5	338.5	351.3	116.7	10.9	0.6	171.9	10.7	11.7	1,282.0
83	0.0	0.0	0.0	19.0	230.9	86.2	3.7	7.0	26.4	10.0	69.6	17.4	470.2
84	35.3	0.0	7.8	94.0	156.8	88.8	34.0	63.5	66.7	121.0	26.1	11.0	705.0
85	54.6	28.1	63.7	75.1	465.0	321.7	38.2	15.9	24.1	45.4	35.6	0.0	1,167.4
86	4.3	50.7	32.5	72.9	141.0	334.8	32.1	10.3	7.9	87.0	119.3	13.4	906.2
87	9.5	0.0	113.0	42.2	85.0	31.7	67.7	108.9	374.9	217.2	34.1	42.6	1,126.8
88	0.0	18.7	60.9	30.9	176.6	234.1	35.5	11.8	129.2	167.9	20.5	23.9	910.0
89	10.6	5.2	121.8	88.7	195.4	314.1	46.3	16.0	24.4	82.8	2.2	0.0	907.5
1990	7.0	0.6	60.4	53.4	59.5	108.1	25.7	2.4	33.3	120.9	25.1	97.7	594.1
91	39.3	13.5	0.0	118.2	433.8	108.1	259.5	51.3	52.5	57.0	1.0	0.0	1,134.2
92	0.0	5.6	62.0	82.7	136.5	156.3	21.0	5.2	54.6	28.9	24.0	24.8	601.6
93	17.0	27.1	73.9	45.5	57.6	143.9	1.6	21.6	65.6	41.3	44.3	14.6	554.0
94	30.4	27.6	102.0	48.6	275.3	196.1	13.9	11.7	85.5	173.0	80.1	2.5	1,046.7
95	0.0	0.0	93.3	222.9	225.7	242.1	154.9	42.6	22.9	23.5	43.5	4.3	1,075.7
Ave.	15.5	23.9	59.2	102.9	207.8	283.6	76.6	36.3	55.9	88.1	55.3	21.0	1,026.2
Max.	73.9	121.9	137.4	254.0	465.0	839.9	392.6	167.9	374.9	311.3	179.3	97.7	
Min.	0.0	0.0	0.0	17.5	55.4	31.7	1.6	1.0	0.6	0.0	1.0	0.0	

Table B-3 Monthly Rainfall Data (8/8)

Project : Okyereko
Station No. :
Station Name : Okyereko

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1978	0.0	11.2	3.2	104.2	151.2	112.6	22.6	7.0	6.1	99.8	40.1	22.1	580.1
79	0.0	53.3	70.5	65.5	158.5	304.2	63.3	72.3	68.6	226.1	117.2	22.1	1,221.6
1980	6.9	19.6	36.5	137.7	205.6	227.4	81.5	64.6	69.6	104.8	45.4	9.4	1,009.0
81	13.0	31.6	64.8	95.6	319.1	226.0	20.4	55.9	76.1	44.1	7.5	15.0	969.1
82	23.9	0.0	69.9	173.6	219.4	54.2	92.9	0.0	2.5	99.4	19.9	30.3	786.0
83	0.0	0.0	22.0	47.0	76.2	109.2	0.0	15.9	45.6	0.0	69.1	54.7	439.7
84	31.9	0.0	0.0	128.1	136.9	75.9	60.0	30.3	38.3	110.9	35.6	7.4	655.3
85	16.1	0.0	105.0	3.1	550.7	139.6	122.9	54.6	27.7	88.0	44.7	1.7	1,154.1
86	34.0	5.2	27.6	44.9	137.1	143.7	107.1	0.0	25.0	87.3	24.5	6.3	642.7
87	5.7	0.0	184.4	46.5	110.2	92.1	63.9	154.2	214.0	158.0	4.0	18.7	1,051.7
88	0.0	121.6	39.7	40.2	112.2	165.8	32.2	12.5	50.2	97.4	22.7	14.8	709.3
89	0.0	21.7	66.0	63.3	155.1	231.8	11.4	60.5	42.0	62.8	10.6	0.0	725.2
1990	0.0	31.0	6.0	58.3	14.4	331.8	49.4	3.0	41.0	98.4	21.8	127.8	782.9
91	51.4	52.4	40.5	134.8	289.8	74.8	74.6	232.0	20.9	29.6	53.5	5.2	1,059.5
92	0.0	0.0	4.6	29.2	195.3	43.0	45.0	4.0	53.0	47.0	93.0	28.4	542.5
93	31.4	24.5	2.7	62.4	0.0	170.9	11.5	34.4	100.2	82.7	79.3	18.3	618.3
94	32.5	9.0	48.3	12.7	147.8	255.5	33.0	31.1	67.4	66.1	40.1	0.0	743.5
95	0.0	20.0	45.2	32.1	128.2	189.1	85.5	0.0	0.0	67.0			
Ave.	13.7	22.3	46.5	71.1	172.7	163.8	54.3	46.2	52.7	87.2	42.9	22.5	795.7
Max.	51.4	121.6	184.4	173.6	550.7	331.8	122.9	232.0	214.0	226.1	117.2	127.8	
Min.	0.0	0.0	0.0	3.1	0.0	43.0	0.0	0.0	0.0	0.0	4.0	0.0	

Table B-4 Maximum Daily and 3-Day Rainfall

Year	Maximum One (1) Day Rainfall (mm)			
	Ashaiman	Aveyime	Kpando	Mankessim/Okyereko
1976	56.4		115.1	56.4
1977	66.5		50.0	108.2
1978	53.1		52.8	50.5
1979	75.9		82.8	81.3
1980	121.9	50.5	56.1	84.4
1981	114.2	60.7	73.1	115.8
1982	86.1	65.5	52.6	84.8
1983	54.8	N.A.	50.8	72.6
1984	56.4	102.1	213.8	70.9
1985	60.5	82.8	106.7	121.8
1986	43.6	62.7	78.0	132.0
1987	78.8	104.1	85.6	119.7
1988	78.5	68.1	119.5	123.3
1989	41.5	58.9	86.1	67.2
1990	74.5	71.1	91.9	48.3
1991	88.6	82.0	85.8	163.3
1992	88.3	N.A.	77.2	125.5
1993	81.0	N.A.	50.4	67.9
1994	70.7	50.8	234.3	105.5
1995	129.4	137.4	87.3	97.5
R.P.	Frequency Analysis			
2 Years	72.4	70.4	76.9	93.5
5 Years	94.4	92.6	116.8	120.5
10 Years	108.5	109.6	152.9	135.4

Year	Maximum Three (3) Days Continuous Rainfall (mm)			
	Ashaiman	Aveyime	Kpando	Mankessim/Okyereko
1976	83.1		118.7	76.5
1977	84.8		72.2	141.5
1978	109.5		67.8	134.1
1979	91.2		92.2	139.0
1980	123.9	64.6	82.8	128.2
1981	126.1	71.9	88.9	136.9
1982	113.8	88.2	92.0	105.9
1983	58.9	N.A.	56.6	110.7
1984	75.5	186.6	213.8	70.9
1985	60.5	120.4	117.8	151.1
1986	58.2	72.6	104.4	134.6
1987	153.8	106.9	121.7	201.4
1988	86.7	84.3	226.9	141.3
1989	69.0	102.6	121.4	106.5
1990	74.5	94.5	165.3	68.8
1991	88.6	85.6	95.9	164.1
1992	90.2	N.A.	90.7	138.9
1993	81.3	N.A.	89.2	91.9
1994	75.3	62.5	269.4	105.5
1995	138.5	202.4	105.3	146.3
Frequency Analysis				
2 Years	87.6	91.5	105.7	121.0
5 Years	111.9	127.3	152.0	152.3
10 Years	128.0	156.1	187.5	171.4

Table B-5 Results of Runoff Study at Ashaiman Project

Year	Month	Rainfall	Evaporation		Intake	Runoff		
		(mm)	(mm)	(m^3)	(m^3)	(m^3)	(mm)	(%)
1994	Feb.	4.3	199.5	122,193	0	20,952	0.254	5.9
	Mar.	76.8	218.3	126,980	0	190,108	2.307	3.0
	Apr.	9.5	235.1	124,583	0	30,351	0.368	3.9
	May	136.4	160.8	80,583	0	200,267	2.430	1.8
	Jun.	200.7	111.3	98,044	41,429	1,447,279	17.436	8.7
	Jul.	3.5	137.9	127,824	36,598	66,674	0.809	23.1
	Aug.	14.1	125.6	110,068	61,592	45,586	0.553	3.9
	Sep.	49.8	132.8	109,222	106,067	109,320	1.237	2.5
	Oct.	121.7	150.6	119,593	39,377	179,508	2.178	1.8
	Nov.	56.9	157.4	116,885	121,068	66,312	0.790	1.4
	Dec.	0.0	165.9	110,834	133,589	23,295	0.283	-
	Sub-total	673.7	1,795.2	1,246,809	539,719	2,379,654	28.647	4.3
1995	Jan.	0.0	174.4	100,941	113,296	22,382	0.272	-
	Feb.	4.5	217.4	113,037	95,348	85,115	0.802	17.8
	Mar.	126.9	218.4	109,625	10,811	234,824	2.850	2.2
	Apr.	96.5	129.4	66,187	0	65,978	0.799	0.8
	May	89.7	132.1	69,603	0	193,725	2.351	2.6
	Jun.	200.6	99.4	61,603	0	820,917	9.963	5.0
	Jul.	218.7	106.8	171,683	0	4,825,991	58.488	26.7
	Aug.	34.7	103.7	176,398	0	74,985	0.893	2.6
	Sep.	25.8	143.9	237,555	0	735,809	8.930	34.6
	Oct.	51.7	181.9	295,027	30,780	154,530	1.867	3.6
	Nov.	40.4	121.6	194,013	46,040	157,056	1.906	4.7
	Dec.	13.0	129.3	200,184	46,296	42,409	0.515	4.0
	Sub-total	902.5	1,758.3	1,795,856	342,571	7,413,721	89.636	9.9
1996	Jan.	0.0	138.0	205,662	23,904	95,272	1.156	-
	Feb.	28.2	173.7	250,219	77,076	140,910	1.710	6.1
	Mar.	98.3	208.8	293,088	16,693	284,622	3.361	3.4
	Apr.	70.2	161.0	224,863	71,267	233,612	2.835	4.0
	May	239.9	138.9	191,327	-	802,154	9.316	3.9
	Jun.	166.2	133.3	208,184	-	890,880	10.632	6.4
	Sub-total	602.8	953.7	1,373,343	188,941	2,447,451	29.011	4.8
	Total	2,179.0	4,507.2	4,416,009	1,071,230	12,240,826	147.294	6.8

Table B-6 Water Level and Discharge at Kpong Dam Tail Side

Year	Minimum Water Level (m) A.S.L.												
	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep..	Oct.	Nov.	Dec.	Year
1996	2.98	3.35	3.50	3.49	3.10	3.10							2.98
1995	3.50	3.00	3.00	3.00	3.05	3.35	3.30	3.30	3.35	3.15	3.10	3.20	3.00
1994	3.60	3.75	3.75	3.65	3.60	3.60	3.50	3.00	3.00	2.52	2.50	3.30	2.50
1993	3.25	3.30	3.50	3.50	3.50	3.05	3.50	3.50	3.50	3.50	3.50	3.50	3.05
1992	2.55	3.05	3.00	2.95	2.85	2.65	2.65	2.80	3.30	3.40	3.30	3.50	2.55
1991	2.90	3.50	3.50	3.50	3.00	2.75	2.90	2.50	2.50	2.35	2.90	2.65	2.35
1990	2.60	2.75	2.80	2.50	2.90	2.75	2.75	3.00	2.80	2.85	2.70	3.00	2.50
1989	2.99	2.55	3.00	3.00	2.90	2.70	3.00	2.80	2.50	2.55	2.50	2.50	2.50
1988	2.60	2.70	2.55	2.70	2.80	3.00	2.55	2.75	1.75	2.45	2.60	2.80	1.75
1987	2.70	2.70	2.75	2.65	2.80	2.80	2.60	2.60	2.50	2.20	2.25	2.60	2.20
1986	2.20	2.40	2.40	2.40	2.45	2.07	2.10	2.55	2.50	2.45	2.50	2.50	2.07
1985	1.55	1.55	1.50	1.80	2.00	2.10	1.90	1.90	1.75	1.90	2.00	2.00	1.50
1984	0.90	0.90	0.90	0.85	1.00	1.00	1.00	1.10	1.46	1.50	1.25	1.55	0.85
1983	1.80	1.75	1.60	1.75	1.72	1.64	1.60	1.60	1.55	1.55	1.70	0.80	0.80
1982	2.30	2.40	2.40	2.30	2.25	2.40	2.50	2.40	2.48	2.50	2.25	2.30	2.25
1981					2.50	2.55	2.50	2.20	2.45	2.26	2.40	2.35	2.20

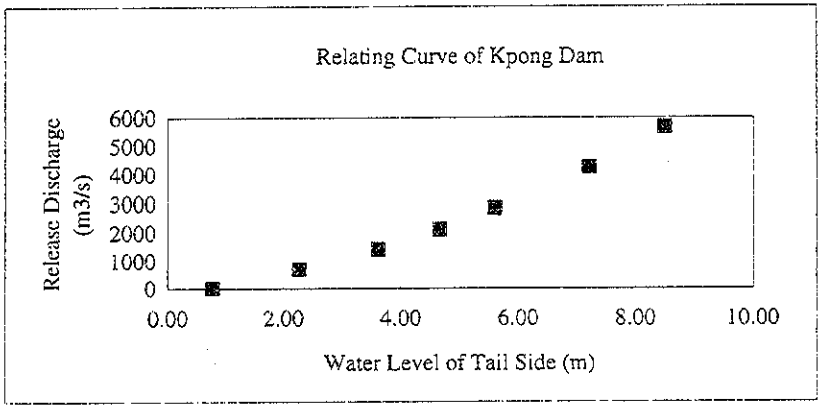
Year	Minimum Release Discharge (m3/s)												
	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep..	Oct.	Nov.	Dec.	Year
1996	1083	1279	1358	1353	1147	1147							1083
1995	1358	1094	1094	1094	1120	1279	1252	1252	1279	1173	1147	1199	1094
1994	1411	1490	1490	1437	1411	1411	1358	1094	1094	840	830	1252	830
1993	1226	1252	1358	1358	1358	1120	1358	1358	1358	1358	1358	1358	1120
1992	856	1120	1094	1067	1014	909	909	988	1252	1305	1252	1358	856
1991	1041	1358	1358	1358	1094	962	1041	830	830	750	1041	909	750
1990	882	962	988	830	1041	962	962	1094	988	1014	935	1094	830
1989	1088	856	1094	1094	1041	935	1094	988	830	856	830	830	830
1988	882	935	856	935	988	1094	856	962	463	803	882	988	463
1987	935	935	962	909	988	988	882	882	830	675	699	882	675
1986	675	777	777	777	803	614	628	856	830	803	830	830	614
1985	368	368	345	486	581	628	533	533	463	533	581	581	345
1984	61	61	61	38	109	109	109	156	326	345	227	368	38
1983	486	463	392	463	448	411	392	392	368	368	439	14	14
1982	724	777	777	724	699	777	830	777	819	830	699	724	699
1981					830	856	830	675	803	703	777	750	675

Frequency Analysis

Year	Minimum Water Level (m) A.S.L.												
	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep..	Oct.	Nov.	Dec.	Year
1/2	2.51	2.63	2.53	2.59	2.62	2.50	2.50	2.53	2.47	2.45	2.46	2.52	2.06
1/5	1.90	1.98	1.82	1.93	2.06	1.92	1.92	2.00	1.94	1.98	1.98	1.89	1.47
1/10	1.60	1.65	1.54	1.63	1.78	1.67	1.73	1.72	1.68	1.75	1.75	1.60	1.23

Year	Minimum Discharge (m3/s)												
	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep..	Oct.	Nov.	Dec.	Year
1/2	835	898	845	877	893	830	830	845	814	803	808	840	609
1/5	533	571	496	548	609	543	543	581	552	571	571	529	330
1/10	392	415	363	406	477	425	453	448	430	463	463	392	217

Note : Release discharge from Kpong dam is calculated on the basis of relating curve given below.



