No. 2

THE GOVERNMENT OF MAURITIUS

THE FEASIBILITY STUDY ON PORT LOUIS WATER SUPPLY PROJECT IN MAURITIUS

SUPPORTING REPORT (I)

APPENDIX A

APPENDIX B

JUNE 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

S D S
[redacted]
89-082(2/3)

THE FEASIBILITY STUDY
ON
PORT LOUIS WATER SUPPLY PROJECT
IN MAURITIUS

SUPPORTING REPORT (I)

APPENDIX A
APPENDIX B

JUNE 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

APPENDIX - A
HYDROLOGY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

1. INTRODUCTION

1.1 General

This Appendix describes the result and process of the meteorological and hydrological study during the period from May 1988 to Jun 1989, which covers, (1) availability of water for the project , (2) preparation of hydrological information for structural designs.

1.2 Study Area

The project area covers the whole basin of Grand River North West (GRNW) and Port Louis City. GRNW is one of the largest river of the island with the catchment of 113.21 km^2 at Municipal Dyke. Water resource for Port Louis Water Supply Project (The Project) is to be developed from the surface water of the basin, therefore the study area is set to be GRNW basin.

The study area consists of Central Plateau whose elevation is more than 300 m, and gorge area which is formed by river channel erosion of GRNW. Central Plateau inclines gently westward to north-westward and high mountain area are located in the eastern and south-eastern ridge of the plateau. 66 percent of the plateau is utilized as permanent sugar cane field. Tea trees are planted in relatively high elevation area in southeastern rim of GRNW. These cultivated area is covered with thick or enough vegetation against surface soil erosion occurring in summer season when the basin has intensive rainfall. Natural forest remains in southern and north-eastern rim of the basin. The area is 11 percent of GRNW. There are some urbanized areas such as Rose Hill, Quatre Bornes, Phoenix and Curepipe, which are located along the western side of the GRNW. Proportion of land use is as follows,

	Land Use	Area (km^2)	Percentage (%)
Plateau	Sugar cane field	22.6	20
	Tea plantation	3.8	3
	Forest ,et.	10.5	9
	Urbanized area	74.2	66
Gorge	Forest/Bush	2.1	2
	Total	113.2	100

From the climatical point of view, One year is divided into two seasons. One is the summer season from November to April, and another is the winter season from May to October. 70 percent of annual total rainfall falls in the summer season. Driest month is October when this basin has only 3.5 percent of annual total rainfall on an average. Heaviest rainfall occurs usually in December to March which is caused by cyclone, or by front of Inter Tropical Convergence Zone. Annual average rainfall ranges from 1400 mm in the north to 3200 mm in the south.

Discharge of the GRNW basin is changed according to the above mentioned climatical cycle. Mean annual total discharge of GRNW at Municipal Dyke (113.2 km^2) is estimated to be 88 MCM. One eighth of total discharge is presently used for water supply. The rest runs through into the sea as unused water because there is no surface water storage facilities in the basin and the flow volume is changeable and not reliable for perennial use.

2. RAINFALL AND OTHER METEOROLOGICAL FACTORS

2.1 Rainfall Data and Other Meteorological Data

2.1.1 Rainfall data

In and around the Study Area, fifty six rainfall gauging stations are in operation by CWA, Meteorological Office and some sugar estates. These data have been collected and compiled by Meteorological Service. Some of them have quite a long recording duration of about 100 years,such as Alma, Reduit Experimental Station and Vacoas. Automatic recorders are operated at Vacoas and Velle Rive. Rests of the stations are daily reading of total rainfall at every A.M. 8:00. Original data in the past twenty five years are still stored in Meteorological Service. On the other hand the previous data are missing or not well preserved.

Location of these stations in the study area is shown in Fig.A.2.1.

2.1.2 Other meteorological data

There are four meteorological stations in/around GRNW basin,such as Reduit,Vacoas,Velle Rive and Curepipe. Observed items are temperature, sunshine/radiation, evaporation, humidity and surface wind. Of them, evaporation, dew point temperature and wind velocity are used for this study. Location of these four stations are shown in Fig.A.2.4. As for dew point temperature, data at Plaisance are also referred.

a) Evaporation

Evaporation data at three meteorological stations such as Reduit experimental station, Vacoas and Velle Rive are available in/around the GRNW basin. Class-A pan evaporation and Penman estimate for 20 year averages (1961-1980) are as follows (*),

---

(*) The Climate of Mauritius, Meteorological service,second edition, 1984

(Unit : mm)

Stations	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
Class-A pan													
Vacoas	171	179	176	155	161	133	123	107	107	122	141	164	1739
Reduit	169	178	182	151	155	129	111	96	104	119	137	163	1694
Belle Rive	132	142	127	113	115	105	103	89	87	89	101	123	1326
Penman's Formula													
Curepipe	142	153	158	140	135	110	90	67	78	93	105	129	1400

All the selected damsites for comparative study(Appendix-D) are located in the area corresponding to 1600 mm to 1800 mm counter line Therefore,monthly mean values of A-pan evaporation at Reduit experimental station where proposed dam (TRO) reservoir is located are used to evaluate evaporation loss from dam reservoirs.

Average annual A-pan evaporation reaches 1694 mm at Reduit. Maximum and minimum evaporation rate is 5.9 mm/day in January and 3.2 mm/day in June. Evaporation from wide open water surface is estimated to be 70 % of Class A-pan evaporation of corresponding season.

b) Dew point temperature

Dew point temperatures during extremely heavy storms are collected in order to estimate probable maximum precipitation for dam/spillway design. Collected data are as follows,

Date	Storm	Observed Stations
20-25,Dec. 1961	Cyclone Beryl	Vacoas, Plaisance
17-20,Jan. 1964	Cyclone Danielle	Vacoas, Plaisance
5- 7,Feb. 1975	Cyclone Gervaise	Vacoas, Plaisance, Velle Rive,Sans Souci
15-27,Jan. 1980	Cyclone Hyacinth	Vacoas, Plaisance,
4-6, Jan. 1987	Torrential rain	Vacoas, Plaisance,Reduit, Pamplemousses,Wooton, Harbour Radio,Sans Souci
12-14,Feb. 1987	Cyclone Clothilda	Vacoas, Plaisance

Detail of method to estimate PMP from data above is described in section 2.4.

c) Wind velocity

Extreme wind is caused by cyclone. One of the severest wind at Mon Desert during Cyclone Gervaise (82 miles per hour in one hour average) is selected to determine design wind velocity which is applied to calculate height of wind waves in Dam reservoir by S.M.B. Method, or,

$$H = 0.86 \times 10^{-3} \times V_{10}^{1.1} \times F^{0.45}$$

where , H : wave height caused by wind (m)

F : length of reservoir (m)

V_n : wind speed of n minutes average (m/sec)

Ratio of probable maximum speed averaged over 10 minutes to that averaged over one hour is set to be 1.06 (*).

Data of annual highest wind speed of 30 MPH (miles per hour) and above over a whole hour recorded during tropical cyclones at Pamplemousses from 1876 to 1975(*) indicate that the selected wind velocity corresponds to about 100-year return period. Plotting position of annual highest wind series and selected wind magnitude are shown in Fig. A.2.5.

2.1.3 Selected rainfall stations

In order to investigate feature of rainfall and to develop basin rainfall by Thiessen polygon method, 22 stations are selected and daily figures of these stations are collected from Meteorological Services,though they include more or less lacking of records.

Meteorological Service has constructed daily basis rainfall data-base and this process is now under way. In the line of the Study ,JICA team cooperate to compile daily basis data-base of 22 stations in/around GRNW with Meteorological Service. Compiled daily basis data are for recent 22 years (1965 -1986,87). Missing data are to be replaced by the data of nearest stations under consideration of correlation of monthly total rainfall,if necessary. Table A.2.1 is monthly summary of rainfall of the said 22 stations.

(*) B.M.PADAYA ,Cyclone of Mauritius Region, Meteorological Service, Mauritius, April, 1984.

Area where a rainfall station covers is about 5 km^2 on an average. This density is enough to estimate basin rainfall even though the rainfall pattern is sporadic.

2.2 Basin Rainfall

2.2.1 Area - rainfall station allocation

In order to assess flood or long term runoff ratio of several catchment area such as five tributaries or, proposed damsite, the rainfall data collected at the stations were transformed into basin rainfall. Thiessen polygon network method is applied because , as mentioned above, rainfall station is well distributed and density of station is appropriate. There are clear tendency that annual rainfall increases by elevation of the location, and this pattern can also be observed in a heavy storm like cyclone,but this polygonal network can represent such spatial distribution by topographic condition in the area. Fig.A.2.3 shows applied Thiessen Polygon, and Table A.2.2 shows area-rainfall allocation for several basins.

Annual basin rainfall at five water level gauging stations (W03,W04,W05,W08 and W10) range from 2300 mm to 2550 mm on an average. Basin rainfall of five main tributaries, that is, the Plaines Wilhems river, the Terre Rouge river,the Cascade river, the Profonde river and the Moka river become small in this order. Monthly summary of basin rainfalls of five stations are shown in Table A.2.3.

2.2.2 Relationship between area and rainfall (Heavy Storm)

Area rainfall depth as a percentage of the point rainfall (area reduction factor) is obtained from iso-hyetal map for several storm of intensive cyclones. In general ,rainfall depth increases by the elevation and most intensive rainfall area is located in mountainous side. Area - rainfall reduction assessed by selected heavy storm indicates that area reduction ratio during intensive cyclone in the area is relatively uniform and this ratio decreases gradually by the area as shown in Fig.A.2.4. This is because rainfall area of intensive cyclone is large enough . Daily shower in the summer season by local air convection is quite sporadic and basin rainfall of such kind event is changeable ,therefore the relation between basin rainfall and area developed above is not available for such small rainfalls. Fig A.2.6 shows also two different equations such as Flecher method and Horton equation. Cyclone Gervaise(5-7,Feb. 1975) has relatively wide and uniform rainfall area than usual estimate by these two equations.

2.3 Probability of Rainfall

Annual maximum rainfall usually occurs during December to February and extremely heavy rainfalls result from cyclone or unstable convergent air mass stimulated by cyclone. Duration of these heavy rainfalls depend on the hysteresis of the cyclone and large scale climatical system.

Annual maximum point rainfalls at selected 20 stations and the largest among these stations for recent 23 years (one-day, two-day, three-day) are tabulated in Table A.2.4 ,A.2.5 and A.2.6. to assess the maximum point rainfall by several return periods ,which may occur somewhere in GRNW. Some probability density functions such as Gumbel, Pearson III,Harzen, and Modified Log-Normal (IWAI) are applied. From the standpoint of safety, the estimated maximum values by return periods are selected as shown Table A.2.7. Followings are summary of probable maximum point rainfall in GRNW.

Probable Rainfall in GRNW (Unit : mm)

Return Period	One-day	Two-day	Three-day
1000	935	1381	1551
200	771	1114	1260
100	701	1003	1140
50	630	901	1021
20	536	765	864
10	463	661	751
5	387	551	632
2	272	398	470
10000	1168	1799	1999

According to observed data, annual maximum of one-day, two-day, three-day duration occurred in a sequence of one storm.

Annual one-day point maximum rainfall in GRNW is based on recent 22 years condition. Therefore rainfall data at Vacoas whose available daily maximum rainfall data lasts for 62 years are also used to calculate annual maximum point rainfall at fixed site, and to assess annual maximum point rainfall in GRNW tabulated above. Annual probable maximum point rainfalls at Vacoas (1926-1987) by some return periods indicates that both of estimated rainfall by several return periods coincides well with each other as shown below. In general Maximum point rainfall by return periods in GRNW are slightly greater than that at fixed station because the point where annual maximum rainfall may occur changes every year.

(Unit : mm)

Return Period	Maximum One-day Point Rainfall in GRNW (1960-1987)	Maximum One-day Point Rainfall at Vacoas (1926-1987)
1000	935	986
200	771	673
100	701	571
50	630	480
20	536	373
10	463	314
5	387	252
2	272	159

2.4 Probable Maximum Rainfall

2.4.1 Cyclonic-adjustment method

According to equation of continuity on water vapor, precipitation increases with relation to quantity of vapor if other conditions are the same. Therefore, it can be thought that probable maximum rainfall might occur if the air had contained maximum water vapor during the heaviest rainfall in the past. Based on the theory, Probable Maximum rainfall is estimated from one of the heaviest rainfall by multiplying the ratio of seasonally/spatially maximum water vapor to the actual water vapor.

As the historically maximum rainfall for recent 23 years, rainfall on February 6, 1975 , Cyclone Gervaise, when dew point temperature data are also observed , is applied. The largest rainfall during the cyclone occurred at Bagatelle and daily amount is estimated to reach 561mm. During the storm, the highest persisting 12-hour dew point temperature is about 22°C at Vacoas (EL.424 m)(see Table A.2.8). Corresponding 1000 millibar point temperature is 20.5°C. 6-hour moving average of dew point temperature at Vacoas and Plaisance are shown in Fig. A.2.7. On the other hand, possible highest 1000 millibar dew point temperature is estimated to be 28°C which is surface water temperature of the sea in summer season in the region because the distance between the Study area and the sea is less than 10 km and main moisture source is thought to be the sea.

Precipitable water at dew point temperature 20.5°C and 28°C is 67mm and 122mm respectively. Finally, probable one day maximum point rainfall by the selected storm is calculated as follows,

$$PMP = R_{max} \times (W_{28}/W_{20.5})$$
$$= 1021 \text{ mm}$$

where,

PMP : Probable Maximum One-day point rainfall in GRNW,

R_{max}: The past maximum precipitation (561 mm at Bagatelle),

W_t : Precipitable water at 1000 millibar dew point temperature t°C.

2.4.2 Statistic method

Cyclonic-adjustment method is one of the best method to estimate PMP,but the result deeply depend on the selected heavy storm. Therefore, many heavy storms should be examined to maximize an estimated precipitation. According to statistical analysis, based on data in Japan, between 100-year or 200-year precipitation and PMP which is estimated from cyclone-adjustment method, the following equations are developed. Japan is Typhoon-attacked area and extreme precipitations are mainly caused by Typhoon or related to Typhoon. Therefore these equation will be also good indication for PMP in Mauritius,

$$PMP = P_{100} \times 1.51 + 23.1 \quad (I) \quad ,or,$$
$$PMP = P_{200} \times 1.30 + 35.9 \quad (II)$$

where; P_{100},P_{200} are precipitation of 100 or 200 year return period.

PMP by means of these formulae are 1081 mm, 1038 mm ,respectively

2.4.3 Comparison of extreme rainfalls

From the safety of dam structure, several extreme precipitations, such as PMP by cyclonic adjustment method, PMP by two statistical formulae and 10000-year one-day precipitation are compared. Of them 10000-year one-day precipitation is the largest of these four cases.

Cyclonic-adjustment	Formula (I)	(II)	10000-year
1021 mm	1081 mm	1039 mm	1168 mm

3. RUNOFF

3.1 Discharge Data

3.1.1 Discharge data

There are six gauging stations in operation in GRNW basin as shown in Fig A.2.3. Of them, five stations are in tributaries in central plateau. The rest station ,W13, is located at Municipal Dyke in GRNW. Conditions of operation and equipment are as follows,

Station	River name	Recorder	Flow condition
W03	Plaines Wilhems	A,D	concrete control section
W04	Terre Rouge	A,D	concrete control section
W05	Cascade	A,D	concrete control section
W08	Profonde	A,D	concrete control section
W10	Moka	A,D	natural control section
W13	GRNW	A	concrete control section

A : Automatic recorder D: daily staff reading

Gauging station on the Profonde river (W08), the Cascade river (W05), the Terre Rouge river (W04) ,the Plaines Wilhems river (W03) and GRNW at Municipal Dike (W13) have concrete control weir with iron blade, and critical flow occur over the weirs. As for the gauging station on the Moka river (W10), the river bed section about 10 meters downstream of the station is covered with fresh lava and critical flow also occurs over the section. The duration of record for each station is shown in Fig.A.3.1. These stations have been well maintained and operated by CWA, Hydrological Section and data have been published as hydrological year book since 1966.

All the surface flow at Municipal Dyke (W13) is abstracted in the driest period of every year,being carried through Municipal Pipeline into Pailles treatment plant ,so water level often drops down below the lowest level of the weir crest in the seasons. At station W13, conduct pipe which connects reservoir of Municipal Dyke and the cylinder of a float of the recorder is set at the same level as that of low flow section of the weir. Furthermore, abstracted water volume at Municipal Dyke has not been observed. Therefore recorded data at W13 are, so far, not available especially for dry seasons.

There is another station in the Moka river called W12,but it has not been operated since 1972. Therefore, the data of the station is not used in the study. Table A.3.1 shows monthly discharge of 6 stations.

3.1.2 Rating curves at water level gauging stations

Rating curves currently used for the five water level gauging stations in GRNW basin do not cover relatively high water level which occasionally happen during flood peak, because above mentioned concrete sections at the water level gauging stations are designed for low flow measurement. In order to evaluate flood ,especially extreme flood peak, rating curve for the range of high water level is developed for each station by means of non-uniform flow equations based on the following procedure,

(1) Conducting cross sectional survey of control section where critical flow condition occurs,

(2) Calculate critical depth (H0) at the section by given discharge (Q),

(3) Calculate river flow profile from the control section to staff gage or section where recorder is installed,and determine the water level (H) at the station which corresponds to a given discharge (Q).

(4) Develop the relation between water levels at gage (H) and corresponding discharges (Q).

According to this procedure , rating curve for each station is developed. Procedure (3) requires cross sections along river channel. In this case the same section is applied to calculate the profile ,because the distance between control section and recorder is at most 15 m and this assumption did not cause notable error. Manning's N is estimated to be 0.4. Sensitivity of N value does not result in remarkable influence. Newly developed rating table is assessed and modified to fit low flow part of existing rating curve which has been used in CWA Hydrological Section.

Newly developed rating curves are shown in Table A.3.2.

Flood analysis described in chapter 4 in this Appendix is based on these new rating curves.

3.1.3 Surface water abstraction

There are 36 abstraction facilities in GRNW. These abstraction right are authorized by Supreme Court though there exist, so far 5 of illegal abstractions. Total abstractions exceed 1.1 $m^3$3/sec in GRNW, excluding those at Municipal Dyke and CEB (run-of-river type) power station. CWA has monitored the abstraction condition and conducted continual direct measurement. Besides, several automatic recorders were installed on canals and have been operated by CWA.

Of them, 23 abstractions were selected and their connections are simplified from the standpoint of influence of abstraction volume on river flow. 5 abstractions (W002, W003, W006, W019 and W026) are located downstream of gauging stations. The rest,or, 18 abstractions are located upstream of water level gauging stations and the influence of these 18 abstractions on river flows is reflected in river flow data at the gauging stations such as W03,W04,W05,W08,W10.

