THE KINGDOM OF THAILAND

MINISTRY OF AGRICULTURE AND COOPERATIVES

THE FEASIBILITY STUDY
ON
THE LAM DOM YAI BASIN IRRIGATION PROJECT

ANNEX

DECEMBER 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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The Overall Basin Study and Feasibility Study on the Lam Dom Yai Basin Irrigation Project were intermittently carried out during the period from Febrary 1991 to January 1992 in the Thailand. For the studys, the following topographic surveys were executed by the Topographic Survey Division , Royal Irrigation Department(RID).

1. Topographic Survey for the Overall Basin Study

a) Profile Survey at Eight Potential Damsites

Name of dam sites : D-23 Lam Dom Yai(M)
: D-24 Lam Som
: D-25 Huai Ari
: D-28 Lam Dom Yai(L)
: D-29 Huai Fang Deang(L)
: J-1 Lam Som (L)
: J-2 Huai Fang Deang(M)
: J-7 Huai Bon

Scale : Horizontal Scale (HS) = 1/100
: Vertical Scale (VS) = 1/2,000

b) Topograhic Survey for the Five Reservoir Area

Name of dam sites : D-23 Lam Dom Yai(M)
: D-24 Lam Som
: D-25 Huai Ari
: D-28 Lam Dom Yai(L)
: J-1 Lam Som (L)

Scale : 1/10,000

2. Topographic Survey for the Feasibility Study

a) Profiling and Cross Sectional Survey for the D-28 Dam and Spillway Axis

Scale : Horizontal Scale (HS) = 1/2,000
: Vertical Scale (VS) = 1/100

b) Topographical Mapping for Dam Site

Scale : 1/2,000

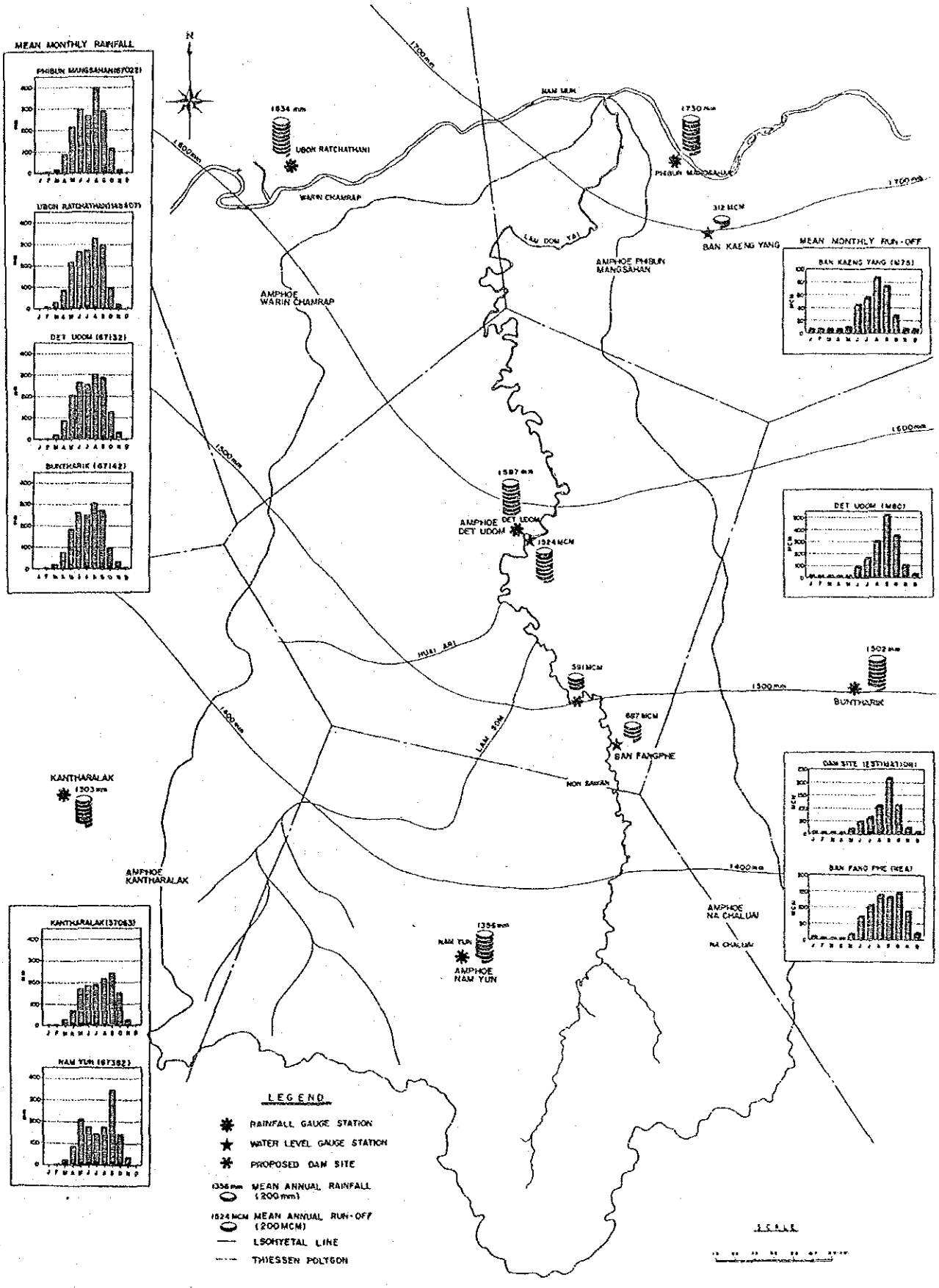
c) Topographical Mapping for Beneficial Areas of D-28

Scale : 10,000

d) Topographical Mapping for Two Sample Areas for the Typical Design of On-farm Facilities

Scale : 1/4,000

ANNEX B. METEOROLOGY AND HYDROLOGY



HYDROLOGICAL MAP OF THE LAM DOM YAI BASIN

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PART-I OVERALL BASIN STUDY

CHAPTER I METEOROLOGY

1.1 General

Meteorological conditions in the study area is governed by the southwest monsoon from the Indian Ocean and the northeast monsoon from the Chinese Continent. The southwest monsoon brings proper rainfall, while the northeast one generates heavy dry spell over the study area. Dynamics of these monsoons affect the meteorological environment of the northeastern Thailand including the study area.

Meteorological data observation in and around the study area are being carried out by the Meteorological Department (MD), Ministry of communication, and other governmental agencies such as Hydrology Division of RID (Royal Irrigation Department). Most of the observatories are the rainfall gauge stations equipped with an 8-inch standard rain gauge. A long-term synthetic climatological observation data are only available at the Northeastern Region Meteorological Center in Ubon Ratchathani located at Ubon Airport.

1.2 Rainfall

Thirteen rainfall gauge stations are being operated by the MD and RID in and around the study area. The study area can be divided into six sub-areas by Thiessen Polygon with the seven rainfall observatories related to the Lam Dom Yai basin. General description of the selected observatories are as follows;

RID Code No.	Name of Station	Observed Period	Mean Annual 1/ Rainfall	Areal 2/ Ratio
67072	Warin Chamrap	1952 to date	1,417 mm	8 %
67022	Phibun Mangsahan	1955 to date	1,730 mm	6 %
67132	Det Udom	1952 to date	1,597 mm	33 %
67142	Bun Tharik	1955 to date	1,503 mm	6 %
67382	Nam Yun	1980 to date	1,356 mm	41 %
57063	Kantharalak	1952 to date	1,303 mm	6 %

Note; 1/ Mean Annual Rainfall
Mean average value from 1960 to 1989.
Some lacking data are supplemented by the correlation method using the data of neighboring observatories.

2/ Areal Ratio
Percentage of area demarcated by the Thiessen Polygon.

Mean annual rainfall in the Lam Dom Yai basin is estimated at 1,468 mm using the areal ratio mentioned above. Monthly rainfall of each observatory is shown in Table B-1. Generally, more than 100 mm of monthly rainfalls occur in May, then increases up to August as the peak. Monthly rainfall decreases from September to January, and the rainfall in the mid-dry season (Dec. to Feb.) scarcely occur.

The Lam Dom Yai basin can be broadly divided into upper, middle and lower-basins based on the Thiessen Polygon and the basin demarcation by the related tributaries. Rainfalls in such basins are represented by the three rainfall observatories, Nam Yun, Det Udom and Phibun Mangsahan. Annual mean rainfall in the basin reaches is as follows;

Reach	Station	Annual Mean
Upper reach	Nam Yun	1,356 mm
Middle reach	Det Udom	1,597 mm
Lower reach	Phibun Mangsahan	1,730 mm

These annual mean rainfall tends to decrease from the northeast to the southwest ends of the study area i.e. from upper to lower reaches of the Lam Dom Yai basin.

1.3 Successive No-rain Days

Successive no-rain days in the upper, middle and lower-reaches is estimated during the major irrigation period from end of May to beginning of December. Occurrence of those successive no-rain days is noticeable in October and November. 30 days are an average through the major irrigation periods, though 7 to 8 days occur in beginning of irrigation period on an average. Probable no-rain days is as follows;

Unit : days

Return Period	Upper reach Nam Yun	Middle reach Det Udom	Lower reach Phibun Mangsahan
2	22	28	37
5	33	41	49
10	41	50	57
30	56	64	67
50	63	70	72
100	74	79	79

TABLE B-1 RAINFALL RECORDS IN EACH RAIN-GAUGE OBSERVATORY (1/6)
OBSERVATORY: NUM YUN

UNIT: mm

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1961	0.0	0.0	0.0	95.8	258.3	132.5	169.7	176.2	372.3	132.5	0.0	9.5	1346.8
1962	0.0	27.9	37.1	100.0	205.2	131.4	176.4	185.8	393.1	109.2	0.0	0.0	1366.1
1963	0.0	0.0	67.1	0.0	289.9	172.8	157.2	145.6	354.5	169.6	104.5	0.0	1461.2
1964	0.0	0.0	19.8	59.5	295.9	142.0	129.9	172.7	354.2	158.7	32.6	0.0	1365.3
1965	0.0	66.5	1.1	152.2	171.9	228.6	129.0	118.0	304.8	40.7	7.1	0.0	1219.9
1966	0.0	0.0	74.3	103.9	309.4	175.0	162.0	165.9	345.8	166.2	0.0	0.0	1502.5
1967	0.0	0.0	0.0	149.3	187.0	160.7	175.2	211.6	309.8	168.8	60.6	0.0	1423.0
1968	0.0	0.0	11.9	80.9	184.1	164.4	140.2	217.6	417.7	38.0	0.0	0.0	1254.8
1969	1.8	0.0	0.3	65.5	227.0	192.5	156.6	116.6	362.9	157.3	0.0	0.0	1280.5
1970	0.0	0.0	0.0	111.0	236.9	209.5	143.5	233.9	286.0	77.4	0.0	0.0	1298.2
1971	0.0	0.0	0.0	94.4	189.0	191.3	166.1	192.5	310.4	58.1	0.0	0.0	1201.8
1972	0.0	0.0	0.0	78.3	148.8	247.4	150.4	126.1	382.0	196.3	80.6	0.0	1409.9
1973	0.0	0.0	0.0	69.4	211.3	133.7	161.0	200.8	309.9	81.4	8.9	0.3	1176.7
1974	4.6	0.0	64.4	83.7	250.0	176.9	135.7	220.9	301.4	154.7	74.8	2.6	1469.7
1975	14.0	54.2	41.1	40.9	223.6	174.8	143.9	230.6	355.0	313.5	195.9	19.5	1807.0
1976	0.0	0.0	181.8	77.1	242.9	164.4	136.6	174.7	326.0	171.3	23.7	27.2	1525.7
1977	0.0	0.0	54.6	61.3	141.8	136.5	131.0	163.1	351.7	27.8	5.5	1.5	1074.8
1978	0.0	0.0	58.1	150.8	195.1	128.2	129.9	168.8	312.8	88.5	67.1	0.0	1299.3
1979	0.0	0.0	0.0	68.3	191.2	256.8	117.3	160.7	370.8	26.9	0.0	0.0	1192.0
1980	0.0	7.2	0.0	93.9	188.8	166.6	146.2	113.0	373.8	213.6	39.3	0.0	1342.4
1981	0.0	5.6	0.0	94.1	125.3	235.3	190.0	189.2	172.5	153.5	47.9	0.0	1213.4
1982	0.0	8.5	21.9	137.9	200.2	201.9	73.9	153.7	494.4	138.8	92.7	0.0	1523.9
1983	0.0	8.5	0.0	8.3	237.4	214.6	150.4	174.2	350.7	178.4	0.0	0.0	1322.5
1984	0.0	0.0	12.0	171.8	147.1	182.3	30.7	406.9	392.4	407.7	16.2	0.0	1767.1
1985	0.0	7.8	0.0	146.8	208.2	110.2	146.8	78.6	306.4	109.3	11.1	0.0	1125.2
1986	0.0	0.0	41.7	36.4	222.3	136.5	282.3	257.2	302.4	129.2	53.8	15.0	1476.8
1987	0.0	0.0	0.0	0.1	167.4	265.3	119.8	153.9	345.2	117.6	189.9	0.0	1359.2
1988	0.0	0.0	9.6	151.2	402.9	221.9	78.8	160.0	368.0	193.9	0.0	0.0	1586.3
1989	0.0	0.0	73.6	96.2	138.5	45.4	193.4	154.6	342.0	78.9	8.7	0.0	1131.3
1990	0.0	7.5	177.2	7.0	361.6	106.1	263.6	185.4	247.1	259.3	72.2	0.0	1687.0
AVE.	0.7	6.5	31.6	86.2	218.6	173.5	149.6	180.3	340.5	143.9	39.8	2.5	1373.7