H (m)	Q (m3/s)
0.77	0
2.27	708
3.61	1416
4.67	2124
5.60	2832
7.21	4248
8.50	5663

Table B-7 Monthly Discharge in Ochi-Amisa at Mankessim

Discharge Units: m3/s

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	YEAR
56	23.08	36.10	7.99	113.72	14.64	2.41	11.61	26.05	30.87	16.42	1.98	1.13	23.75
57	1.98	8.21	23.79	19.60	28.06	8.41	10.53	11.50	6.97	8.75	1.33	2.07	11.00
58	1.44	1.19	8.50	19.34	2.04	0.82	0.74	2.32	2.10	2.01	0.74	0.34	3.46
59	1.22	3.57	18.97	30.44	23.02	2.75	2.46	11.44	17.24	6.34	1.36	1.27	10.04
60	1.81	18.80	7.56	25.74	12.71	5.38	2.38	19.34	17.64	7.73	2.49	0.99	10.23
61	0.99	6.91	2.89	57.26	41.94	6.80	3.68	9.20	9.94	4.30	2.10	1.22	12.28
62	2.63	4.05	9.37	71.39	16.31	12.15	4.30	13.11	27.92	14.70	4.90	2.83	15.28
63	2.89	10.85	6.26	15.57	42.16	24.15	28.06	55.73	20.70	12.91	2.49	1.30	18.73
64	4.73	6.77	7.76	43.35	3.51	6.37	2.21	1.70	2.61	2.46	2.61	1.36	7.09
65	8.72	5.27	5.35	45.08	16.79	6.51	10.22	6.71	4.81	1.84	1.30	1.93	9.53
66	1.27	2.12	11.67	10.56	26.45	10.85	14.87	14.44	11.72	8.27	1.87	0.71	9.64
67	1.02	5.10	5.95	33.98	12.18	3.68	7.65	8.50	6.51	3.40	3.11	2.55	7.78
68	1.84	5.80	10.76	32.28	66.54	28.20	72.60	35.74	17.50	12.06	5.49	3.03	24.41
69	7.73	8.01	14.22	29.28	13.51	6.80	4.25	14.10	14.36	5.15	2.61	1.22	10.13
70	6.29	9.26	16.25	34.40	10.93	3.60	7.56	20.90	18.72	4.22	4.30	3.17	11.64
71	2.29	3.68	4.33	18.38	17.92	4.70	5.52	10.22	5.80	5.66	1.25	0.85	6.75
72	2.21	5.55	4.81	23.98	17.84	6.94	4.19	3.85	8.47	2.52	2.29	0.91	6.97
73	0.45	3.14	1.64	26.36	12.94	4.50	11.33	13.08	8.66	6.48	2.10	0.45	7.60
74	1.87	1.27	16.85	45.28	33.58	10.11	41.77	16.37	8.55	3.85	0.85	1.61	15.18
75	4.25	2.41	5.38	22.96	22.00	4.64	1.61	3.65	5.72	0.65	0.57	0.71	6.24
76	3.26	3.17	10.79	14.81	3.62	2.55	0.76	0.45	1.95	0.59	0.42	0.40	3.57
77	0.42	0.71	4.16	14.13	3.26	0.42	0.64	1.54	0.28	0.14	0.14	0.14	2.16
78	0.42	4.19	12.09					3.79	5.83	3.06	3.45	2.07	
79	2.15	2.55	4.87	62.67	57.54	14.19	31.74	30.98	23.39	16.99	6.23	5.21	21.58
80	5.21	5.18	19.20	55.56	20.81								
86	2.83	4.62	4.11	12.32	10.02	2.52	2.44	6.29	5.89	2.24	0.28	0.14	4.49
87			1.99	3.28	5.71	21.68	80.70	58.70	6.95	2.51	1.20	1.13	
88	2.21	3.03	3.57	12.46	16.74	2.24	10.19	28.97	9.46	3.94			
89		1.36	3.79	14.50	46.98	8.64	12.49	16.71	0.62	3.91	1.98	1.13	

Table B-8 Maximum Discharge in Ochi-Amsa at Mankessim

Discharge Units: m3/s

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	YEAR
71	4.30	13.11	8.47	47.03	54.82	7.16	13.22	18.26	10.51	12.37	1.76	1.27	54.82
72	6.46	17.73	13.05	65.84	82.23	16.00	13.34	10.99	17.08	7.48	6.97	5.01	82.23
73	3.45	10.42	3.88	85.21	58.59	20.08	35.68	24.13	19.74	21.44	5.97	0.54	85.21
74	6.46	4.79	73.65	79.32	124.11	28.46	209.37	23.16	12.91	8.52	1.76	7.28	209.37
75	12.60	4.79	22.12	65.84	56.38	9.85	2.86	10.14	24.10	21.10	1.10	3.26	65.84
76	10.42	8.78	17.41	23.16	9.32	13.51	1.76	0.96	5.01	1.93	0.42	0.42	23.16
77	0.42	3.88	13.96	85.21	10.00	0.42	4.11	7.48					85.21
78	0.42	5.97	60.97					6.97	9.60	5.01	6.20	2.27	60.97
86	7.22	10.42	6.20	37.29	54.17	3.26	3.45	20.42	10.42	2.66	0.00	0.00	54.17
87	0.00	57.48	3.26	19.06	23.53	59.78	203.43	191.79	14.27	3.26	1.76	1.93	203.43
88	4.22	9.06	9.85	34.15	88.32	3.06	22.46	126.15	17.41	5.49	0.00	0.00	126.15
89	0.00	2.86	4.73	52.07	116.21	19.74	28.46	48.03	11.55	5.97	3.68	1.42	116.21

Table B-9 Monthly Discharge in Ayensu at Winneba Road

Discharge Units: m3/s

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
62	1.98	3.34	8.75	42.08	36.39	14.05	4.22	7.59	13.17	11.38	4.59	4.59
63	5.44	14.22	10.28	14.53	36.98	32.96	42.08	44.83	19.43	9.66	6.57	5.21
64	7.22	11.13	16.06	31.29	12.54	4.53	7.36	4.11	3.71	4.22	2.92	4.50
65	4.13	4.79	5.47	39.98	28.46	13.00	15.94	24.61	4.08	4.70	2.89	2.27
66	2.27	4.76	11.10	11.30	16.51	14.44	12.29	15.21	17.98	16.51	2.78	1.98
67	3.54	6.85	7.76	44.57	15.97	4.90	10.22	11.24	8.47	4.30	3.94	3.31
68	4.98	3.57	6.12	35.74	46.84	74.61	111.57	60.31	22.80	12.32	5.80	5.66
69	7.79	9.91	8.44	45.02	14.53	8.64	5.13	6.06	10.65	4.56	3.62	2.24
70	5.69	4.70	14.02	19.06	4.45	2.01	5.27	13.90	14.41	2.86	2.61	1.78
71	2.01	1.84	2.58	13.62	8.86	4.30	5.10	10.02	3.28	2.69	1.25	1.16
72	3.79	3.65	3.17	21.97	12.60	4.87	4.67	3.37	6.03	2.44	1.16	0.76
73	0.71	1.13	1.16	9.77	6.54 *	7.73 *	10.82	7.56 *	3.34	1.78	0.93	0.25
74	2.29	1.95	8.38	52.24	82.80 *	51.65 *	41.23	16.14 *	9.09	4.08	1.13	2.12
75	4.13	1.59	3.45	15.29 *	18.12 *	4.02 *	2.32 *	3.51 *	5.78 *	3.06	0.42 *	1.36
76	5.24	5.04	4.64	9.68 *	5.07 *	1.19 *	0.59 *	1.08 *	5.30 *	1.64 *	0.91 *	0.54 *
77	0.62 *	0.34	4.84 *	14.64 *	3.11 *	0.96 *	1.56 *	6.17 *	3.00 *	2.07 *	0.57 *	0.82 *
78	1.16 *	4.59 *	11.21 *	23.22 *	1.78 *	0.88 *	0.99 *	1.44 *	1.30 *	0.54 *	0.42 *	
79	0.25 *	0.57 *	2.07 *	38.48 *	20.87 *	10.59 *	11.75 *	19.91 *	10.68 *	4.50 *	1.08 *	0.62 *
80	1.25 *	1.02 *	4.11 *				30.47 *			3.65 *	1.08 *	1.25 *
81	1.70 *	1.08 *	22.68 *	30.78 *				6.40 *		1.76 *		
82									4.25 *			
83												
84		1.27 *	2.24 *	18.60 *	16.25 *	20.64 *	4.84 *	8.72 *	4.70 *	1.56 *		0.34 *
85	0.74 *	0.85 *									0.03 *	0.17 *
86	0.14 *	1.44 *	0.25 *									
87						24.83 *	47.91 *					0.59 *
88	1.22 *	0.68 *	0.65 *	20.05 *	8.72 *		1.50 *	7.08 *	6.17 *	3.00 *	0.40 *	0.03 *
89	0.03 *	0.40 *	1.47 *	6.71 *	25.34 *	5.27 *	7.99 *		2.10 *	1.61 *	0.08 *	0.00 *
90	0.00 *	0.08 *	0.31 *	8.07 *					0.59 *	1.76 *	1.02 *	0.48 *
Frequency Analysis												
1/2	0.42	0.84	2.01	16.18	10.37	5.46	3.97	6.04	3.69	2.03	0.52	0.32
1/5	0.11	0.37	0.59	10.03	4.06	1.67	1.20	2.77	1.85	1.24	0.23	0.11
1/10	0.06	0.23	0.33	7.80	2.59	0.98	0.72	1.72	1.18	0.91	0.12	0.01

Note : Frequency Analysis is made on the basis of the * data

Table B-10 Runoff Estimate by Tank Model Method at Ashaiman in May 1987

Runoff Coefficient	C1=	1.2000	C2=	0.0350	C3=	0.0050	C4=	0.0020	C5= 0.0010
Height of Holes	Z1=	120.00	Z2=	10.00	Z3=	8.00	Z4=	5.00	
Percolation Coefficient	K1=	0.50	K2=	0.40	K3=	0.30	K4=	0.20	

Year	Month	Days	Rainfall (mm)	First Tank				Second Tank			Third Tank			Forth Tank			Estimated Total (mm)
				Depth (mm)	Runoff 1 (mm)	Runoff 2 (mm)	Percola. (mm)	Depth (mm)	Runoff 3 (mm)	Percola. (mm)	Depth (mm)	Runoff 4 (mm)	Percola. (mm)	Depth (mm)	Runoff 5 (mm)	Percola. (mm)	
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1987	5	1	17.5	21.623	0.000	0.407	10.812	20.229	0.061	8.091	19.403	0.029	5.821	15.315	0.015	3.063	0.512
	5	2	0.0	10.405	0.000	0.014	5.202	17.279	0.046	6.911	20.465	0.031	6.139	18.376	0.018	3.675	0.110
	5	3	9.8	14.988	0.000	0.175	7.494	17.815	0.049	7.126	21.420	0.033	6.426	21.109	0.021	4.222	0.278
	5	4	12.5	19.820	0.000	0.344	9.910	20.550	0.063	8.220	23.181	0.036	6.954	23.820	0.024	4.764	0.467
	5	5	0.0	9.566	0.000	0.000	4.783	17.050	0.045	6.820	23.010	0.036	6.903	25.935	0.026	5.187	0.107
	5	6	0.0	4.783	0.000	0.000	2.392	12.576	0.023	5.031	21.102	0.032	6.331	27.053	0.027	5.411	0.082
	5	7	0.0	2.392	0.000	0.000	1.196	8.719	0.004	3.487	18.227	0.026	5.468	27.083	0.027	5.417	0.057
	5	8	0.0	1.196	0.000	0.000	0.598	5.825	0.000	2.330	15.062	0.020	4.519	26.158	0.026	5.232	0.046
	5	9	0.0	0.598	0.000	0.000	0.299	3.794	0.000	1.518	12.041	0.014	3.612	24.513	0.025	4.903	0.039
	5	10	0.0	0.299	0.000	0.000	0.149	2.426	0.000	0.970	9.385	0.009	2.816	22.401	0.022	4.480	0.031
			39.8		0.000	0.939			0.291			0.267			0.232		1.729
	5	11	0.0	0.149	0.000	0.000	0.075	1.530	0.000	0.612	7.173	0.004	2.152	20.051	0.020	4.010	0.024
	5	12	0.0	0.075	0.000	0.000	0.037	0.956	0.000	0.382	5.399	0.001	1.620	17.640	0.018	3.528	0.018
	5	13	7.3	7.337	0.000	0.000	3.669	4.242	0.000	1.697	5.475	0.001	1.643	15.737	0.016	3.147	0.017
	5	14	0.0	3.669	0.000	0.000	1.834	4.380	0.000	1.752	5.584	0.001	1.675	14.249	0.014	2.850	0.015
	5	15	0.0	1.834	0.000	0.000	0.917	3.545	0.000	1.418	5.325	0.001	1.598	12.982	0.013	2.596	0.014
	5	16	0.0	0.917	0.000	0.000	0.459	2.586	0.000	1.034	4.761	0.000	1.428	11.801	0.012	2.360	0.012
	5	17	0.0	0.459	0.000	0.000	0.229	1.781	0.000	0.712	4.045	0.000	1.214	10.643	0.011	2.129	0.011
	5	18	10.1	10.329	0.000	0.012	5.165	6.233	0.000	2.493	5.325	0.001	1.597	10.101	0.010	2.020	0.022
	5	19	0.0	5.153	0.000	0.000	2.577	6.316	0.000	2.527	6.253	0.003	1.876	9.947	0.010	1.989	0.012
	5	20	0.0	2.577	0.000	0.000	1.288	5.078	0.000	2.031	6.406	0.003	1.922	9.869	0.010	1.974	0.013
			17.4		0.000	0.012			0.000			0.014			0.133		0.158
	5	21	0.0	1.288	0.000	0.000	0.644	3.691	0.000	1.476	5.958	0.002	1.787	9.673	0.010	1.935	0.012
	5	22	0.0	0.644	0.000	0.000	0.322	2.537	0.000	1.015	5.183	0.000	1.555	9.284	0.009	1.857	0.010
	5	23	0.0	0.322	0.000	0.000	0.161	1.683	0.000	0.673	4.301	0.000	1.290	8.708	0.009	1.742	0.009
	5	24	0.0	0.161	0.000	0.000	0.081	1.090	0.000	0.436	3.447	0.000	1.034	7.992	0.008	1.598	0.008
	5	25	0.0	0.081	0.000	0.000	0.040	0.694	0.000	0.278	2.691	0.000	0.807	7.193	0.007	1.439	0.007
	5	26	0.0	0.040	0.000	0.000	0.020	0.437	0.000	0.175	2.058	0.000	0.617	6.364	0.006	1.273	0.006
	5	27	0.0	0.020	0.000	0.000	0.010	0.272	0.000	0.109	1.550	0.000	0.465	5.550	0.006	1.110	0.006
	5	28	6.0	6.010	0.000	0.000	3.005	3.168	0.000	1.267	2.352	0.000	0.706	5.140	0.005	1.028	0.005
	5	29	43.2	46.205	0.000	1.267	23.103	25.004	0.085	10.001	11.648	0.013	3.494	7.601	0.008	1.520	1.373
	5	30	0.0	21.835	0.000	0.414	10.918	25.835	0.089	10.334	18.474	0.027	5.542	11.616	0.012	2.323	0.542
	5	31	0.0	10.503	0.000	0.018	5.252	20.663	0.063	8.265	21.170	0.032	6.351	15.632	0.016	3.126	0.129
			49.2		0.000	1.699			0.238			0.075			0.095		4.046