In this study, future water consumption conditions of abstracted water such as purpose,volume,seasonal fluctuation are assumed to be the same as those at present. Therefore abstraction volumes between gauging stations and Municipal Dyke (above mentioned 5 abstractions) are assessed intensively. Direct measurement data at these five abstraction sites are collected to develop the relation between river flow and abstraction volume which is described in section 3.3. Intakes of some canals have sluice gate. In these cases, empirical relations between water depth and discharge are estimated on an assumption that seasonal operation does not change by years.

Fig.A.3.2 shows location of selected abstraction and water level gauging stations.

3.2 Discharge of GRNW Basin

3.2.1 Discharge of five tributaries (at 5 gauging stations)

Discharge data at 5 gauging stations reflect not only natural flow but also artificial abstraction upstream under the hydro-meteorological conditions from 1966 to 1986. Average annual runoff ratio,therefore, changes by basins because the existing flow include effect of artificial abstractions as mentioned above. Table A.3.3 shows annual average run-off ratio at gauging water level gauging stations. There is no abstraction upstream of W10 in the Moka river and flow condition at W10 is better than other four stations.

Fig.A.3.3 shows the duration curves of 10-day mean flow of five water level gauging stations. Reliability of each tributaries is shown below.

(m^3/sec)

Station	average	Reliability 80 %	90 %	95 %
W03	0.48	0.170	0.137	0.120
W04	0.48	0.102	0.087	0.077
W05	0.73	0.247	0.182	0.157
W08	0.32	0.136	0.109	0.091
W10	0.69	0.230	0.171	0.145

3.2.2 Direct measurement through GRNW

Five gauging stations are located in the Central Plateau. On the other hand, proposed intake site for the project will be located at Municipal Dyke or its adjacent site. The residual area between gauging stations and Municipal Dyke is 24 km^2 ,or 21 per cent of catchment area of GRNW at Municipal Dyke.

In order to estimate available water at Municipal Dyke (W13) whose data are not available, relationship between gauging stations and flow downstream was established on the basis of actual direct measurements carried by CWA Hydrological section and JICA team, which cover the dry season in 1988 (on June 3,September 8 ,October 29, October 30, November 1 and November 3). The measuring site had been previously selected and also cleaned to be a good condition for current metering. Locations of the sites and their conditions are shown in Fig.A.3.4. Details of the direct measurement conditions and methods are shown in DATA BOOK of this report.

Followings are the relationship between the discharge at each gauging station and discharge downstream,which makes estimate of discharge at W13 possible. The selected relations are summarized in Table A.3.4 and Fig.A.3.5 (Site identifier such as A-6 are indicated in Fig.A.3.4).

a) Moka river

Discharges at W10 and A-6 are compared with each other. Abstractions which exist between W10 and A-6 are also added to the discharge of A-6. Therefore the coefficient is defined as the ratio of "the discharge at A-6,W002 and W003" against "the discharge W10".

According to the direct measurements on June 3, October 30, November 3 of 1988, the coefficient ranges from 1.33 to 1.69 and these figures are relatively stable. On the other hand, catchment area at W10 and A-6 are 15.1 km^2 and 24.7 km^2 respectively ,so area increase ratio is 1.64.

To estimate daily discharge at A-6 from data at W10, average value of three coefficients, or, 1.47 but not area increase ratio is used because the former is in safe side to estimate available water.

b) Plaines Wilhems river

Discharges at W03 and B-1 are compared. Abstraction which exists between W03 and B-1, or, Plaines wilhems canal (W019), is also added to the discharge of B-1. Therefore the coefficient is defined as the ratio of "the discharge at B-1 (+ W019)" against "the discharge W03".

The whole flow of the Plaines Wilhems river is abstracted at W019 if the flow is less than 300 lit/sec, and the abstracted water is diverted to adjacent basin. Surface water whose origin is groundwater seepage appears again at 1300m downstream of W019 .

According to the direct measurements on October 30 and November 3 of 1988, this seepage volume was 59 lit/sec. This volume was about 50 lit/sec at site investigation on June 3 of 1988. Corresponding discharges at W03 are 84 lit/sec, 98 lit/sec and 300 lit/sec, respectively. This fact indicates that additionally gained flow does not change so much within the range of discharges at W03. On the other hand, catchment area at W03 and B-1 are 27.5 km^2 and 31.0 km^2 respectively ,so, area increase ratio is 1.13.

To estimate daily discharge at B-1 from data at W03, average value of two coefficients, or, 1.65 is used for low flow condition and area increase ratio of 1.13 is applied for high flow condition . As for intermediate flow condition, constant volume of 59 lit/sec is considered to be additional flow.

c) Other three tributaries (Terre Rouge,Cascade,Profonde river)

Accumulated discharges at three gauging stations (W04,W05 and W08), and B-2 are compared. Abstractions of Bagatelle canal (W006) and SIRI(W026) are also added to the discharge of B-2. Therefore, the coefficient is defined as the ratio of "the discharge at B-2,W006 and W026" against "the discharge W04 + W05 + W08".

Discharge at B-2 is not steady usually due to continual power generation at CEB station which is located at Reduit. This power station is run-of-river type and has reservoir capacity of about 6000 m^3. There also exists natural retarding pond located just downstream of the CEB reservoir. The whole river flow runs through penstock of power station and by-passes the pond in the dry season.

To remove the retardation effect of these two reservoirs, CWA Hydrological Section let CEB stop power operation during direct measurement and previous 6 hours on November 3, 1988 (see ATTACHMENT III-2, Direct Measurement in ANNEX A).
On November 3, 1988 ,surface water of the river channel from the Terre Rouge river was stored at these two reservoir and no river flow at CEB station did reach B-2 site during measurement work. Therefore, the discharge at W04 and W05, as well as abstraction of W006 (Bagatelle canal) and W026(SIRI), are added to the flow at B-2 as a total gain at

B-2.

According to the direct measurements on the day, the total flow at B-2 was 527 lit/sec,so the coefficient was 1.39. On the other hand, accumulated catchment area of three stations (W04,W05 and W08) and B-2 are 46.9 km^2 and 55.0 km^2 respectively ,so, area increase ratio is 1.17.

To estimate daily discharge at B-2 from data at(W04+W05+W08), the coefficient of 1.39 is used for low flow condition and area increase ratio of 1.17 is applied for high flow condition . As for intermediate flow condition, constant volume of 147 lit/sec is considered to be additional flow.

d) Estimated flow volume calculated with coefficients mentioned

above is compared with flow volume measured at Municipal dyke (inflow volume into Pailles treatment plant through three pipelines + leakage from three pipelines),which was carried out on Nov,1,1988.

CEB power operation caused cyclic fluctuation on the flow at Municipal dyke, therefore total volumes or average flows for one cycle are applied for this comparison. It turns out that flow volume estimated by the coefficients coincides with actual flow volume at Municipal Dyke within 1 % error as shown below,

Average flow volume at Municipal Dyke (Nov. 1, 1988)

(litter/sec)

Actual Flow Volume *)				
Flow into Pailles Treatment (1)	Leakage from Pipe (2)	Total flow (Actual) (3)=(1)+(2)	Total flow (Estimated) (4)	Error ((3)-(4))/(3)
498.8	50.3	549.1	543.5	1.01 %

Ref : *) Average of flow from AM.10:30 to PM.5:30, November, 1, 1988, which correspond to one cycle of flow fluctuation.(see DATA BOOK P.18)

It is recommended, however, that 1) gauging station W13 is reconstructed so that flow at Municipal Dyke can be recorded appropriately even in driest season (see section 3.1.1), and 2) instrument to measure inflow into Pailles treatment plant is to be installed continuously. Those are inevitable to estimate available discharge at the proposed intake site (Municipal Dyke) more precisely.

3.2.3 Leakage through river channel along GRNW

a) Leakage along GRNW

Preceding preliminary hydrological studies suggest that there may be noticeable flow loss along GRNW ,especially in Soreze area. According to water balance at Municipal Dyke based on direct measurements, flow loss is not detected and gain is observed to the contrary. There is some amount of river deposit along the river, therefore a part of surface water may flow through the river deposit. This loss reappears again at outcrop of rock foundation such as outcrop at Municipal Dyke.

There exists run-of-river type hydro-power station at the Terre Rouge river and the power station releases water into the river channel when retardation pond is filled with water. This operation of power generation causes cyclic fluctuation of flow volume of GRNW as mentioned above. Therefore, flow at Municipal Dyke was measured continuously to a corresponding cycle of the power generation operation to erase the artificial effect.

According to direct measurement on November 1, total amount of five tributaries was 570 lit/sec. Abstraction downstream of the five stations reached 275 lit/sec and rest of flow was 295 lit/sec (570 - 275). On the other hand , the average flow at Municipal Dyke was 549 lit/sec,which means that additional flow between gauging stations and Municipal Dyke was 254 lit/sec (549-295).

(Unit : lit/sec)

Date 1/Nov,1988

W03	W04	W05	W08	W10	Total(1) (a)	Abstraction(2) (b)	W13(3) (c)	Balance (c)-((a)-(b))
79.2	130.4	176.3	114.5	69.6	570.0	275.0	549.1	+254.1

(1) : Total flow at five gauging stations (Average of AM.9:00 - PM.1:00)

(2) : W019,W026,W002,W003 and W006

(3) : Average of AM.10:30 - PM.17:30

It seems as if there was loss along the river channel if values (a) and (c) are compared. But,if abstractions between gauging stations and Municipal Dyke are adequately taken into consideration, total discharge at Municipal Dyke is much more than those of accumulated flow at five gauging stations,implying no flow loss in the river course. For detail,see Direct Measurement of ANNEX A.

b) Leakage from Municipal Dyke, Municipal Pipelines

Leakage from Municipal Dike and Municipal Pipelines is assessed to confirm necessity of reconstruction or maintenance of present intake and transmission facilities. From findings during the direct measurement work mentioned above,the following conclusions are deduced.

- Leakage water from Ø27" pipe at upstream pipe bridge is main source of river flow downstream of Municipal Dyke. Its contribution is about 90 %.

- Leakage from three pipes is 8 % in the present condition and this proportion can be reduced to be 1 % by repair of Ø27" pipe at the pipe bridge upstream. In this case, almost river flow will disappear.

- Seepage through foundation of Municipal Dyke can not be observed in low flow season (September to November in 1988). In case water level of Municipal Dyke reservoir rises by near the crest of low flow section of the weir, seepage through dam abut occurs. This volume is ,however, negligible based on the observation carried out in June to August,1988.

3.3 Water Balance of TRO Damsite

3.3.1 Water balance simulation diagram

Surface flow volume of GRNW decreases gradually in the winter season and the flow can not meet present water demand as well as future demand, unless new storage facilities for water supply is prepared. To assess present water supply capacity and necessary storage volume against given water demand, water balance study was carried out.

Water balance is checked at Pailles treatment plant because the whole of water considered in the Project is treated in the plant. There are three pipelines connected to the plant, such as Municipal pipelines, Montebello pipeline, Soreze pipeline. Surface water developed by the Project is conveyed by Municipal pipelines.

Proposed damsite is located in the Terre Rouge river and 300m upstream of confluence with the Plaines Wilhems river. On the other hand, proposed intake site is Municipal Dyke which is located 2800 m downstream of TRO damsite. The flow is fed by two major blanches (The Plaines Wilhems river, the Moka river) between TRO and the intake site. Therefore available water consists of two portion. One is regulated flow from TRO dam reservoir, and another is non regulated flow from the residual basin. According to water balance at Pailles treatment plant, deficit volume is calculated and water is released from TRO dam reservoir to meet the deficit. From this procedure necessary volume to solve water deficit is determined based on river flow into TRO dam , flow of the residual basin and dam operation rule.

River system diagram and location of existing water supply facilities are shown in Fig.A.3.4. Conditions of the simulation are summarized as follows,

a) Intake Site

Municipal Dyke is set to be the intake site, since the existing facilities at Municipal Dyke can be utilized with some additional construction of pipeline and intake facility, leading to the least cost plan.

b) Damsite

Several alternative damsites such as Guibies, MW4, TR0, TR9, NW0, NW3 are selected for the damsite, requiring the simulation for all of these damsites. However, only the simulation at TR0 site is presented, since the same result is found to be obtained at all the damsites in this simulation due to total surface flow which is much more than the required storage.

c) Existing Pipeline

There exist two pipelines. One is Soreze system, and another is Montebello system.

- Soreze system

Source of Soreze system is surface water of the Moka river and intake water is consumed mainly for industry in Soreze and Montebello area. The rest of the flow reaches Pailles treatment plant, but the amount of the flow is negligible during peak consumption hours. This system receive water from two intake weir. One is pipeline at Soreze dam(W002) and another is open canal (W003,Pailles canal) which is located at 150 m downstream of Soreze dam.

Pailles canal was originally constructed for irrigation,but CWA has priority to use this water for potable water at present. Water through the canal is impounded in small reservoir and carried through Ø236 pipeline after chlorination. This pipeline is finally connected to Pailles treatment plant. Water that reaches Pailles treatment plant is unstable and depends on the consumption of Soreze area, so this system is considered not to be available for Pailles treatment.

Capacity of each pipelines is 26 lit/sec in the simulation, which is entitled for each waterway and less than the actual capacity of these facilities.

- Montebello system

Source of Montebello system is surface water of the Profonde river and abstracted at Martindale bridge (W006). This water runs through Bagatelle canal and pours into bagatelle reservoir. Montebello pipeline was constructed from the reservoir to Pailles Treatment plant. Capacity of the pipe is said to be 283 lit/sec. Bagatelle reservoir has spillway through which surplus water is diverted into Profonde river. There exists about 10 lit/sec abstraction for irrigation directly from the pipeline.

In the simulation, capacity of Montebello pipeline is set to be 283 lit/sec. This figure also does not cause any influence on scale of dam and dam reservoir because almost all flow through the pipeline reaches Pailles treatment plant.

d) Discharge data

10-day average of discharge data for recent 20 years at five gauging stations is used for the simulation study. Discharge of Moka river (W10) is modified with new rating table (see DATA BOOK, Direct measurement). As mentioned in section 3.2.3, additional discharge from residual catchment area downstream of gauging stations is also considered in order to grasp total available discharge. Those are,

- Total discharge from Plaines Wilhems river basin (lit/sec)
  - Low flow condition : $1.65 \times Q_{W03}$
  - Intermediate flow condition : $Q_{W03} + 59$
  - High flow condition : $1.13 \times Q_{W03}$

  where, Q_{W03} :discharge at W03 (lit/sec)

- Total discharge from Moka river basin (lit/sec)
  - for any flow condition : $1.47 \times Q_{W10}$

  where, Q_{W10} :discharge at W10 (lit/sec)

- Total discharge from Terre Rouge river basin (lit/sec)
  - Low flow condition : $1.39 \times (Q_{W04}+Q_{W05}+Q_{W08})$
  - Intermediate flow condition : $(Q_{W04}+Q_{W05}+Q_{W08}) + 147$
  - High flow condition : $1.17 \times (Q_{W04}+Q_{W05}+Q_{W08})$

  where, Q_{W04} : discharge at W04 (lit/sec),
  Q_{W05} : discharge at W05 (lit/sec),
  Q_{W08} : discharge at W08 (lit/sec).

Duration curve of both inflow volume into TRO dam reservoir and the flow from the rest area (residual flow) are shown in Fig. A.3.6.

e) Abstraction

In this study, future water consumption conditions of abstracted water such as purpose,volume,seasonal fluctuation are assumed to be the same as those at present. Abstractions which are located upstream of five gauging stations (W03,W04,W05,W08,W10) are reflected in observed river flow data at the stations , therefore abstractions between gauging stations and Municipal Dyke are assessed to estimate inflow into dam reservoir and flow from residual basin. Direct measurement data at these five abstraction sites are collected to develop the relation between river flow and abstraction volume. Intakes of some canals have sluice gate. In these cases, empirical relations between water depth and abstraction volume are estimated on an assumption that seasonal operation does not change by years.

The following surface water abstractions between five gauging stations and Municipal Dyke are taken into account,

Abstraction Code	Name of Canal	Abstracted Volume (lit/sec)	
Plaines Wilhems River			
W019	Plaines Wilhems Canal	$Q = Q_{W03}$	$Q_{W03} < 300$ lit/sec
		$= 300$	$Q_{W03} > 300$ lit/sec
		where, Q_{W03}	:discharge at W03
Terre Rouge River			
W026	SIRI	8 lit/sec (daily mean)	
Profonde River			
W006	Bagatelle canal	$Q = -19.57 + 1.67 \times Q_{W08}$	$Q_{W08} < 217$ lit/sec
		$= 345$	$Q_{W08} > 217$ lit/sec
		where, Q_{W08}	:discharge at W08
Moka river			
W002	DWS pipeline	26 lit/sec	
W003	Pailles canal	$Q = -5.78 + 0.470 \times Q_{W10}$	$Q_{W10} < 436$ lit/sec
		$= 199$	$Q_{W10} > 436$ lit/sec
		where, Q_{W10}	:discharge at W10

Abstracted water of W006 and W003 runs through canals and then flows into pipelines. If flow volume exceeds pipe capacity, surplus water spills through spillway and flows into river channel again. This so called return flow is considered as available water (see Fig.A.3.4).

f) River maintenance flow

iver maintenance flow of 0.05 m^3/sec is considered necessary to preserve present environmental condition and amenity of reaches downstream of Municipal Dyke.

g) Water loss during infiltration at Pailles treatment plant

Loss of water at Pailles treatment plant is considered to be 5 percent,which consists of,

- backwash water for rapid sand filters,
- sludge drain from sedimentation basins, and
- miscellaneous use.

h) Evaporation

Evaporation from the surface of dam reservoir is estimated from Class-A pan evaporation rate multiplied by 0.7. 10-day mean evaporation rate is then estimated to apply for reservoir operation. These values are shown in Table A.3.5.

i) Leakage from dam reservoir

Leakage may happen from TRO dam reservoir through the left bank of the reservoir, because the left bank is very narrow. Based on ground water simulation study, the following relation between leakage volume and water level of dam reservoir is developed. Actually, ground water flows into dam reservoir if water level of the reservoir is lower than 176 m. From the standpoint of safety the inflow volume is neglected. For detail, see Appendix B,Annex B-2.

$$Q_{leak} = 0.5461 \times (H - 176)^{1.55} + 1.15 \quad (H > 176)$$
$$= 0 \quad (H < 176)$$

where;

Q_{leak}: leakage volume from TRO dam reservoir (lit/sec)
H : water level of dam reservoir (m)

10-day average volume of leakage from the reservoir is calculated based on the water level of the beginning of each

10-day and the leakage volume is subtracted from stored volume in the reservoir. This leakage is assumed to appear again in the Plaines Wilhems river.