TABLE B-1 RAINFALL RECORDS IN EACH RAIN-GAUGE OBSERVATORY (2/6)
OBSERVATORY: DET UDOM

UNIT: mm

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1961	0.0	0.0	0.0	104.2	318.9	128.6	413.6	298.6	368.6	119.4	0.0	5.6	1757.5
1962	0.0	8.6	28.5	112.2	191.7	127.6	476.5	320.3	422.6	98.4	0.0	0.0	1786.4
1963	0.0	0.0	49.0	0.0	386.5	257.8	341.8	242.4	319.3	154.0	90.8	0.0	1841.6
1964	0.0	0.0	16.6	43.7	405.4	161.3	152.8	292.9	319.0	142.9	30.8	0.0	1565.4
1965	0.0	21.8	3.8	197.6	115.4	431.6	141.8	193.4	182.5	35.0	9.2	0.0	1332.1
1966	0.0	0.0	53.9	118.0	429.8	265.2	368.4	281.3	293.2	151.0	0.0	0.0	1960.8
1967	0.0	0.0	0.0	194.0	149.5	220.1	448.9	364.9	193.6	153.4	54.1	0.0	1778.5
1968	0.0	0.0	11.2	80.0	142.7	228.2	230.0	375.1	491.3	32.5	0.0	0.0	1591.0
1969	1.8	0.0	3.3	53.7	244.1	320.9	332.8	188.3	339.1	141.9	0.0	0.0	1625.9
1970	0.0	0.0	0.0	129.1	269.3	373.8	243.3	410.5	128.8	68.5	0.0	0.0	1623.3
1971	0.0	0.0	0.0	102.6	153.6	313.4	395.3	331.8	194.0	51.0	0.0	0.0	1541.7
1972	0.0	0.0	0.0	75.3	62.0	494.0	283.9	207.2	393.8	178.5	71.3	0.0	1766.0
1973	0.0	0.0	0.0	60.9	207.4	133.7	374.3	346.3	193.6	72.6	10.7	0.2	1399.7
1974	4.6	0.0	47.0	84.5	294.1	271.9	185.9	380.9	174.3	139.5	66.1	1.5	1650.3
1975	14.0	17.6	31.1	13.2	237.9	264.5	239.8	397.6	313.9	285.1	167.4	11.5	1993.6
1976	0.0	0.0	127.1	74.3	279.1	231.4	201.2	296.3	241.5	155.6	23.2	16.0	1645.7
1977	0.0	0.0	40.4	46.8	45.9	143.6	159.7	276.4	314.1	23.1	7.9	0.9	1058.8
1978	0.0	0.0	42.8	195.7	171.2	117.7	149.3	286.5	204.4	79.1	60.0	0.0	1306.7
1979	0.0	0.0	0.0	58.8	160.7	524.3	63.7	272.7	367.3	22.2	0.0	0.0	1469.7
1980	0.0	1.5	0.0	102.0	153.5	234.4	260.6	182.4	366.4	194.0	36.4	0.0	1531.2
1981	0.0	0.7	2.4	124.2	137.2	334.6	270.4	413.1	126.7	121.4	29.3	0.0	1560.0
1982	0.0	0.0	65.8	98.1	36.5	229.2	370.6	382.0	553.1	104.4	59.4	4.4	1903.5
1983	0.0	0.0	2.4	25.2	125.1	442.4	191.2	198.2	175.3	223.0	0.2	0.0	1383.0
1984	0.0	0.0	21.9	117.1	189.7	92.4	163.0	550.1	363.8	304.0	50.0	0.0	1852.0
1985	0.0	2.0	28.1	273.2	288.3	182.0	196.6	316.9	298.1	42.4	70.0	0.0	1697.6
1986	0.0	0.0	9.8	25.5	291.2	281.7	254.5	292.8	266.6	146.9	29.2	4.4	1602.6
1987	0.0	0.0	6.4	33.1	59.7	315.0	301.6	332.4	463.5	121.0	138.6	0.0	1771.3
1988	0.0	0.0	0.3	148.3	388.8	417.8	88.8	194.2	148.6	160.6	2.6	0.0	1550.0
1989	0.0	0.0	35.9	59.7	226.4	207.9	192.1	284.3	142.4	142.7	3.4	0.0	1294.8
1990	0.0	0.5	87.1	36.9	300.8	295.5	307.9	319.5	440.9	107.7	56.7	0.0	1953.5
AVE.	0.7	1.8	23.8	92.9	215.4	268.1	260.0	307.6	293.3	125.7	35.6	1.5	1626.5

TABLE B-1 RAINFALL RECORDS IN EACH RAIN-GAUGE OBSERVATORY (3/6)
OBSERVATORY: BUNTHARIK

UNIT: mm

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1961	0.0	0.0	17.5	69.4	198.2	214.6	333.0	398.3	340.4	252.5	0.0	0.0	1823.9
1962	0.0	0.0	0.0	67.7	241.3	208.1	486.8	315.7	433.6	77.2	0.0	0.0	1830.4
1963	0.0	0.0	12.2	9.3	126.9	239.4	310.8	385.2	325.5	139.2	22.5	0.0	1571.0
1964	0.0	0.0	2.5	53.1	339.9	183.7	228.7	410.1	333.5	147.3	44.4	0.0	1743.2
1965	2.3	3.4	7.9	171.8	239.4	455.0	337.0	300.1	206.5	4.7	0.0	79.4	1807.5
1966	0.0	0.0	5.2	74.4	506.7	164.8	454.2	243.7	304.5	127.1	16.8	49.6	1947.0
1967	0.0	0.0	0.0	285.7	141.6	369.8	363.6	192.4	299.2	235.2	43.0	0.0	1930.5
1968	0.0	0.0	0.0	90.9	144.0	169.1	232.5	493.2	463.2	69.6	0.0	0.0	1662.5
1969	5.8	0.0	21.9	8.5	230.6	213.5	360.8	127.1	366.2	127.0	0.0	0.0	1461.4
1970	0.0	0.0	0.0	65.4	228.5	551.2	278.1	316.7	221.5	60.4	0.0	44.1	1765.9
1971	0.0	0.0	9.2	100.6	72.1	415.8	249.8	310.0	189.3	0.0	0.0	0.0	1346.8
1972	0.0	31.0	5.4	45.4	21.2	451.3	192.3	185.6	310.0	10.8	103.6	0.0	1356.6
1973	5.3	0.0	5.8	24.1	83.5	91.0	77.4	52.8	61.4	20.1	0.0	0.0	421.4
1974	0.0	0.0	8.0	28.8	32.7	34.5	108.0	365.1	78.6	22.3	162.7	8.6	849.3
1975	3.2	6.9	14.2	35.4	180.1	342.3	211.3	530.3	260.6	151.3	44.0	0.0	1779.6
1976	0.0	2.1	7.9	47.2	129.2	232.5	191.4	158.2	282.7	71.8	47.2	0.0	1170.2
1977	0.0	0.0	0.0	0.0	0.0	90.0	125.4	155.7	104.6	46.0	7.6	0.0	529.3
1978	0.0	0.0	96.0	134.6	126.0	201.3	359.9	551.9	246.1	90.1	35.2	0.0	1841.1
1979	0.0	0.0	0.0	61.1	186.0	394.7	71.9	458.1	169.1	0.0	0.0	0.0	1340.9
1980	0.0	0.0	0.0	31.5	159.4	204.7	210.0	58.8	146.3	127.5	74.9	0.0	1013.1
1981	0.0	0.0	0.0	90.2	268.3	169.0	126.1	77.4	115.0	43.4	32.1	0.0	921.5
1982	0.0	0.0	0.0	65.2	98.5	181.7	225.0	217.7	428.1	0.0	46.5	11.6	1274.3
1983	0.0	0.0	0.0	26.2	80.1	310.0	144.6	322.2	360.8	190.5	0.0	0.0	1434.4
1984	0.0	0.0	86.6	129.0	244.7	273.8	208.4	704.1	343.4	300.3	36.9	0.0	2327.2
1985	0.0	0.0	35.1	249.4	239.1	197.6	236.9	276.0	169.4	102.3	0.0	0.0	1505.8
1986	0.0	0.0	13.6	48.3	332.7	333.5	329.9	314.3	139.5	53.9	56.1	0.0	1621.8
1987	0.0	0.0	55.6	95.6	63.4	486.9	359.6	340.6	401.4	60.2	165.2	0.0	2028.5
1988	0.0	0.0	0.0	127.7	439.5	221.9	189.3	154.0	223.0	222.1	0.0	0.0	1577.5
1989	0.0	0.0	59.9	55.4	263.1	107.2	294.3	552.0	350.4	69.2	13.3	0.0	1764.8
1990	0.0	0.0	64.4	33.2	425.0	630.4	298.7	412.2	505.4	260.7	52.3	0.0	2682.3
AVE.	0.6	1.4	17.6	77.5	194.7	271.3	253.2	312.7	272.6	102.8	33.5	6.4	1544.3

TABLE B-1 RAINFALL RECORDS IN EACH RAIN-GAUGE OBSERVATORY (4/6)
OBSERVATORY: PHIBUN MANGSAHAN

UNIT: mm

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1961	0.0	0.0	22.1	3.5	232.6	213.6	293.2	328.7	202.4	234.4	0.0	0.0	1530.5
1962	0.0	104.5	2.2	4.3	277.7	281.5	253.9	470.4	484.3	75.1	0.0	0.0	1953.9
1963	0.0	0.0	10.1	2.2	20.6	129.2	55.0	233.3	164.5	195.0	25.5	0.0	835.4
1964	0.0	0.0	80.2	0.0	502.0	156.5	296.7	240.0	447.0	258.5	65.4	0.0	2046.3
1965	0.0	0.0	10.2	138.1	368.8	441.2	199.9	255.3	276.4	20.3	0.0	0.0	1710.2
1966	0.0	5.2	83.4	91.5	252.8	571.9	153.5	316.8	228.7	61.1	0.0	0.0	1764.9
1967	0.0	0.0	0.0	147.8	176.1	145.5	324.2	609.5	345.8	134.9	10.1	0.0	1893.9
1968	0.0	0.0	0.5	141.5	157.5	56.5	293.5	827.4	544.9	72.4	0.0	0.0	2094.2
1969	0.0	10.2	21.1	47.7	265.4	140.7	375.1	176.3	201.6	132.4	0.0	0.0	1370.5
1970	0.0	0.0	0.0	60.6	131.8	420.4	178.7	387.0	80.3	20.2	0.0	0.0	1279.0
1971	0.0	0.0	0.0	31.2	105.5	201.0	276.0	207.2	151.8	20.3	0.0	0.0	993.0
1972	0.0	65.5	70.2	22.5	75.7	578.2	362.4	301.0	300.9	135.4	55.5	30.0	1997.3
1973	10.0	0.0	15.0	60.0	190.0	141.8	448.3	314.4	285.5	50.4	0.0	0.0	1515.4
1974	0.0	8.4	0.0	270.9	206.3	233.2	221.3	548.1	241.7	70.1	32.5	4.5	1837.0
1975	6.2	34.7	0.0	72.4	268.6	445.9	325.2	306.2	466.1	187.7	40.7	0.0	2153.7
1976	0.0	0.0	0.0	44.4	274.1	243.6	353.9	381.6	284.9	246.2	17.2	14.5	1860.4
1977	0.0	0.0	53.1	85.5	47.6	97.7	293.2	257.5	404.0	14.9	0.0	0.0	1253.5
1978	0.0	0.0	15.7	110.2	196.4	312.5	248.9	610.1	354.2	61.8	15.1	0.0	1924.9
1979	0.0	0.0	0.0	72.7	313.6	720.4	237.9	434.1	321.2	5.3	0.0	0.0	2105.2
1980	0.0	0.0	16.5	52.5	351.1	334.4	311.0	299.0	260.7	57.1	44.1	0.0	1726.4
1981	0.0	32.4	0.0	121.6	277.6	416.3	285.2	617.7	208.1	97.7	64.6	0.0	2121.2
1982	0.0	0.0	4.2	182.1	85.1	378.9	253.7	387.4	391.5	50.9	100.8	0.0	1834.6
1983	0.0	0.0	0.0	19.7	145.4	400.5	260.0	423.1	325.5	231.3	0.0	0.0	1805.5
1984	0.0	0.0	12.9	186.9	214.7	137.6	225.8	727.3	358.3	180.9	20.7	0.0	2065.1
1985	29.5	0.0	51.0	260.3	169.3	277.6	213.8	444.7	293.3	207.7	21.1	0.0	1968.3
1986	0.0	0.0	25.8	25.6	319.8	333.2	256.4	575.7	271.5	222.6	21.2	0.0	2051.8
1987	0.0	0.0	0.0	35.2	123.8	448.4	411.0	520.5	229.3	119.9	50.4	0.0	1938.5
1988	0.0	0.0	0.0	98.1	294.1	422.4	122.8	242.5	188.7	201.1	0.0	0.0	1569.7
1989	0.0	0.0	104.6	235.6	272.4	155.5	381.2	261.6	181.6	29.1	0.0	0.0	1621.6
1990	0.0	18.3	137.5	24.0	220.8	412.2	416.1	288.2	324.3	144.2	22.5	0.0	2008.1
AVE.	1.5	9.3	24.5	88.3	217.9	308.3	277.6	399.8	294.0	118.0	20.2	1.6	1761.0