Note :
(1) : Observation Data at Tema
(2) : (2)n-1 + (1) - (3)n-1 - (4)n-1 - (5)n-1
(3) : ((2) - Z1) x C1
(4) : ((2) - Z2) x C2
(5) : (2) x K1
(6) : (6)n-1 + (5) - (7)n-1 - (8)n-1
(7) : ((6) - Z3) x C3
(8) : (6) x K2
(9) : (9)n-1 + (8) - (10)n-1 - (11)n-1
(10) : ((9) - Z4) x C4
(11) : (9) x K3
(12) : (12)n-1 + (11) - (13)n-1 - (14)n-1
(13) : (12) x C5
(14) : (12) x K4
(15) : (3) + (4) + (7) + (10) + (13)

Table B.11 Runoff Estimate by Tank Model Method from 1986 to 1995 at Ashaiman

Month	10 days	1986 Runoff	1986 Rainfall	1987 Runoff	1987 Rainfall	1988 Runoff	1988 Rainfall	1989 Runoff	1989 Rainfall	1990 Runoff	1990 Rainfall	1991 Runoff	1991 Rainfall	1992 Runoff	1992 Rainfall	1993 Runoff	1993 Rainfall	1994 Runoff	1994 Rainfall	1995 Runoff	1995 Rainfall
1	1	0.000	0.0	0.161	13.8	0.000	0.0	0.010	0.0	0.000	0.0	0.041	0.0	0.000	0.0	0.000	0.0	0.005	8.2	0.000	0.0
1	2	0.000	0.0	0.042	0.0	0.000	0.0	0.001	0.0	0.000	0.0	0.005	0.0	0.000	0.0	0.000	0.0	0.029	1.1	0.000	0.0
1	3	0.000	0.0	0.024	10.2	0.000	0.0	0.000	0.0	0.005	1.4	0.005	5.7	0.000	0.0	0.000	0.0	0.014	0.0	0.000	0.0
2	1	0.001	2.8	0.034	0.0	4.241	90.1	0.000	0.0	0.002	0.0	0.019	0.0	0.000	0.0	0.014	5.8	0.002	0.0	0.000	0.0
2	2	0.462	22.9	0.014	5.2	1.254	0.0	0.000	0.0	0.048	11.3	0.041	11.2	0.000	0.0	0.013	0.1	0.276	23.7	0.000	0.0
2	3	0.481	21.6	0.015	0.0	0.085	0.0	0.000	0.0	0.043	4.7	0.033	6.1	0.000	0.0	0.002	0.0	0.096	0.0	0.000	0.2
3	1	0.081	7.1	0.006	5.7	0.440	26.7	0.005	3.4	0.031	0.0	0.034	0.0	0.000	0.0	0.001	1.8	0.656	30.4	1.073	39.0
3	2	0.042	3.1	0.020	0.0	0.735	16.5	0.028	13.9	0.005	0.0	0.013	4.7	0.503	35.2	0.018	7.7	0.307	0.0	6.966	121.9
3	3	0.377	18.4	1.524	36.9	0.066	9.0	0.042	0.0	0.001	5.5	0.017	0.0	0.144	0.5	1.204	39.8	0.049	3.6	0.846	4.2
4	1	0.043	15.2	0.053	1.0	3.043	59.6	1.744	39.6	0.027	2.8	6.145	112.7	0.023	0.0	0.280	12.5	1.052	32.4	0.072	0.0
4	2	0.057	2.0	0.010	0.0	0.180	0.2	2.281	62.0	0.355	18.6	0.787	22.9	0.967	35.0	1.038	34.4	0.075	0.0	1.419	56.6
4	3	0.069	10.7	1.389	44.5	0.057	17.5	1.838	40.6	2.766	57.7	0.959	39.5	0.097	0.0	0.315	14.1	0.015	5.1	2.435	40.7
5	1	0.703	26.8	1.729	39.8	2.934	53.5	2.220	50.3	4.693	97.9	1.101	30.2	5.596	113.2	0.603	27.8	0.520	30.7	2.563	48.6
5	2	0.050	2.5	0.158	17.4	0.341	24.5	1.124	23.8	1.000	16.9	2.302	51.3	4.032	88.6	0.597	31.7	0.134	9.1	0.633	19.9
5	3	1.090	56.2	2.106	49.2	0.384	21.4	0.456	19.3	0.137	0.0	5.795	108.1	5.532	52.5	0.388	27.2	3.953	87.6	3.494	67.3
6	1	0.766	37.0	0.330	0.0	0.638	34.6	1.875	56.1	0.033	13.2	1.701	43.2	0.302	14.3	5.905	118.9	5.753	119.4	3.562	79.2
6	2	0.581	26.4	0.044	0.0	1.148	49.1	0.261	8.7	2.081	49.0	0.566	19.0	3.219	65.1	1.457	0.8	1.626	16.2	4.425	87.8
6	3	0.137	0.0	0.010	3.4	5.265	88.5	3.746	104.8	1.224	50.1	0.238	18.8	0.147	0.6	1.607	34.4	0.510	19.5	3.820	85.0
7	1	0.024	0.0	0.011	0.0	1.527	43.9	1.368	6.5	0.174	12.6	5.762	103.9	0.030	4.1	0.080	7.2	0.112	2.5	29.246	138.5
7	2	0.003	0.5	0.002	0.2	0.288	0.9	2.765	54.3	0.062	0.5	4.996	84.6	0.366	20.4	0.029	0.0	0.022	1.0	0.408	0.2
7	3	0.002	0.3	0.362	21.0	0.044	0.0	0.326	4.2	0.014	0.0	0.317	0.8	0.123	0.0	0.005	0.0	0.006	0.2	0.055	1.5
8	1	0.002	0.0	0.369	26.7	0.005	0.0	0.045	0.0	0.002	0.0	0.038	1.4	0.022	0.0	0.000	0.0	0.008	2.3	0.010	1.7
8	2	0.000	0.0	0.218	15.9	0.002	0.8	0.007	0.5	0.000	0.0	0.011	10.2	0.003	0.0	0.109	12.5	0.008	4.1	0.009	1.6
8	3	0.000	0.0	0.106	14.8	0.005	1.0	0.030	9.1	0.000	0.1	0.042	1.3	0.002	1.6	0.036	0.7	0.016	0.6	0.024	7.6
9	1	0.000	0.0	1.851	70.8	0.084	14.4	0.016	3.8	0.037	10.8	0.016	3.1	0.010	2.4	2.590	53.3	0.011	2.7	0.020	0.8
9	2	0.006	2.3	1.372	24.3	0.700	28.4	0.020	11.4	0.819	28.4	0.291	20.2	0.008	0.5	0.284	3.6	0.018	3.6	0.005	0.3
9	3	0.014	3.0	13.062	202.8	0.606	30.1	0.045	0.5	0.180	0.0	0.055	0.0	0.004	1.7	0.063	4.6	0.030	8.5	0.001	0.0
10	1	0.063	11.0	3.141	45.6	0.129	15.0	0.656	23.8	0.041	12.4	2.261	56.7	0.005	4.3	0.017	0.0	1.584	42.5	0.000	0.0
10	2	2.811	58.2	0.954	29.6	0.204	21.6	1.794	49.3	0.477	19.1	0.385	1.9	0.121	10.8	0.003	0.0	0.465	25.2	0.000	0.0
10	3	0.360	4.0	0.137	0.5	0.154	15.8	1.111	26.3	0.053	0.0	0.057	0.5	0.030	1.2	0.000	0.0	0.075	5.8	0.005	4.5
11	1	0.061	5.8	0.018	0.0	0.071	0.4	0.065	9.0	0.061	10.6	0.008	0.1	0.013	5.9	0.000	0.0	0.036	4.9	0.657	26.1
11	2	0.022	0.0	0.002	0.0	0.017	0.7	0.047	5.6	0.031	4.7	0.002	0.0	0.018	0.0	0.323	22.0	0.030	5.4	0.052	6.0
11	3	0.003	0.3	0.000	0.0	0.004	0.0	0.316	16.0	0.014	3.6	0.000	0.0	0.004	0.0	0.976	32.9	0.025	4.4	0.028	0.0
12	1	0.005	1.2	0.189	14.0	0.282	17.3	0.029	0.0	0.023	5.7	0.000	0.0	0.000	0.0	0.425	20.8	0.013	0.4	0.010	1.8
12	2	1.031	28.7	0.022	0.0	2.767	48.5	0.004	0.0	5.501	98.3	0.000	0.0	0.000	0.0	0.068	2.5	0.003	0.0	0.005	0.0
12	3	0.053	0.0	0.003	0.0	0.091	0.0	0.000	0.0	0.303	7.0	0.000	0.0	0.000	0.0	0.019	0.0	0.000	0.0	2.864	54.0
Total		9.400	368.0	29.490	693.3	27.793	730.0	24.274	642.9	20.244	542.9	34.042	758.1	21.322	457.9	18.468	517.1	17.536	501.1	64.711	895.0
Runoff Ratio		2.55%		4.25%		3.81%		3.78%		3.73%		4.49%		4.66%		3.57%		3.50%		7.23%	

Table B-12 Runoff Estimate by Tank Model Method from 1986 to 1995 at Mankessim

Month	10 days	1986 Runoff	1986 Rainfall	1987 Runoff	1987 Rainfall	1988 Runoff	1988 Rainfall	1989 Runoff	1989 Rainfall	1990 Runoff	1990 Rainfall	1991 Runoff	1991 Rainfall	1992 Runoff	1992 Rainfall	1993 Runoff	1993 Rainfall	1994 Runoff	1994 Rainfall	1995 Runoff	1995 Rainfall
1	1	0.010	4.3	0.012	9.0	0.001	0.0	0.005	0.0	0.000	0.0	0.045	0.0	0.000	0.0	0.277	17.0	0.005	9.2	0.000	0.0
1	2	0.009	0.0	0.028	0.0	0.000	0.0	0.001	0.0	0.000	0.0	0.017	9.5	0.000	0.0	0.041	0.0	0.034	5.6	0.000	0.0
1	3	0.002	0.0	0.006	0.5	0.000	0.0	0.054	10.6	0.024	7.0	0.953	29.8	0.000	0.0	0.007	0.0	0.273	15.6	0.000	0.0
2	1	0.009	3.6	0.002	0.0	0.008	4.8	0.017	0.0	0.009	0.0	0.449	12.5	0.000	0.0	0.032	10.2	0.049	0.0	0.000	0.0
2	2	0.373	19.5	0.001	0.0	0.019	3.4	0.003	0.9	0.001	0.6	0.044	0.4	0.014	5.6	0.070	16.9	0.100	13.4	0.000	0.0
2	3	0.886	27.6	0.000	0.0	0.030	10.5	0.004	4.3	0.002	0.0	0.007	0.6	0.011	0.0	0.053	0.0	0.436	14.2	0.000	0.0
3	1	0.095	1.0	0.309	18.2	2.331	60.9	3.971	73.6	0.018	11.2	0.003	0.0	0.003	0.0	0.601	30.8	1.143	47.4	1.289	52.6
3	2	0.029	7.9	2.476	54.6	0.517	0.0	1.515	44.6	0.768	36.6	0.001	0.0	2.469	61.5	0.283	15.1	2.084	41.2	1.879	34.3
3	3	0.226	23.6	1.185	40.2	0.058	0.0	0.277	3.6	0.288	12.6	0.000	0.0	0.254	0.5	0.643	28.0	1.103	13.4	0.195	6.4
4	1	0.558	19.6	0.114	3.7	0.592	26.6	0.224	18.2	0.195	9.8	0.780	40.6	0.043	9.6	0.140	0.0	0.065	3.8	0.091	12.2
4	2	0.097	10.0	0.087	14.4	0.072	1.0	0.471	29.2	0.035	4.2	1.122	41.9	1.505	45.6	0.509	32.4	0.018	0.0	9.008	168.6
4	3	2.017	43.3	0.459	24.1	0.024	3.3	1.099	41.3	1.277	39.4	0.896	35.7	0.997	27.5	0.278	13.1	1.577	44.8	4.028	42.1
5	1	2.199	57.0	0.469	23.0	2.398	58.0	2.485	46.2	0.111	12.2	1.497	41.6	4.022	83.9	0.068	3.0	7.081	105.5	0.297	2.2
5	2	0.230	10.7	0.884	36.8	5.912	98.8	7.051	105.6	0.522	22.1	66.166	185.9	0.738	21.7	0.495	21.5	0.542	21.7	1.831	50.2
5	3	2.477	73.3	0.984	25.2	0.442	19.8	1.798	43.6	0.415	25.2	13.343	206.3	1.276	30.9	0.387	33.1	7.338	148.1	10.578	173.3
6	1	5.481	100.5	0.079	1.7	4.907	93.3	11.580	183.4	0.772	34.8	1.988	36.8	16.398	139.3	4.203	95.1	9.368	155.2	2.860	58.3
6	2	27.708	225.5	0.185	14.8	1.902	49.1	3.066	58.4	1.085	38.3	0.391	12.4	0.295	15.6	1.788	4.0	1.960	9.6	10.873	175.5
6	3	2.942	8.8	0.224	15.2	5.151	91.7	2.426	72.3	0.797	35.0	1.847	58.9	0.076	1.4	2.420	44.8	0.796	31.3	0.893	8.3
7	1	0.670	31.0	0.055	0.6	1.627	32.4	2.964	44.9	0.139	15.7	7.035	114.3	0.021	4.3	0.087	0.7	0.143	0.1	10.018	146.3
7	2	0.138	0.8	0.014	2.7	0.158	2.8	0.164	1.4	0.073	1.8	10.083	144.7	0.022	11.6	0.014	0.0	0.044	8.1	0.428	2.6
7	3	0.028	0.3	2.036	64.4	0.033	0.3	0.027	0.0	0.041	8.2	0.512	0.5	0.053	5.1	0.002	0.9	0.029	5.7	0.069	6.0
8	1	0.009	2.0	1.091	24.7	0.005	0.4	0.004	0.4	0.020	1.7	0.085	14.4	0.025	2.2	0.006	2.1	0.022	1.5	0.042	11.5
8	2	0.004	0.1	0.265	22.2	0.002	0.0	0.001	2.6	0.008	0.0	0.049	14.9	0.011	1.2	0.103	13.6	0.009	9.4	0.038	1.2
8	3	0.005	8.2	2.795	62.0	0.013	11.4	0.044	13.0	0.002	0.7	0.701	22.0	0.009	1.8	0.047	5.9	0.038	0.8	1.065	29.9
9	1	0.027	0.3	4.423	98.1	3.284	69.5	0.039	8.7	0.292	18.8	2.163	50.5	0.005	2.5	1.862	48.2	3.417	68.1	0.063	0.2
9	2	0.013	2.0	2.867	59.2	1.920	41.3	0.034	10.8	0.079	10.7	0.209	1.5	0.018	4.6	0.244	4.1	0.163	2.6	0.012	0.4
9	3	0.020	5.6	23.019	217.6	0.388	18.4	0.050	4.9	0.053	3.8	0.035	0.5	1.892	47.5	0.080	13.3	0.121	14.8	0.166	22.3
10	1	0.250	15.4	9.968	142.1	16.667	141.3	0.790	36.8	3.394	70.8	1.037	37.1	0.114	8.4	0.297	18.8	0.672	31.7	0.094	2.5
10	2	2.544	55.3	3.539	62.3	1.371	10.0	1.175	40.8	2.648	48.1	0.258	4.3	0.068	15.5	0.055	3.0	0.567	40.6	0.022	0.0
10	3	0.535	16.3	0.478	12.8	0.377	16.6	0.181	5.2	0.196	2.0	0.168	15.6	0.065	5.0	0.120	19.5	5.706	100.7	0.250	21.0
11	1	4.008	69.8	0.090	7.0	0.176	16.1	0.032	0.8	0.183	17.4	0.063	0.0	0.043	9.4	0.077	9.3	3.046	54.3	1.871	43.5
11	2	0.230	0.0	0.032	5.0	0.075	4.4	0.008	0.8	0.074	3.3	0.017	1.0	0.189	13.9	0.061	8.5	0.365	16.6	0.088	0.0
11	3	2.342	49.5	0.399	22.1	0.027	0.0	0.004	0.6	0.032	4.4	0.006	0.0	0.049	0.7	0.231	26.5	0.134	9.2	0.013	0.0
12	1	0.505	12.4	2.060	42.6	0.007	0.9	0.003	0.0	2.150	49.1	0.001	0.0	0.078	11.4	0.385	14.6	0.050	2.5	0.005	2.4
12	2	0.062	1.0	0.070	0.0	0.498	23.0	0.001	0.0	1.512	35.2	0.000	0.0	0.112	13.3	0.059	0.0	0.013	0.0	0.009	1.9
12	3	0.010	0.0	0.010	0.0	0.040	0.0	0.000	0.0	0.385	13.4	0.000	0.0	0.042	0.1	0.010	0.0	0.002	0.0	0.007	0.0
Total		56.749	906.2	60.716	1126.8	51.029	910.0	41.570	907.5	17.603	594.1	111.972	1134.2	30.915	601.6	16.036	554.0	48.514	1046.7	58.082	1075.7
Runoff Ratio		6.26%		5.39%		5.61%		4.58%		2.96%		9.87%		5.14%		2.89%		4.63%		5.40%	