3.3.2 Required storage volume

a) Dead storage

Sediment analysis indicates that 70 % of total sediment trapped into TRO dam reservoir reaches 0.29 MCM after 100 years. Corresponding dead water level is therefore set to be 139.0 m. Effective storage is defined as volume above 139.0 m.

b) Reservoir operation

Water balance is calculated at Pailles treatment plant and deficit is assessed as a volume which should be supplied from proposed reservoir.
Inflow into dam reservoir is stored up to effective storage. Inflow exceeds a given storage capacity is spilt through spillway. Water is to be released from dam reservoir only when deficit occurs at Pailles treatment, otherwise water which flow into the dam reservoir is stored as unused water. Required necessary storage to meet given demand is determined by changing effective storage of dam reservoir.

c) Required Storage Volume

Minimum storage volume with which no deficit occurs for 21 years (from November 1966 till October 1986) is defined as required storage volume.

Required storage volumes for several given demands are shown in Fig. A.3.7. The severest hydrological condition occurred in hydrological year 1983, therefore required storage volume actually coincides with the storage to meet the severest hydrological condition.

According to the recent 21 year hydrological condition, 1) No deficit may occur if production demand is less than 0.45 m^3/sec, and 2) Required storage volume increases rapidly especially if demand is more than 0.8 m^3/sec. Required storage volume corresponding to the demand in year 2030 (or 0.95 m^3/s + maintenance flow of 0.05 m^3/s + 5% for the loss at treatment plant = 1.05 m^3/s) is 6.3 MCM.

The present demand of 62,000 m^3/day or 0.72 m^3/s) may cause a deficit of 1.3 MCM deficit under the severest condition, which explains the severity of water supply condition in 1983-1984.

Fig.A.3.8 and Fig.A.3.9 show released water, inflow and the required volume for the demand in 2030 under hydrological conditions of recent 20 years and average condition respectively.

d) Influence of leakage through left balk on required storage volume

In order to certify the influence of leakage through left bank on required storage volume, reservoir operation with or without leakage is calculated. As for a case "with project", following two operation rules are additionally applied.

(1) leakage volume is derived from dam reservoir according to the relation to water level which is shown in 3.3.1 i),

(2) leakage from the reservoir through left bank appears in the river channel of the Plaines Wilhems river .

Leakage water through left abut appears again in the river channel of the Plaines Wilhems and available at Municipal Dyke. Water balance is calculated at Pailles treatment plant and some of leakage water is counted as inflow into Municipal Dyke.

Accordingly water released from TRO dam reservoir can be saved in proportion to this "effective leakage". Inefficient part of leakage occurs in summer season when river flow is abound. On the other hand, leakage becomes effective in winter season because river flow decreases and also leakage itself becomes small. From the comparison with two cases (with and without leakage),it turns out ;

- river flow including the leakage is so small in the crucial drought condition that the river flow can not remove deficit at Pailles treatment plant. In other words, The whole of leakage is effective at Pailles treatment in the most crucial condition,

- Therefore, leakage through the left bank does not effect required storage volume of TRO dam reservoir.
  Table.A.3.6 and Table A.3.7 represent the average release pattern from dam reservoir in the case of with or without leakage. Followings are the summary of these two cases.

Case	Spillout (MCM)	Release from Dam (MCM)	Leakage (MCM)
w/o leakage(a)	41.32	7.50	-
with leakage(b)	40.92	7.06	0.84
Difference(a)-(b)	0.40	0.44	0.84

Annual average of leakage through left bank is 0.84 MCM. Of them,0.40 MCM is originated from relatively high flood water which would be otherwise spilt out as unused water through spillway.

The rest,or 0.44 (Total leakage - spilt out leakage) is originated from stored water which would be otherwise released from dam to downstream effectively. Effective leakage,that is, saved water due to the increase of river flow is 0.44 MCM (7.50 MCM - 7.06 MCM). These figures indicates that leakage of water which is once stored into the dam reservoir is still fully effective for the demand downstream. Water balance for 21 years under the conditions of with or without the Project are tabulated in DATA BOOK.

3.3.3 Reliability of water supply

a) Reliability and effective storage

Reliavility of water supply increases by storage volume. In order to evaluate the relation between reliability and effective storage volume of dam reservoir, the reliavility defined as below is used;

$$\text{Reliavility} = 1 - N_{deficit}/N_{total}$$

where,

$N_{deficit}$: Numbers of days when deficit occur

N_{total} : Numbers of total days when flow data are available(Jan.11,1966 to Oct.31,1986,or, 7589 days)

The relationship between reliavility and demand (production level) for several effective storages is shown in Fig.A.3.7 and Table A.3.10.

This figure also indicates that reliability under present condition (demand : 0.72 m^3/sec , no storage) is 95 % ,or, deficit may occur 18 days in a year on an average. If no storage is prepared, reliability will decrease to 80 %, or, deficit will occur for 70 days in the year 2030 (production demand: 1.05 m^3/sec).

Water demand of low estimate is selected in the Study. Other projections,such as medium and high projection will cause water deficit even if 6.3 MCM storage is constructed in GRNW basin. Water demands of production level in the year 2030 are 1.31 m^3/sec for high projection and 1.24 m^3/sec for medium projection respectively. Reliavility under these two demand projections are calculated as follows;

	Demand in the year 2030		
	Low estimate (1.05 m^3/sec)	Medium estimate (1.24 m^3/sec)	High estimate (1.31 m3/sec)
Reliability	100 %	98.8 %	97.7 %

If water demand increases according to high projection, reliability will be 98.8 % ,or, deficit will occur for 4 days in a year. In case of medium estimate reliability will be 97.7 % ,or, deficit will occur for 8 days.

b) Water supply reduction rate

Deficit volume and number of days when deficit occurs is calculated by given storage volumes through water balance simulations. In order to check severity of deficit and supply reliability for a certain storage volume, water supply reduction ratio (C) are calculated. This ratio is calculated by a formula shown below, which means that water supply is reduced to make severity of constraint constant during a period when deficit occurs,

$$C = (S_o - S) / N / 86400 / Q$$

where, C : Water supply reduction ratio

S : Given storage (m^3)

S_o: Required storage (m^3)

N : Number of days when deficit occur

Q : Water demand (m^3/sec)

Table A.3.8 presents number of days when deficit occurs and water supply reduction rate for the demand in 2030 under various given storages. Following is a summary of water supply reduction rate under the hydrological condition 1983 and 22 year average.

	Reservoir Storage Volume (MCM)			
Condition	0.0	2.0	4.0	6.0
Year 1983				
deficit days	220 days	110 days	70 days	10 days
reduction	33 %	45 %	38 %	23 %
Average (1966-1986)				
deficit days	107 days	23 days	5 days	1 days
reduction	19 %	30 %	39 %	31 %

c) Statistic feature of drought

Year 1983 is selected as base year of hydrological condition because the year is the driest during river flow observation period which has continued from 1966. In order to assess severity of the year, statistical analysis was carried out. According to the water balance simulation, a spell of water deficit finishes within one hydrological cycle and water flow into Pailles treatment can meet the demand in the year 2030.

Required storage at Pailles treatment plant, that is, accumulated volume in a spell of deficit during one hydrological cycle reflects succeeding rainfall in the GRNW basin. To estimate required storage when no river flow in

GRNW is available , relationship between required storage volume of each hydrological year from 1966 to 1986 and monthly rainfall at Vacoas is developed. The Result of multiple regression analysis is as follows,

$$V_y = \underset{i=1,12}{E}(a_i \times R_{i,y}) + 6.942$$

Where, i : umber counted from December,or i=1 means December and i=12 means November of next hydrological year,

y : hydrological year y,

V_y : Estimated required storage volume of given hydrological cycle (MCM) mainly occurs in the hydrological year y,

$R_{i,y}$: 3 month moving average whose central month is month i of year y,

a_i : coefficient for $R_{i,y}$ shown as below,

i	1	2	3	4	5	6	7	8	9	10	11	12
month	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
a_i	-2.50	-0.80	-1.18	3.64	-7.17	-0.07	-2.91	7.49	-28.66	-5.17	-2.12	6.16

Correlation coefficient : 0.84

Actual required storage and estimated ones by means of the equation mentioned above is shown in Fig.A.3.10. Required storage of 17 years (1951 to 1965 ,1986, 1987) are additionally given from monthly rainfall of corresponding hydrological year at Vacoas as shown in Fig.A.3.11.

Finally, frequency analysis of required storage volume is carried out in order to assess drought condition for relatively long term. Storage of 4 MCM and 6 MCM correspond to 6 year and 22 year return periods,respectively. Frequency curve of required storage volume is shown in Fig.A.3.12.

3.3.4 Capacity of existing facilities

In order to assess incremental benefit between with and without the Project, the future supply condition with existing facility is estimated by the simulation mentioned above. In this case, storage capacity is considered to be zero.

Existing water supply facility whose source are GRNW basin do not have any storage capacity to meet deficit during dry season. Besides this, capacity of transmission pipeline from Municipal Dyke decreases. Therefore, future supply volume by existing facility depends on the severest of the two factors,that is, hydrological condition and capacity of pipeline facilities.

a) decrease of supply capacity

Transmission capacity in the future is tabulated as follows. For detail, see 3.3.2 of Main Report.

Capacity of Existing Facility (m^3/sec)

Pipeline	1988	1990	2000	2010	2030
Pailles	0.622	0.618	0.591	0.502	0.470
Montevello	0.283	0.283	0.283	0.283	0.283
Total	0.905	0.901	0.874	0.785	0.753

b) Supply volume without storage

Supply volume under two hydrological conditions such as hydrological year 1983 and recent 22 years average are examined. Following are the result of reservoir operation with enough transmission capacity under these two hydrological conditions. Details are shown in Table A.3.9 (1)-(9) and Table A.3.10.

(m^3/sec)

Hydrological condition	1988	1990	2000	2010	2030
1983	0.737	0.720	0.796	0.830	0.851
22-year average	0.784	0.766	0.887	0.952	0.990

As shown in above two tables , dominant factor on supply is determined by hydrological condition by the year 2000. On the other hand, transmission pipeline capacity decides the severity of water deficit after the year 2000.

4. FLOOD ANALYSIS

4.1 Analysis of Effective Rainfall

Effective rainfall is defined as the part of rainfall which is discharged as flood or intermediate flow through river channel.

Seven storms and 27 flood hydrographs at 4 gauging stations (W03,W04,W05 and W08) are selected to assess flood run-off ratio and effective rainfall in the basin. Run-off ratio is quite low if the total rainfall is less than 250 mm and its value is 17 %. If total rainfall reaches 250 mm, run-off ratio becomes large and this value reaches 60 % as shown Fig.A.4.1. The heavy rainfalls of several storms range from 100 mm to some 700 mm.

The catchment area mainly consists of gentle plateau whose cultivated area as well as natural forest is covered with thick or enough vegetation. Initial loss of rainfall is relatively large due to the gentle slope of the basin and high storage effect.

The following relation between rainfall and effective rainfall is deduced from efective rainfall analysis, that is,

$$Re = 0.170 * R \quad (Rs < 250 \text{ mm})$$
$$Re = 0.625 * R \quad (250 \text{ mm} < Rs)$$

where, R : Rainfall (mm/hour)
Re: Effective Rainfall (mm/hour)
Rs: Accumulated Rainfall (mm)

Flood runoff ratio increases according to total rainfall depth if rainfall intensity is the same level ,because larger part of ground surface become satulated. In order to refrect this tendency on Probable Maximum Flood (PMF) , runoff ratio when total rainfall depth exceeds 700 mm is estimated to be 80 % which is maximum value of flood runoff ratio in Tercialy or Quaternary mountainous area,or,

$$Re = 0.800 * R \quad (700 \text{ mm} < Rs)$$

4.2 Storage Function Method

In order to decide design flood, flood simulation is carried out by means of "storage function method".

The storage function presumes a rainfall storage defined by the balance of rainfall and run-off volume, and computes the discharge in time series from the changing of the storage volume in the basin by means of the equation of continuity of volume and the storage function,or,

$$S = K \cdot Q^p \quad (1)$$

$$Re \times A/3.6 - Q = dS/dT \quad (2)$$

where,

S : Storage ($m^3/s \cdot hour$)

Q : Discharge (m^3/s)

K,p: Constants

Re : Effective rainfall (mm)

A : Catchment Area (km^2)

Discharge which occurs by given rainfall is calculated by means of these equations. K value and p value mathematically represent a capacity of basin storage and speed of runoff,respectively.

To apply a set of parameters K,p to other basins, storage and discharge are represented in millimeter in the catchment area. Accordingly the constants K,p are changed as follows,

$$S = s \times A / 3.6 \quad (3)$$

$$Q = q \times A / 3.6 \quad (4)$$

where,

s : Storage depth (mm)

q : Discharge depth (mm/hr.)

Substituting (3) and(4) into equations (1),(2) ,the following expressing for storage are obtained,which is the framework of the method.

$$s = k \times q^p \quad (5)$$

$$ds/dt = r - q \quad (6)$$

where, k : $(3.6/A)^{1-p} \times K$

Dimension of the parameters k,p are independent of the area of the basin. If hydrological and geographical condition of the basins are equal with each other, the same value of the parameters k,p are applicable.

4.3 Composition of Model

4.3.1 Selected storms in the past

Both daily staff reading and automatic water level recording have been operated at each station of five tributaries. As for W13(Municipal Dyke), only automatic recorder is operated because of hardness of accessibility. In order to determine two parameters (k,p), following four cases of flood events which have both hydrographs at water level gauging stations and corresponding basin rainfall information are selected as follows,

Case	Date	Name	Station	Hourly Rainfall
A-1	7,Feb.1975	(Cyclone Gervaise)	W03	Vacoas
-2			W04	Vacoas
-3			W05	Vacoas
B	16,Jan.1985	(Cyclone Celestina)	W13	Vacoas, Velle Rive

These storms have wide and uniform rainfall pattern and total amount during the storm are large. Out of these, Case A is the largest storm for recent 20 years (1966-1986) according to one-day rainfall. Peak flood of each station in the storm also indicates maximum height.

4.3.2 Basin rainfall and duration

By means of Thiessen polygon, daily basin rainfall of these stations(W03,W04,W05,W13) for four cases (A-1,A-2,A-3 and B) are calculated according to area-rainfall allocation described in chapter 2 and Table A.2.2. Hourly rainfall data at only two stations are available. But hourly rainfall pattern in the Study area is the same ,so long as heavy rainfall such as cyclone are concerned. Fig. A.4.2 shows that hourly rainfall pattern at Vacoas and Velle Rive are almost similar by cyclones. Based on this information, hourly rainfall patterns at Vacoas during the corresponding storms are applied for basin rainfalls of four cases (A-1,2,3 and B).

4.3.3 Determination of parameter k,p

Parameters of the model (k,p) are determined so that a simulated flood hydrograph coincides with the actual one. As a initial value ,k and p are set as a function of mean slope of the basin by the following equations.

$$k = 118.84 \cdot I^{0.3}$$
$$p = 0.175 \cdot I^{-0.235}$$

where ,

I : Mean slope of the basin

This is empirically developed by flood data of the Tone river,one of the largest river in Japan. By substituting 1/23.5 for I value,which is the mean slope of GRNW basin , the parameters k,p are computed to be 99.7 and 0.374 respectively. These values are scrutinized with the actual flood hydrograph of four cases by trial and error. Finally determined parameter sets for each flood is as follows;

Case	k value	p value	Station	Catchment Area (km^2)
A-1	25.6	0.415	W03	29.7
A-2	41.1	0.415	W04	17.6
A-3	32.7	0.415	W05	8.3
B	24.5	0.415	W13	113.2

K values of A-2 and A-3 are larger because station W04 and W05 are located in the Central Plateau covered with sugar cane and slope of these catchment is quite gentle. On the other hand, W03 is located in the Plaines Wilhems river which is the most urbanized area. Station W13 is located in GRNW gorge. This catchment area include very steep slope area making flood peak high,therefore k value is smallest among them.

4.4 Design Flood at TRO Damsite

4.4.1 Simulation model

Based on the calibration with actual hyetograph and hydrograph, 4 sets of parameters are determined as mentioned above. Proposed dam (TRO) is located at 2km upstream of W13 station and the catchment of the damsite also includes steep slope area in the gorge along rive channel,therefore set of parameter of Case B is applied for design flood at TRO damsite.

4.4.2 Design rainfall

a) Duration of storm

According to observed data, annual maximum of one-day, two-day, three-day duration occurred in a sequence of one storm. Therefore three-day series of probable one-day rainfall by return periods are developed as follows,

$$P_{3rd} = P_{1\text{-}day}$$
$$P_{2nd} = P_{2\text{-}day} \times 2 - P_{3rd}$$
$$P_{1st} = P_{3\text{-}day} \times 3 - P_{2nd} - P_{3rd}$$

where; P_{nth} : one-day probable point rainfall of n-th day
$P_{n\text{-}day}$: n-day probable point rainfall of given return period in GRNW:

b) Basin rainfall

Three-day series of probable rainfall are point rainfall which may occur in GRNW. Therefore this values should be modified based on the relation between area and basin rainfall as mentioned in section 2.2.2. Catchment area of proposed damsite TRO is 54.9 km^2, and area reduction factor of 0.85 is applied as shown in Fig.A.2.4, which is maximum value for the area among curves in the figure.

c) Hourly rainfall pattern

24-hour rainfall record at Vacoas whose amount exceed 180 mm for recent 21 years are selected to determine hourly rainfall pattern for design flood as shown in Fig. A.4.3. Of them, rainfall pattern on 6,Feb. 1975 is considered to be severest on both total volume and intensity, and 24-hour disbursement is finally determined as follows. As for three-day series of one-day rainfalls , same hourly rainfall pattern is considered to repeat three times.

Hour	Percentage	Hour	Percentage
1	0.52	13	5.70
2	3.52	14	12.11
3	0.58	15	13.42
4	1.26	16	6.58
5	0.93	17	0.82
6	1.62	18	0.47
7	2.74	19	0.08
8	6.85	20	0.14
9	6.30	21	2.16
10	10.96	22	1.53
11	9.04	23	1.51
12	10.96	24	0.44

Based on the above result, design rainfall by return period are estimated as follows,

(mm)

Return Year	1st day	2nd day	3rd day	Purpose
10	77	168	393	-
20	84	195	455	coffer dam design
100	116	257	596	
200	125	291	656	dam/spillway design
PMP(*)	171	536	993	free board of dam

(*) 10000-year rainfall is used as PMP. For detail see section 2.4

4.4.3 Design flood

Probable flood peaks and their hydrographs by return periods are developed by using three-day series of probable one-day basin rainfall. The peak discharge of the simulated hydrograph at TRO damsite are 455 m^3/sec at 10-year flood and 796 m^3/sec at 200-year flood, respectively.

Probable floods and their hydrographs are shown in Fig.A.4.5. and summarized below .