TABLE B-1 RAINFALL RECORDS IN EACH RAIN-GAUGE OBSERVATORY (5/6)
OBSERVATORY: WARIN CHAMLAP

UNIT: mm

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1961	0.0	0.0	0.0	35.7	85.0	101.0	180.0	235.0	171.9	112.2	12.2	0.0	933.0
1962	0.0	64.3	110.7	30.8	159.3	226.4	429.6	392.3	407.8	125.2	2.1	0.0	1948.5
1963	0.0	0.0	43.4	36.9	146.5	224.1	262.3	246.9	231.9	100.5	55.0	0.0	1347.5
1964	0.0	0.0	17.6	16.8	341.3	197.0	195.2	250.9	294.2	59.4	59.2	0.0	1431.6
1965	0.0	7.6	2.8	139.0	302.7	407.4	130.8	125.3	177.0	32.8	6.4	0.0	1331.8
1966	0.0	4.1	104.4	82.0	657.3	321.6	427.6	225.8	249.1	15.3	6.7	10.7	2104.6
1967	0.0	0.0	0.0	146.4	98.5	269.8	202.6	293.4	213.8	148.5	23.0	0.0	1396.0
1968	0.0	0.4	0.3	49.6	180.1	238.5	157.6	297.6	573.6	18.2	2.5	0.0	1518.4
1969	0.0	3.3	40.5	80.6	201.2	347.0	349.0	191.4	304.5	55.2	33.3	0.0	1606.0
1970	0.0	0.0	2.3	49.3	116.2	376.9	276.6	371.8	180.4	34.4	3.4	22.1	1433.4
1971	0.0	8.1	0.0	30.5	291.7	251.7	405.9	374.2	135.4	15.6	0.0	2.2	1515.3
1972	0.0	77.7	38.9	46.7	108.1	413.6	388.6	340.1	268.0	70.6	49.5	13.7	1815.5
1973	0.0	10.9	0.0	82.0	186.2	144.9	399.2	215.1	275.4	37.8	4.6	0.0	1356.1
1974	5.3	0.0	35.0	93.2	208.8	208.2	240.4	443.1	175.8	118.5	46.8	2.8	1577.9
1975	3.6	20.9	0.0	67.1	34.5	177.5	214.5	300.4	152.7	49.4	0.0	0.0	1020.6
1976	0.0	0.0	0.0	52.0	126.2	113.9	331.5	211.5	145.2	49.3	11.4	0.0	1041.0
1977	0.0	0.0	32.0	15.2	83.3	68.0	268.1	473.5	367.5	64.8	0.0	0.0	1372.4
1978	0.2	0.0	94.2	279.6	45.2	113.4	301.8	402.2	389.8	40.4	0.0	0.0	1666.8
1979	0.0	13.2	0.0	24.6	250.6	413.2	27.9	527.2	241.0	0.0	0.0	0.0	1497.7
1980	0.0	0.0	0.0	77.9	90.9	114.7	229.6	88.4	459.3	19.9	0.0	0.0	1080.7
1981	0.0	0.0	0.0	79.0	0.0	175.0	196.6	234.0	123.1	76.9	24.6	0.0	909.2
1982	0.0	0.0	0.0	0.0	115.6	107.2	168.1	148.5	468.3	76.7	20.6	0.0	1105.0
1983	0.0	0.0	7.7	37.2	138.6	333.4	169.2	232.0	282.5	175.8	8.4	0.1	1384.9
1984	0.0	0.0	77.9	154.8	196.0	191.5	202.1	449.6	303.0	246.6	20.9	0.0	1842.4
1985	0.5	135.7	41.6	68.5	295.5	175.6	105.2	237.2	234.4	84.5	25.1	0.0	1403.8
1986	0.0	0.0	68.5	2.4	152.0	126.6	172.0	288.4	285.5	187.2	0.0	0.0	1282.6
1987	0.0	0.0	0.0	36.6	69.9	292.2	349.6	221.3	335.9	72.9	72.0	0.0	1450.4
1988	0.0	0.0	0.0	118.8	196.3	274.2	136.2	80.4	223.1	161.4	0.0	0.0	1190.4
1989	0.0	0.0	66.0	105.4	164.3	45.5	248.7	340.8	266.5	138.4	0.0	0.0	1375.6
1990	2.1	31.5	38.3	21.7	268.5	267.4	276.5	161.9	351.5	86.3	42.1	0.0	1547.8
AVE.	0.4	12.6	27.4	68.7	177.0	223.9	248.1	280.0	276.3	82.5	17.7	1.7	1416.2

TABLE B-1 RAINFALL RECORDS IN EACH RAIN-GAUGE OBSERVATORY (6/6)
OBSERVATORY: KANTHARALAK

UNIT: mm

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1961	0.0	0.0	42.5	76.7	120.1	199.5	314.8	136.4	213.5	258.8	8.7	0.0	1371.0
1962	0.0	0.0	0.0	265.3	461.1	180.1	389.2	225.2	251.8	128.4	0.0	0.0	1901.1
1963	0.0	0.0	19.2	6.1	137.1	135.1	113.8	43.0	112.5	24.9	0.0	0.0	591.7
1964	0.0	0.0	0.0	0.0	196.0	142.6	189.9	225.6	250.3	371.3	75.8	0.0	1451.5
1965	0.0	0.0	13.7	77.4	180.6	229.5	165.8	224.7	243.4	102.5	0.0	0.0	1237.6
1966	0.0	4.2	64.2	66.8	166.7	268.7	155.1	221.7	240.2	121.6	0.0	0.0	1309.2
1967	0.0	0.0	0.0	26.5	117.7	235.1	183.1	143.0	51.4	12.3	0.0	0.0	769.1
1968	0.0	0.0	0.0	20.3	76.5	61.0	156.0	11.0	66.3	97.6	8.3	0.0	497.0
1969	16.3	0.0	50.8	0.0	79.4	157.5	212.5	73.4	290.1	93.2	0.0	0.0	973.2
1970	0.0	0.0	33.2	84.7	25.0	40.0	78.3	184.0	150.0	110.0	0.0	0.0	705.2
1971	0.0	0.0	0.0	2.0	189.1	169.2	297.3	210.7	165.1	182.6	0.0	10.6	1226.6
1972	0.0	88.4	24.6	108.8	194.3	393.2	247.3	134.2	302.0	88.4	143.8	0.0	1725.0
1973	14.3	0.0	12.6	60.8	179.8	116.8	202.8	231.8	247.1	127.3	8.4	0.0	1201.7
1974	11.4	0.0	0.0	50.3	106.7	97.3	147.1	312.8	156.0	62.4	27.7	0.0	971.7
1975	0.0	35.7	0.0	23.8	76.7	164.2	184.6	233.2	164.3	79.1	6.8	0.0	968.4
1976	0.0	0.0	90.7	30.1	97.0	141.3	180.8	252.6	393.3	350.5	0.0	0.0	1536.3
1977	0.0	0.0	92.7	30.5	159.9	69.0	108.4	350.1	183.2	94.8	0.0	0.0	1088.6
1978	51.6	0.0	74.2	113.5	233.0	90.0	290.1	193.2	380.0	88.1	41.2	0.0	1554.9
1979	0.0	0.0	0.0	90.7	220.5	263.8	174.1	300.2	277.9	0.0	1.3	0.0	1328.5
1980	0.0	0.8	5.8	96.5	162.9	190.2	165.2	182.0	273.4	367.3	50.3	0.0	1494.4
1981	0.0	27.3	6.1	73.8	262.6	128.1	236.7	156.5	206.5	136.4	40.9	0.0	1274.9
1982	0.0	0.0	7.5	79.9	184.3	292.0	167.4	277.1	622.3	149.4	36.3	0.0	1816.2
1983	0.0	0.0	23.6	66.6	136.1	326.7	215.7	249.4	250.7	250.2	0.0	0.0	1519.0
1984	0.0	0.0	105.5	175.6	234.1	193.6	147.9	313.4	234.1	155.1	39.7	0.0	1599.0
1985	0.0	0.0	38.1	153.6	453.3	169.8	197.1	254.7	362.7	229.8	49.5	0.0	1908.6
1986	0.0	0.0	88.5	63.8	238.5	170.9	197.1	327.4	95.0	199.2	30.0	3.7	1414.1
1987	0.0	0.0	1.2	85.5	67.3	189.0	165.6	198.5	374.2	116.2	229.0	0.0	1426.5
1988	0.0	0.0	0.0	79.1	200.7	450.9	231.0	213.0	205.3	246.9	0.0	0.0	1626.9
1989	0.0	0.0	75.1	101.0	138.6	163.5	212.4	402.0	365.7	161.3	16.5	0.0	1636.1
1990	0.0	18.4	93.5	91.6	242.9	229.0	443.6	255.0	252.8	285.8	33.0	0.0	1945.6
AVE.	3.1	5.8	32.1	73.4	178.0	188.6	205.7	217.9	246.0	156.4	28.2	0.5	1335.7

CHAPTER II HYDROLOGY

2.1 Gauging Station

Measurement of water level, discharge and suspended sediment in the Lam Dom Yai basin is being carried out by RID and NEA (National Energy Authority) at Det Udom (M80, RID) and Ban Fang Phe (53801, NEA), respectively. The other gauging stations located neighboring river basins of Lam Dom Yai such as Ban Kaeng Yang (M75) located in the eastern part, Ban Nam Om (M66) and Ban Alang (M98) in the western part of the study area are available. Among the gauging stations stated above, observed data by the three gauging stations, Det Udom, Ban Fang Phe and Ban Kaeng Yang, will be used for the project planning in view of the scale of drainage area and the rainfall pattern such as total volume of annual and monthly rainfall, etc. General conditions of the selected gauging stations are as follows;

Gauging Station	RID Code No.	Drainage Area (sq.km)	Mean Annual Areal Rainfall (mm)	Mean Annual Run-off (MCM)	Run-off Coeff.
Det Udom	M80	3,363	1,417	1,524	0.32
Ban Fang Phe	53801	1,410	1,369	680	0.35
Ban Kaeng Yang	M75	388	1,696	312	0.46

2.2 Run-off

Mean monthly run-off of each gauging station is shown below. Coincidentally with the monthly rainfall, the peak monthly discharge of Lam Dom Yai takes place among in August, September and October, however, occurrence in September is noticeable.

Annual run-off volume is fluctuated from 470 MCM to 3,000 MCM during the past 25 years in case of the observed records of M80. Also, annual basis run-off coefficients of above mentioned gauging stations varies from 0.3 to 0.4 depending on the total volume of annual rainfall. Monthly run-off of each gauging station is shown in Table B-2.

UNIT:MCM

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Det Udom (M80)												
9.5	4.7	2.8	3.1	11.6	83.4	153.7	292.8	508.5	337.2	94.3	22.9	1523.6
Ban Fang Phe (53801)												
3.8	1.9	1.2	1.5	5.4	35.7	66.8	123.1	214.2	150.5	47.7	11.3	680.0
Ban Kaeng Yang (M75)												
4.5	4.6	4.7	4.6	7.5	42.6	53.8	84.1	71.4	25.5	5.1	3.8	312.0

TABLE B-2 RUN-OFF RECORDS IN EACH WATER LEVEL OBSERVATORY (1/2)

OBSERVATORY : M75 (BAN KAENG YANG)

UNIT : MCM

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1967	0.00	0.46	0.00	0.49	1.15	11.68	42.71	80.72	101.26	33.67	0.95	0.31	273.39
1968	0.03	0.02	0.00	0.00	0.55	4.38	6.01	90.15	107.99	1.73	0.32	0.09	211.26
1969	0.13	0.00	0.03	0.01	5.68	17.39	99.19	34.17	86.30	11.89	3.49	0.26	258.55
1970	0.07	0.00	0.00	0.48	1.43	83.89	87.62	70.23	27.04	14.33	1.82	1.25	288.17
1971	0.05	0.10	0.03	0.20	0.98	23.40	83.26	89.68	39.72	3.36	0.08	0.00	240.87
1972	0.00	0.70	0.57	0.60	0.55	87.00	115.62	67.00	86.08	49.58	9.35	0.98	418.05
1973	0.41	0.09	0.00	0.05	1.26	3.53	43.07	57.95	71.80	3.98	0.49	0.22	182.86
1974	0.21	0.14	0.07	2.32	8.98	32.31	34.32	127.57	33.09	29.43	8.01	0.62	277.06
1975	0.10	0.08	0.03	1.30	3.63	76.67	65.84	92.80	95.04	66.83	34.71	32.71	469.76
1976	31.67	29.00	31.66	22.36	32.94	34.48	31.69	76.85	61.25	21.54	12.38	11.25	397.07
1977	9.78	7.29	8.92	0.56	1.14	1.97	17.00	73.12	114.33	6.09	1.45	1.46	243.11
1978	0.88	0.53	0.26	4.76	6.68	13.63	45.14	117.82	79.04	58.11	7.12	6.42	340.40
1979	6.73	6.00	5.93	2.60	21.82	148.97	42.51	113.78	80.02	3.43	2.99	3.80	438.57
1980	*****	*****	*****	*****	*****	******	******	******	******	*****	*****	*****	******
1981	*****	*****	*****	*****	*****	******	******	******	******	*****	*****	*****	******
1982	8.90	17.69	17.63	16.51	2.77	23.14	57.13	43.41	120.10	13.68	2.05	0.92	323.95
1983	0.81	7.19	10.01	5.83	6.34	52.71	29.67	65.62	16.74	40.28	1.75	0.51	237.46
1984	4.89	6.03	5.16	15.02	12.30	21.84	42.14	159.57	86.22	71.75	3.26	0.72	428.90
1985	6.65	4.29	5.46	7.34	14.97	38.09	24.88	76.44	64.80	14.13	0.57	1.79	259.40
1986	2.78	3.18	1.95	2.65	14.70	28.23	75.07	130.24	59.86	25.11	3.26	2.77	349.82
1987	5.68	4.67	3.42	3.80	1.86	49.66	122.38	86.73	80.71	11.46	7.05	4.83	382.25
1988	9.27	3.91	2.40	4.73	9.62	98.11	11.04	27.81	16.94	29.30	1.23	4.30	218.69
AVE.	4.45	4.57	4.68	4.58	7.47	42.55	53.81	84.08	71.42	25.48	5.12	3.76	311.98