Table B-13 Runoff Estimate by Tank Model Method from 1986 to 1995 at Okyereko

Month	10 days	1986 Runoff	1986 Rainfall	1987 Runoff	1987 Rainfall	1988 Runoff	1988 Rainfall	1989 Runoff	1989 Rainfall	1990 Runoff	1990 Rainfall	1991 Runoff	1991 Rainfall	1992 Runoff	1992 Rainfall	1993 Runoff	1993 Rainfall	1994 Runoff	1994 Rainfall	1995 Runoff	1995 Rainfall
1	1	0.007	3.0	0.011	8.4	0.001	0.0	0.004	0.0	0.000	0.0	0.059	0.0	0.000	0.0	0.366	19.0	0.004	6.5	0.000	0.0
1	2	0.006	0.0	0.026	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.018	8.8	0.000	0.0	0.046	0.0	0.024	3.9	0.000	0.0
1	3	0.001	0.0	0.006	0.5	0.000	0.0	0.027	8.5	0.031	9.2	0.830	27.8	0.000	0.0	0.008	0.0	0.079	11.1	0.000	0.0
2	1	0.006	2.6	0.002	0.0	0.006	3.7	0.014	0.0	0.012	0.0	0.386	11.7	0.000	0.0	0.077	11.4	0.035	0.0	0.000	0.0
2	2	0.118	13.9	0.001	0.0	0.015	2.7	0.002	0.7	0.002	0.8	0.041	0.4	0.012	5.0	0.124	18.8	0.009	9.5	0.000	0.0
2	3	0.375	19.6	0.000	0.0	0.024	8.2	0.003	3.4	0.003	0.0	0.006	0.6	0.010	0.0	0.062	0.0	0.165	10.1	0.000	0.0
3	1	0.064	0.7	0.259	17.0	1.550	47.5	2.844	58.9	0.025	14.8	0.003	0.0	0.003	0.0	0.771	34.4	0.573	33.7	0.965	44.2
3	2	0.021	5.6	2.199	51.0	0.315	0.0	0.945	35.6	1.355	48.2	0.001	0.0	2.061	55.5	0.372	16.9	1.110	29.3	1.300	28.9
3	3	0.054	16.7	1.040	37.5	0.046	0.0	0.199	2.9	0.571	16.6	0.000	0.0	0.221	0.5	0.816	31.2	0.603	9.5	0.159	5.4
4	1	0.246	13.9	0.105	3.4	0.275	20.7	0.097	14.6	0.413	12.9	0.645	37.9	0.039	8.7	0.164	0.0	0.047	2.7	0.054	10.3
4	2	0.061	7.1	0.058	13.5	0.054	0.8	0.256	23.4	0.046	5.5	0.965	39.2	1.230	41.2	0.661	36.2	0.013	0.0	7.266	141.8
4	3	1.158	30.7	0.389	22.4	0.019	2.6	0.683	33.0	2.036	51.9	0.800	33.3	0.813	24.8	0.334	14.6	0.737	31.8	3.110	35.4
5	1	1.283	40.5	0.402	21.5	1.493	45.2	1.695	36.9	0.176	16.0	1.337	38.9	3.466	75.6	0.076	3.3	4.605	74.9	0.243	1.9
5	2	0.143	7.6	0.746	34.4	4.222	77.0	5.282	84.4	0.970	29.2	52.791	173.6	0.602	19.6	0.647	23.9	0.250	15.5	1.339	42.3
5	3	1.140	52.0	0.858	23.5	0.284	15.4	1.206	34.9	0.765	33.1	12.279	192.7	1.060	27.9	0.517	37.0	4.390	105.2	8.405	145.9
6	1	3.283	71.2	0.074	1.6	3.467	72.8	8.635	146.6	1.434	45.9	1.800	34.4	8.694	125.7	4.790	106.2	5.663	110.2	2.104	49.0
6	2	8.944	159.9	0.149	13.8	1.202	38.2	2.055	46.6	1.939	50.5	0.347	11.7	0.274	14.0	2.105	4.5	1.135	6.8	8.636	147.4
6	3	1.885	6.2	0.173	14.2	3.412	71.4	1.512	57.8	1.436	46.1	1.621	55.1	0.071	1.3	2.853	50.0	0.364	22.1	0.697	7.0
7	1	0.334	22.0	0.052	0.6	1.053	25.2	2.079	35.9	0.286	20.7	6.347	106.7	0.019	3.9	0.096	0.8	0.092	0.1	8.146	123.0
7	2	0.090	0.6	0.013	2.5	0.118	2.2	0.128	1.2	0.105	2.4	9.286	135.2	0.020	10.5	0.015	0.0	0.031	5.7	0.352	2.2
7	3	0.020	0.2	1.785	60.1	0.026	0.2	0.022	0.0	0.053	10.8	0.475	0.5	0.048	4.6	0.002	1.0	0.020	4.0	0.058	5.0
8	1	0.007	1.4	0.927	23.0	0.004	0.3	0.003	0.4	0.027	2.2	0.077	13.4	0.023	2.0	0.007	2.3	0.016	1.0	0.036	9.7
8	2	0.003	0.1	0.218	20.8	0.001	0.0	0.001	2.1	0.010	0.0	0.045	13.9	0.010	1.1	0.162	15.2	0.007	6.7	0.032	1.0
8	3	0.004	5.8	2.473	58.0	0.010	8.9	0.034	10.4	0.003	1.0	0.594	20.6	0.008	1.6	0.053	6.6	0.027	0.6	0.753	25.2
9	1	0.019	0.2	3.991	91.5	2.222	54.2	0.031	7.0	0.572	24.8	1.937	47.1	0.004	2.3	2.201	53.8	2.003	48.4	0.054	0.2
9	2	0.009	1.4	2.557	55.3	1.266	32.3	0.025	8.6	0.226	14.1	0.192	1.5	0.016	4.2	0.284	4.6	0.108	1.9	0.010	0.3
9	3	0.014	4.0	13.597	203.1	0.207	14.4	0.040	3.9	0.076	5.0	0.033	0.5	1.577	42.8	0.094	14.8	0.046	10.5	0.032	18.8
10	1	0.064	10.9	9.196	132.6	6.192	110.1	0.448	29.5	4.975	93.3	0.914	34.6	0.101	7.6	0.390	21.0	0.308	22.5	0.073	2.1
10	2	1.490	39.3	3.197	58.2	1.086	7.7	0.755	32.7	3.939	63.3	0.231	4.0	0.059	14.0	0.061	3.3	0.167	28.9	0.018	0.0
10	3	0.269	11.6	0.416	11.9	0.213	13.1	0.135	4.1	0.268	2.6	0.134	14.6	0.058	4.5	0.175	21.8	3.449	71.5	0.142	17.6
11	1	2.458	49.5	0.084	6.5	0.074	12.5	0.026	0.6	0.371	22.9	0.057	0.0	0.039	8.5	0.112	10.4	1.780	38.5	1.371	36.6
11	2	0.154	0.0	0.030	4.7	0.056	3.4	0.006	0.6	0.115	4.3	0.016	1.0	0.131	12.5	0.068	9.4	0.176	11.8	0.074	0.0
11	3	1.375	35.1	0.337	20.7	0.021	0.0	0.003	0.5	0.042	5.8	0.005	0.0	0.044	0.6	0.387	29.6	0.077	6.5	0.011	0.0
12	1	0.225	8.8	1.861	39.8	0.005	0.7	0.002	0.0	3.219	64.7	0.001	0.0	0.037	10.3	0.493	16.3	0.036	1.8	0.004	2.0
12	2	0.044	0.7	0.066	0.0	0.275	17.9	0.001	0.0	2.327	46.4	0.000	0.0	0.064	12.0	0.065	0.0	0.009	0.0	0.008	1.6
12	3	0.007	0.0	0.010	0.0	0.031	0.0	0.000	0.0	0.675	17.7	0.000	0.0	0.038	0.1	0.011	0.0	0.001	0.0	0.006	0.0
Total		25.379	642.8	47.303	1052.0	29.243	709.3	29.200	725.7	28.503	782.7	94.276	1059.7	20.850	542.9	19.465	618.3	28.159	743.2	45.458	904.8
Runoff Ratio		3.95%		4.50%		4.12%		4.02%		3.64%		8.90%		3.84%		3.15%		3.79%		5.02%	

FIGURES

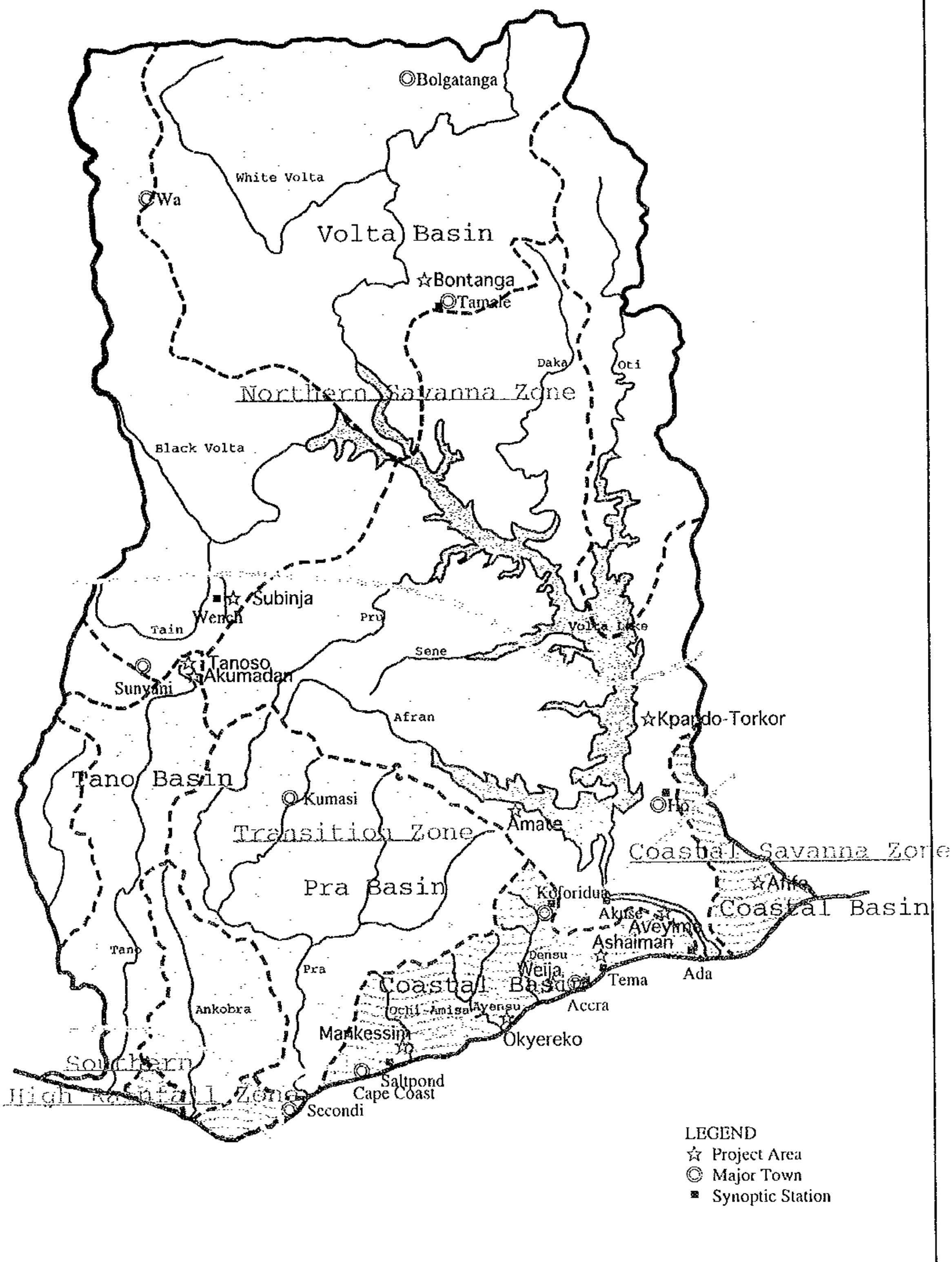


Figure B-1 Meteo- Hydrological Map	THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA / Japan International Cooperation Agency