Probable Peak Discharge

Return Year	Peak discharge (m^3/sec)	Runoff Ratio (%)	Specific Discharge (m^3/sec)	Creager's C
10	455	43	8.1	16.8
20	536	50	9.8	20.2
100	718	50	13.1	27.1
200	796	52	14.5	30.0
PMF	1596	67	29.1	60.1

Creager's C is one of the prevalent indictor to estimate historically maximum flood peak ,defined as follows;

$$q = C \times A^{(A \quad -1)}$$

where, q : historically maximum flood peak ($m^3/sec/km^2$)
C : Creager's C
A : Catchment Area (km^2)

In order to assess the magnitude of selected PMF, the value applied for low latitude zone in Japan (Okinawa region), is compared. This area is located in latitude N 25° to N 33° and severely suffered from typhoons almost every year ,whose climatical and geographical condition is comparable with that of Mauritius.

The value of 56 is applied empirically for Okinawa region. On the other hand ,the value for the PMF at TRO dam site is calculated to be 60.1 (A=54.9, q=29.1)and grater than that in Okinawa, which indicates that estimated PMP is more safe and acceptable to assess safety of TRO dam against extreme flood.

5. SEDIMENT

5.1. Suspended Load Transport

5.1.1 Data available

In order to decide dead storage volume of TRO dam reservoir, sedimentation which flows into the reservoir is estimated by several methods.

Only two sediment data at the lower reaches of GRNW are available. Those are,

Date	Time	Site	Total Solid (mg/l)	Dissolved Solid (mg/l)	Discharge (m^3/sec)
Jan.5,1987	10:45	W04	880	110	60
Jan.5,1987	11:10	W05	780	120	-
Jan.5,1987	11:55	W13	390	150	625

These data are not enough to clarify the relationship between sediment and discharge. Therefore, data of three experimental areas are used though the areas are relatively small. Sediment sampling data and corresponding discharges were measured at 30 minutes intervals at three stations. The feature of these stations and available data are as follows,

Station	River system	Catchment Area (km^2)	Number of days (days)	Vegetation
E04	River Bateau	0.537	9	Pineapple field with under glass
E05	River Vacoas	0.602	8	Natural bush
E06	River Gontran	0.494	11	Tea field

5.1.2. Relationship between daily sediment product and daily discharge

Relationship between sediment content (unit: mg/lit) and specific discharge of daily mean are examined by the data above and following equation is deduced by least square method (see Table A.5.1 and Fig.A.5.1),

$$q_s = 176.1\ q$$

where, q_s : daily mean sediment content (mg/lit)
q : specific discharge of daily mean ($m^3/sec/km^2$) at gauging stations of experimental area.

Sedimentation usually occurs during extreme flood. Relationship between specific discharge at TRO damsite (q_{TRO}) and specific discharge at three gauging stations (q) is estimated by some actual flood events and also Creager's formula, that is,

(q_{TRO})/(q)					
23/12/79	18/Jan/80	2/Mar/80	28/Mar/80	Average	Estimate from Creager's Formula
0.613	0.250	0.170	0.230	0.315	0.203

Therefore, 0.203 is applied for the coefficient to convert q into q_{RO} from the stand point of safety. The relationship between q_s and q_{TRO} is estimated as follows,

$$q_s = 867.5 \times q_{TRO}$$

Daily mean sediment volume is then estimated by following equation,

$$Q_s = q_s \times (1/r) \times 10^{-6} \times Q_{TRO}\ ,$$
$$Q_{TRO} = q_{TRO} * Area$$

where, Q_{TRO} : daily mean discharge at TRO damsite (m^3/sec),

Q_s : daily mean sediment yield corresponding to Q_{TRO}(m^3/sec),

Area : catchment (54.9 km^2),

r : dry density (g/cm^3) .

The above equations are simplified with assumption that r is 1.5 ;

$$Q_s = 10.54 \times 10^{-6} \times Q_{TRO}$$

$$\text{or, } TQ_s = 0.9107 \times {Q_{TRO}}^2$$

where, TQ_s : daily total of sediment yield (m^3)

5.1.3 Estimated sediment yield (suspended load)

Sedimentation in the TRO dam reservoir is estimated on the basis of the equation mentioned above and daily mean discharge at TRO damsite for recent 20 years. Daily mean discharge at TRO damsite is mentioned in section 3.2. Fig.A.5.2 shows estimated sediment yield and its mass curve. Average annual sediment yield is 3949 m^3 ,or 0.07 mm in depth of whole catchment area of the dam under the hydrological conditions for recent 20 years.

5.2. Bed Load Transport

Bed load transport is estimated from present sediment condition in the reservoir of Municipal Dyke on the basis of river section survey and 1:2500 Map. Total sediment volume for recent 57 years (1932 - 1988) is about 8000 m^3 ,or 140 m^3 /year in an average. This figure is quite small because the river bed is quite stable and deposit on the river channel is well balanced along the GRNW.

5.3 Total Sediment Trapped in TRO Dam Reservoir

Total sediment trapped in TRO dam reservoir consists of 1) trapped suspended load and 2) bed load transport.

Trap ratio of wash road into the reservoir is estimated to be 70% of suspended load, or 2764 m^3/year. Total sediment stored in the reservoir is,therefore, estimated to be 2904 m^3/sec and dead volume of the reservoir reaches 0.29 MCM for 1000 year.

6. OPTIMIZATION OF ELECTRIC POWER FACILITIES

6.1 Hydro-Power Scheme

The Project is formulated initially as water supply only ,but this scheme includes medium height dam structure (TRO) whose water head has relatively good potential for power generation. Beside this, the Moka river which has good flow regime is neighboring river of TRO catchment basin. Therefore it is very easy to divert flow of the Moka river into TRO basin. In this chapter,cost of power plant and related main works, and revenue by electricity energy selling are preliminarily assessed and finally one optimum scheme is recommended.

Dam height and its reservoir scale are to be determined from water supply conditions as described in chapter 3. Therefore optimization of the hydro power plant attached to main project are carried out according to three factors ,or , (1) location of power station, (2)diverted flow volume from the Moka river and (3) plant discharge .

As for (1) location of power station, two cases are considered from topographic condition;

Case I   Just downstream of TRO damsite,
Case II   at Municipal dyke.

Net annual revenue of both cases are examined by shifting the rest factors ((2) diverted flow volume from the Moka river ,and (3) plant discharge).

6.2 Cost Estimate

6.2.1 General

The net revenue,which is the index applied in selecting the optimum scheme, requires assessment of project cost and revenue which may be accompanied by hydro power generation. Followings are the main portion of cost for power generation. Cost of operation, maintenance, replacement and re-regulating pond at Municipal dyke are not considered in this chapter.

Estimated cost is annuatized in the following assumptions and capital recovery factor is calculated to be 0.12,

- Discount rate is 10 percent ;
- Construction period is 3 years and cost disbursement of each year is 30 %, 40 %, 30 %,respectively ;
- Electricity supply begins after construction (4th year) ;
- Base year is set to be 4th year.

6.2.2 Cost estimate of diversion work of the Moka river

As for diversion work of the Moka river, diversion alignment and design are preliminarily carried out as shown in Fig A.6.1. Diverted volume is represented by daily mean discharge and capacity of diversion canal is designed to meet with flow which is five times as large as that of daily mean figure. This relation results from the following observed data at W04 (the Terre Rouge river),near to adjacent basin of the Moka river.

(daily mean discharge less than 4 m^3/sec)

Date	Discharge at W04: (a) Peak (m^3/sec)	Discharge at W04: (b) Daily mean (m^3/sec)	(a)/(b)
6, Dec.1966	9.57	2.46	3.9
26, Mar.1967	19.09	3.57	5.3
17, Dec.1967	21.30	3.60	5.9
26, Feb.1969	10.34	1.44	7.2
3, Mar.1969	13.03	2.15	6.1
12, Dec.1969	8.92	2.29	3.9
10, Feb.1974	6.20	2.01	3.1
5, Mar.1974	3.37	0.86	3.9
Average	11.48	2.30	5.0

The cost of diversion work by several flow volume is examined and the results are shown in Table A.6.1. Finally the cost is formulated in relation to daily mean diverted flow ,or,

$$C_{div} = 1.66 \times 10^3 \times Qdiv\text{-}m^{0.434}$$

where, C_{div} : cost of diversion work (Rs.1000)
Qdiv-m : daily mean diverted water (m^3/sec)

6.2.3 Cost estimate of other items

The cost formula of each work item is prepared for the cost estimate in consideration that the approximate cost can be expressed as a function of structural dimensions, head discharge, installed capacity and so on. The cost formulae applied are shown below. The cost formulae require such preliminary design criteria as the determination of penstock diameters, unit size and number of generating equipment.

Cost of Work Items (Unit : US$)

(a) Power house building :	$3.9 \times 10^3 \times (P/HEF^{1/2})^{0.71}$
substructure:	$1.0 \times 10^3 \times (Qp \times HEF^{2/3} \times N^{1/2})^{0.85}$
(b) Power equipment :	$5.9 \times 10^3 \times (P/HEF^{1/2})^{0.90}$
(c) Penstock civil work :	$(0.20 \times D^{1.85} + 0.765 \times D^{1.16}) \times L$
metal work :	$(1.90 \times 10^{-3} \times H + 0.049) \times D^2 \times L \times U$

where, P : installed power capacity (KW)

HEF: effective head (m)

N : number of unit (nos)

Qp : installed capacity discharge (m^3/sec)

L : length of penstock where the wall thickness is to be determined by water pressure (m)

H : water pressure acting on section L (m)

U : unit price per ton = 800 (US$)

D : inner diameter of penstock (m),

Penstock diameter is determined by means of the empirical relationship between discharge and economical diameter, or, $D = 0.969 \times Qp^{0.336}$

6.3 Tariff of Erectricity

Tariff of electricity ,or, selling price of electricity to the Central Electricity Board is estimated tentatively as follows (*).

3 hour peak Rs. 1.20 /KWh

(*)UPDATING OF MASTER PLAN FOR WATER RESOURCES,SOREZE PROJECT,June,1988

12 hour off-peak (I) Rs. 0.80 /KWh
24 hour off-peak (II) Rs. 0.40 /KWh

6.4 Optimization

6.4.1 Installed capacity and operation rule

Average annual energy output under recent 22-year hydrological condition is calculated according to the following assumption,

a) Installed capacity

Installed capacity is determined by plant discharge ,average reservoir water level (ARWL), Tailrace water level (TWL), head loss and efficiency of generator by means of the following equation;

$$E_{install} = 9.8 \times u \times (ARWL - TWL) \times (1-E) \times Q_{plant}$$

where, $E_{install}$: installed capacity (kWh)
u : generator efficiency (= 0.8)
E : head loss rate
Q_{plant} : plant discharge (m^3/sec)

ARWL is defined by Low water level (LWL) and High water Level (HWL)as follows.

$$ARWL = LWL + 2/3 \times (HWL - LWL)$$

Then gross head is defined as deference between ARWL and Tailrace water level (TWL). Tailrace water level is set to be 118.0 m for Case I and 76.0 m for Case II.

Total head loss is roughly estimated to be 7 percent of total gross head for Case II. As for Case I, effective head is set to be the same as gross head because power station in Case I is just downstream of TRO dam site and head loss is thought to be negligible.

Installed capacity for Case I and II are expressed as follows,

	ARWL (m)	TWL (m)	head loss (%)	Installed Capacity (kW)
Case I	173	118	0.00	431 x Q_{plant}
Case II	173	76	0.07	656 x Q_{plant}

b) Operation rule

Water is released from dam reservoir in order to meet with water demand at Pailles treatment plant. This released water is used for generation. Beside this, water which is otherwise unused as spilt water through spillway is also used for generation within capacity of power generator. Re-regulating pond will be constructed to make power generation effective.

Operation is to be performed to supply maximum electricity for 3-hour peak load. Then the rest of generated energy is served as 12-hour off peak (I) and 24-hour off peak (II) as shown in Fig.A.6.2.

6.4.2 Optimization of plant scale and diverted discharge from Moka river

Optimization is carried out by shifting both plant discharge and diverted flow from the Moka river. Examined diverted flow from the Moka river ranges from 0.0 m^3/sec(without diversion)to full diversion. For all cases , entitled water right downstream of diversion site (52 lit/sec) is precedently released into original river channel of the Moka river. Examined plant discharge ranges from 2.0 m^3/sec to 13.0 m^3/sec by each fixed diverted flow from the Moka river. These results are shown in Table A.6.2 and Fig.A.6.3.

Diversion from the Moka river makes this power generation scheme beneficial if the daily mean diverted flow is less than 3.0 m^3/sec. If the flow is more than 3 m^3/sec, net revenue decreases gradually. Relationship between net revenue and diverted flow from Moka river with optimum installed plant capacity is shown Fig.A.6.4. Annual net revenue under optimum condition is estimated to be Rs. 6,650,000 per annum.

In case that power station is located at Municipal dyke, length of penstock will be 1800 m and annuatized cost of civil and metal work of the penstock construction is almost the same as erefore ,power station at Municipal dyke (Case II) turns to be unfeasible.

Average power output of the optimum power facilities is finally determined as follows. Details are shown in Table A.6.4.

Feature of facilities	(optimum case)
Power Facilities (just downstream of TRO damsite)	
Installed capacity	3900 KW
Installed discharge	9.0 m^3/sec
Total energy output	11.0 GWh/year
- 3 hour peak energy output	5.0 GWh/year
- 12 hour off-peak	5.1 GWh/year
- 24 hour off-peak	0.9 GWh/year
Moka river diversion	
Daily mean diverted flow	3.0 m^3/sec
Flow capacity of channel	15.0 m^3/sec

TABLES

TABLE A.2.1 MONTHLY TOTAL RAINFALL (1/22)

Station : Beau-Bois (MDA)
Code : FF301

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965			466.6	199.6	263.1	541.3	166.9	101.3	255.3	298.5	226.3	134.6	
1966	174.8	112.3	386.3	164.3	326.9	113.3	30.5	176.3	147.6	112.0	102.4	33.5	1880.1
1967	82.8	324.6		146.3	498.9	308.4	112.5	159.0	233.2	170.7	110.2	170.2	
1968	234.4	361.2	83.1	903.0	526.0	65.5	99.8	94.0	178.8	88.1	117.6	77.7	2829.3
1969	115.1	151.9	122.9	222.8	278.1	336.6	218.4	105.4	236.2	166.6	59.2	17.0	2030.2
1970	66.3	624.6	586.2	329.7	700.5	143.5	116.3	187.2	125.2	161.8	75.2	57.4	3174.0
1971	66.0	96.3	420.4	493.8	134.4	336.3	207.0	58.4	187.5	131.6	36.1	50.8	2218.4
1972	179.6	49.5	269.5	610.2	267.0	310.4	186.4	296.4	171.5	370.3	40.4	200.4	2952.2
1973	202.9	191.5	330.2	289.1	494.8	120.9	185.2	195.6	147.1	257.6	80.3	43.7	2538.7
1974	18.3	155.2											
1975			154.9	619.8	282.4	180.8	233.7	143.0	132.8	120.9	164.3	46.7	
1976	106.7	119.4	289.6	442.5	211.1	217.4	338.6	222.0	84.1	188.7	72.6	122.7	2415.3
1977	88.4	264.9	498.9	368.0	114.6	341.9	185.9	97.0	163.6	79.0	75.7	78.0	2355.9
1978	67.3	277.4	408.2	91.2	335.3	527.8	68.6	153.7	199.6	147.3	89.9	50.3	2416.6
1979	98.3	140.5	303.5	488.4	208.8	174.8	148.8	127.8	96.5	198.9	48.8	38.4	2073.4
1980	151.6	846.8	1354.6	267.7	894.8	368.3	220.2	97.0	137.2	67.8	104.9	108.0	4619.0
1981	86.1	90.2	168.4	123.4	321.3	654.1	99.8	72.9	112.0	117.6	120.1	108.0	2073.9
1982	151.1	289.6	272.3	1262.6	190.8	103.4	420.4	163.1	182.9	207.0	201.2	212.9	3657.1
1983	212.9	202.2	310.4	166.9	110.5	124.2	84.8	72.4	121.7	69.9	57.7	106.2	1639.6
1984	145.5	489.0	314.2	271.5	154.4	183.4	108.5	119.1	109.7	145.5	130.0	65.3	2236.2
1985	109.5	174.7	567.7	1024.1	243.0	189.8	83.7	180.4	164.4	143.3	135.1	118.1	3133.8
1986	116.6	406.1	182.1	356.2	327.7	136.5	229.4	64.0	59.7	237.0	37.4	129.8	2282.4
1987	80.8	195.3	850.[illegible]	1204.7	261.1	736.3	188.2	117.3	123.4	142.3	78.5	111.5	4089.6
Average	121.7	265.0	397.1	456.7	324.8	282.5	169.7	136.5	153.2	164.7	98.4	94.6	2664.7
Maximum	234.4	846.8	1354.6	1262.6	894.8	736.3	420.4	296.4	255.3	370.3	226.3	212.9	-
Minimum	18.3	49.5	83.1	91.2	110.5	65.5	30.5	58.4	59.7	67.8	36.1	17.0	-
Var.	54.6	190.7	275.4	340.2	189.2	182.6	88.1	57.0	49.0	73.5	49.5	52.4	759.3

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (2/22)

Station : Bagatelle (MDA)
Code : DD308

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965	7.0	123.0	265.2	158.5	100.3	285.2	88.9	47.5	128.8	116.8	133.1	39.6	1494.0
1966	122.7	39.6	217.2	68.8	166.4	72.1	19.3	132.1	63.8	54.6	27.7	7.4	991.6
1967	39.1	293.4	331.0	36.3	215.1	207.3	37.1	62.7	112.8	82.6	45.7	69.6	1532.7
1968	179.3	157.2	44.5	531.6	374.7	45.5	64.0	47.8	95.3	26.9	31.8	18.0	1616.5
1969	51.3	111.8	37.1	242.8	159.5	143.0	117.6	55.1	87.4	52.8	9.7	1.5	1069.6
1970	16.3	364.5	392.9	187.2	594.1	28.4	51.8	75.7	33.3	64.0	27.2	23.9	1859.3
1971	15.5	16.0	168.9	278.1	40.9	170.2	217.7	20.8	70.9	46.0	8.1	14.7	1067.8
1972	124.5	44.2	127.8	286.5	138.2	128.0	41.9	131.3	72.6	189.2	8.6	93.5	1386.3
1973	72.6	49.8	155.7	118.4	329.4	38.6	81.3	89.4	45.5	107.7	27.9	13.2	1129.5
1974	4.6	60.5	133.0	237.0	169.0	60.0	64.0	65.0	110.0	91.0	86.0	14.0	1094.0
1975	6.0	179.0	72.1	565.9	116.8	54.4	73.7	50.8	8.9	41.4	56.1	12.4	1237.6
1976	34.3	35.1	173.5	253.7	105.4	87.1	132.8	104.6	38.9	69.9	22.9	88.4	1146.6
1977	42.4	188.5	263.9	235.0	112.0	208.8	104.4	32.3	91.7	37.3	26.7	26.7	1369.6
1978	16.3	119.6	231.9	134.6	159.5	284.0	24.1	71.9	88.6	55.1	35.3	23.6	1244.6
1979	80.0	36.1	204.7	376.2	64.0	156.7	70.4	43.9	41.9	109.0	18.8	12.4	1214.1
1980	18.8	537.2	885.7	151.4	455.2	169.2	120.1	54.9	42.4	9.4	27.4	39.1	2510.8
1981	18.8	70.9	129.5	35.6	140.2	355.6	36.6	34.0	36.3	38.6	33.5	24.1	953.8
1982	34.8	222.0	187.2	705.1	106.2	111.0	188.5	69.3	91.4	103.6	82.0	158.2	2059.4
1983	122.4	114.0	142.7	142.7	26.9	85.1	25.9	30.2	59.9	21.8	10.9	27.4	810.3
1984	69.1	303.5	214.4	218.7	74.9	113.3	45.2	53.3	42.9	46.7	58.4	13.0	1253.5
1985	45.7	82.5	435.9	727.2	145.7	98.7	36.1	101.1	62.7	41.7	33.0	37.3	1847.7
1986	78.5	199.4	102.4	242.7	191.0	33.2	75.2	20.1	19.3	75.2	6.1	50.5	1093.5
1987	47.0	125.7	562.6	594.4	147.1	355.1	59.2	14.2	72.4	36.6	20.3	36.1	2070.6
Average	54.2	151.0	238.2	283.8	179.7	143.1	77.2	61.2	66.0	66.0	36.4	36.7	1393.6
Maximum	179.3	537.2	885.7	727.2	594.1	355.6	217.7	132.1	128.8	189.2	133.1	158.2	-
Minimum	4.6	16.0	37.1	35.6	26.9	28.4	19.3	14.2	8.9	9.4	6.1	1.5	-
Var.	45.2	123.6	184.9	199.4	133.3	97.0	49.8	32.0	30.6	39.2	29.4	35.1	415.4