OBSERVATORY : 53801 (BAN FANG PHE)

UNIT: MCM

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1969	1.49	0.70	0.51	0.61	13.80	26.00	95.20	100.00	225.00	109.00	38.20	7.39	618.00
1970	2.08	0.84	0.44	1.49	2.03	43.30	66.00	193.00	97.70	52.10	20.00	5.34	484.00
1971	1.65	0.67	0.35	0.41	2.58	36.60	127.00	188.00	191.00	78.20	18.40	4.87	649.00
1972	1.95	2.64	1.19	1.64	0.55	89.50	136.00	84.50	491.00	153.00	94.00	33.70	1090.00
1973	8.36	4.45	1.94	1.18	2.12	3.76	18.40	31.20	67.80	64.80	13.70	4.68	222.00
1974	4.22	2.78	2.33	3.18	9.24	15.80	17.80	103.00	90.80	114.00	54.80	10.30	429.00
1975	3.48	2.08	1.97	1.96	4.10	41.00	95.20	144.00	265.00	195.00	83.40	16.90	855.00
1976	******	**********	**********	**********	**********	******	******	******	******	******	******	******	*******
1977	3.90	1.95	1.33	0.64	0.70	0.56	10.80	129.00	******	92.90	14.80	4.47	*******
1978	2.09	1.01	0.96	1.13	2.66	15.60	87.60	******	205.00	205.00	35.60	8.01	*******
1979	3.40	1.88	1.07	1.09	5.92	97.50	103.00	207.00	168.00	97.40	10.80	4.45	702.00
1980	2.00	0.99	0.63	0.93	2.90	16.70	29.70	72.90	221.00	320.00	164.00	26.20	858.00
1981	6.99	3.23	1.40	1.19	7.74	65.90	84.80	137.00	130.00	123.00	39.00	9.02	610.00
1982	3.72	1.87	0.65	6.56	1.96	33.20	59.60	83.90	299.40	116.30	37.80	12.40	657.00
1983	4.39	2.07	1.07	0.66	1.77	21.50	53.40	145.00	124.00	286.20	60.10	11.00	711.00
1984	5.00	2.06	1.14	0.93	5.35	26.70	41.20	266.00	409.00	283.00	47.50	16.10	1100.00
1985	5.14	2.09	1.60	2.20	11.54	41.47	70.22	134.85	290.34	86.62	27.26	8.46	678.00
1986	4.31	1.49	0.68	0.63	3.11	11.80	88.63	148.30	230.00	126.50	34.46	10.00	682.00
1987	3.33	1.32	0.88	0.45	0.88	22.63	62.43	73.07	234.03	106.21	88.25	14.56	621.00
1988	5.49	2.41	0.94	1.62	25.25	99.76	53.78	83.81	126.88	282.37	41.44	11.71	726.00
1989	3.36	1.77	1.82	2.29	4.11	4.38	34.70	136.94	203.75	118.47	29.90	6.85	548.00
AVE.	3.82	1.92	1.15	1.54	5.42	35.68	66.77	123.07	214.19	150.50	47.67	11.32	680.00

TABLE B-2 RUN-OFF RECORDS IN EACH WATER LEVEL OBSERVATORY (2/2)

OBSERVATORY : M80 (DET UDOM)

UNIT : MCM

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1966	*****	****	****	2.88	124.78	50.80	337.40	530.63	712.90	170.43	71.60	32.54	2033.96
1967	16.38	7.87	4.57	4.93	4.38	34.38	90.70	157.28	465.51	335.77	37.76	14.54	1174.06
1968	6.64	2.85	1.45	2.84	17.54	42.89	26.39	300.81	580.54	164.68	27.82	9.95	1184.37
1969	4.72	1.94	1.28	0.85	10.82	89.39	206.67	220.65	352.73	234.99	79.42	14.52	1217.97
1970	5.87	2.51	1.33	1.30	6.61	130.89	170.39	388.47	231.50	135.91	46.28	13.64	1134.70
1971	4.51	1.80	1.40	1.75	5.40	67.27	344.13	353.45	387.10	169.52	49.16	11.45	1396.94
1972	5.62	4.74	2.65	4.86	1.35	217.05	435.72	241.92	1496.62	358.13	155.87	70.33	2994.85
1973	17.15	5.56	1.44	0.27	2.54	4.97	30.62	73.71	189.17	111.64	24.38	9.13	470.58
1974	3.42	1.02	0.31	2.01	17.55	33.41	30.75	293.89	217.75	244.49	86.86	20.21	951.67
1975	9.49	4.74	3.34	3.88	7.95	80.79	213.54	270.77	664.01	562.91	156.80	32.01	2010.22
1976	14.35	9.18	7.08	4.38	14.61	41.18	105.56	307.30	309.83	401.95	197.32	27.39	1440.13
1977	9.95	3.71	1.89	1.26	1.37	0.83	14.16	205.10	522.74	194.52	27.99	9.70	993.22
1978	3.95	1.66	1.37	3.75	5.44	22.93	120.39	527.87	333.17	649.90	67.85	17.66	1755.94
1979	7.49	3.74	2.25	1.85	6.51	182.94	289.52	523.85	357.60	234.86	22.07	9.97	1642.63
1980	5.42	3.31	2.69	2.29	6.55	45.89	57.18	86.13	429.14	598.38	284.49	47.63	1569.09
1981	17.12	7.34	4.63	4.72	21.76	163.26	243.37	282.24	278.81	270.51	75.17	26.65	1395.57
1982	12.98	7.83	5.77	9.20	4.90	41.70	127.60	216.10	1016.60	335.30	81.90	28.30	1888.18
1983	11.10	6.00	3.80	2.00	3.85	75.33	153.88	308.99	186.71	640.80	146.31	20.63	1559.39
1984	9.67	4.63	2.52	1.10	6.60	36.40	89.80	412.50	1111.10	594.80	101.40	33.90	2404.42
1985	16.20	7.70	4.80	5.23	50.22	104.50	188.75	437.11	713.23	235.86	60.96	19.36	1843.89
1986	7.17	2.98	1.45	1.26	8.02	53.76	197.41	309.14	509.94	248.67	82.88	23.88	1446.54
1987	7.88	2.93	2.06	2.23	14.75	69.02	181.99	296.30	732.70	260.21	183.73	33.11	1786.91
1988	14.79	9.92	3.59	7.96	38.17	371.58	119.41	224.07	235.48	556.31	112.80	19.62	1713.70
1989	6.71	4.36	3.58	2.39	9.47	7.85	96.93	295.75	373.95	216.37	59.52	13.69	1090.56
1990	6.38	3.11	8.99	8.81	25.18	156.07	200.35	417.52	601.63	733.28	132.26	34.15	2327.73
AVE.	9.37	4.64	3.09	3.38	12.15	86.43	155.63	297.95	512.40	353.74	95.87	23.39	1558.05

PART-II (FEASIBILITY STUDY)

Through the Overall Basin Study in the Lam Dom Yai basin, D28 reservoir project has been given the top priority among the possible projects in the basin and selected as the project to be carried out the feasibility study. In the subsequent Chapters, study results specified on the D28 reservoir projects are described in detail.

CHAPTER III HYDROLOGICAL CONDITIONS

3.1 Rainfall

On the basis of the Thiessen Polygon applied for the Lam Dom Yai basin, rainfalls in the projected area can be divided into two areal patterns. One is for the watershed area of proposed dam and the other is the irrigation area. Areal rainfalls composing point rainfall values of Nam Yun, Buntharik and Det Udom are considered as those for the watershed area. Point rainfall values at the Det Udom rainfall gauge station can be applied for the proposed irrigation area. Areal ratio of the watershed area is as follows;

Gauging station	Areal Ratio (%)	Area (sq.km)
Nam Yun	76.7	956.3
Buntharik	19.5	243.1
Det Udom	3.8	47.4
Total	100.0	*1,246.8

* direct watershed area

Estimated monthly-basis mean areal rainfall at the watershed area of the proposed dam is as follows and monthly value of each year is shown in Table B-3.

Unit: mm

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
0.7	5.3	28.6	84.7	213.8	196.2	174.0	210.9	325.5	135.2	38.4	3.2	1416.4

3.2 Run-off

Two water level gauging stations, M80 of RID at Det Udom and 53801 of NEA at Ban Fang Phe, are located near and around the proposed

TABLE B-3 ESTIMATED AREAL RAINFALL AT THE D-28 WATERSHED AREA

UNIT: mm

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1961	0.0	0.0	3.4	91.0	248.9	148.4	211.1	224.0	366.0	155.2	0.0	7.5	1455.5
1962	0.0	21.7	29.6	94.4	211.8	146.1	248.1	216.3	402.1	102.6	0.0	0.0	1472.7
1963	0.0	0.0	55.7	1.8	261.8	188.9	194.1	195.8	347.1	163.0	87.9	0.0	1496.1
1964	0.0	0.0	16.3	57.7	308.7	151.0	149.9	223.5	348.9	156.0	34.8	0.0	1446.8
1965	0.4	52.5	2.5	157.7	182.8	280.2	169.9	156.4	280.8	33.5	5.8	15.4	1337.9
1966	0.0	0.0	60.1	98.7	352.3	176.6	226.5	185.6	335.8	158.1	3.3	9.5	1606.5
1967	0.0	0.0	0.0	177.5	176.8	203.7	222.1	213.8	303.3	181.2	56.9	0.0	1535.3
1968	0.0	0.0	9.6	82.7	174.7	167.7	161.6	277.2	429.5	44.0	0.0	0.0	1347.0
1969	2.5	0.0	4.6	53.9	228.3	201.5	203.0	121.3	362.6	150.9	0.0	0.0	1328.6
1970	0.0	0.0	0.0	102.9	236.6	282.2	173.4	256.7	267.4	73.8	0.0	8.6	1401.6
1971	0.0	0.0	1.8	95.9	164.8	239.4	191.0	220.7	282.3	46.5	0.0	0.0	1242.4
1972	0.0	6.0	1.0	71.8	120.6	296.6	164.1	140.7	368.3	159.6	84.7	0.0	1413.4
1973	1.0	0.0	1.1	60.1	186.2	125.6	152.7	177.7	256.9	69.2	7.2	0.2	1037.9
1974	3.7	0.0	52.8	73.1	209.4	152.9	132.4	254.9	252.9	128.2	91.6	3.8	1355.7
1975	11.9	43.6	35.5	38.7	215.4	210.7	160.5	295.7	335.1	280.8	165.4	15.4	1808.7
1976	0.0	0.4	145.9	71.1	221.9	180.1	149.7	176.5	314.2	151.3	28.2	21.5	1460.8
1977	0.0	0.0	43.4	48.7	110.5	127.7	131.2	166.0	302.2	31.2	6.0	1.2	968.1
1978	0.0	0.0	64.7	149.3	180.5	142.0	175.4	247.8	295.6	88.4	60.7	0.0	1404.4
1979	0.0	0.0	0.0	66.5	188.9	293.7	106.5	222.9	331.4	21.5	0.0	0.0	1231.4
1980	0.0	5.6	0.0	82.1	182.0	176.7	163.1	105.1	329.5	196.3	46.2	0.0	1286.6
1981	0.0	4.3	0.1	94.5	153.7	226.1	180.7	175.9	159.7	130.9	44.2	0.0	1170.1
1982	0.0	6.5	19.2	122.2	174.2	199.1	114.5	174.6	483.8	110.5	82.4	2.5	1489.5
1983	0.0	6.5	0.1	12.4	202.5	241.8	151.0	203.8	345.9	182.4	0.0	0.0	1346.4
1984	0.0	0.0	26.8	161.4	167.6	196.7	70.2	470.0	382.1	382.9	21.5	0.0	1879.2
1985	0.0	6.1	7.8	171.7	217.2	130.0	166.2	125.9	279.6	105.1	11.3	0.0	1220.9
1986	0.0	0.0	35.1	38.2	246.3	180.4	290.5	269.6	269.0	115.4	53.3	11.7	1509.5
1987	0.0	0.0	11.0	19.9	143.0	310.3	173.4	197.0	360.7	106.4	183.2	0.0	1504.9
1988	0.0	0.0	7.4	146.4	409.4	229.4	100.7	160.2	331.4	197.9	0.0	0.0	1582.8
1989	0.0	0.0	69.5	86.9	166.1	63.8	213.0	236.9	335.7	79.5	9.4	0.0	1260.8
1990	0.0	5.8	152.0	13.1	371.6	215.3	272.4	234.7	304.7	253.7	66.6	0.0	1889.9
AVE.	0.7	5.3	28.6	84.7	213.8	196.2	174.0	210.9	325.5	135.2	38.4	3.2	1416.4

dam-site. Especially, Ban Fang Phe gauging station locates in the proposed reservoir area. To estimates the run-off volumes at the proposed dam-site, run-off model using the Tank Model Method has been developed through the Phase I study of the project. The model was calibrated by the observed record at Ban Fang Phe.