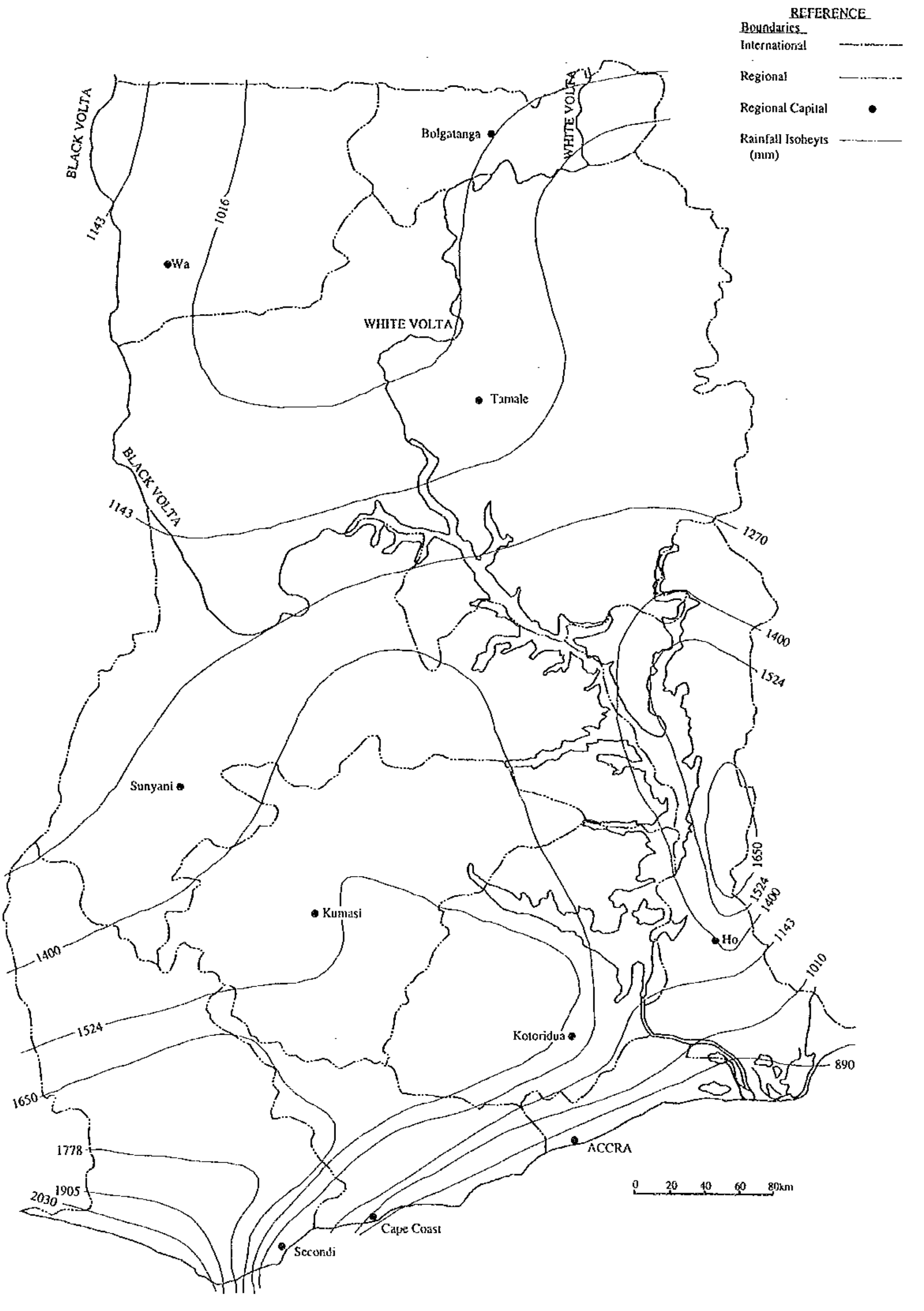


Figure B-2

Mean Annual Rainfall

THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA

Japan International Cooperation Agency

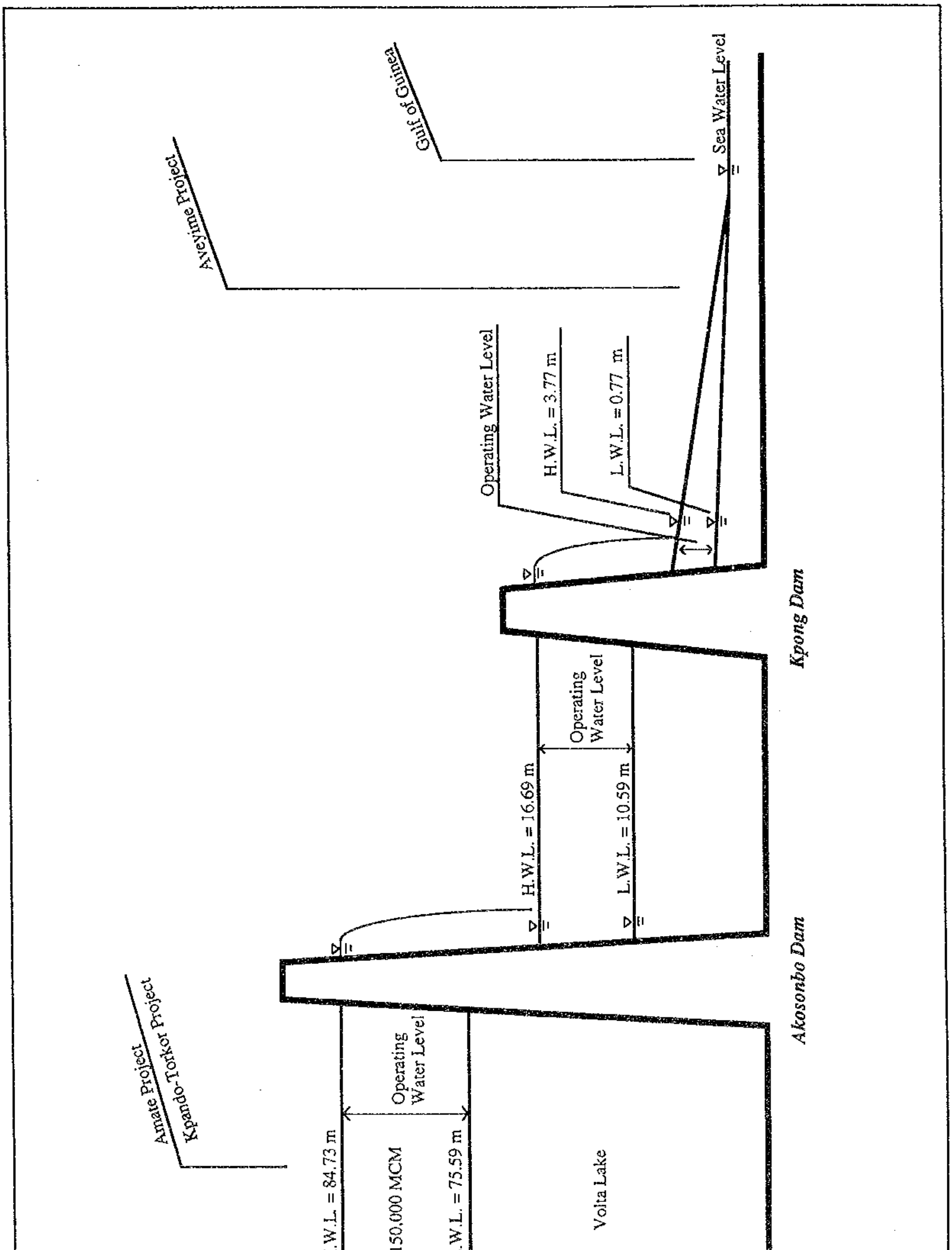


Figure B-3 **Operating Water Level of Akosonbo Dam and Kpong Dam**	**THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA** Japan International Cooperation Agency

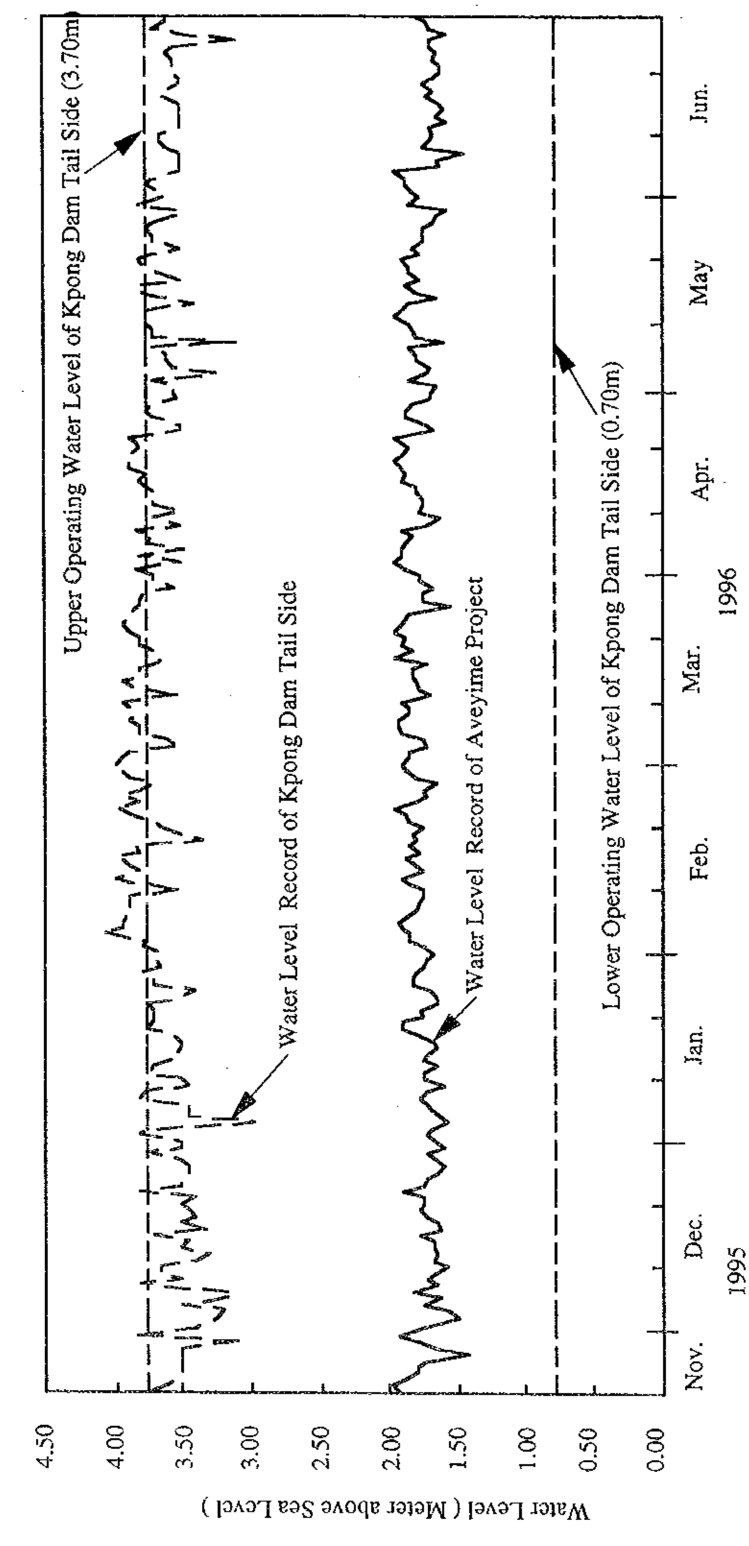


Figure B-4 **Water Level Fluctuation of Kpong Dam Tail Side and Aveyime Project**	**THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA** Japan International Cooperation Agency

Figure B-5 **Water Level Fluctuation of Volta Lake**	**THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA** Japan International Cooperation Agency

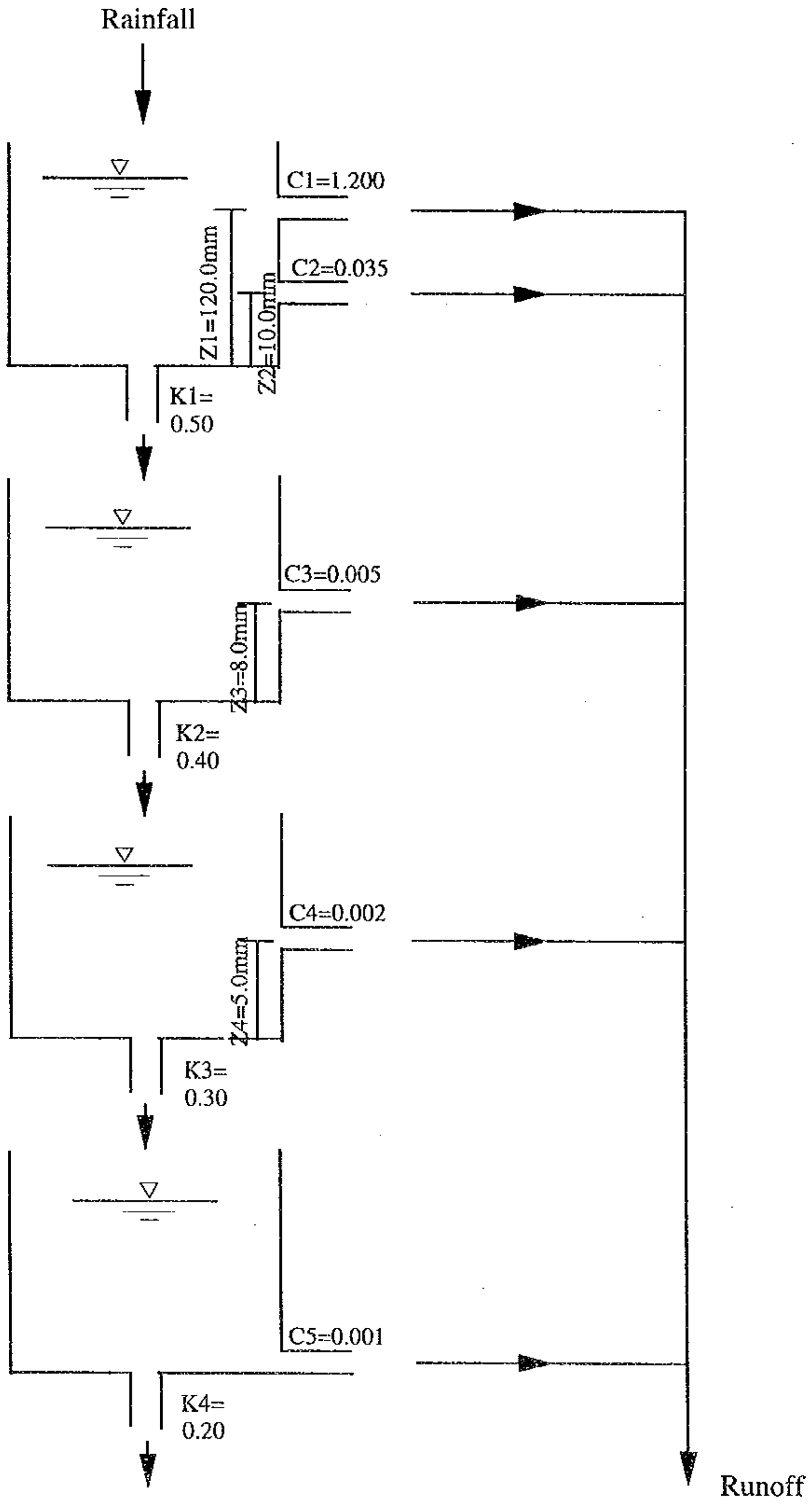


Figure B-6 **Structure of Tank Model at Ashaiman Project**	**THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA** Japan International Cooperation Agency