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (3/22)

Station : Mon Desert Alma
Code : FF302

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965	16.0	183.0	525.8	158.8	175.5	441.5	123.7	56.9	204.7	211.1	206.5	90.2	2393.6
1966	172.7	74.9	380.0	119.9	273.1	66.8	23.1	196.9	102.9	82.3	42.7	17.3	1552.4
1967	64.0	301.0	498.0	96.8	462.8	242.8	80.5	114.8	179.6	132.6	73.4	115.1	2361.3
1968	191.8	260.6	77.2	725.2	481.8	54.4	95.0	122.7	147.6	53.1	79.5	43.2	2332.0
1969	83.8	122.4	78.7	285.8	214.4	260.6	166.6	91.7	149.6	117.1	51.3	10.7	1632.7
1970	78.0	562.4	625.9	231.4	713.5	57.7	78.7	151.1	82.8	114.6	68.1	36.3	2800.4
1971	40.6	56.6	299.7	444.0	87.9	260.6	214.4	39.4	121.4	100.6	22.9	30.7	1718.8
1972	151.1	171.5	547.4	525.0	235.7	236.2	110.2	209.0	114.6	340.4	29.5	169.9	2840.5
1973	143.3	101.1	260.1	252.2	439.7	105.9	144.8	157.0	99.8	185.2	55.4	23.6	1968.0
1974	11.2	104.4	643.6	196.9	489.7	330.7	193.5	207.8	338.1	215.4	132.3	265.2	3128.8
1975	256.0	425.2	110.2	585.0	267.2	101.1	139.4	91.4	37.6	90.4	114.0	18.0	2235.7
1976	38.9	67.3	204.2	344.9	148.8	153.9	222.5	162.8	61.0	137.4	36.8	128.0	1706.6
1977	63.2	184.7	457.5	324.1	118.4	229.6	145.0	46.5	128.8	61.0	50.3	46.0	1855.0
1978	42.9	168.1	286.8	88.9	253.7	490.2	44.5	108.7	148.6	94.5	52.3	35.8	1815.1
1979	97.3	92.5	362.2	395.2	140.2	171.2	97.5	85.6	57.7	146.3	31.0	38.4	1715.0
1980	94.2	766.3	1373.6	230.6	452.1	220.5	104.4	59.4	68.6	30.0	45.2	73.4	3518.4
1981	42.4	58.2	103.6	84.1	243.3	528.1	64.5	50.5	77.2	77.5	78.5	79.0	1486.9
1982	75.7	304.5	281.2	913.1	136.7	94.2	252.7	123.7	125.0	171.5	135.9	170.9	2785.1
1983	144.5	176.0	239.5	181.9	61.2	74.4	50.5	52.6	80.8	42.2	41.4	73.4	1218.4
1984	18.5	415.5	268.2	246.1	92.2	138.9	79.8	68.1	75.4	108.5	129.8	34.8	1675.9
1985	77.7	118.4	655.4	993.9	202.8	129.9	42.9	127.8	115.3	85.9	91.7	77.5	2719.1
1986	117.1	320.1	120.4	346.9	278.6	61.4	143.8	44.4	43.4	153.9	20.3	78.2	1728.5
1987	59.4	123.4	700.0	833.2	248.4	577.6	111.2	38.9	87.9	92.2	42.7	51.8	2966.8
Average	90.5	224.3	395.6	374.1	270.3	218.6	118.7	104.7	115.1	123.6	70.9	74.2	2180.7
Maximum	256.0	766.3	1373.6	993.9	713.5	577.6	252.7	209.0	338.1	340.4	206.5	265.2	-
Minimum	11.2	56.6	77.2	84.1	61.2	54.4	23.1	38.9	37.6	30.0	20.3	10.7	-
Var.	60.5	174.5	284.4	262.7	160.0	154.5	59.8	54.1	63.1	67.3	44.8	60.0	603.8

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (4/22)

Station : Minissy (MDA)
Code : FF303

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965			351.8	140.0	123.4	395.7	110.5	61.7	167.1	158.8	172.7	61.2	
1966	191.3	50.0	401.1	99.3	233.4	72.4	18.3	165.9	86.4	75.4	36.6	11.7	1441.7
1967	66.3	299.5		62.7	259.8	236.5	55.6	91.4	148.6	120.4	70.4	114.6	
1968	207.0	174.2	70.4	604.8	478.0	58.4	74.7	89.9	131.3	44.5	65.5	25.7	2024.4
1969	77.5	138.2	57.4	265.4	146.1	176.8	148.8	80.3	123.7	92.2	44.2	5.8	1356.4
1970	51.3	433.3	504.4	216.2	636.0	43.7	59.4	116.6	51.3	86.1	45.5	32.5	2276.3
1971	27.2	32.8	264.4	357.9	56.6	194.1	231.9	25.4	83.8	71.4	16.8	23.4	1385.6
1972	128.5	96.0	207.0	463.8	189.5	175.0	69.3	165.9	100.1	238.8	21.3	128.8	1984.0
1973	137.9	58.7	208.5	184.9	410.2	52.3	103.1	136.1	74.2	139.4	44.5	18.8	1568.7
1974	8.6	83.8											
1975			88.9	538.7	189.0	75.9	85.3	81.8	19.1	58.4	88.1	16.3	
1976	36.1	54.9	197.4	238.5	105.2	113.3	144.0	134.6	41.9	91.4	23.6	100.6	1281.4
1977	50.3	236.7	382.8	301.2	113.8	196.6	103.4	36.3	112.0	50.8	28.7	23.1	1635.8
1978	29.7	157.7	289.1	131.6	219.2	330.2	43.9	85.3	103.4	68.6	41.4	24.1	1524.3
1979	81.8	56.6	300.5	393.2	73.9	159.0	63.5	41.1	38.6	107.7	25.4	21.6	1363.0
1980	24.6	739.4	1238.0	188.2	543.6	222.3	126.2	57.7	57.7	19.8	37.1	64.3	3318.8
1981	31.8	73.7	172.2	53.1	199.4	541.8	48.8	43.9	57.4	67.3	62.5	45.7	1397.5
1982	52.1	285.8	204.2	916.4	133.9	146.1	237.7	87.1	103.4	156.5	103.4	196.1	2622.6
1983	138.4	138.2	178.6	173.5	43.2	74.2	36.3	44.2	64.0	29.2	22.4	51.3	993.4
1984	108.2	531.6	258.8	250.2	75.4	115.3	64.5	56.1	56.1	78.7	110.0	22.6	1727.7
1985	67.3	135.6	564.9	900.7	189.1	131.3	47.5	126.6	100.1	72.6	67.6	57.9	2461.2
1986	107.2	256.8	96.0	353.6	216.7	49.1	100.6	27.9	31.2	110.5	12.7	59.7	1421.9
1987	59.2	147.3	682.8	727.5	214.9	497.9	74.9	23.9	90.2	50.6	24.9	38.4	2632.3
Average	80.1	199.1	320.0	343.7	220.5	184.4	93.1	80.9	83.7	90.4	53.0	52.0	1800.8
Maximum	207.0	739.4	1238.0	916.4	636.0	541.8	237.7	165.9	167.1	238.8	172.7	196.1	-
Minimum	8.6	32.8	57.4	53.1	43.2	43.7	18.3	23.9	19.1	19.8	12.7	5.8	-
Var.	53.5	175.5	259.9	246.9	155.6	138.0	55.7	43.1	37.9	48.7	37.5	45.2	584.7

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (5/22)

Station : Bega
Code : DD312

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965	8.0	131.0	223.0	152.1	64.8	298.2	80.5	55.6	112.8	111.5	162.8	43.4	1443.8
1966	175.8	18.5	458.5	61.2	179.3	67.6	12.2	122.7	45.2	43.7	33.8	10.9	1229.4
1967	37.6	265.2	401.1	34.3	185.4	149.1	17.0	62.2	109.7	113.8	50.0	61.7	1487.2
1968	260.9	249.2	50.8	622.6	436.4	48.5	28.7	119.6	122.4	27.7	63.5	19.6	2049.8
1969	20.6	142.0	16.0	286.5	172.0	119.1	140.5	45.5	78.7	67.1	30.7	1.3	1119.9
1970	8.6	462.5	369.6	199.1	753.1	23.6	56.4	74.9	41.1	66.0	33.3	19.8	2108.2
1971	22.6	13.0	229.6	397.0	52.0	209.0	275.0	21.8	70.6	60.2	18.0	58.7	1427.5
1972	177.0	87.6	129.5	457.2	151.1	171.2	56.4	164.8	75.2	176.3	14.5	133.6	1794.5
1973	105.4	104.4	201.9	176.3	396.0	158.0	78.2	87.6	71.9	111.3	40.1	22.1	1553.2
1974	2.8	81.0	74.7	306.6	203.2	69.3	38.4	120.9	69.9	130.8	59.2	38.6	1195.3
1975	8.1	222.5	148.3	606.3	136.4	63.8	100.1	53.1	2.5	39.1	41.1	48.8	1470.2
1976	61.0	26.4	124.2	402.8	67.6	117.9	133.4	90.7	47.0	56.1	40.4	43.9	1211.3
1977	51.3	153.7	273.8	378.0	203.7	213.1	74.7	50.0	104.6	33.8	25.7	15.2	1577.6
1978	15.7	128.3	380.2	160.0	221.7	382.0	26.7	114.0	98.0	50.8	40.1	27.2	1644.9
1979	120.1	53.3	223.3	376.4	68.8	184.9	57.9	42.7	28.4	120.4	15.2	10.9	1302.5
1980	16.5	636.0	975.4	180.3	487.2	227.8	105.9	49.3	51.6	12.4	19.1	61.5	2823.0
1981	30.7	64.5	158.8	27.4	161.5	387.6	31.8	39.6	75.7	45.7	42.2	27.2	1092.7
1982	47.2	178.6	294.6	772.7	152.1	192.8	245.1	69.1	81.5	144.5	58.4	151.6	2388.4
1983	146.3	134.4	150.1	171.5	24.1	33.3	21.3	24.1	48.3	23.9	8.1	21.8	807.2
1984	75.9	330.7	170.4	233.9	41.9	80.3	32.8	58.9	29.0	42.9	77.7	8.4	1182.9
1985	50.3	159.5	534.9	744.0	129.3	126.5	33.0	133.3	60.7	47.0	37.3	58.4	2114.2
1986	83.3	313.7	82.0	231.4	172.5	27.4	70.9	12.2	25.9	106.6	4.3	111.2	1241.4
1987	47.7	108.5	683.3	726.0	126.5	355.0	59.2	28.0	115.8	34.1	9.9	43.2	2337.2
Average	68.4	176.7	276.3	334.9	199.4	161.1	77.2	71.3	68.1	72.4	40.2	45.2	1591.4
Maximum	260.9	636.0	975.4	772.7	753.1	387.6	275.0	164.8	122.4	176.3	162.8	151.6	-
Minimum	2.8	13.0	16.0	27.4	24.1	23.6	12.2	12.2	2.5	12.4	4.3	1.3	-
Var.	65.8	145.6	218.9	222.4	166.4	108.7	66.2	40.0	31.8	43.6	32.1	38.5	487.7

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (6/22)

Station : Reduit Experimental Station
Code : DD314

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965	11.0	119.0	226.1	140.0	146.6	260.4	86.6	67.6	126.0	126.7	124.0	54.6	1488.4
1966	215.4	38.9	357.6	81.0	180.6	72.9	18.3	140.2	63.8	58.7	30.5	11.2	1269.0
1967	69.1	304.3	426.2	43.4	181.9	154.4	33.8	67.3	106.9	112.3	34.8	76.2	1610.6
1968	215.4	169.4	64.5	517.9	383.5	42.7	74.7	49.5	127.5	33.3	53.1	20.8	1752.3
1969	59.9	136.1	45.7	257.8	131.3	171.2	120.1	43.9	89.2	74.4	36.6	5.8	1172.2
1970	24.1	407.2	436.4	208.3	510.0	32.5	51.3	86.9	49.0	72.4	33.0	26.4	1937.5
1971	18.8	23.6	142.2	348.5	53.3	161.8	161.8	22.9	78.5	68.3	12.4	21.1	1113.3
1972	125.5	117.3	187.2	399.5	165.1	133.6	79.2	137.7	83.1	162.3	19.3	124.0	1733.8
1973	106.4	106.4	183.9	147.6	402.3	56.6	70.9	118.4	67.6	101.3	37.3	20.3	1419.1
1974	9.1	62.7	153.7	217.9	127.5	70.9	77.5	76.2	73.4	120.7	101.1	26.9	1117.6
1975	14.5	255.5	89.4	662.4	143.3	56.6	104.6	65.5	26.4	54.9	49.8	58.2	1581.2
1976	35.3	34.5	244.6	259.3	77.7	99.3	109.2	133.9	42.7	73.4	30.2	62.2	1202.4
1977	30.2	162.6	346.5	214.4	131.3	195.6	93.5	23.6	92.7	42.2	34.0	23.6	1390.1
1978	39.6	127.0	241.0	131.3	185.9	330.5	32.8	95.3	83.1	55.6	44.7	32.0	1398.8
1979	102.9	51.1	214.4	338.6	69.1	170.2	55.1	47.0	36.6	103.6	21.3	11.4	1221.2
1980	19.6	598.9	942.8	186.7	402.6	196.6	111.8	53.6	52.3	15.0	29.5	53.8	2663.2
1981	23.6	60.2	157.7	33.5	149.1	383.3	34.5	40.1	61.2	51.8	50.0	33.0	1078.2
1982	45.5	216.4	228.9	816.4	120.4	147.6	224.0	70.4	83.1	131.6	80.0	194.1	2358.1
1983	114.8	118.9	143.5	139.4	24.9	55.1	26.4	31.8	53.3	27.2	14.2	29.5	779.0
1984	91.2	348.2	232.4	162.3	50.3	72.6	46.5	56.6	35.6	43.4	82.0	15.5	1236.7
1985	40.1	153.2	509.8	704.9	145.5	112.3	35.6	95.8	69.1	52.6	50.3	50.3	2019.3
1986	88.9	276.9	69.9	206.5	179.8	32.5	80.0	21.6	21.7	97.5	7.6	85.4	1168.4
1987	50.2	109.3	770.9	801.3	156.6	390.3	75.3	32.0	80.5	51.8	26.9	56.2	2601.3
Average	67.4	173.8	278.9	305.2	179.1	147.8	78.4	68.6	69.7	75.3	43.6	47.5	1535.3
Maximum	215.4	598.9	942.8	816.4	510.0	390.3	224.0	140.2	127.5	162.3	124.0	194.1	-
Minimum	9.1	23.6	45.7	33.5	24.9	32.5	18.3	21.6	21.7	15.0	7.6	5.8	-
Var.	57.4	135.8	215.9	231.1	122.6	104.3	46.4	36.2	27.8	36.9	28.1	41.6	484.6

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (7/22)

Station : Minissy (Highlands)
Code : FF304

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965	12.0	97.0	305.8	188.2	159.8	432.8	93.0	83.8	168.4	159.3	164.8	66.8	1931.7
1966	254.0	36.1	544.8	113.8	220.0	79.2	18.8	183.4	103.9	71.1	38.6	15.2	1678.9
1967	69.9	299.5	493.0	82.6	226.6	207.3	51.3	101.9	165.6	138.2	54.4	92.2	1982.2
1968	208.5	168.1	90.4	666.0	440.4	33.3	30.2	80.3	115.6	30.5	41.7	26.2	1931.2
1969	32.0	105.7	27.9	304.5	176.3	185.9	152.9	75.9	107.2	87.9	36.8	6.1	1299.2
1970	61.2	503.2	454.9	262.1	744.7	39.9	65.5	127.5	81.8	108.7	45.0	26.4	2521.0
1971	27.9	39.4	297.2	422.0	83.0	239.0	244.0	33.3	132.8	89.4	29.7	19.3	1657.0
1972	169.7	107.2	145.3	580.9	193.3	179.8	75.9	186.9	96.0	255.0	23.4	143.3	2156.7
1973	116.6	108.7	224.0	216.7	363.2	103.9	98.8	140.0	112.5	174.8	57.4	19.1	1735.6
1974	3.6	102.1	104.1	287.8	164.1	59.7	45.7	109.2	115.3	142.7	61.0	58.7	1254.0
1975	19.3	234.4	65.0	640.1	176.0	98.6	145.8	81.8	31.0	80.0	80.8	14.7	1667.5
1976	33.5	40.6	117.6	424.4	116.3	112.8	141.7	139.2	53.1	102.6	29.0	96.3	1407.2
1977	37.6	159.3	309.1	332.7	117.3	208.0	91.9	71.6	130.6	58.9	48.0	38.1	1603.2
1978	46.0	156.0	329.2	163.1	277.6	408.7	71.4	105.4	100.6	78.2	47.8	27.4	1811.3
1979	108.0	56.1	320.5	413.8	110.7	182.4	77.5	76.7	45.0	138.9	27.7	19.6	1576.8
1980	33.3	689.6	1188.2	235.0	613.4	267.2	121.7	69.6	93.2	32.3	50.3	79.8	3473.5
1981	54.6	65.5	183.4	68.3	183.1	558.3	50.5	58.7	88.9	72.1	82.6	48.0	1514.1
1982	56.6	291.6	207.8	1159.0	154.4	137.2	313.9	149.6	169.9	220.0	110.2	191.8	3162.0
1983	142.0	181.1	197.6	175.3	40.1	83.1	43.9	50.8	71.9	31.5	24.1	37.3	1078.7
1984	113.5	433.8	239.3	221.7	68.1	116.3	76.5	72.1	60.7	78.2	87.1	25.1	1592.6
1985	51.6	164.3	465.5	859.6	156.2	141.7	43.2	116.3	99.0	76.7	78.2	59.0	2311.3
1986	93.0	313.2	104.4	320.0	236.9	44.4	123.9	38.8	44.7	137.4	11.7	56.6	1525.0
1987	52.3	144.5	680.7	938.7	243.2	479.3	88.1	52.8	85.8	61.5	36.3	50.9	2914.1
Average	78.1	195.5	308.5	394.6	228.9	191.2	98.5	95.9	98.8	105.5	55.1	52.9	1903.7
Maximum	254.0	689.6	1188.2	1159.0	744.7	558.3	313.9	186.9	169.9	255.0	164.8	191.8	-
Minimum	3.6	36.1	27.9	68.3	40.1	33.3	18.8	33.3	31.0	30.5	11.7	6.1	-
Var.	63.1	160.2	249.5	281.9	165.5	143.9	67.1	41.7	37.7	56.8	33.2	43.6	596.9