A day basis run-off from the proposed watershed area is re-computed by the developed run-off model taking the watershed area and areal rainfall into account. Computed monthly-basis run-off in each year is shown in Table B-4 and summary of the results is as follows;

Unit:MCM

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Average year												
3.7	2.1	2.0	1.7	17.5	45.6	61.7	108.6	211.6	110.6	19.9	6.2	591.0
1/5 Low water year												
4.2	2.6	2.3	1.9	6.9	31.0	70.4	121.2	184.1	63.7	7.3	5.2	500.8
1/5 High water year												
5.4	3.4	3.0	3.5	40.1	93.9	84.7	119.4	184.1	149.2	13.2	8.1	699.1

	Annual run-off	Run-off coefficient
Max.	1100.8 MCM	47 %
Mean	591.0 MCM	33 %
Min.	258.5 MCM	21 %

Mean annual specific discharge of 0.474 MCM/sq.km can be obtained through the run-off calculation. This estimated value shows same extent as M80 of 0.453 MCM/sq.km and Ban Fang Phe of 0.487 MCM/sq.km.

CHAPTER IV DESIGN FLOOD AND SEDIMENT

For the determination of design flood discharge of the proposed dam facilities, analyses of observed flood records and estimation of flood by analytical method using rainfall records have been made.

4.1 Observed Flood Records

At the existing gauging stations (M80 of RID and 53801 of NEA), momentary peak discharge (flood) of the year has been recorded during 24-years for M80 and 21-years for 53801. Using these discharge records,

TABLE B-4 ESTIMATED RUN-OFF AT THE D-28 DAM-SITE

UNIT: MCM

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1961	1.717	0.738	0.337	0.020	31.881	20.946	53.863	118.778	235.464	145.169	8.421	4.902	622.24
1962	2.299	0.950	0.531	0.262	4.021	34.856	96.634	125.955	230.786	127.983	6.871	4.395	635.54
1963	1.886	0.875	0.475	0.181	19.237	17.955	67.921	87.515	248.082	145.475	34.488	6.310	630.40
1964	3.578	1.425	0.682	0.415	41.727	15.535	55.100	107.260	241.654	148.897	7.703	5.540	629.51
1965	2.802	1.419	1.037	1.350	9.078	90.237	81.902	114.361	186.436	15.403	5.680	3.693	513.40
1966	2.039	1.198	0.900	0.746	59.082	26.108	141.481	127.692	233.430	51.069	14.302	5.847	663.89
1967	3.349	1.824	1.274	3.556	9.195	30.120	89.104	109.362	209.481	160.148	8.872	6.400	632.68
1968	3.701	2.031	1.497	1.025	6.628	23.314	25.513	180.923	314.447	34.184	6.721	4.174	604.16
1969	2.223	1.371	1.046	0.582	5.997	36.951	75.799	73.176	213.195	74.059	15.807	5.114	505.32
1970	2.497	1.247	0.763	0.421	19.069	105.519	86.982	129.363	138.967	57.131	9.006	4.829	555.79
1971	2.152	0.959	0.483	0.131	0.795	37.211	92.345	97.265	189.486	45.615	5.559	3.315	475.32
1972	1.362	0.596	0.241	0.000	0.000	68.598	24.233	55.227	258.417	93.569	13.847	5.879	521.97
1973	3.571	1.396	0.617	0.264	3.177	10.348	11.007	43.116	162.689	41.895	4.629	2.854	285.56
1974	1.138	0.486	0.181	0.017	2.795	13.761	16.976	130.035	148.428	93.733	22.946	4.854	435.35
1975	2.747	1.194	0.714	0.322	5.884	69.828	74.407	138.351	286.421	235.828	95.117	8.546	919.36
1976	5.838	2.612	4.872	3.217	19.162	57.002	73.395	119.202	163.303	131.994	27.160	7.165	614.93
1977	5.593	3.153	2.768	2.248	2.182	2.061	3.240	16.324	184.568	28.125	4.970	3.307	258.54
1978	2.439	1.840	1.795	4.431	9.208	11.446	57.019	180.281	169.148	75.095	22.530	6.890	542.12
1979	4.248	2.471	2.026	1.630	9.322	50.912	81.209	111.086	151.941	61.038	6.337	4.027	486.25
1980	2.546	1.757	1.536	1.169	5.961	14.222	26.976	11.471	219.058	135.207	14.896	5.604	440.40
1981	3.158	1.683	1.294	0.884	3.218	46.123	54.860	69.465	70.843	51.442	15.976	4.911	323.86
1982	2.679	1.446	1.157	0.924	4.151	21.101	16.139	50.096	331.234	98.027	29.502	6.718	563.17
1983	4.285	2.024	1.439	0.948	2.984	31.970	42.355	104.875	149.986	204.878	13.215	5.750	564.71
1984	2.970	1.532	1.117	1.477	9.135	42.555	36.291	229.653	402.609	344.822	19.717	8.930	1100.81
1985	7.389	4.320	3.800	5.926	43.719	42.916	55.999	75.613	164.975	57.976	9.469	7.407	479.51
1986	5.042	3.676	3.573	3.235	25.150	30.352	143.716	170.792	179.291	85.484	15.412	8.895	674.62
1987	6.515	4.182	3.808	3.318	4.099	65.981	83.809	74.318	289.039	73.746	92.830	11.130	712.77
1988	7.925	4.715	4.068	3.647	85.936	221.333	21.310	78.052	163.563	175.028	15.248	9.059	789.89
1989	6.209	4.429	4.330	4.072	10.686	4.932	37.655	155.233	210.774	84.284	10.088	8.110	540.80
1990	5.702	4.296	10.229	4.183	72.096	123.673	123.006	174.036	199.666	239.191	39.673	11.867	1007.62
AVE.	3.653	2.062	1.953	1.687	17.519	45.596	61.675	108.629	211.579	110.550	19.900	6.214	591.02

probable flood and its specific discharge can be calculated as follows;

Return Period	M80(Det Udom) A = 3363 sq.km (1)	(2)	53801(Ban Fang Phe) A = 1410 sq.km (1)	(2)
1000	3779.0	1.124	563.9	0.400
500	3157.5	0.939	526.9	0.374
200	2449.1	0.728	478.3	0.339
100	1990.7	0.592	441.7	0.313
50	1592.2	0.473	404.9	0.287
10	868.5	0.258	317.0	0.224
5	629.6	0.187	275.9	0.195

Note; (1):Flood discharge cu.m/sec
(2):Specific discharge cu.m/sec/sq.km

4.2 Flood Discharge Using the Rainfall Records

Judging from the observed rainfall and discharge records, one day and three consecutive days' rainfall values are considered for estimation of probable flood. Return period of less than 100-year and over 100-year are employed for such estimation respectively. As for the peak position on a day-basis arrangement of hyeto-graph, rear heading type is applied taking the tendency of the observed rainfall pattern into account. Following one day or n-day consecutive and hourly rainfall record are employed for estimation.

One Day or n-day rainfall... point rainfall value of Nam Yun station

Hourly rainfall.. observed value at Northeastern Region Meteorological Center in Ubon Ratchathani

To determine the hyeto-graph of the probable flood, rainfall intensity during the unit time is calculated below by means of specific coefficient method, since actual hyeto-graph of the certain rainfall is not available;

Items	Return Period 50	100	200	500	1000
(1) $Rn^{24} = In^{24}$	149.1	156.4	163.2	171.5	177.4
(2) $In^t = Rn^t * (24/t)$					
Rn^1	95.1	100.8	106.2	112.8	117.5
$In^1 = Rn^1 * 24$	2282.4	2419.2	2548.8	2707.2	2820.0

to be continued

Items	Return Period 50	100	200	500	1000
(3) $Bn^1 = In^1 / In^{24}$	15.31	15.47	15.62	15.79	15.90
(4) $b=(24-Bn^1 xt)/(Bn^1-1)$	0.61	0.59	0.57	0.56	0.54
(5) $a' = b + 24$	24.61	24.59	24.57	24.56	24.54
(6) $Bn = a' / (t + b)$	24.61 / (t+0.61)	24.59 / (t+0.59)	24.57 / (t+0.57)	24.56 / (t+0.56)	24.54 / (t+0.54)
(7) $In = Rn^{24} * Bn$	3669.4 / (t+0.61)	3845.9 / (t+0.59)	4009.8 / (t+0.57)	4212.0 / (t+0.56)	4354.4 / (t+0.56)

· Note; (1) one day rainfall with n-year probability
(2) t-hour rainfall with n-year probability
(3) specific coefficient
(4) coefficient defined by (3)
(5) coefficient defined by (4)
(6) specific coefficient
t: flood concentration time
(7) hourly rainfall intensity with n-year probability

Regarding the flood concentration time, Luziha formula is employed for estimation. Formula is as follows;

$$tp = L / W$$
$$W = 72 * (H / L)^{0.6}$$

where, L : river length from the origin (km)
W : average velocity of river flow (km/hour)
H : height difference in the section "L" (km)

$$W = 72*(0.57/53.5)^{0.6} = 4.719 \text{ km/hour}$$
$$tp = 53.5/4.719 = 11.3 \text{ hour}$$

Thus, the hyeto-graph of the specified flood can be calculated using the values mentioned above and the hourly distribution is made with the following equations.

$$i_{tb1}^{tb2} = a*b*r^2*\{1/(tb1+b*r)-1/(tb2+b*r)\}/24$$
$$i_{ta2}^{ta1} = a*b*(1-r)^2*\{1/(ta1+b*(1-r))-1/(ta2+b*(1-r))\}/24$$

where, a,b : value defined by specific coefficient method
r : position of the peak in daily rainfall distribution (in case of rear heading type is 0.8)
ta : time after the peak
tb : time before the peak

The run-off function method is employed for estimation of probable flood. The method has been developed on the basis of the linear response function. Basic equation can be expressed as follows;

$$Q = 0.2778\ A\ f\ r\ \{e^{-at'}(at' + 1) - e^{-at}(at + 1)\}$$
$$t' = t - to$$
$$tp = to\ e^{ato} / (e^{ato} - 1)$$

where, Q : discharge (cu.m/sec)
A : water shed area 1560.9 (sq.km)
f : run-off coefficient 0.32
r : rainfall intensity during the unit time (mm/h)
t : unit time for calculation 1.0 (hour)
to: unit time of rainfall duration 1.0 (hour)
tp: flood concentration time 11.3 (hour)
a : flood modulus defined as tp and to ($hour^{-1}$)
in case of to = 1 hour, $tp = e^a / (e^a - 1)$
therefore, $a = 2.30\ \log_{10}(tp / (tp - 1))$

The summary of calculated results of the probable flood is as follows;

Return Period year	Peak Flood Discharge cu.m/sec	Specific Discharge cu.m/sec/sq.km
1000	1,143.8	0.733
500	1,086.7	0.696
200	1,010.1	0.647
100	819.6	0.525
50	781.5	0.501

4.3 Design Flood Discharge

The specific discharges of the probable flood are summarized as shown below estimated by the observed records and the analytical method using the rainfall records.

Return Period	Specific Discharge (cu.m/sec/sq.km) Det Udom 3363 sq.km	Ban Fang Phe 1410 sq.km	Dam-site 1560.9 sq.km
1000	1.124	0.400	0.733
500	0.939	0.374	0.696
200	0.728	0.339	0.647
100	0.592	0.313	0.525
50	0.473	0.287	0.501
10	0.258	0.224	-
5	0.187	0.195	-

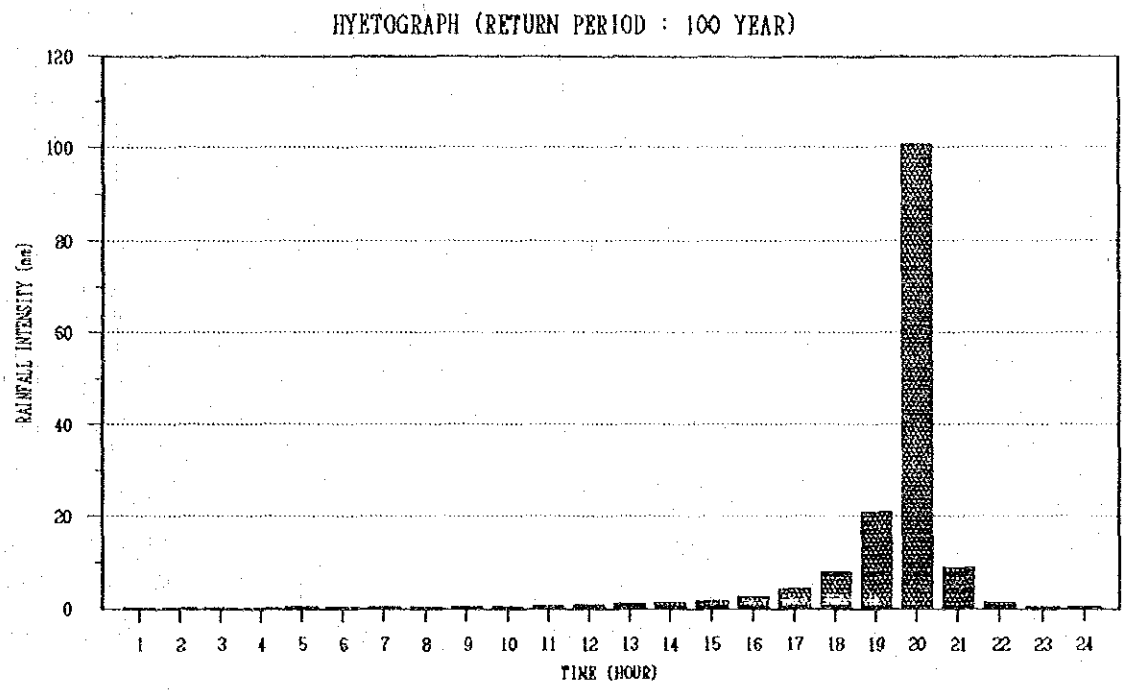
The Ban Fang Phe observatory locates in a proposed reservoir area and its records will present actual river flow conditions on the proposed dam-site. Among the specific discharges converted from the probable flood, however, the values of Ban Fang Phe show the lowest values since it seems to be regulated by the inundation effects of tributaries in the upper-basin. On the other hand, the Det Udom observatory has 3,363 sq.km of watershed area and composes two major river basins, the Lam Dom Yai and Lam Som.