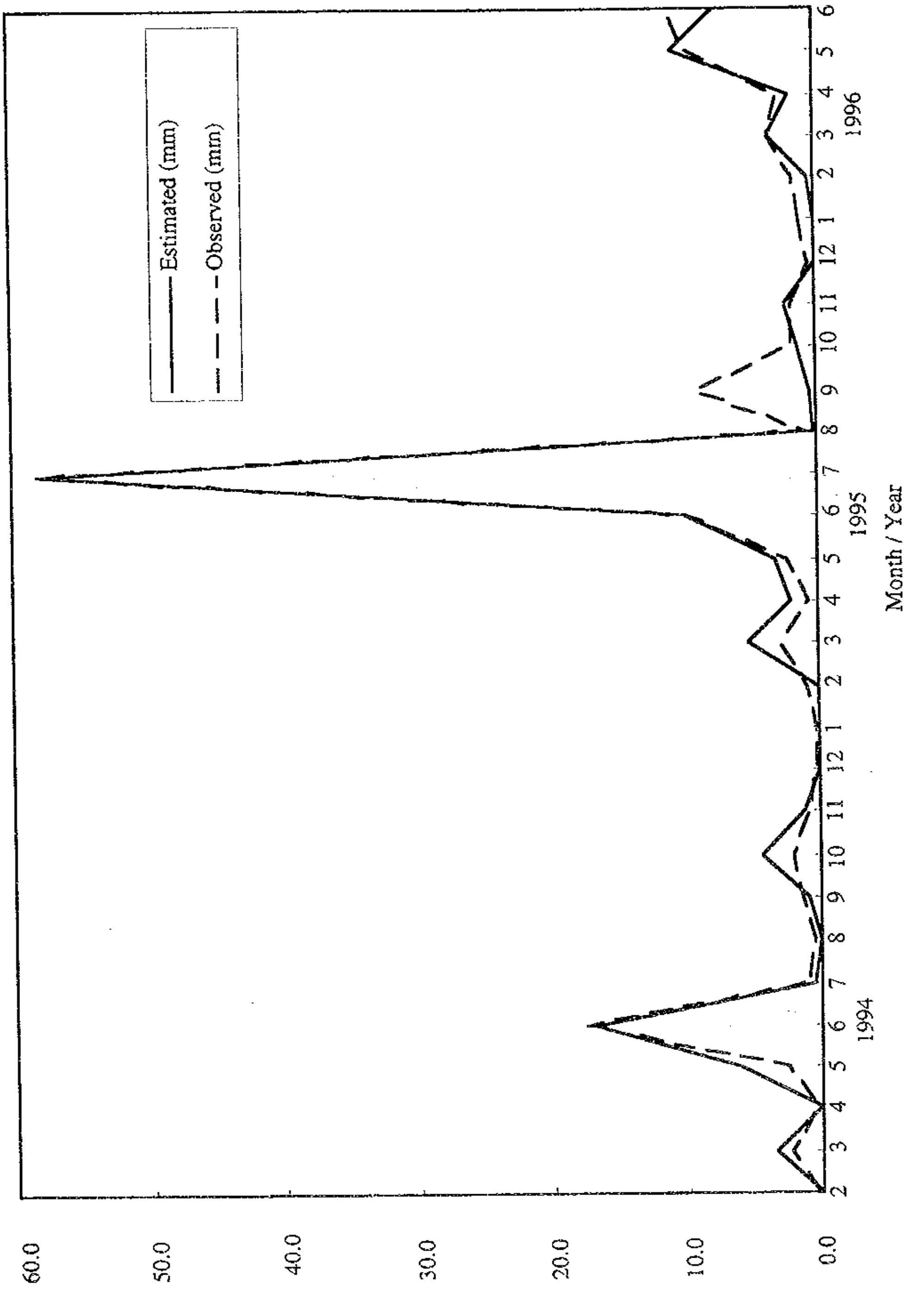


Figure B-7 **Calibration Result of Tank Model** **Ashaiman Project**	**THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA** Japan International Cooperation Agency

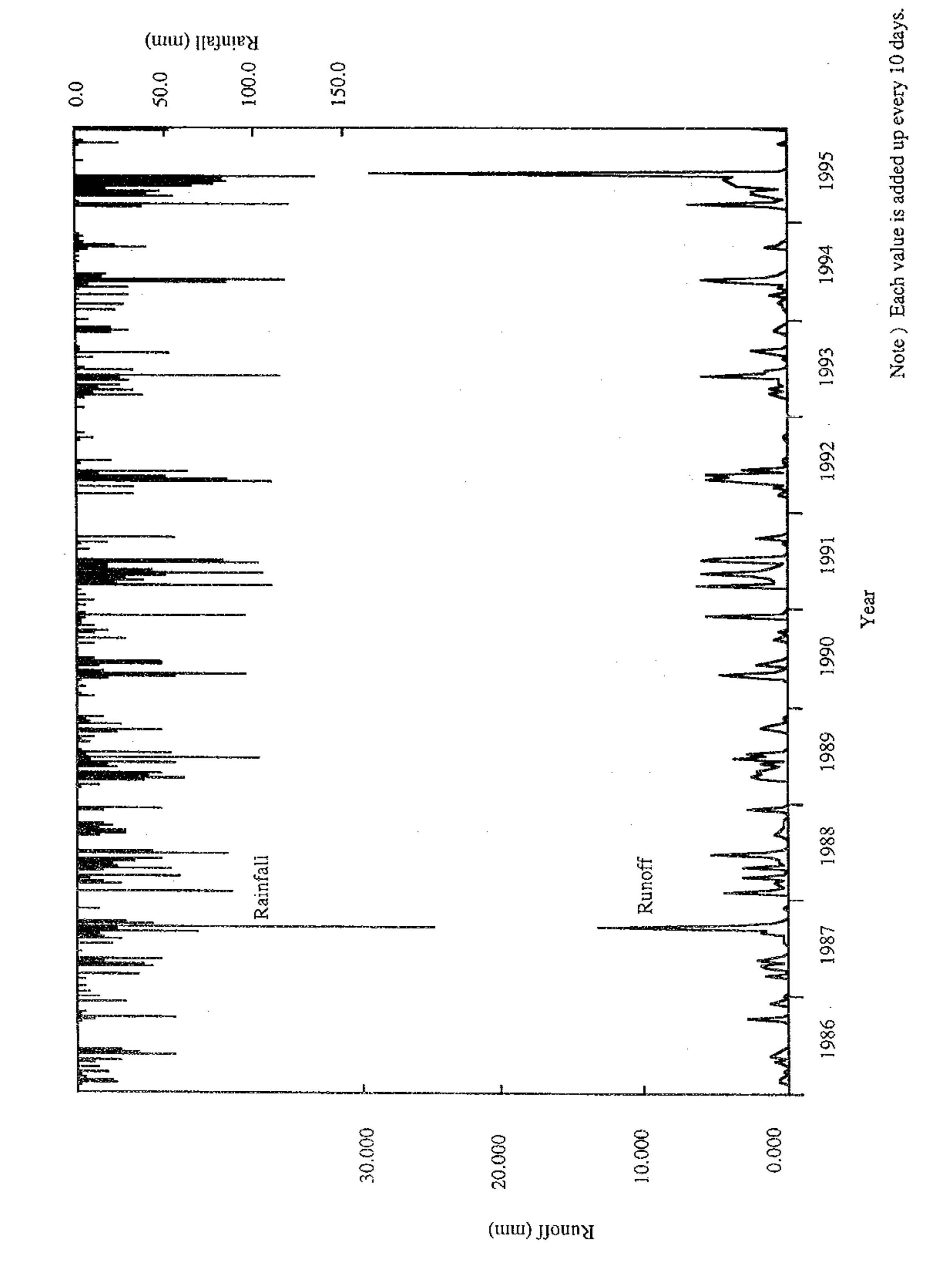


Figure B-8
Runoff Estimation by Tank Model Method from 1986 to 1995 at Ashaiman Project

THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA

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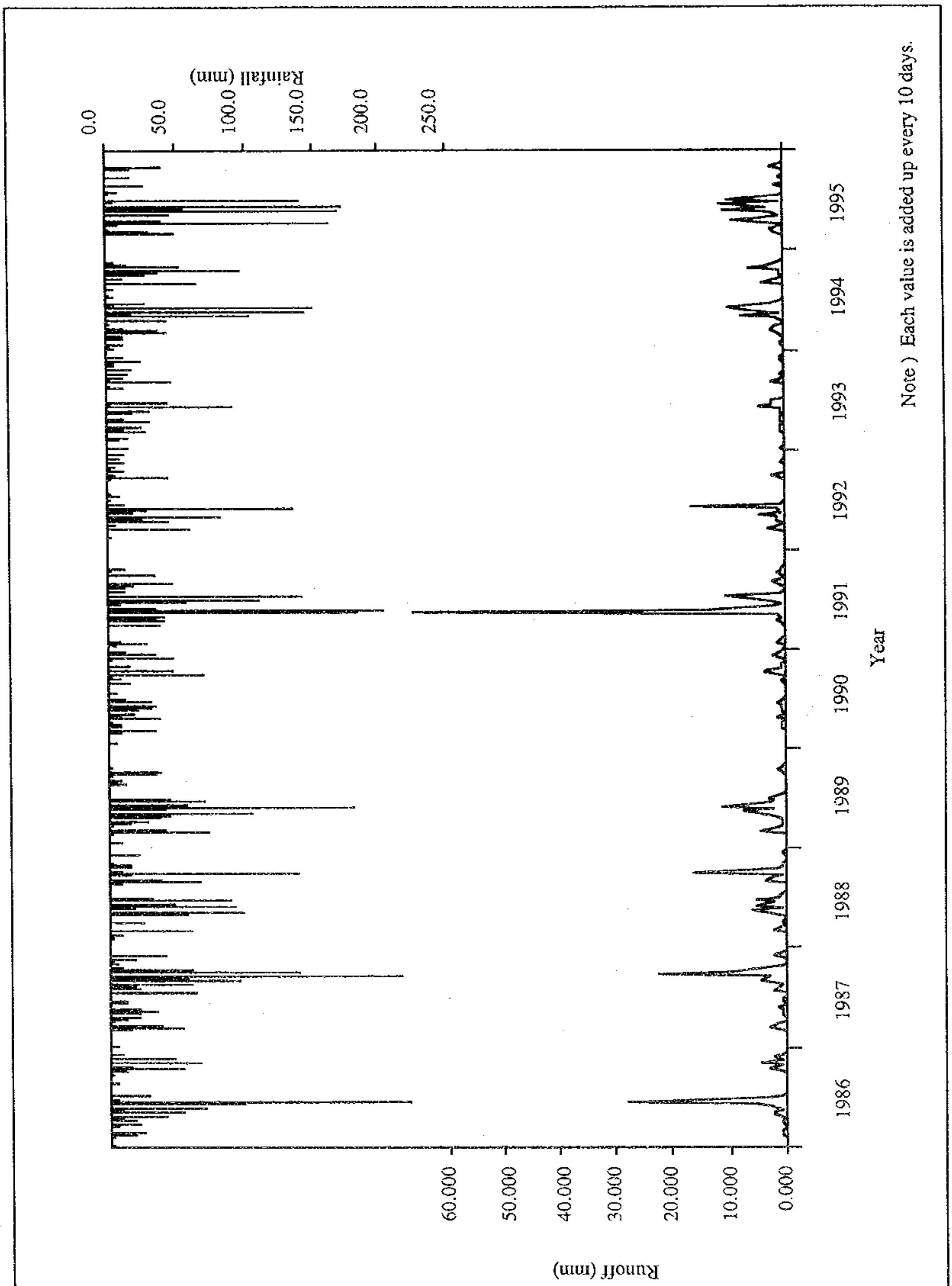

Figure B-9 Runoff Estimationby Tank Model Method from 1986 to 1995 at Mankessim Project	THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA Japan International Cooperation Agency