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (8/22)

Station : Alma (MDA)
Code : FF405

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965	34.0	192.0	382.3	229.1	320.5	567.7	174.2	90.7	306.8	322.1	197.4	139.7	2956.5
1966	276.9	129.5	464.6	216.2	339.1	116.6	65.8	276.6	196.1	148.8	112.0	46.2	2388.4
1967	83.8	270.5	644.0	199.4	489.7	331.5	193.5	207.8	338.6	221.0	140.0	267.0	3386.7
1968	256.0	417.6	136.4	863.3	648.5	61.7	131.6	104.9	225.6	109.0	144.5	80.3	3179.3
1969	124.2	174.5	143.0	399.5	241.8	407.4	250.7	112.0	293.1	213.9	82.8	16.8	2459.7
1970	63.2	513.6	620.0	316.7	764.8	124.7	158.5	259.3	167.9	135.9	77.0	59.7	3261.4
1971	77.0	91.2	362.5	587.5	174.2	374.1	216.2	84.8	228.3	160.0	36.1	62.2	2454.1
1972	164.8	60.2	250.7	649.5	297.2	326.4	213.9	288.0	208.5	477.3	44.7	227.1	3208.3
1973	284.2	211.1	340.4	302.5	482.6	143.0	160.0	270.8	147.6	256.0	114.3	32.0	2744.5
1974	19.6	162.6	369.0	352.0	421.0	111.0	203.0	154.0	193.0	301.0	72.0	43.0	2401.1
1975	37.0	197.0	224.8	736.1	331.7	180.1	330.5	174.8	143.0	159.8	198.4	44.2	2757.2
1976	114.6	139.7	268.0	537.0	220.7	301.0	345.7	271.0	109.7	221.5	84.3	167.4	2780.5
1977	87.1	396.2	492.3	397.8	163.3	375.7	217.4	95.0	227.8	101.9	91.4	74.2	2720.1
1978	71.4	404.1	415.3	143.5	394.7	749.3	96.3	172.0	235.0	165.1	92.7	47.8	2987.0
1979	107.2	94.2	379.0	510.0	241.6	158.2	125.0	161.3	113.5	233.9	63.8	83.6	2271.3
1980	115.1	751.8	1364.2	366.3	950.5	547.4	214.4	133.4	152.7	77.5	127.0	149.9	4950.0
1981	156.2	116.3	238.0	118.1	333.8	905.5	125.0	97.3	151.6	129.5	127.1	86.6	2585.0
1982	180.8	259.8	266.4	1199.6	211.1	147.6	479.3	227.6	230.4	322.6	266.7	281.9	4073.9
1983	211.3	281.7	379.2	198.4	129.0	181.4	116.1	89.7	167.1	76.2	65.8	124.0	2019.8
1984	119.6	475.7	359.7	266.7	139.7	211.6	131.3	122.7	115.6	172.5	161.3	72.9	2349.2
1985	133.4	225.8	652.3	1106.2	207.6	258.1	106.7	208.3	207.2	128.8	142.3	116.1	3492.7
1986	122.7	413.8	198.4	381.4	377.7	179.7	259.3	102.6	85.6	220.5	52.3	137.2	2531.2
1987	143.0	204.0	721.4	1222.5	240.5	803.1	254.3	166.9	125.0	130.8	95.3	114.1	4220.7
Average	129.7	268.8	420.5	491.3	353.1	328.8	198.6	168.3	190.0	195.0	112.6	107.5	2964.3
Maximum	284.2	751.8	1364.2	1222.5	950.5	905.5	479.3	288.0	338.6	477.3	266.7	281.9	-
Minimum	19.6	60.2	136.4	118.1	129.0	61.7	65.8	84.8	85.6	76.2	36.1	16.8	-
Var.	71.8	164.1	256.0	323.4	200.1	231.9	92.2	68.1	64.5	92.6	54.4	70.9	686.4

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (9/22)

Station : Evene
Code : 147285

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965			234.7	142.2	106.7	283.5	63.0	57.4	102.1	95.5	191.8	55.1	
1966	182.4	18.0	340.1	80.0	190.5	59.9	20.1	141.5	67.3	58.2	35.1	9.9	1202.9
1967	59.7	280.7	413.5	53.6	233.7	135.4	31.8	66.0	106.2	103.4	45.2	68.8	1597.9
1968	222.0	190.2	58.9	492.3	374.9	37.3	30.2	93.2	111.5	36.1	50.3	31.5	1728.5
1969	25.4	149.4	21.8	261.1	138.9	146.8	146.8	52.8	79.5	63.8	33.0	3.8	1123.2
1970	20.8	383.8	347.7	203.5	554.5	21.8	49.0	83.8	50.0	71.1	29.2	16.8	1832.1
1971	18.8	21.3	214.6					27.9	86.6	66.8	18.5	20.3	
1972	170.7	113.3	112.5	439.9	150.4	137.4	60.5	164.8	75.2	176.3	14.5	133.6	1749.0
1973	96.3	93.2	181.1	184.7	364.7	120.7	60.7	75.4	70.9	95.8	30.0	14.0	1387.3
1974	1.5	69.9	62.7	253.5	154.2	106.2	47.8	84.6	59.4	117.1	49.5	39.6	1046.0
1975	8.9	238.5	121.7	653.5	155.4	60.5	137.2	51.1	5.6	38.6	45.7	33.3	1549.9
1976	29.0	24.1	102.1	429.5	82.3	104.9	128.5	93.0	54.6	70.9	29.2	60.2	1208.3
1977	27.4	171.7	270.8	380.0	108.2	190.2	68.6	52.3	90.7	46.7	29.2	29.2	1465.1
1978	16.8	130.6	325.6	106.4	168.9	332.5	42.2	86.6	84.1	48.8	43.4	19.3	1405.1
1979	82.3	35.1	207.8	339.9	85.9	162.3	45.0	44.5	30.2	92.5	14.7	11.9	1151.9
1980	24.6	569.0	940.8	167.4	478.3	223.0	92.2	54.4	52.6	12.2	25.9	50.8	2691.1
1981	22.6	46.0	161.8	31.5	164.8	381.0	23.9	38.6	55.9	51.6	46.7	25.7	1050.0
1982	56.4	164.8	271.3	731.0	121.2	168.4	237.2	70.4	85.6	125.5	76.7	111.5	2220.0
1983	106.4	104.6	145.3	136.1	20.3	50.5	23.4	27.7	50.3	24.1	15.2	21.3	725.4
1984	85.6	317.0	185.4	222.8	42.2	70.1	46.5	48.8	42.7	53.3	89.2	11.4	1214.9
1985	49.8	189.0	486.4	720.6	115.6	133.1	32.0	117.8	75.4	46.2	41.6	57.9	2065.3
1986	81.8	300.2	59.9	221.0	200.2	25.6	60.5	20.1	22.1	105.2	7.6	83.1	1187.3
1987	47.0	113.8	651.7		241.6	375.6	64.1	31.6	83.8	40.1	21.8	65.1	
Average	65.3	169.3	257.3	297.6	193.3	151.2	68.7	68.9	67.1	71.3	42.8	42.4	1495.1
Maximum	222.0	569.0	940.8	731.0	554.5	381.0	237.2	164.8	111.5	176.3	191.8	133.6	-
Minimum	1.5	18.0	21.8	31.5	20.3	21.8	20.1	20.1	5.6	12.2	7.6	3.8	-
Var.	58.5	133.1	207.7	206.5	133.1	105.6	50.8	35.6	26.2	37.0	36.9	32.8	454.6

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (10/22)

Station : Cote d'Or
Code : FF306

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965	26.0	230.0	354.3	267.5	247.7	548.6	132.1	76.2	231.1	214.6	228.6	114.3	2671.0
1966	277.1	70.4	527.6	137.2	292.1	88.9	20.3	223.8	128.8	101.9	72.4	27.9	1968.2
1967	81.3	354.3	578.1	126.2	367.0	249.4	81.3	134.6	201.2	191.8	81.3	129.5	2576.1
1968	284.5	345.4	104.1	839.5	552.7	39.4	46.7	166.1	181.6	63.8	69.3	50.3	2743.5
1969	56.4	171.5	56.1	322.6	237.5	215.9	175.5	100.8	188.0	141.0	56.4	17.0	1738.6
1970	62.0	573.0	529.8	314.2	688.3	69.9	114.8	179.1	111.5	147.3	50.5	36.6	2877.1
1971	51.1	57.9	297.7	502.0	106.0	257.0	171.0	43.9	165.9	112.0	30.5	33.0	1828.0
1972	116.3	75.4	189.2	504.2	192.0	195.1	96.0	204.2	115.8	264.4	10.7	168.7	2132.1
1973	101.1	126.2	255.3	277.1	468.4	100.8	132.1	155.4	165.4	185.2	70.4	13.0	2050.3
1974	1.5	102.6	168.4	300.0	209.0	40.1	48.8	152.7	126.5	167.6	32.0	29.0	1378.2
1975	13.5	214.9	113.3	550.7	227.8	156.7	150.9	93.2	45.2	84.3	101.1	18.8	1770.4
1976	43.2	43.2	206.0	419.6	133.6	168.1	194.6	172.7	80.5	127.0	46.2	103.9	1738.6
1977	53.3	163.6	368.0	371.1	122.7	232.2	100.6	68.6	137.2	64.3	53.1	46.2	1780.8
1978	47.2	218.9	324.1	121.4	255.0	489.2	65.8	115.6	121.2	97.8	74.9	30.7	1961.9
1979	121.7	70.9	319.0	427.5	153.4	182.4	80.5	108.7	63.8	148.8	35.1	58.7	1770.4
1980	25.9	703.3	1233.9	309.1	695.7	327.4	149.6	65.0	102.6	40.4	63.5	100.6	3817.1
1981	65.5	63.2	203.2	78.2	232.2	662.7	57.7	57.4	78.2	78.7	92.5	57.4	1726.9
1982	65.3	241.0	254.8	916.9	147.8	105.9	325.9	141.0	149.9	213.1	100.6	204.2	2866.4
1983	136.9	180.3	274.3	171.5	60.2	73.9	58.7	53.3	78.7	57.2	41.7	70.9	1257.6
1984	114.0	15.3	11.4	179.8	96.8	182.6	123.4	100.3	78.7	116.3	102.4	42.4	1163.6
1985	3.2	4.6	762.5	1139.2	240.0	207.4	66.0	168.6	161.5	118.9	126.5	111.0	3109.4
1986	180.9	408.4	123.5	399.9	315.7	80.3	162.8	85.6	48.5	204.4	25.1	92.2	2127.3
1987	86.0	160.2	689.1	1312.0	281.7	538.2	130.8	81.8	102.6	90.9	49.5	94.0	3616.8
Average	87.6	199.8	345.4	434.2	274.9	226.6	116.8	119.5	124.5	131.8	70.2	71.8	2203.1
Maximum	284.5	703.3	1233.9	1312.0	695.7	662.7	325.9	223.8	231.1	264.4	228.6	204.2	-
Minimum	1.5	4.6	11.4	78.2	60.2	39.4	20.3	43.9	45.2	40.4	10.7	13.0	-
Var.	73.7	172.9	270.3	319.5	171.0	171.1	64.4	50.0	49.1	58.0	43.9	49.4	695.4

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (11/22)

Station : Bagatelle (Highland)
Code : FF307

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965	38.0	157.0	305.6	240.3	225.8	475.7	136.4	94.7	200.4	194.1	186.9	99.1	2354.0
1966	288.3	46.5	522.5	119.1	221.2	78.5	16.3	214.6	120.1	86.4	49.3	21.1	1783.8
1967	93.5	350.5	628.7	122.9	345.9	232.2	73.7	141.0	187.5	175.8	67.1	126.0	2544.6
1968	293.9	245.4	107.2	699.0	468.1	34.3	48.0	97.8	148.1	55.4	56.4	48.0	2301.5
1969	47.8	136.9	54.6	362.0	217.9	197.1	176.8	88.4	163.6	115.8	46.0	11.7	1618.5
1970	62.2	444.5	401.6	261.1	650.7	67.3	88.4	159.3	114.3	146.1	46.7	32.5	2474.7
1971	35.6	55.1	303.3	400.0	87.0	247.0	219.0	53.3	151.4	121.7	38.6	28.2	1740.1
1972	134.9	116.1	135.4	513.3	208.0	198.1	101.9	197.1	117.6	253.7	25.9	136.9	2138.9
1973	140.5	172.7	223.3	230.6	399.0	126.7	104.9	137.4	133.6	157.7	61.7	20.6	1908.8
1974	5.8	112.5	108.7	267.0	230.1	65.8	56.6	166.9	96.3	149.9	42.9	51.3	1353.8
1975	18.8	249.7	112.3	670.3	280.9	98.0	208.5	103.9	34.0	87.9	95.5	12.4	1972.3
1976	28.2	49.3	202.9	432.3	157.7	109.0	163.3	183.9	64.8	110.2	34.5	91.2	1627.4
1977	39.6	167.1	330.5	336.0	138.4	273.6	96.3	74.2	137.7	83.6	48.0	59.9	1784.9
1978	45.7	152.4	332.0	117.3	298.7	508.5	80.0	109.2	105.7	87.9	50.5	23.4	1911.4
1979	92.2	42.9	301.2	377.4	164.6	166.4	80.5	97.8	66.3	126.0	27.7	28.2	1571.2
1980	38.6	633.2	1147.3	307.3	556.0	291.3	144.0	81.5	112.8	37.3	65.5	95.5	3510.5
1981	41.1	52.6	215.4	72.6	182.9	549.1	53.1	44.7	89.2	80.0	75.7	42.9	1499.4
1982	58.2	246.4	218.2	1022.6	145.8	134.6	326.1	157.5	134.4	193.0	106.7	189.5	2932.9
1983	118.4	174.2	269.0	154.2	58.7	71.4	49.8	64.0	65.8	32.0	35.6	57.2	1150.1
1984	96.3	365.0	260.1	265.2	70.4	130.8	91.2	76.2	72.6	103.4	97.5	34.3	1662.9
1985	56.1	129.8	575.5	842.0	172.5	159.8	50.8	130.3	121.9	108.4	104.6	70.9	2522.6
1986	100.3	326.4	143.3	324.6	312.2	71.6	113.8	50.0	37.3	150.6	17.0	82.8	1729.9
1987	48.3	140.7	660.1	976.6	316.0	451.3	116.1	83.0	108.8	87.4	44.0	129.0	3161.3
Average	83.6	198.6	328.6	396.3	256.9	206.0	112.8	113.3	112.3	119.3	61.9	64.9	2054.6
Maximum	293.9	633.2	1147.3	1022.6	650.7	549.1	326.1	214.6	200.4	253.7	186.9	189.5	-
Minimum	5.8	42.9	54.6	72.6	58.7	34.3	16.3	44.7	34.0	32.0	17.0	11.7	-
Var.	73.2	142.5	240.2	265.7	146.5	150.2	68.3	47.5	42.4	52.0	36.3	46.0	578.1

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (12/22)

Station : Valetta
Code : FF408

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965	35.0	218.0	420.4	264.4	345.9	620.0	188.0	92.7	304.3	304.3	197.9	154.7	3145.6
1966	272.3	120.9	423.7	208.0	361.4	115.1	57.4	291.1	169.4	151.4	95.3	36.1	2302.0
1967	84.1	357.1	600.0	168.1	429.8	387.9	131.3	179.8	311.9	233.7	127.8	274.1	3285.5
1968	218.7	414.5	159.3	812.5	605.0	50.0	148.3	126.2	229.6	100.6	134.6	87.9	3087.4
1969	134.9	171.2	123.7	401.6	268.0	368.8	233.9	122.7	285.2	213.4	90.7	30.2	2444.2
1970	67.6	531.9	648.0	288.0	727.7	108.7	165.9	279.7	152.4	202.4	76.2	65.8	3314.2
1971	66.3	81.8	336.0	537.2	156.5	340.9	185.4	80.0	198.6	160.3	37.8	60.5	2241.3
1972	159.8	71.9	246.6	609.1	283.0	327.4	196.3	269.0	190.2	427.5	52.1	227.3	3060.2
1973	300.7	182.9	310.4	260.9	503.7	150.6	140.0	298.5	170.9	285.5	118.1	29.5	2751.6
1974	24.6	161.0	344.0	317.0	308.0	87.0	216.0	159.0	173.0	264.0	74.0	35.0	2162.7
1975	34.0	17.0	240.8	758.7	235.7	176.5	293.4	176.5	138.4	146.3	183.1	33.0	2433.5
1976	79.0	84.1	300.2	597.9	226.3	276.9	339.1	304.3	87.4	192.3	55.1	156.0	2698.5
1977	87.9	327.2	540.5	367.0	151.1	355.6	207.0	75.4	197.9	95.0	89.9	74.2	2568.7
1978	62.0	416.8	422.7	142.2	433.8	751.3	117.9	145.8	195.8	162.8	100.6	39.4	2991.1
1979	165.6	109.5	435.1	598.9	298.2	199.9	106.2	124.2	98.3	213.6	55.4	99.8	2504.7
1980	119.4	826.5	1416.6	421.1	832.1	563.1	231.4	118.6	168.9	86.9	140.0	138.7	5063.2
1981	195.1	99.3	255.8	117.9	302.3	808.5	103.6	72.1	144.0	125.2	132.8	76.5	2433.1
1982	132.8	238.8	562.1	1060.2	229.9	146.3	427.7	217.7	200.9	320.5	264.7	236.2	4037.8
1983	179.8	268.2	351.3	210.1	119.4	207.0	106.7	123.7	170.4	85.6	82.8	100.3	2005.3
1984	118.6	494.0	384.3	227.1	133.9	224.3	156.2	118.9	111.3	177.3	132.6	67.6	2345.9
1985	124.2	189.8	595.1	1132.1	202.8	283.3	89.7	222.5	215.9	144.8	136.4	123.7	3460.2
1986	162.6	372.6	196.4	382.6	388.1	241.7	228.3	97.0	80.3	236.2	44.7	175.0	2605.4
1987	122.7	182.1	644.7	1124.2	384.8	700.3	229.1	156.2	145.0	114.1	86.3	131.3	4020.7
Average	128.2	258.1	432.9	478.6	344.7	325.7	186.9	167.5	180.0	193.2	109.1	106.6	2911.4
Maximum	300.7	826.5	1416.6	1132.1	832.1	808.5	427.7	304.3	311.9	427.5	264.7	274.1	-
Minimum	24.6	17.0	123.7	117.9	119.4	50.0	57.4	72.1	80.3	85.6	37.8	29.5	-
Var.	71.0	184.9	257.9	306.2	179.2	215.2	83.6	74.7	60.6	83.9	52.8	69.3	706.9