Taking the present conditions of water level observatories related to the proposed dam-site into account, the probable flood discharges estimated by the analytical method at the proposed dam-site will be employed as the design flood values in view of conservative estimation. The estimated values show the medium values compared with the Ban Fang Phe and Det Udom flood discharges.

In the spillway design of proposed dam, return period of 500-year flood is considered for safety as the design discharge of spillway. Summary of the design flood is as follows, and hyeto- and hydro-graphs of return period 100 and 500-year are shown in Fig. B-1, B-2.

Spillway	Return Period	Probable Flood cu.m/sec
Design Discharge	500	1086.7

FIGURE B-1 HYETO- AND HYDRO-GRAPHS OF DESIGN FLOOD
(PROBABILITY OF 100 YEARS)



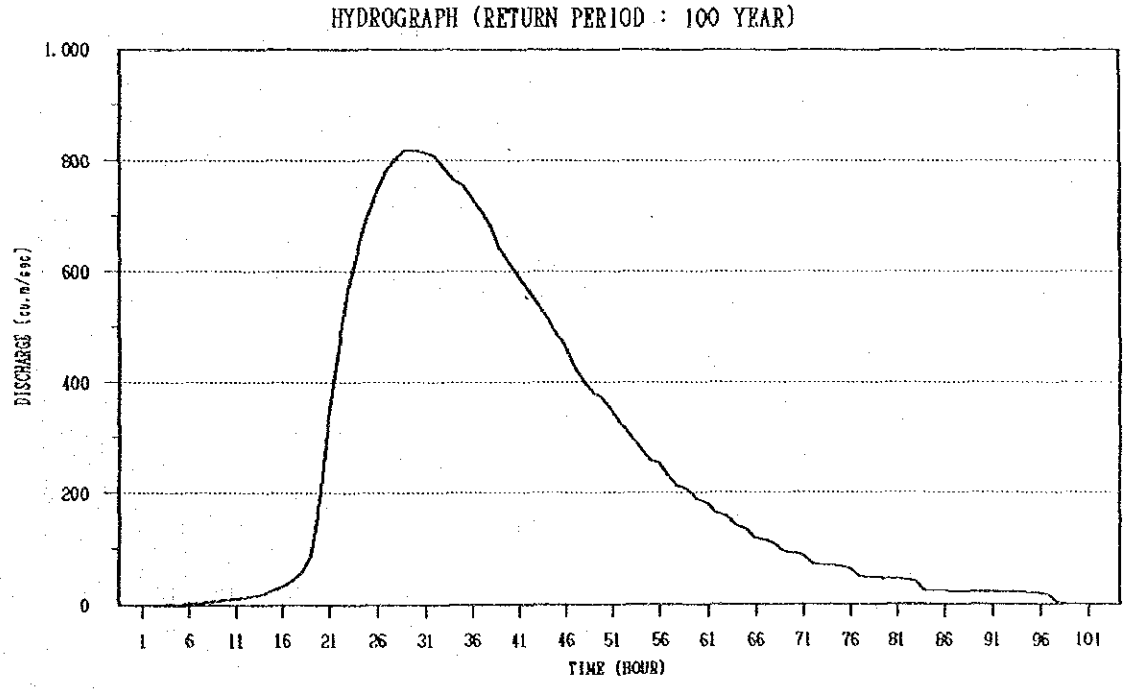
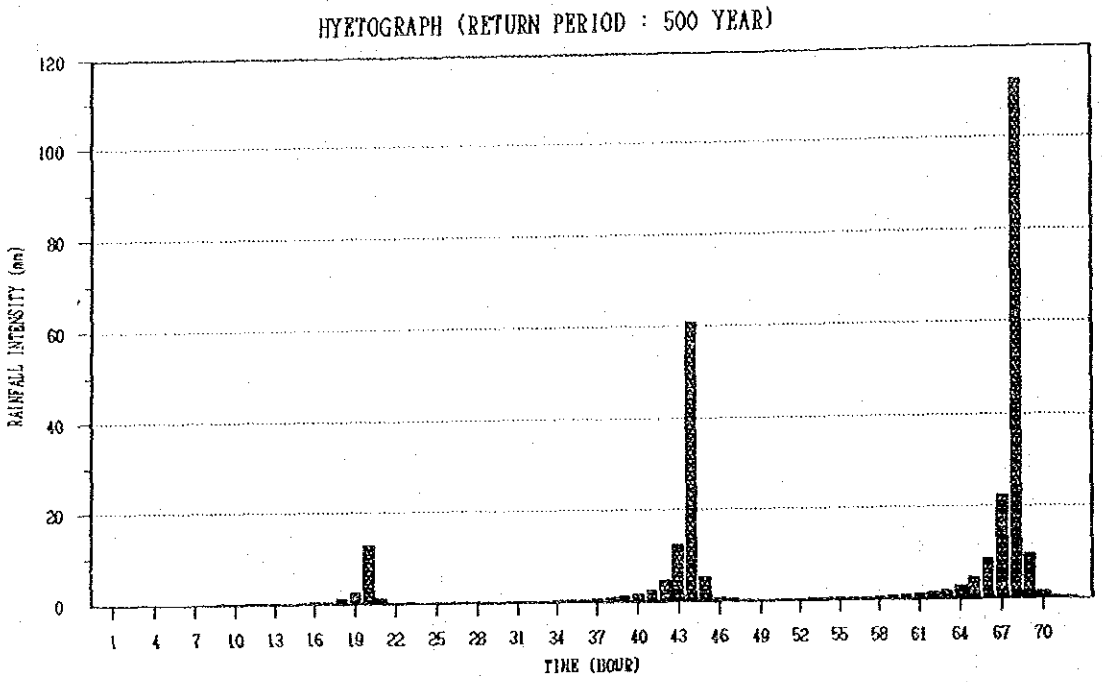
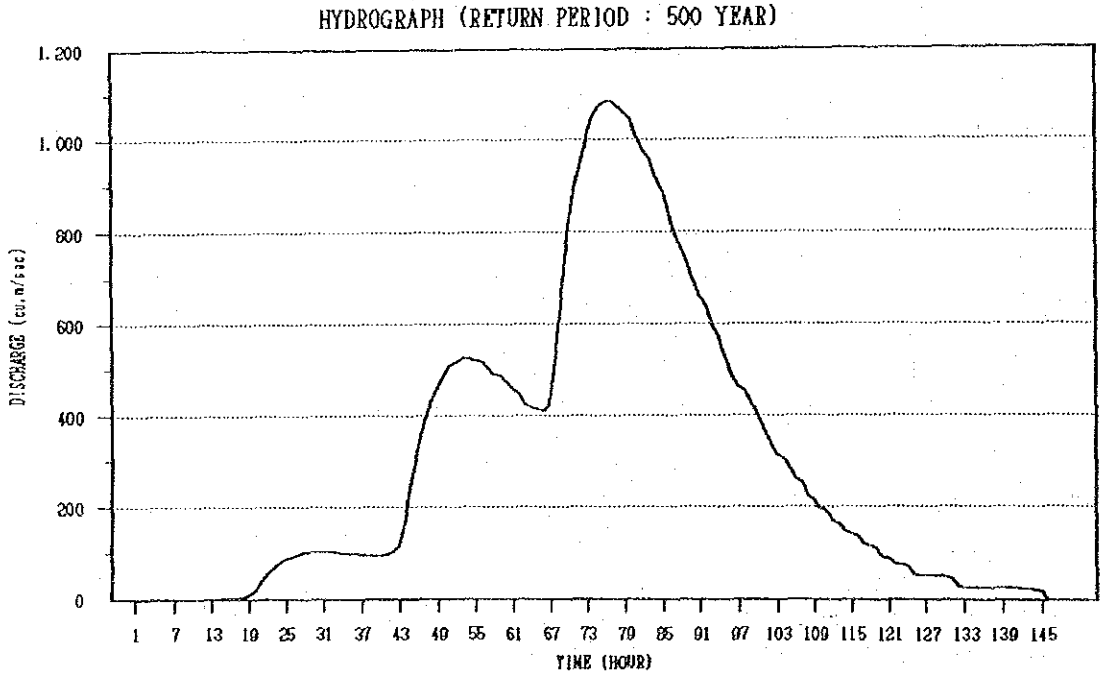


FIGURE B-2 HYETO- AND HYDRO-GRAPHS OF DESIGN FLOOD
(PROBABILITY OF 500 YEARS)





4.4 Probable Maximum Flood (PMF)

Probable flood with return period of 1 to 100 and 1 to 500 has been decided as the design discharge of the proposed dam with the consideration stated in the above Section. In addition to those considerations, basic dimensions of the proposed dam facilities will be checked by the probable maximum flood (PMF) defined theoretically as greatest flood.

Prior to estimate the PMF, PMP (possible maximum precipitation) was calculated by means of statistical procedure on the basis of the Operational Hydrology Report No.1, 'Manual for Estimation of Probable Maximum Precipitation,' World Meteorological Organization.

By the statistical analysis of annual maximum daily rainfall in Nam Yun and hourly rainfall in the Northeastern Regional Meteorological Center, the mean (Xn) and standard deviation (Sn) of a series of n annual maxima can be expressed as shown below. The mean (Xn-m) and standard deviation (Sn-m) of the annual series computed after excluding the maximum value in the series are also expressed as follows;

	Hourly rainfall	Daily rainfall
Xn-m/Xn	54.22/56.23 = 0.96	108.45/111.10 = 0.98
Sn-m/Sn	15.94/17.13 = 0.93	28.61/ 32.28 = 0.81

Adjustment factor for Xn by maximum observed rainfall (Mr) and length of record (Lr).

Mr	1.001	1.009
Lr	1.030	1.010
Adjusted Xn	57.97	113.22

Adjustment factor for Sn by maximum observed rainfall(Mr) and length of record (Lr).

Mr	1.100	0.990
Lr	1.130	1.020
Adjusted Sn	21.29	32.60

Following statistical variable for maximum rainfall (Km) can be selected.

Km	9	14.5

With these values, maximum unadjusted point values of PMP can be estimated using the equation 'Xm = Xn + Km x Sn'.

Unadjusted PMP	210.4	579.2

Adjustment of PMP based on hourly data to true maximum values.

Adjusted PMP	237.8	585.0

Adjustment of point PMP to the proper areal value for the size of basin.

Adjustment factor	0.60	0.86
PMP	142.7 mm/hour	503.1 mm/day

The probable maximum flood (PMF) is estimated with the same procedure of probable flood as mentioned in Section 4.2. The results are as follows;

Probable Maximum Precipitation (PMP)	503.1 mm/day
	142.7 mm/hour
Equation for rainfall intensity	13,563.58 / (t + 2.96)
probable Maximum Flood	2,553.1 cu.m/sec

Hyeto- and hydro-graphs of the PMP are shown in Fig. B-3.

4.5 Sediment

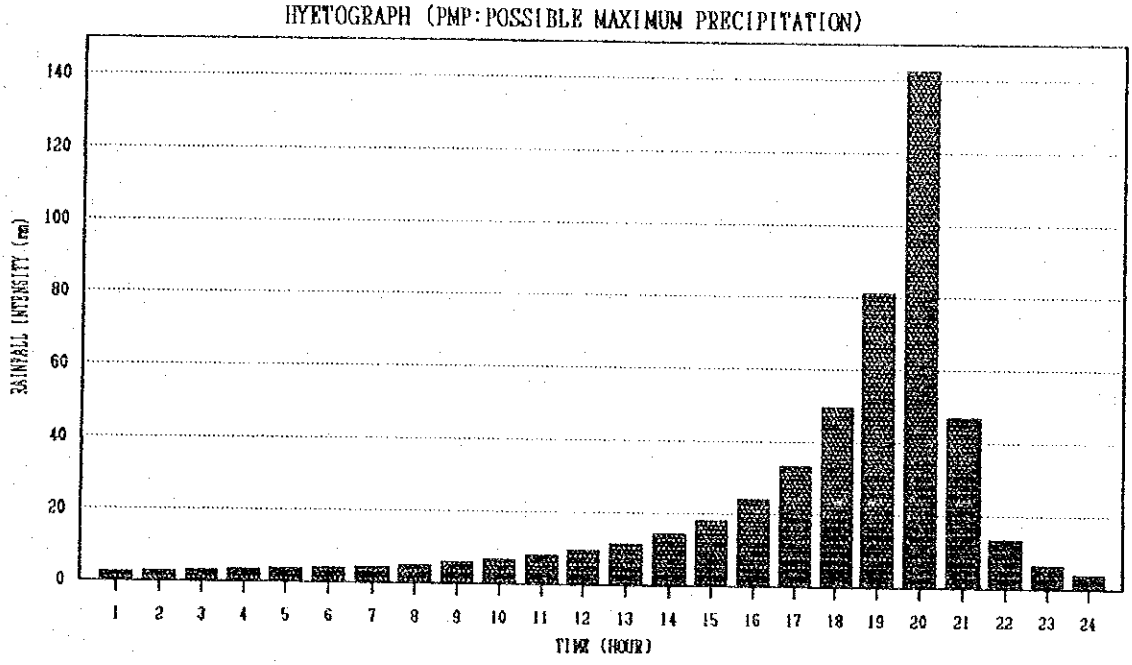
Suspended sediment volume of the Lam Dom Yai has been measured at the gauging stations of M80 in Det Udom and 53801 in Ban Fang Phe. Mean annual value of suspended sediment are as follows;