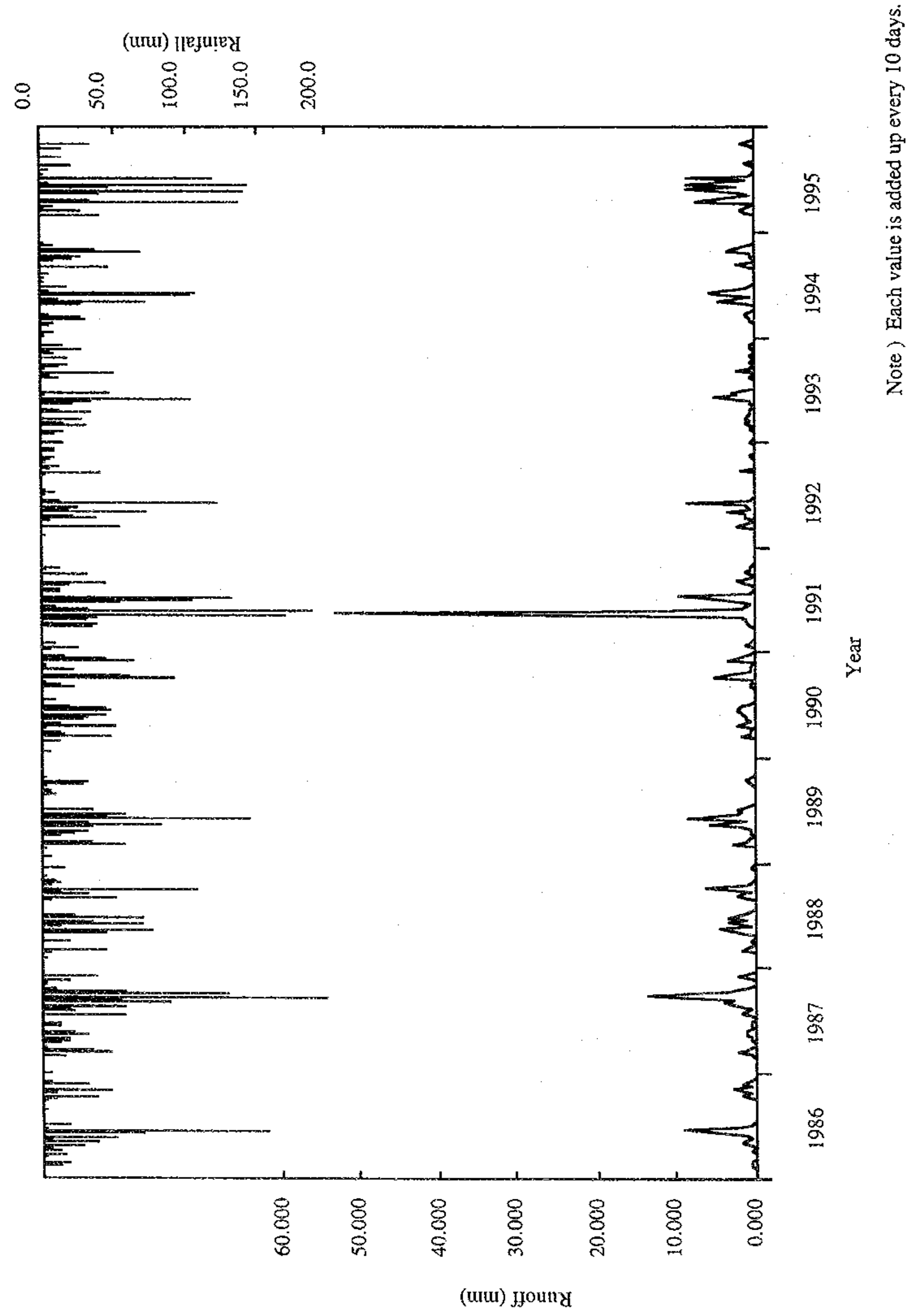

Figure B-10

Runoff Estimation by Tank Model Method from 1986 to 1995 at Okyereko Project

THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA

Japan International Cooperation Agency

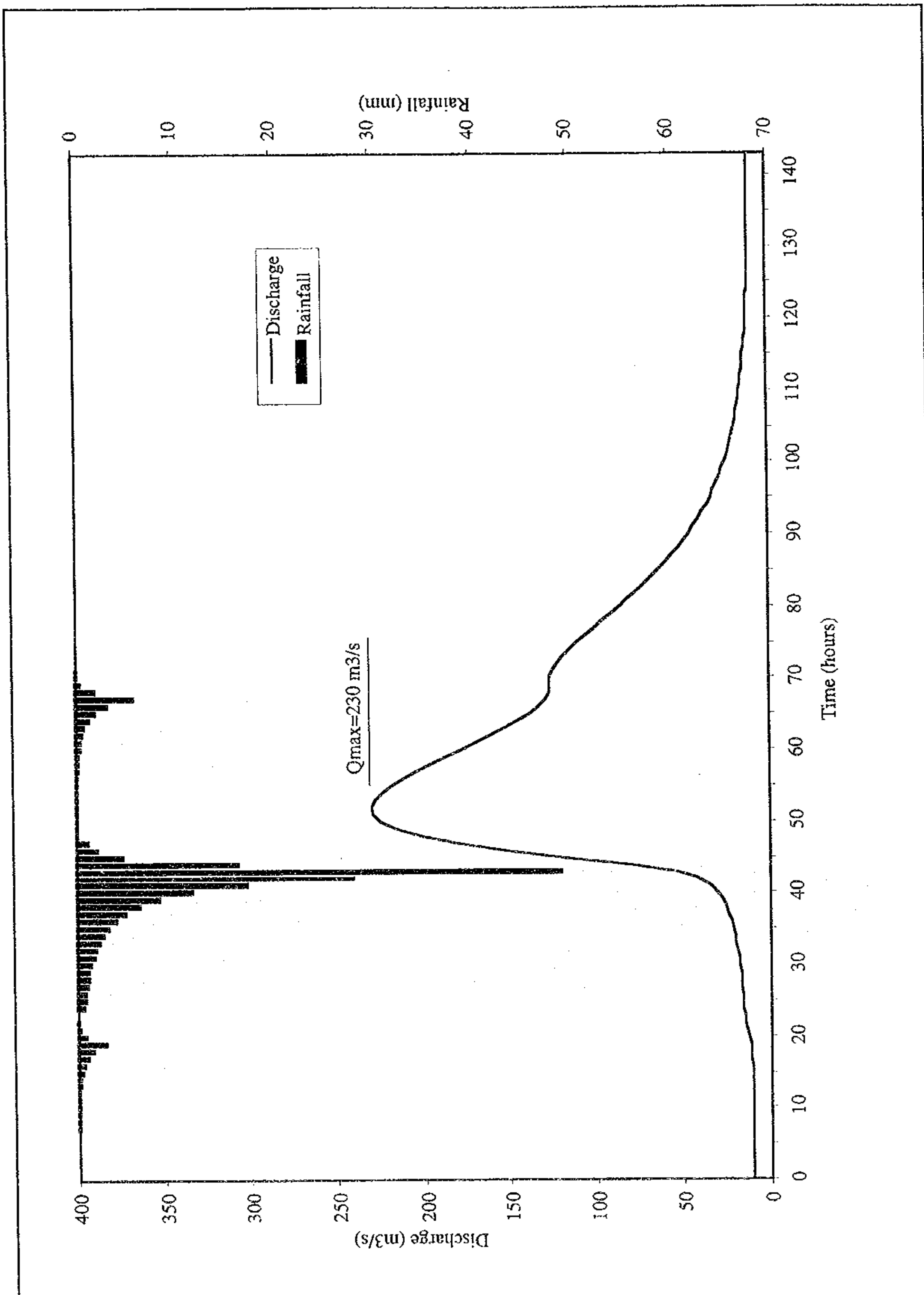

Figure B-11 **Flood Discharge by Unit Graph Method in Ochi-amisa River (Return Period 10-year)**	**THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA** Japan International Cooperation Agency

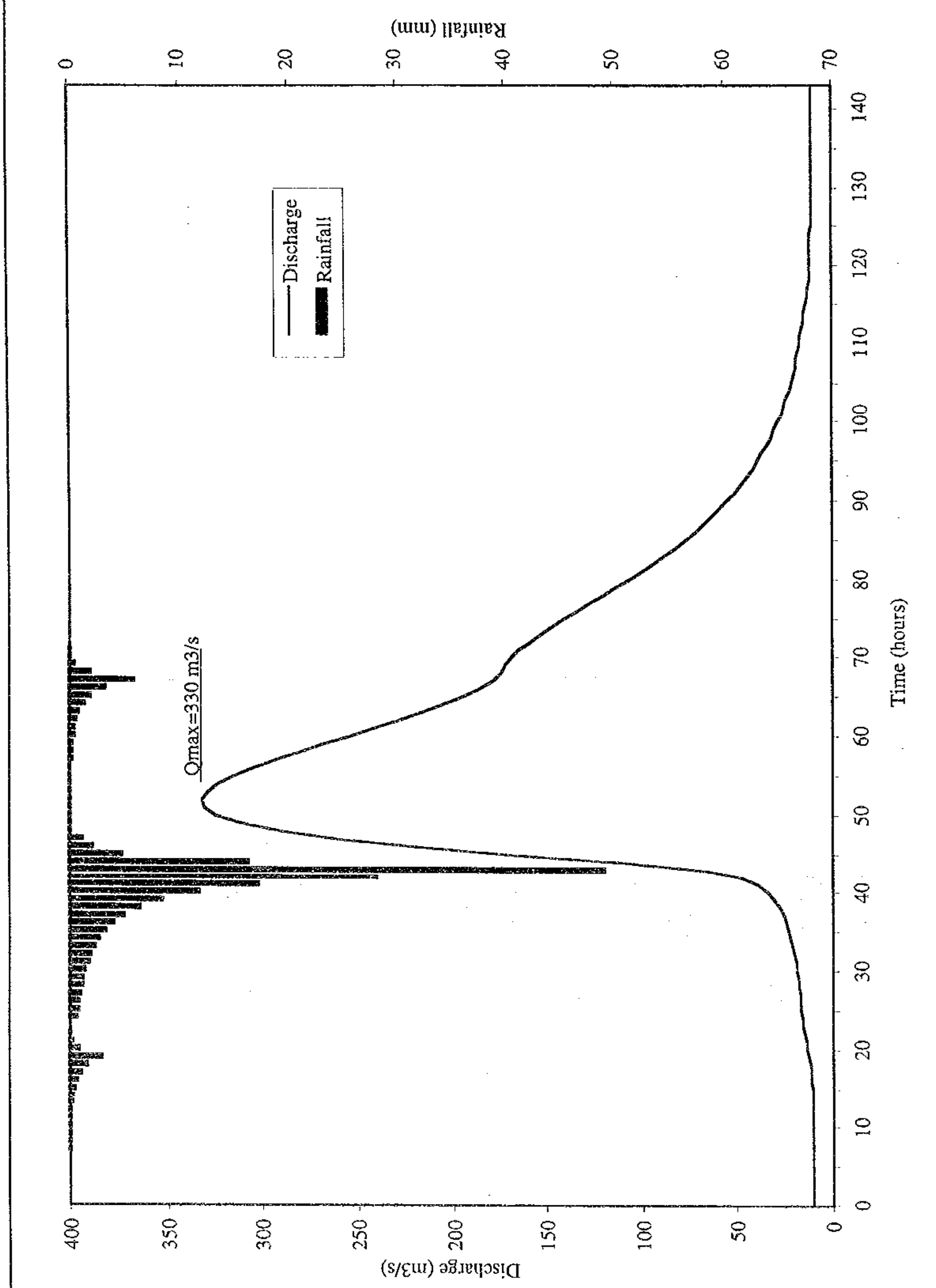

Figure B-12 **Flood Discharge by Unit Graph Method in Ochi-amisa River (Return Period 25-year)**	**THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA** Japan International Cooperation Agency

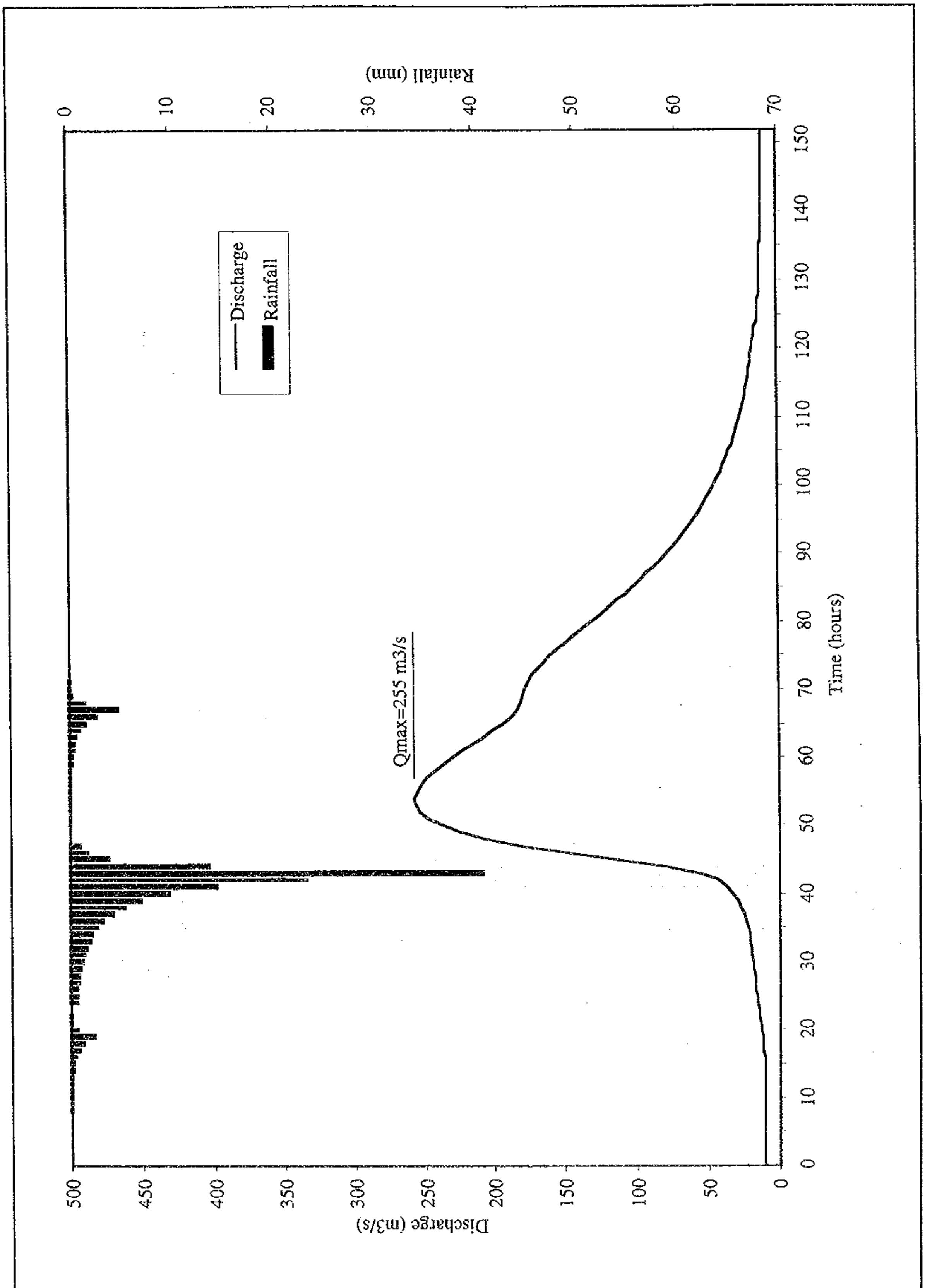

Figure B-13 **Flood Discharge by Unit Graph Method in Ayensu River (3- Day Rainfall / Return Period 10 -Year)**	**THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA**
	Japan International Cooperation Agency