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (13/22)

Station : Trianon
Code : DD317

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965	10.0	93.0	238.8	139.2	286.8	131.8	85.9	52.8	111.3	131.8	134.1	50.8	1466.2
1966	178.1	34.8	313.7	90.7	197.4	78.2	23.4	151.9	60.5	64.3	20.3	6.4	1219.5
1967	69.3	264.7	366.0	57.7	204.2	130.3	41.7	77.0	112.3	105.7	43.4	97.5	1569.7
1968	175.8	160.8	72.4	458.2	343.2	26.7	63.8	48.8	90.9	40.4	50.8	33.5	1565.1
1969	58.2	102.6	77.5	234.7	127.5	148.8	152.9	49.5	92.7	67.6	32.5	6.4	1150.9
1970	38.9	421.4	383.3	231.4	472.9	37.8	51.3	114.0	158.0	63.5	20.3	12.4	2005.3
1971	11.7	86.1	144.0	337.3	51.8	202.2	194.6	31.5	98.8	70.6	10.2	11.9	1250.7
1972	126.7	89.2	88.4	476.3	172.0	145.0	68.8	151.6	61.5	142.0	9.1	100.6	1631.2
1973	135.9	91.9	164.8	159.3	356.0	79.5	70.4	110.0	67.8	103.0	31.8	9.9	1380.3
1974		79.5	108.0	171.5	161.0	67.6	64.8	81.8	55.4	111.3	52.8	15.5	
1975	9.7	207.5	109.7	601.2	154.2	64.3	103.9	61.0	15.0	32.3	49.5	15.5	1423.7
1976	18.3	22.4	214.1	301.0	103.4	105.7	98.6	144.8	41.4	70.4	17.8	53.1	1190.8
1977	20.8	169.7	297.7	326.4	99.8	192.0	93.2	12.4	79.0	35.6	34.5	27.4	1388.6
1978	12.4	145.5	245.4	102.9	169.7	287.5	54.1	76.2	65.0	47.5	26.4	14.5	1247.1
1979	63.8	26.9	214.9	333.2	83.6	151.1	34.5	45.0	27.7	83.8	7.6	8.9	1081.0
1980	32.5	621.8	817.6	179.8	461.3	217.7	83.3	22.6	30.7	1.0	25.9	14.5	2508.8
1981	8.1	38.4	177.0	29.0	148.6	385.1	25.7	21.3	54.4	27.4	35.3	17.5	967.7
1982	33.3	146.3	259.3	724.2	126.0	116.1	240.3	55.9	48.3	101.3	54.4	125.7	2031.0
1983	83.8	48.3	147.3	106.4	14.5	36.3	33.0	43.0	59.0	30.0	29.0	100.0	730.6
1984	100.0	351.0			43.0	107.0	54.0	56.0	51.0	75.0	107.0	19.0	
1985													
1986													
1987													
Average	62.5	160.1	233.7	266.3	188.8	135.5	81.9	70.4	69.0	70.2	39.6	37.1	1415.1
Maximum	178.1	621.8	817.6	724.2	472.9	385.1	240.3	151.9	158.0	142.0	134.1	125.7	-
Minimum	8.1	22.4	72.4	29.0	14.5	26.7	23.4	12.4	15.0	1.0	7.6	6.4	-
Var.	54.9	148.4	165.3	184.4	127.5	86.5	54.8	41.9	33.1	36.4	30.6	37.0	408.9

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (14/22)

Station : Highlands
Code : FF313

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965	23.0	158.0	357.6	186.9	200.2	485.4	168.7	72.4	237.5	205.2	212.9	76.7	2384.5
1966	265.2	26.2	526.5	159.8	279.1	78.5	25.4	247.9	117.1	79.8	45.5	18.3	1869.2
1967	72.1	283.7	569.0	117.3	297.2	241.0	100.3	139.7	202.7	208.0	84.1	118.4	2433.6
1968	310.4	288.8	145.5	640.8	451.1	45.0	88.1	116.8	182.9	73.7	61.5	42.4	2447.0
1969	53.1	138.4	41.9	337.6	235.7	252.5	140.2	73.4	138.7	139.2	48.0	7.1	1605.8
1970	63.8	403.1	371.6	260.1	657.9	89.9	80.0	161.0	94.7	130.0	40.9	29.7	2382.8
1971	32.0	58.9	256.0	487.0	89.0	281.0	200.0	44.5	126.7	102.9	35.6	33.3	1746.9
1972	124.2	113.3	86.6	500.1	149.6	237.0	84.6	183.4	100.6	243.3	2032.0	134.1	3988.8
1973	172.7	159.0	250.2	204.5	396.5	87.1	82.0	111.5	122.7	151.6	41.4	14.2	1793.5
1974	12.2	98.6	97.8	278.4	191.8	129.0	46.0	200.7	100.8	166.9	35.8	38.6	1396.5
1975	16.8	169.9	156.5	517.4	235.0	106.9	305.1	93.0	38.6	66.3	100.6	20.1	1826.0
1976	41.1	41.4	143.0	489.5	141.0	152.4	160.0	138.2	76.2	107.4	44.5	81.8	1616.5
1977	43.4	179.8	324.9	352.6	185.9	247.4	99.1	73.7	114.6	66.3	53.3	47.8	1788.7
1978	30.2	208.8	321.8	120.4	286.8	508.5	111.5	103.9	153.9	88.9	39.9	46.2	2020.8
1979	92.5	53.6	336.0	402.1	196.3	185.2	94.7	99.6	55.6	118.4	32.3	41.7	1707.9
1980	49.3	762.8	1166.9	335.0	593.6	281.2	126.0	81.3	85.1	48.0	78.2	74.9	3682.3
1981	63.5	43.7	236.0	89.9	201.4	467.6	64.0	49.3	91.7	88.9	91.2	78.2	1565.4
1982	81.3	207.3	291.3	931.4	125.2	136.7	283.2	136.9	134.9	195.1	113.0	215.6	2851.9
1983	104.6	154.2	263.1	223.8	57.7	110.0	69.9	65.5	92.5	41.9	36.6	47.8	1267.5
1984	117.3	424.7	320.3	177.3	69.1	147.3	74.9	72.9	71.6	114.6	107.7	29.5	1727.2
1985	63.8	186.4	591.6	789.4	142.8	268.5	43.9	136.0	107.7	84.6	78.0	89.9	2582.6
1986	116.8	313.4	194.0	333.0	263.6	148.0	90.2	47.0	41.9	156.9	18.3	106.7	1829.8
1987	53.6	161.8	625.1	904.5	393.1	413.1	122.4	95.5	117.6	75.4	43.9	105.4	3111.4
Average	87.1	201.6	333.6	384.3	253.9	221.7	115.7	110.6	113.3	119.7	151.1	65.1	2157.7
Maximum	310.4	762.8	1166.9	931.4	657.9	508.5	305.1	247.9	237.5	243.3	2032.0	215.6	-
Minimum	12.2	26.2	41.9	89.9	57.7	45.0	25.4	44.5	38.6	41.9	18.3	7.1	-
Var.	73.1	159.8	237.2	238.3	152.0	132.9	68.2	50.7	47.0	54.1	403.1	47.2	690.8

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (15/22)

Station : Hermitage
Code : FF411

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965			344.9	277.6	307.8	572.5	167.1	77.2	283.0	275.3	220.0	125.7	
1966	345.9	61.5	626.1	144.0	275.1	99.1	41.9	255.0	163.3	115.3	65.8	40.9	2233.9
1967	92.2	434.8	594.4	171.2	453.4	322.8	166.4	256.3	343.4	303.0	141.0	181.6	3460.5
1968	443.5	394.5	204.0	866.1	699.3	52.6	97.0	164.1	242.3	105.4	110.0	62.2	3440.9
1969	78.2	191.0	83.1	456.9	335.5	347.5	222.3	111.3	282.4	203.2	81.8	10.2	2403.3
1970	30.5	475.0	525.0	391.2	745.2	150.1	131.8	255.3	193.0	228.3	65.5	66.5	3257.6
1971	86.4	90.7	351.5					76.2	258.1	203.5	55.1	63.0	
1972	140.7	92.7	159.0	614.4	253.2	285.5	125.2	164.8	75.2	176.3	14.5	133.6	2235.2
1973	282.4	257.6	330.7	280.9	520.2	207.5	171.5	257.6	210.8	246.9	97.3	20.1	2883.4
1974	3.3	105.7	166.9	378.5	279.4	101.6	84.1	335.3	152.7	313.9	66.0	37.1	2024.4
1975	21.8	167.9	201.7	582.4	288.5	174.2	339.1	161.8	63.8	130.8	162.8	20.8	2315.7
1976	96.3	62.7	176.0	550.4	199.4	206.0	282.2	255.5	101.9	150.1	79.2	112.3	2272.0
1977	57.9	127.5	458.0	496.6	272.8	409.2	193.0	126.0	211.8	100.6	79.2	82.8	2615.4
1978	48.5	287.0	389.6	169.2	455.9	602.7	113.5	132.8	138.4	144.5	65.5	47.0	2594.9
1979	164.1	62.5	365.0	503.7	261.9	219.5	126.0	134.6	101.3	156.2	34.3	116.6	2245.6
1980	32.8	661.9	1133.6	397.5	618.2	400.1	166.9	101.9	167.4	71.6	108.2	120.9	3980.9
1981	72.6	82.8	241.0	89.4	214.4	694.4	81.8	73.4	130.8	126.5	139.2	67.8	2014.2
1982	72.1	251.7	277.9	1015.7	143.0	141.5	471.2	236.0	213.6	283.7	206.5	260.9	3573.8
1983	136.4	212.9	273.3	195.8	114.8	138.4	75.4	106.7	136.1	53.8	65.8	73.2	1582.7
1984	113.5	445.5	339.3	225.6	134.4	259.3	141.7	127.8	114.3	169.4	115.6	55.9	2242.3
1985	95.3	155.4	585.7	982.9	236.2	266.2	91.4	181.8	174.7	119.9	135.1	111.7	3136.2
1986	157.0	377.7	294.9	365.8	422.4	190.5	164.8	77.5	69.3	236.7	32.5	139.9	2529.0
1987	91.5	217.5	340.8	996.6	361.2	602.3	183.1	191.2	125.2	117.6	75.3	96.0	3398.3
Average	121.0	237.1	367.9	461.5	345.1	292.9	165.3	167.8	171.9	175.3	96.4	89.0	2691.3
Maximum	443.5	661.9	1133.6	1015.7	745.2	694.4	471.2	335.3	343.4	313.9	220.0	260.9	-
Minimum	3.3	61.5	83.1	89.4	114.8	52.6	41.9	73.4	63.8	53.8	14.5	10.2	-
Var.	105.3	160.8	217.1	278.4	171.1	179.1	94.5	73.1	73.2	73.1	51.1	56.4	618.8

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (16/22)

Station : Vacoas
Code : FF316

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965	34.0	153.0	362.6	193.0	317.6	330.8	125.5	75.0	226.5	190.1	227.5	104.9	2340.5
1966	251.4	55.4	431.0	149.0	277.8	85.3	22.3	261.8	102.1	135.4	88.2	21.8	1881.5
1967	78.0	340.2	540.5	139.4	327.5	218.7	121.6	124.9	172.1	188.0	86.1	144.0	2481.0
1968	237.0	209.7	156.8	518.1	427.1	44.6	90.8	86.6	160.7	91.7	78.7	39.8	2141.6
1969	59.3	166.8	96.1	203.5	212.2	269.3	113.4	98.5	150.8	156.0	53.4	12.5	1591.8
1970	51.9	397.9	470.2	272.5	522.2	86.6	92.9	169.6	130.4	160.2	36.2	33.8	2424.4
1971	33.0	65.1	229.0	575.1	87.8	249.7	202.8	61.2	161.4	125.6	35.4	43.6	1869.7
1972	146.7	112.7	109.8	498.3	193.5	247.1	83.0	174.8	124.9	217.1	53.8	134.3	2096.0
1973	211.5	147.3	237.4	201.5	427.6	97.1	76.5	165.4	121.4	195.8	60.4	27.0	1968.9
1974	11.5	92.9	205.1	219.7	253.5	120.8	110.9	153.7	132.3	169.8	61.5	37.5	1569.2
1975	24.2	180.8	168.1	712.0	183.6	116.9	256.9	128.5	30.9	92.9	151.6	18.7	2065.1
1976	69.0	98.8	230.6	406.9	137.8	132.7	177.5	183.8	79.1	122.3	55.8	78.2	1772.5
1977	46.9	241.2	434.9	298.9	166.1	260.7	124.4	61.3	125.1	81.7	72.0	47.3	1960.5
1978	40.0	280.4	355.3	195.5	284.9	417.8	89.9	85.4	152.6	91.7	61.1	46.7	2101.3
1979	89.7	67.6	290.7	435.0	255.8	210.1	66.2	114.0	76.8	150.2	47.5	30.0	1833.6
1980	38.5	601.6	1067.9	481.9	602.9	369.9	103.2	63.8	103.2	62.6	75.8	78.0	3649.3
1981	38.1	58.1	259.7	59.0	193.5	607.5	63.7	63.4	122.0	101.7	107.3	79.8	1753.8
1982	93.6	181.6	224.8	829.4	125.4	167.4	261.8	157.6	163.2	220.9	109.1	209.8	2744.6
1983	119.2	149.2	230.3	184.3	60.9	92.0	89.1	59.1	97.3	55.5	44.9	50.5	1232.3
1984	128.9	474.8	285.4	147.6	76.8	171.0	89.2	95.0	94.9	132.3	80.9	34.2	1811.0
1985	85.0	209.7	469.1	868.8	145.4	226.4	55.2	112.9	110.2	117.5	95.3	95.8	2591.3
1986	102.0	213.4	145.5	348.4	337.4	86.8	118.4	53.2	39.3	186.6	34.4	121.4	1786.8
1987	47.9	117.0	647.7	769.1	225.7	322.6	119.9	98.9	119.5	100.4	51.7	134.2	2754.6
Average	88.6	200.7	332.5	378.6	254.0	214.4	115.4	115.1	121.6	136.8	76.9	70.6	2105.3
Maximum	251.4	601.6	1067.9	868.8	602.9	607.5	261.8	261.8	226.5	220.9	227.5	209.8	-
Minimum	11.5	55.4	96.1	59.0	60.9	44.6	22.3	53.2	30.9	55.5	34.4	12.5	-
Var.	65.8	136.2	210.5	235.1	137.1	130.0	57.7	51.6	42.4	47.3	42.1	49.5	498.1

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (17/22)

Station : Wooton
Code : FF418

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965	70.0	259.0	530.9	205.0	305.8	684.3	225.0	227.3	397.5	302.0	288.5	238.0	3733.4
1966	291.6	89.7	545.8	191.3	414.5	118.9	76.5	496.6	300.2	293.6	81.8	51.6	2952.0
1967	129.8	378.5	581.9	206.8	339.3	390.4	195.8	238.0	417.8	312.9	165.6	237.0	3593.8
1968	377.7	304.3	217.2	768.6	577.9	69.6	166.4	172.5	264.9	187.7	129.8	109.7	3346.2
1969	119.6	161.0	196.3	270.3	269.7	428.2	210.1	127.0	324.6	245.6	86.6	28.4	2467.6
1970	50.8	444.8	714.8	399.0	679.7	216.4	207.5	327.7	238.8	243.1	74.2	72.9	3669.5
1971	96.3	170.7	278.6	492.0	196.6	279.7	220.2	127.3	281.9	202.9	57.4	109.5	2513.1
1972	142.0	85.3	282.7	502.2	218.4	356.9	186.4	258.3	284.0	384.0	63.2	260.1	3023.6
1973	374.9	246.9	324.9	370.3	578.8	173.5	159.8	279.1	197.1	332.2	116.3	47.2	3201.1
1974	23.9	146.3	354.6	330.2	288.3	154.4	206.2	198.1	228.3	324.6	80.0	54.1	2389.1
1975	52.8	272.3	250.2	594.4	280.4	242.8	440.2	232.7	91.7	185.7	286.0	24.1	2953.3
1976	96.3	64.0	406.9	468.6	239.3	271.5	323.1	321.1	138.4	220.0	111.3	136.1	2796.5
1977	65.0	133.9	523.7	276.9	276.4	414.0	240.5	84.6	208.8	164.3	79.8	91.9	2559.8
1978	56.1	353.8	437.9	175.0	533.9	582.4	99.8	196.9	225.8	182.1	76.2	112.0	3032.0
1979	123.5	84.3	426.2	619.5	419.1	281.4	146.3	227.1	154.2	262.6	91.4	86.9	2922.5
1980	83.6	725.2	1421.4	654.6	674.4	389.6	437.1	130.8	232.4	109.0	183.4	161.3	5202.7
1981	132.3	125.2	288.8	84.1	282.4	960.4	102.1	98.8	219.2	156.7	181.1	133.4	2764.5
1982	140.5	299.0	294.6	1216.7	206.0	172.7	454.2	336.8	320.8	342.4	216.7	286.5	4286.8
1983	168.4	265.2	344.4	237.0	130.6	239.0	134.1	133.6	184.4	85.1	81.0	90.4	2093.2
1984	113.0	510.0	422.4	229.1	183.9	323.1	186.9	200.7	184.4	261.4	154.4	92.5	2861.8
1985	129.8	242.3	629.7	1371.9	222.5	391.2	95.3	186.4	208.3	212.1	194.3	168.9	4052.6
1986	162.8	367.8	398.3	457.5	582.4	136.4	173.0	106.7	87.4	297.7	54.6	230.9	3055.4
1987	105.2	165.6	769.9	1150.4	364.2	575.3	245.1	230.9	135.9	165.4	116.3	153.2	4177.3
Average	135.0	256.3	462.7	490.0	359.3	341.4	214.4	214.7	231.6	238.0	129.1	129.4	3202.1
Maximum	377.7	725.2	1421.4	1371.9	679.7	960.4	454.2	496.6	417.8	384.0	288.5	286.5	-
Minimum	23.9	64.0	196.3	84.1	130.6	69.6	76.5	84.6	87.4	85.1	54.6	24.1	-
Var.	91.3	155.2	254.6	340.4	162.3	202.1	104.4	93.3	83.7	76.4	67.1	74.8	716.9