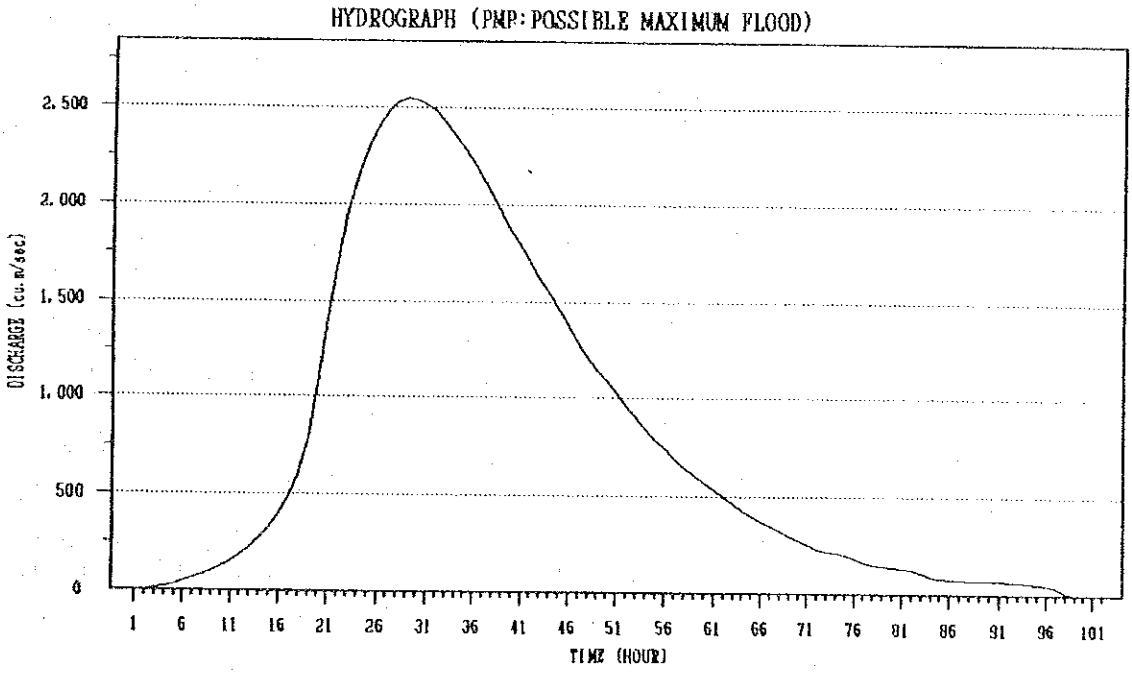
Station	Drainage Area (sq.km)	Annual Average (ton)	Range (100 ton)	Unit sediment (ton/sq.km/year)
Det Udom (M80)	3,363	221,707	204 - 269	66.0
Ban Fang Phe (NEA)	1,410	64,578	15.4- 133	45.8

No significant increase or decrease of inflow sediment is observed in the past records. Following conditions are taken up to determine the sediment volume to be stored in the proposed reservoir;

- 100-year sediment accumulation is adopted for the proposed reservoir.

FIGURE B-3 HYETO- AND HYDRO-GRAPHS OF PROBABLE MAXIMUM FLOOD





- Direct watershed area of 1246.8 sq.km is regarded as the origin of the inflow sediment.

- Mean annual inflow sediment volume is applied for the design sediment, since retention period of such accumulation is 100-years.

- A trap efficiency of 100 % is considered taking into account the pre-said items.

- A density of inflow sediment is assumed as 1.1 ton/cu.m.

Under these conditions, specific inflow sediment of the Lam Dom Yai will vary 60 to 42 cu.m/sq.km/year on an average. As the design sediment volume of the proposed reservoir, 100 cu.m/sq.km of annual inflow sediment volume is conservatively adopted. Summary of sediment inflow of the proposed reservoir is as follows;

Watershed area at dam-site	1,246.8 sq.km
Average annual run-off	591.0 MCM
Average annual suspended sediment inflow per square kilometer	110.0 ton
Average annual suspended sediment yield per square kilometer	100.0 cu.m
Average annual sediment accumulation	0.12468 MCM
100-year sediment accumulation	12.468 MCM

CHAPTER V WATER BALANCE CALCULATION

5.1 Major Premises

1) Reservoir inflow

Run-off on a day basis at the proposed dam-site is employed as the inflow volume in the reservoir. Those run-off volumes are calculated by the developed run-off model of the project. Out of the total inflow volume, 95 percent is counted as the effective inflow volume. Remaining five percent is the river maintenance flow of the lower-reaches.

2) Reservoir loss

Evaporation from the reservoir surface and seepage from the reservoir-bed are taken up as the reservoir loses. 70 percent of the Pan evaporation value and 1 mm/day at the reservoir area are considered as the evaporation from the reservoir surface and seepage from the reservoir-bed, respectively. Adopted evaporation value is as follows;

UNIT:mm

JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
120.9	120.3	150.1	146.3	128.7	112.0	113.8	104.2	105.8	110.2	118.1	120.9

3) Irrigation demand

Two types of irrigation demand are considered for water balance calculation. One is for cropping pattern of Type-1 and the other is the Type-2. Cropping components and its intensity are as follows based on the study results of the agricultural development plan of the project.

Crop	Type-1	Type-2
Wet season crop		
paddy rice	96.3%	93.2%
vegetable	-	3.1%
perennial fruits	3.7%	3.7%
Dry season crop		
vegetable	5.0 to 20.0%	5.0 to 20%

4) Rural water supply

Annual domestic water requirement is 3.0 MCM. Domestic water will be discharged from the reservoir combined with the irrigation water.

5.2 Calculation Procedure

Water balance calculation of the proposed reservoir is made for 30 years from 1961 to 1990 on a day basis. Return period of 1/5 is applied for the reservoir water utilization. This means that water shortage at the proposed reservoir is allowable seven times during the calculation period of thirty years. Following procedures are executed to formulate the proposed irrigation area;

First step : Preliminary study on the possible irrigable area and the project economy was made to decide the optimum cropping intensity during the dry season. As the results, 15% is selected in case of proposed cropping pattern of Type-1.

Second step : Using the cropping pattern of Type-1 and under the condition of above-mentioned, irrigation area of the project could be formulated as shown below on the basis of trial calculation of the water balance.

wet season paddy	32,750 ha
dry season vegetable	5,100 ha
perennial crop	1,250 ha

Third step : In case of cropping pattern Type-2, area of the dry season vegetable could be increased due to decrease of irrigation area of the wet season paddy. For the water balance calculation using the cropping pattern of Type-2, irrigable area during the dry season is taken up as the parameter to formulate the projected irrigation area. As the results of trial calculation, irrigation area of cropping pattern Type-2 is projected as follows;

wet season paddy	31,700 ha
wet season vegetable	1,050 ha
dry season vegetable	5,440 ha
perennial crop	1,250 ha

Table B-5 and B-6 are the monthly-basis calculation results. Fig. B-4 and B-5 show the behavior of reservoir water level, inflow and outflow volume of the reservoir for cropping pattern of Type-1 and Type-2, respectively.

TABLE B-5 RESULTS OF WATER BALANCE STUDY (CROPPING PATTERN TYPE-I) (1/8)

PROJECT SITE : D-28
DRAINAGE AREA : 1246.8 sq.km

IRRIGATION AREA
CROPPING PATTERN TYPE-I
PADDY : 32750 ha
UPLAND CROP (DRY): 5100 ha
PERENNIAL CROP : 1250 ha

RESERVOIR CAPACITY
TOTAL :117.107 MCM
EFFEC. :104.639 MCM
DEAD : 12.468 MCM
RESERVOIR WATER LEVEL
N.W.L. :139.500 m
DEAD :134.350 m

YEAR	MONTH	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV LOSS	END OF MONTH W.L.	END OF MONTH STORAGE	SPILLAGE	SHORTAGE
		mm	MCM	MCM	MCM	m	MCM	MCM	MCM
1961	JAN	0.0	1.717	19.982	7.487	138.775	91.269	0.000	0.000
	FEB	0.0	0.713	19.193	5.608	137.964	67.146	0.000	0.000
	MAR	3.4	0.338	15.141	4.631	137.134	47.695	0.000	0.000
	APR	91.0	0.019	6.531	3.150	136.602	38.032	0.000	0.000
	MAY	248.9	31.882	2.004	2.445	137.839	63.870	0.000	0.000
	JUN	148.4	20.947	30.495	3.512	137.234	49.764	0.000	0.000
	JUL	211.1	53.863	5.973	3.005	138.796	91.956	0.000	0.000
	AUG	224.0	118.774	0.834	4.753	139.500	117.107	82.097	0.000
	SEP	366.0	235.463	0.259	4.357	139.500	117.107	219.076	0.000
	OCT	155.2	145.166	1.943	6.786	139.500	117.107	129.181	0.000
	NOV	0.0	8.416	3.112	7.877	139.406	113.509	0.604	0.000
	DEC	7.5	4.901	15.447	7.469	138.895	95.249	0.000	0.000
	ANNUAL	1455.5	622.199	120.915	61.082			430.957	0.000
1962	JAN	0.0	2.298	17.532	6.200	138.203	73.703	0.000	0.000
	FEB	21.7	0.913	19.072	4.424	137.296	51.075	0.000	0.000
	MAR	29.6	0.529	12.973	3.830	136.389	34.774	0.000	0.000
	APR	94.4	0.263	3.399	2.588	135.934	29.038	0.000	0.000
	MAY	211.8	4.020	2.638	1.765	135.878	28.453	0.000	0.000
	JUN	146.1	34.856	26.566	2.220	136.246	32.780	0.000	0.000
	JUL	248.1	96.634	6.542	2.232	139.466	115.808	0.000	0.000
	AUG	216.3	125.958	0.268	5.598	139.500	117.107	112.498	0.000
	SEP	402.1	230.785	0.259	4.840	139.500	117.107	214.150	0.000
	OCT	102.6	127.982	1.943	6.498	139.497	117.009	113.241	0.000
	NOV	0.0	6.872	3.115	7.831	139.381	112.591	0.000	0.000
	DEC	0.0	4.396	18.059	7.521	138.773	91.187	0.000	0.000
	ANNUAL	1472.7	635.505	112.367	55.547			439.888	0.000
1963	JAN	0.0	1.889	17.532	5.917	138.053	69.532	0.000	0.000
	FEB	0.0	0.843	19.072	4.251	137.100	47.010	0.000	0.000
	MAR	55.7	0.478	15.203	3.322	135.925	28.939	0.000	0.000
	APR	1.8	0.180	6.389	2.267	135.114	20.453	0.000	0.000
	MAY	261.8	19.234	2.049	1.810	136.396	34.867	0.000	0.000
	JUN	188.9	17.956	2.317	2.053	137.127	47.556	0.000	0.000
	JUL	194.1	67.919	0.268	3.296	139.271	108.515	0.000	0.000
	AUG	195.8	87.514	0.268	3.996	139.500	117.107	70.284	0.000
	SEP	347.1	248.082	0.259	3.996	139.500	117.107	231.426	0.000
	OCT	163.0	145.479	1.943	6.069	139.500	117.107	130.195	0.000
	NOV	87.9	34.490	1.980	7.072	139.462	115.637	25.186	0.000
	DEC	0.0	6.314	17.420	7.801	138.929	96.415	0.000	0.000
	ANNUAL	1496.1	630.378	84.700	51.850			457.091	0.000