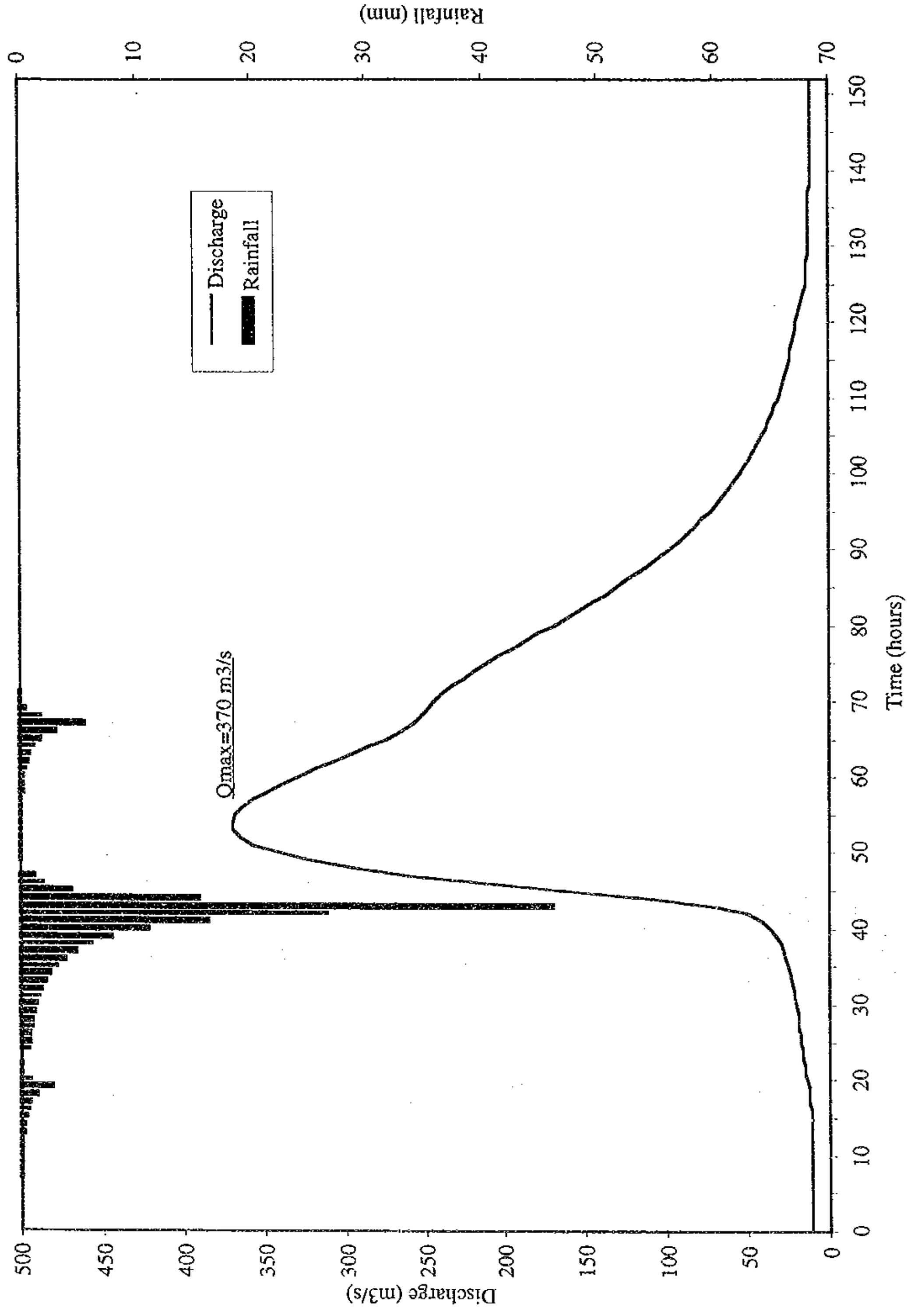

Figure B-14
Flood Discharge by Unit Graph Methodin Ayensu River
(3-Day Rainfall / Return Period 25 -Year)

THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA

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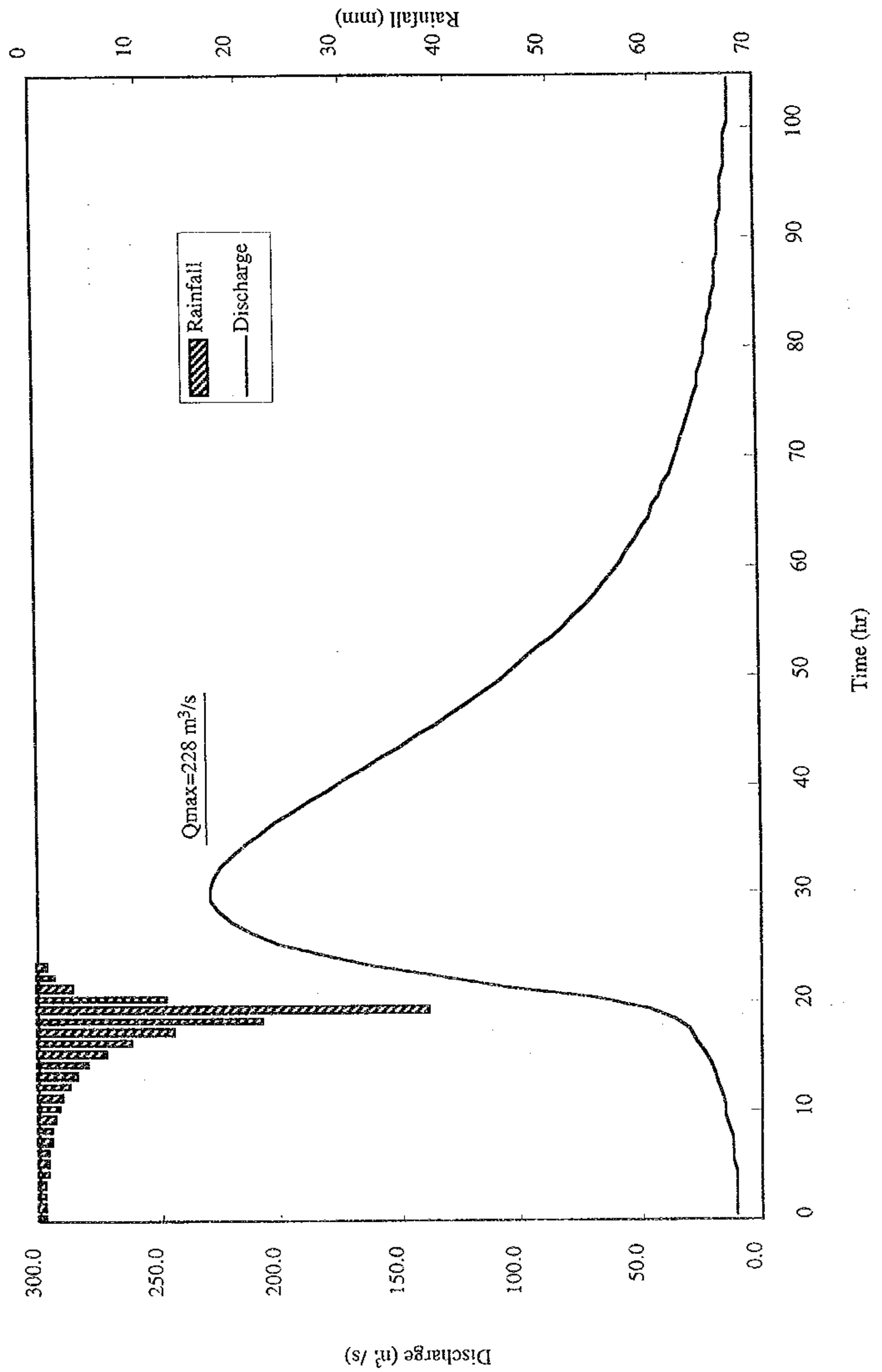

Figure B-15 **Flood Discharge By Unit Graph Method In Ayensu River (Daily Rainfall / Return Period 10-year)**	**THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA**
	Japan International Cooperation Agency

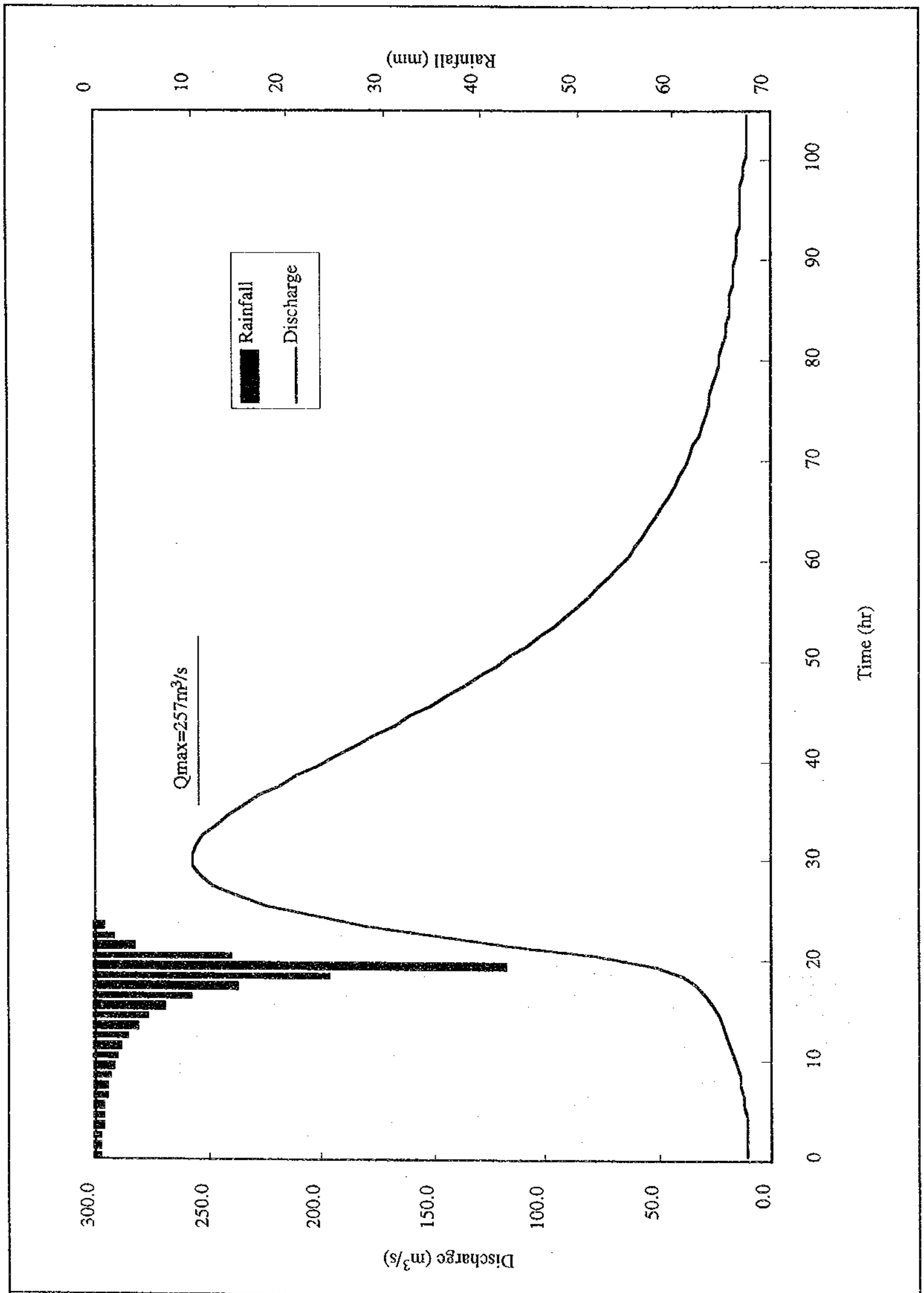

Figure B-16
Flood Discharge by Unit Graph Method in Ayensu River
(Daily Rainfall / Returnpriod 25-year)

THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA

Japan International Cooperation Agency

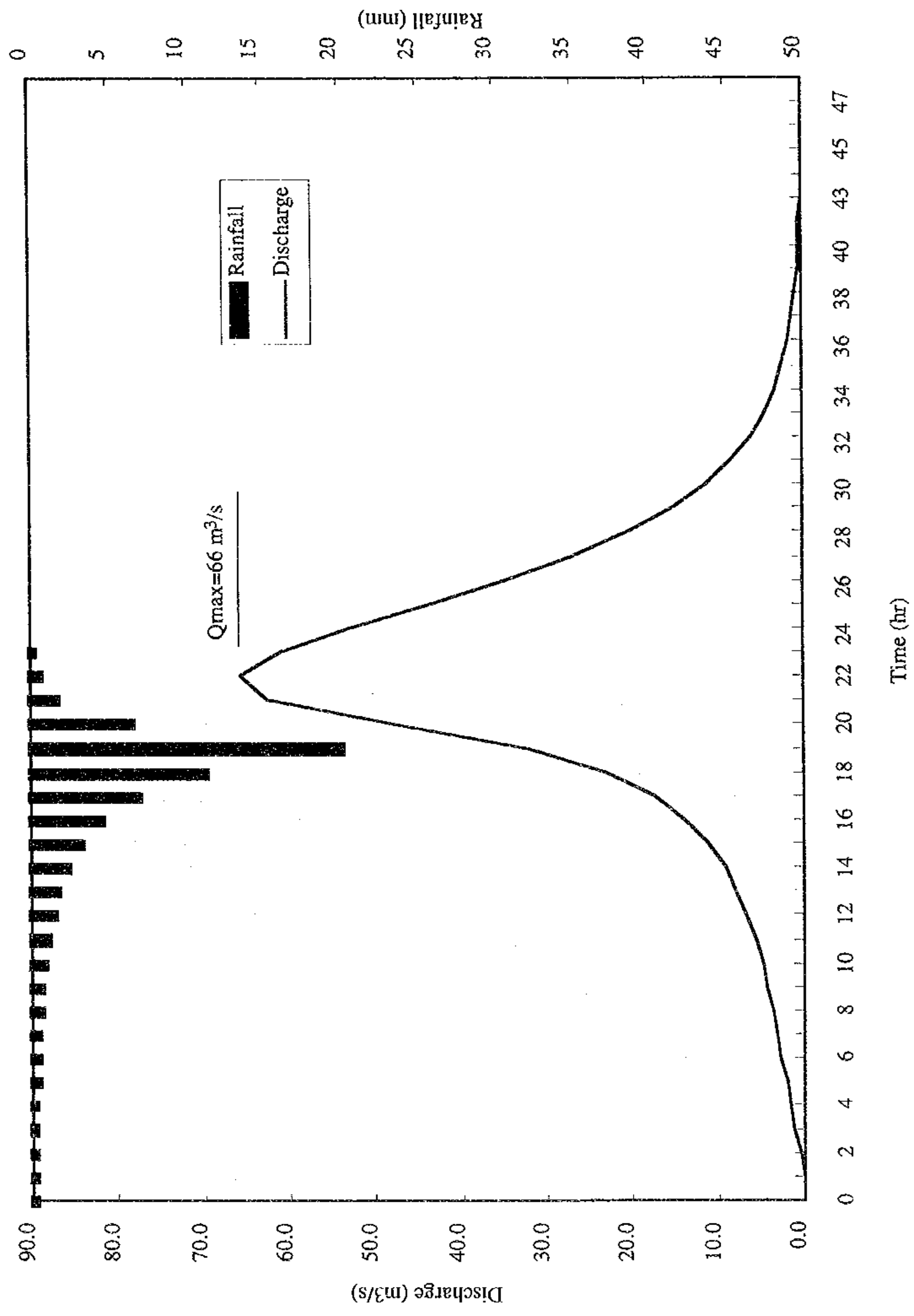

Figure B-17 **Flood Discharge by Unit Graph Method in Gyorwulu River (Daily Rainfall / Returnpriod10-year)**	**THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA** Japan International Cooperation Agency