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (18/22)

Station : Curpipe Garden
Code : 194304

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965			564.0	246.0	445.0	614.0	235.0						
1966			487.0	222.5	391.5	134.0	50.0	357.0	147.0	206.0	119.0	48.0	
1967	104.0	98.0	607.8	211.7	262.0	266.0	275.8	200.3	309.4	321.0	141.4	313.0	3110.4
1968	207.0	321.8	204.0	857.0	629.2	58.5	89.5	137.0	234.0	168.5	135.0	68.0	3109.5
1969	113.0	177.0	147.0	313.5	279.0	458.3	200.5	114.5	278.5	231.0	61.5	25.5	2399.3
1970	54.0	501.5	684.0	293.0	605.1	174.5	153.0	277.4	160.5	225.8	80.2	71.0	3280.0
1971	113.1	110.5	358.5	710.3	156.8	287.5	209.5	104.5	263.5	202.0	56.5	103.0	2675.7
1972	148.5	64.0	271.1	567.0	301.0	406.0	230.0	300.5	215.0	440.9	62.0	188.0	3194.0
1973	343.9	254.5	320.8	408.7	514.5	153.1	93.0	231.7	194.0	291.5	126.0	50.0	2981.7
1974	21.5	125.5	293.3	300.8	297.6	227.3	260.0	251.0	214.0	191.2	89.0	48.0	2319.2
1975	59.0	266.3	304.0	223.9	264.6	169.0	287.0	179.5	56.0	109.9	2341.5	114.0	4374.7
1976	123.5	140.6	219.0	502.5	260.0	319.0	259.0	256.5	140.5	176.0	157.8	130.0	2684.4
1977	62.0	272.0	499.5	263.0	204.0	366.1	225.5	78.0	178.0	155.7	122.5	204.5	2630.8
1978	75.0	365.0	462.1	187.0	363.0								
1979			381.5	594.1	464.9	214.5	175.3	225.0	151.0	222.9	81.7	44.5	
1980	55.0	666.0	1162.0	676.5	701.1	384.0	99.0	155.5	255.1	93.0	151.6	140.5	4539.3
1981	93.5	109.5											
1982													
1983													
1984													
1985													
1986													
1987													
Average	112.4	248.0	435.4	411.1	383.7	282.1	189.5	204.9	199.8	216.8	266.1	110.6	3060.3
Maximum	343.9	666.0	1162.0	857.0	701.1	614.0	287.0	357.0	309.4	440.9	2341.5	313.0	-
Minimum	21.5	64.0	147.0	187.0	156.8	58.5	50.0	78.0	56.0	93.0	56.5	25.5	-
Var.	78.4	165.9	238.9	204.7	156.4	140.5	73.4	78.2	64.6	85.5	576.6	77.3	672.3

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (19/22)

Station : Curpipe Experimental Station
Code : FF423

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965													
1966													
1967													
1968			267.4	782.8	616.4	59.7	91.0	91.7	319.0	143.9	186.5	95.5	
1969	116.4	199.4	149.8	308.3	184.8	424.5	218.1	140.5	324.9	297.2	105.8	24.3	2494.0
1970	54.9	466.0	702.0	411.0	655.0	156.3	220.2	342.0	302.2	297.9	83.0	103.2	3793.7
1971	69.7	107.8	387.2	758.3	181.5	365.6	226.5	135.3	329.9	221.5	71.7	126.1	2981.1
1972	146.3	75.7	209.7	561.7	224.7	414.6	220.2	320.0	252.5	469.7	23.5	235.7	3154.3
1973	279.0	323.3	335.4	455.7	593.9	185.6	147.6	275.0	215.3	341.4	171.1	48.8	3372.1
1974	28.3	160.6	342.5	356.1	370.4	175.8	284.2	229.6	247.6	291.8	67.8	44.9	2599.6
1975	39.4	108.5	303.1	164.0	280.0	216.5	437.4	223.2	117.1			40.4	
1976	135.6	115.9	383.7		289.6	335.0		392.1		220.3	140.0	133.5	
1977	65.9	248.6	511.1	392.1	272.2	434.1	232.3	130.6	188.2	167.7	126.6	127.6	2897.0
1978	76.6	407.7	488.2	165.0	486.6	649.8	120.4	196.5	209.3	217.4	75.0	82.9	3175.4
1979	122.5	117.6	352.8	503.7	457.4	202.1	203.8	210.5	136.4	209.5	101.2	71.8	2689.3
1980	70.5	552.6	1317.8	650.3	652.4	362.8	160.8	147.5	238.9	121.7	149.1	140.5	4564.9
1981	89.8	75.9	339.2	153.2	367.3	728.5	87.5	126.2	212.5	218.2	157.0	120.1	2675.4
1982	113.2	252.6	189.7	1232.4	179.7	186.4	329.5	205.9	150.9	265.1	144.9	256.3	3506.6
1983	156.3	225.2	320.6	221.2	116.2	199.0	120.7	131.1	209.9	88.5	91.7	142.6	2023.0
1984	146.8	549.5	464.2	264.3	234.5	267.0	192.7	229.6	261.7	230.9	130.1	68.2	3039.5
1985	112.7	240.6	552.7	1039.6	126.7	353.2	75.6	242.1	179.2	160.4	230.0	152.3	3465.1
1986	150.5	365.9	233.2	423.6	495.7	132.5	121.8	98.1	69.4	264.2	99.3	117.4	2571.6
1987	120.8	154.9	610.1	1125.3	219.9	656.2	272.5	226.9	159.0	130.0	81.9	124.5	3882.0
Average	110.3	249.9	423.0	524.7	350.2	325.3	198.0	204.7	217.0	229.3	117.7	112.8	3063.0
Maximum	279.0	552.6	1317.8	1232.4	655.0	728.5	437.4	392.1	329.9	469.7	230.0	256.3	-
Minimum	28.3	75.7	149.8	153.2	116.2	59.7	75.6	91.7	69.4	88.5	23.5	24.3	-
Var.	54.9	150.1	248.3	319.8	175.6	180.9	89.3	80.4	70.8	87.1	47.8	57.7	598.2

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (20/22)

Station : Belle Rive (SIRI)
Code : FF415

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965			494.3	286.8	436.6	733.3	218.2	93.5	421.6	348.0	245.6	219.7	
1966	366.8	124.2	568.7	230.9	368.3	120.7	76.7	361.4	232.7	213.9	95.3	49.0	2808.5
1967	109.0	459.7	654.1	202.2	414.8	437.9	234.4	237.5	348.2	326.9	154.4	309.6	3888.7
1968	327.4	356.1	218.7	815.8	631.7	58.4	92.7	193.3	286.8	144.8	155.7	101.9	3383.3
1969	126.0	211.8	123.7	497.6	294.1	409.7	242.3	119.1	316.0	260.9	101.9	21.1	2724.2
1970	68.3	366.0	544.1	384.8	791.2	175.5	208.0	297.4	235.0	255.0	98.6	63.0	3486.9
1971	112.0	114.0	311.2	582.2	211.6	313.2	206.5	124.0	293.4	219.5	75.4	93.5	2656.3
1972	168.1	103.9	260.6	637.5	269.5	335.5	163.1	261.4	230.6	438.7	64.3	202.7	3135.9
1973	339.1	207.8	353.1	376.2	552.7	309.6	216.9	289.6	202.7	310.1	142.2	68.8	3368.8
1974	35.6	159.8	282.7	372.1	350.5	119.1	192.3	181.9	223.8	362.0	83.8	94.7	2458.2
1975	65.0	189.7	197.6	581.4	329.2	218.7	406.7	217.4	129.5	175.0	261.6	50.3	2822.2
1976	127.3	131.8	350.3	587.8	255.0	293.1	349.3	331.0	134.6	216.4	126.7	160.8	3064.0
1977	78.2	173.5	491.0	411.2	284.5	407.2	230.6	156.2	258.6	130.3	118.6	95.0	2834.9
1978	89.7	385.1	440.7	135.6	540.0	719.1	131.8	167.4	207.5	229.1	80.5	97.5	3224.0
1979	145.0	117.3	399.0	613.4	362.2	375.7	127.3	174.0	153.4	264.2	97.8	113.8	2943.1
1980	79.0	709.4	1408.9	467.1	737.6	445.0	179.8	125.5	223.5	106.4	167.1	56.9	4706.4
1981	135.6	105.9	197.6	210.3	292.0	873.1	133.9	102.6	192.2	177.9	167.4	112.1	2700.7
1982	115.7	292.9	265.0	1513.8	262.0	238.0	768.8	437.6	403.2	466.3	207.7	381.8	5352.8
1983	199.6	274.7	335.5	216.7	157.5	194.8	114.1	136.7	197.4	85.3	87.0	102.4	2101.7
1984	93.1	578.5	441.9	262.0	166.8	297.8	178.0	162.4	160.0	243.9	138.1	96.0	2818.5
1985	137.5	227.1	642.9	1151.3	223.5	312.8	114.6	200.9	223.4	167.9	182.1	177.2	3761.2
1986	195.1	411.3	354.1	404.0	530.4	210.7	234.2	119.3	99.0	302.4	56.4	215.1	3132.0
1987	133.4	248.8	630.9	1174.4	458.8	629.0	243.9	288.4	155.2	172.0	124.0	125.4	4384.2
Average	147.6	270.4	433.3	526.7	387.9	357.7	220.2	207.8	231.7	244.2	131.8	130.8	3290.1
Maximum	366.8	709.4	1408.9	1513.8	791.2	873.1	768.8	437.6	421.6	466.3	261.6	381.8	-
Minimum	35.6	103.9	123.7	135.6	157.5	58.4	76.7	93.5	99.0	85.3	56.4	21.1	-
Var.	87.7	158.8	255.4	340.5	170.1	204.6	139.1	89.4	81.5	97.1	54.0	84.9	749.3

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (21/22)

Station : Phoenix
Code : FF312

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965	26.0	166.0	326.4	191.3	169.2	383.0	100.1	56.1	189.5	161.8	172.0	86.6	2027.9
1966	225.0	59.2	321.6	135.1	276.1	79.5	33.0	227.8	96.0	108.7	31.5	15.0	1608.6
1967	75.7	312.4	462.5	104.1	290.8	196.9	73.4	88.0	146.1	151.6	68.1	111.3	2080.9
1968	242.1	222.0	125.0	528.1	397.0	37.3	83.3	72.6	156.5	68.8	50.8	34.8	2018.3
1969	77.2	126.0	77.7	316.5	134.9	241.6	134.4	85.3	139.2	127.0	46.2	6.1	1512.1
1970	42.7	370.8	394.5	246.9	606.0	80.5	80.8	152.7	70.6	120.7	26.2	27.7	2220.0
1971	29.5	56.1	253.7	412.8	71.6	243.6	190.0	45.2	148.8	114.3	22.4	31.5	1619.5
1972	122.2	104.0	87.1	552.2	158.8	235.2	112.5	156.5	111.8	222.0	32.5	140.2	2034.9
1973	161.5	144.3	232.4	132.1	395.7	20.8	73.2	136.1	112.3	135.6	33.3	8.6	1586.0
1974	8.9	80.8											
1975	18.0	206.0	96.0	512.1	170.0	81.5	241.0	86.9	27.2	54.6	83.3	20.3	1596.9
1976	34.5	73.9	261.1	302.5	106.4	97.8	138.9	143.8	76.5	103.1	39.9	51.3	1429.8
1977	62.7	177.8	447.0	221.5	148.8	221.2	114.3	48.8	111.3	65.3	50.5	39.1	1708.4
1978	23.6	288.0	307.8	133.9	256.5	472.9	120.1	96.5	122.9	81.3	56.9	29.0	1989.6
1979	94.0	41.9	259.8	379.0	178.6	180.3	58.4	78.2	54.9	129.0	35.1	22.4	1511.6
1980	73.9	592.6	1115.1	317.5	559.3	273.6	101.9	67.1	87.1	36.6	58.4	67.8	3350.8
1981	42.4	35.8	236.7	55.9	170.9	489.7	35.8	44.2	78.5	83.8	98.0	57.2	1429.0
1982	59.4	174.5	265.7	877.6	136.4	237.7	272.3	111.5	115.1	179.3	107.4	210.3	2747.3
1983	82.3	114.3	202.4	146.3	37.6	86.4	34.0	46.7	57.2	31.5	23.6	27.7	890.0
1984	112.8	394.0	239.3	174.2	41.4	133.9	61.7	63.5	60.2	102.6	109.7	24.1	1517.4
1985	43.9	220.2	438.4	740.7	126.0	155.2	36.6	127.3	94.0				
1986													
1987													
Average	79.0	188.6	307.5	324.0	221.6	197.4	104.8	96.7	102.8	109.4	60.3	53.2	1845.3
Maximum	242.1	592.6	1115.1	877.6	606.0	489.7	272.3	227.8	189.5	222.0	172.0	210.3	-
Minimum	8.9	35.8	77.7	55.9	37.6	20.8	33.0	44.2	27.2	31.5	22.4	6.1	-
Var.	62.3	136.2	216.3	216.5	154.4	129.5	64.4	46.8	39.4	47.6	37.6	50.5	525.0

Var. : Standard Deviation

TABLE A.2.1 MONTHLY TOTAL RAINFALL (22/22)

Station : Reunion
Code : FF319

(Unit : mm)

Hydrological Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total
1965	27.0	133.0	310.1	201.9	225.6	428.8	161.8	64.0	244.9	165.4	193.8	109.0	2265.2
1966	235.7	57.7	396.2	146.8	277.9	67.6	19.1	278.4	94.7	106.9	143.0	21.3	1845.3
1967	82.3	362.2	509.8	171.2	292.9	242.3	119.9	110.0	138.4	216.9	87.1	143.3	2476.3
1968	292.9	289.8	120.9	622.0	379.5	69.3	82.8	122.4	198.4	97.3	67.3	32.8	2375.4
1969	61.2	171.7	97.5	362.2	324.1	381.0	139.2	131.8	188.5	199.6	65.3	14.7	2136.9
1970	37.3	460.2	604.8	333.8	683.8	92.7	125.0	233.2	173.0	186.4	42.9	35.6	3008.6
1971	35.3	84.8	264.9	674.4	104.9	273.1	202.2	76.7	143.0	137.9	42.2	58.2	2097.5
1972	171.2	107.0	159.0	590.8	263.4	324.1	173.7	237.2	183.1	320.5	70.9	186.2	2787.2
1973	227.6	146.1	328.4	239.8	590.8	110.2	117.1	204.5	149.6	242.8	72.9	40.4	2470.2
1974	14.7	127.0	100.3	342.1	333.8	210.3	125.7	225.0	199.6	177.0	55.6	26.4	1937.8
1975	40.1	217.2	159.5	506.0	196.9	139.4	357.9	131.8	52.3	153.2	216.7	19.1	2190.0
1976	40.1	63.8	236.0	619.0	197.4	238.5	234.7	262.9	110.0	73.7	17.3	47.8	2141.0
1977	4.6	245.1	429.5	401.6	90.4	356.1	131.1	91.9	115.3	128.5	44.5	81.3	2119.8
1978	37.1	376.7	380.5	191.5	342.1	480.3	53.6	89.2	152.1	67.8	39.6	66.3	2276.9
1979	85.9	37.8	416.1	554.2	251.0	228.9	80.5	151.9	55.4	129.8	27.9	8.0	2027.3
1980	25.7	356.9	1189.2	588.0	621.5	165.4	137.4	116.6	165.4	53.3	99.3	100.1	3618.7
1981	30.7	68.8	250.4	158.8	158.8	509.3	4.8	54.1	154.2	71.9	39.4	44.2	1545.3
1982	110.5	184.4	258.6	784.9	103.4	105.9	237.2	168.9	182.1	200.9	107.2	225.0	2669.0
1983	103.1	191.3	278.1	154.2	79.8	106.2	73.9	71.1	108.5	52.3	51.1	53.1	1322.6
1984	149.9	372.1	337.6	187.5	100.3	226.6	107.7	104.6	134.9	149.4	65.5	37.3	1973.3
1985	79.0	259.6	512.1	917.1	126.3	286.6	49.5	136.3	119.8	134.2	128.3	110.6	2859.3
1986	95.9	346.9	142.7	358.5	431.9	83.1	106.5	60.5	44.1	188.2	29.7	109.4	1997.4
1987	23.5	95.0											
Average	87.4	206.7	340.1	413.9	280.7	233.0	129.1	142.0	141.2	147.9	77.6	71.4	2271.2
Maximum	292.9	460.2	1189.2	917.1	683.8	509.3	357.9	278.4	244.9	320.5	216.7	225.0	-
Minimum	4.6	37.8	97.5	146.8	79.8	67.6	4.8	54.1	44.1	52.3	17.3	8.0	-
Var.	76.8	122.1	230.9	222.6	171.1	132.0	77.5	67.7	50.1	65.5	51.2	55.8	488.9

Var. : Standard Deviation

TABLE A.2.2 AREA-RAINFALL ALLOCATION

Station	W03	W04	W05	W08	W10	Residual Basin	TRO Damsite	Municipal Dyke
Cachment Area (Km2)	29.7	17.6	20.7	8.3	13.2	23.7	54.9	113.2
1 Beau Bois					0.14			0.02
2 Bagatelle (M)						0.18	0.03	0.04
3 Mon Desert			0.06	0.50	0.86	0.24	0.13	0.20
4 Minissy (M)						0.20	0.03	0.04
5 Bega						0.15	0.02	0.03
6 Reduit (Exper.St.)						0.12	0.02	0.03
7 Minissy (H)		0.11	0.10				0.07	0.04
8 Alma			0.16	0.50			0.14	0.07
9 Ebene	0.04					0.11	0.02	0.03
10 Cote d'Or		0.10	0.22				0.12	0.06
11 Bagatelle (H)	0.05	0.20					0.06	0.04
12 Valetta			0.46				0.17	0.08
13 Trianon	0.14	0.46					0.15	0.11
14 Highlands	0.24	0.13					0.04	0.08
15 Hermitage	0.04							0.01
16 Vacoas	0.09							0.02
17 Wooton	0.19							0.05
18 Curpipe (Exper.St.)	0.21							0.06
19 Bellerive								
20 Reunion								
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Ref. (M) : Mon Desert Alma Sugar Estate
(H) : Highlands Sugar Estate