YEAR	MONTH	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV LOSS	END OF MONTH W.L.	END OF MONTH STORAGE	SPILLAGE	SHORTAGE	(2/8)
		mm	MCM	MCM	MCM	m	MCM	MCM	MCM	
1964	JAN	0.0	3.580	17.532	6.318	138.281	75.956	0.000	0.000	
	FEB	0.0	1.418	19.080	4.808	137.403	53.415	0.000	0.000	
	MAR	16.3	0.682	15.150	3.761	136.415	35.152	0.000	0.000	
	APR	57.7	0.415	5.486	2.340	135.808	27.721	0.000	0.000	
	MAY	308.7	41.727	0.268	1.509	137.905	65.585	0.000	0.000	
	JUN	144.5	15.535	28.651	2.906	137.187	48.786	0.000	0.000	
	JUL	156.4	55.100	9.985	4.116	138.645	87.030	0.000	0.000	
	AUG	212.1	107.258	0.268	4.129	139.500	117.107	63.356	0.000	
	SEP	345.6	241.652	0.866	4.478	139.500	117.107	221.645	0.000	
	OCT	170.7	148.898	1.943	6.360	139.485	116.531	140.379	0.000	
	NOV	34.8	7.701	2.554	7.317	139.418	113.977	0.000	0.000	
	DEC	0.0	5.538	17.420	7.666	138.862	94.152	0.000	0.000	
	ANNUAL	1446.8	629.504	119.203	55.706			425.380	0.000	
1965	JAN	0.4	2.802	17.532	6.030	138.186	73.241	0.000	0.000	
	FEB	52.5	1.375	16.527	4.249	137.419	53.772	0.000	0.000	
	MAR	2.5	1.039	17.404	3.812	136.302	33.543	0.000	0.000	
	APR	157.7	1.339	2.858	2.510	135.973	29.447	0.000	0.000	
	MAY	182.8	9.078	2.610	1.743	136.315	33.718	0.000	0.000	
	JUN	280.2	90.236	2.134	2.122	139.450	115.186	0.000	0.000	
	JUL	169.9	81.904	1.415	5.060	139.500	117.107	69.414	0.000	
	AUG	156.4	114.359	0.824	4.680	139.500	117.107	103.139	0.000	
	SEP	280.8	186.435	3.816	4.478	139.489	116.684	169.246	0.000	
	OCT	33.5	15.402	55.201	5.442	138.095	70.672	0.000	0.000	
	NOV	5.8	5.680	2.564	4.735	138.025	68.769	0.000	0.000	
	DEC	15.4	3.694	18.059	4.513	137.232	49.706	0.000	0.000	
	ANNUAL	1337.9	513.342	140.944	49.374			341.800	0.000	
1966	JAN	0.0	2.036	17.532	3.299	136.092	30.818	0.000	0.000	
	FEB	0.0	1.156	19.072	1.864	134.352	12.493	0.000	-1.512	
	MAR	60.1	0.899	12.396	0.690	134.350	12.468	0.000	-12.207	
	APR	98.7	0.746	5.416	0.528	134.350	12.468	0.000	-5.236	
	MAY	352.3	59.081	0.268	1.254	137.962	67.088	0.000	-0.015	
	JUN	176.6	26.109	25.524	3.135	137.814	63.233	0.000	0.000	
	JUL	226.5	141.479	0.841	4.531	139.500	117.107	75.160	0.000	
	AUG	185.6	127.691	0.268	4.549	139.500	117.107	116.492	0.000	
	SEP	335.8	233.431	0.858	5.201	139.500	117.107	215.702	0.000	
	OCT	158.1	51.069	33.107	6.149	139.500	117.107	9.261	0.000	
	NOV	3.3	14.298	3.115	7.765	139.430	114.421	5.390	0.000	
	DEC	9.5	5.855	18.059	7.138	138.881	94.787	0.000	0.000	
	ANNUAL	1606.5	663.850	136.455	46.102			422.005	-18.970	
1967	JAN	0.0	3.345	17.532	6.202	138.221	74.224	0.000	0.000	
	FEB	0.0	1.767	19.072	4.563	137.351	52.268	0.000	0.000	
	MAR	0.0	1.275	17.543	3.887	136.190	32.050	0.000	0.000	
	APR	177.5	3.552	3.492	2.266	135.994	29.666	0.000	0.000	
	MAY	176.8	9.200	2.006	1.832	136.375	34.568	0.000	0.000	
	JUN	203.7	30.121	3.408	2.149	137.586	57.625	0.000	0.000	
	JUL	222.1	89.101	0.857	3.419	139.500	117.107	20.889	0.000	
	AUG	213.8	109.357	0.829	5.074	139.500	117.107	97.989	0.000	
	SEP	303.3	209.481	0.259	5.081	139.500	117.107	193.670	0.000	
	OCT	181.2	160.146	1.928	7.073	139.500	117.107	143.140	0.000	
	NOV	56.9	8.871	3.110	7.479	139.443	114.939	0.006	0.000	
	DEC	0.0	6.402	17.500	7.762	138.910	95.759	0.000	0.000	
	ANNUAL	1535.3	632.620	87.537	56.788			455.694	0.000	

YEAR	MONTH	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV LOSS	END OF MONTH W.L.	END OF MONTH STORAGE	SPILLAGE	SHORTAGE	(3/8)
		mm	MCM	MCM	MCM	m	MCM	MCM	MCM	
1968	JAN	0.0	3.699	17.532	6.278	138.264	75.464	0.000	0.000	
	FEB	0.0	2.029	19.080	4.795	137.408	53.516	0.000	0.000	
	MAR	9.6	1.496	17.200	3.907	136.323	33.831	0.000	0.000	
	APR	61.2	1.029	3.500	2.598	135.903	28.711	0.000	0.000	
	MAY	172.8	6.638	1.916	1.933	136.121	31.168	0.000	0.000	
	JUN	184.1	23.310	1.458	2.170	137.231	49.685	0.000	0.000	
	JUL	157.3	25.508	0.268	2.515	138.111	71.135	0.000	0.000	
	AUG	288.5	180.924	0.268	4.388	139.500	117.107	119.767	0.000	
	SEP	429.5	314.444	0.259	4.862	139.500	117.107	291.187	0.000	
	OCT	44.0	34.184	2.585	7.214	139.468	115.866	27.820	0.000	
	NOV	0.0	6.719	3.125	7.786	139.348	111.337	0.000	0.000	
	DEC	0.0	4.173	17.500	7.454	138.747	90.347	0.000	0.000	
	ANNUAL	1347.0	604.153	84.691	55.900			438.773	0.000	
1969	JAN	2.5	2.223	17.532	5.647	138.043	69.268	0.000	0.000	
	FEB	0.0	1.324	19.072	4.248	137.110	47.207	0.000	0.000	
	MAR	4.6	1.046	17.543	3.327	135.771	27.331	0.000	0.000	
	APR	53.9	0.585	4.016	2.288	135.222	21.583	0.000	0.000	
	MAY	228.3	5.998	2.527	1.480	135.383	23.274	0.000	0.000	
	JUN	201.5	36.951	3.945	1.746	137.370	52.687	0.000	0.000	
	JUL	203.0	75.798	1.415	3.009	139.500	117.107	3.164	0.000	
	AUG	121.3	73.177	0.826	5.074	139.500	117.107	63.620	0.000	
	SEP	362.6	213.195	0.259	4.840	139.500	117.107	197.439	0.000	
	OCT	150.9	74.057	1.418	6.069	139.500	117.107	62.870	0.000	
	NOV	0.0	15.807	3.095	7.906	139.410	113.683	7.441	0.000	
	DEC	0.0	5.113	17.420	7.632	138.842	93.488	0.000	0.000	
	ANNUAL	1328.6	505.276	89.067	53.265			334.535	0.000	
1970	JAN	0.0	2.497	17.532	6.088	138.150	72.224	0.000	0.000	
	FEB	0.0	1.203	19.072	4.425	137.239	49.871	0.000	0.000	
	MAR	0.0	0.763	17.543	3.711	135.963	29.341	0.000	0.000	
	APR	102.9	0.424	3.530	2.162	135.458	24.052	0.000	0.000	
	MAY	236.6	19.072	2.535	1.810	136.589	37.826	0.000	0.000	
	JUN	282.2	105.520	0.676	2.844	139.500	117.107	17.444	0.000	
	JUL	173.4	86.981	0.841	6.068	139.500	117.107	75.724	0.000	
	AUG	256.7	129.363	0.268	4.812	139.500	117.107	117.818	0.000	
	SEP	267.4	138.967	0.866	5.322	139.500	117.107	125.834	0.000	
	OCT	73.8	57.130	48.511	5.915	138.937	96.673	20.281	0.000	
	NOV	0.0	9.009	3.120	6.677	138.900	95.436	0.000	0.000	
	DEC	8.6	4.828	17.428	6.163	138.297	76.431	0.000	0.000	
	ANNUAL	1401.6	555.757	131.921	55.998			357.101	0.000	
1971	JAN	0.0	2.153	17.532	4.975	137.515	55.962	0.000	0.000	
	FEB	0.0	0.926	19.072	3.450	136.358	34.321	0.000	0.000	
	MAR	1.8	0.484	17.543	2.508	134.566	14.730	0.000	0.000	
	APR	95.9	0.130	3.492	0.598	134.350	12.468	0.000	-1.706	
	MAY	164.8	0.797	1.425	0.219	134.350	12.468	0.000	-0.888	
	JUN	239.4	37.211	0.884	0.902	137.072	46.462	0.000	-0.429	
	JUL	191.0	92.345	0.841	4.073	139.500	117.107	12.169	0.000	
	AUG	220.7	97.263	0.839	4.549	139.500	117.107	87.014	0.000	
	SEP	282.3	189.487	0.858	4.598	139.500	117.107	174.559	0.000	
	OCT	46.5	45.618	6.013	7.153	139.387	112.799	34.480	0.000	
	NOV	0.0	5.559	3.115	7.524	139.242	107.442	0.000	0.000	
	DEC	0.0	3.312	18.059	7.141	138.593	85.388	0.000	0.000	
	ANNUAL	1242.4	475.285	89.673	47.689			308.223	-3.023	

YEAR	MONTH	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV LOSS	END OF MONTH W.L.	END OF MONTH STORAGE	SPILLAGE	SHORTAGE
		mm	MCM	MCM	MCM	m	MCM	MCM	MCM
1972	JAN	0.0	1.360	17.532	5.523	137.830	63.636	0.000	0.000
	FEB	6.0	0.593	19.080	3.850	136.794	41.269	0.000	0.000
	MAR	1.0	0.242	18.000	2.984	135.119	20.514	0.000	0.000
	APR	69.8	0.000	3.047	1.432	134.691	16.036	0.000	0.000
	MAY	92.5	0.000	3.134	1.070	134.350	12.468	0.000	-0.627
	JUN	284.7	68.598	1.250	2.621	138.220	74.199	0.000	-0.443
	JUL	202.0	24.232	0.841	3.401	138.827	92.977	0.000	0.000
	AUG	139.8	55.227	0.814	3.725	139.500	117.107	21.020	0.000
	SEP	371.4	258.419	0.858	4.960	139.500	117.107	238.336	0.000
	OCT	161.5	93.567	1.385	6.935	139.500	117.107	84.102	0.000
	NOV	84.7	13.846	2.592	5.891	139.500	117.107	5.065	0.000
	DEC	0.0	5.881	17.428	7.882	138.958	97.384	0.200	0.000
	ANNUAL	1413.4	521.965	85.960	50.274			348.723	-1.069
1973	JAN	1.0	3.571	17.532	6.266	138.316	76.991	0.000	0.000
	FEB	0.0	1.350	19.072	4.720	137.451	54.482	0.000	0.000
	MAR	1.1	0.618	17.543	3.935	136.306	33.592	0.000	0.000
	APR	60.1	0.266	3.427	2.388	135.838	28.029	0.000	0.000
	MAY	186.2	3.174	0.789	1.437	135.913	28.819	0.000	0.000
	JUN	125.6	10.348	27.499	1.335	134.350	12.468	0.000	-2.652
	JUL	152.7	11.006	7.116	0.752	135.195	21.302	0.000	-6.247
	AUG	177.7	43.118	0.268	1.346	137.711	60.650	0.000	0.000
	SEP	256.9	162.692	0.259	3.292	139.500	117.107	94.550	0.000
	OCT	69.2	41.895	2.572	6.921	139.497	117.005	30.411	0.000
	NOV	7.2	4.631	3.165	7.198	139.340	111.041	0.000	0.000
	DEC	0.2	2.851	18.051	7.235	138.689	88.463	0.000	0.000
	ANNUAL	1037.9	285.521	117.293	46.827			124.961	-8.899
1974	JAN	3.7	1.138	17.532	5.615	137.936	66.389	0.000	0.000
	FEB	0.0	0.471	19.072	4.051	136.929	43.714	0.000	0.000
	MAR	52.8	0.180	12.566	2.975	135.868	28.343	0.000	0.000
	APR	73.1	0.019	5.376	1.626	135.200	21.359	0.000	0.000
	MAY	209.4	2.794	1.425	1.175	135.205	21.414	0.000	0.000
	JUN	152.9	13.761	1.250	1.329	136.179	31.908	0.000	0.000
	JUL	132.4	16.975	2.037	1.994	136.945	44.004	0.000	0.000
	AUG	254.9	130.031	0.268	3.255	139.500	117.107	46.905	0.000
	SEP	252.9	148.425	1.417	4.478	139.500	117.107	135.112	0.000
	OCT	128.2	93.732	2.009	6.499	139.482	116.406	81.241	0.000
	NOV	91.6	22.947	1.960	6.606	139.446	115.056	14.585	0.000
	DEC	3.8	4.854	18.059	7.419	138.863	94.189	0.000	0.000
	ANNUAL	1355.7	435.328	82.969	47.022			277.842	0.000
1975	JAN	11.9	2.748	17.055	5.868	138.208	73.863	0.000	0.000
	FEB	43.6	1.155	17.310	4.339	137.398	53.310	0.000	0.000
	MAR	35.5	0.716	17.395	3.617	136.261	32.978	0.000	0.000
	APR	38.7	0.320	3.935	2.411	135.733	26.936	0.000	0.000
	MAY	215.4	5.885	1.986	1.203	135.963	29.338	0.000	0.000
	JUN	210.7	69.827	0.884	2.171	138.816	92.618	0.000	0.000
	JUL	160.5	74.403	1.989	4.534	139.500	117.107	39.672	0.000
	AUG	295.7	138.356	0.826	4.024	139.500	117.107	126.590	0.000
	SEP	335.1	286.420	0.808	4.237	139.500	117.107	267.057	0.000
	OCT	280.8	235.830	1.433	5.208	139.500	117.107	217.400	0.000
	NOV	165.4	95.118	1.973	6.042	139.500	117.107	82.350	0.000
	DEC	15.4	8.544	15.756	7.677	139.084	101.791	0.000	0.000
	ANNUAL	1808.7	919.322	81.351	51.331			733.069	0.000

YEAR	MONTH	RAINFALL mm	INFLOW MCM	IRRIG. DEMAND MCM	RESERV LOSS MCM	END OF MONTH W.L. m	STORAGE MCM	SPILLAGE MCM	SHORTAGE MCM
1976	JAN	0.0	5.839	17.620	6.676	138.517	83.028	0.000	0.000
	FEB	0.4	2.613	19.414	5.130	137.724	60.967	0.000	0.000
	MAR	145.9	4.871	14.991	3.820	137.088	46.784	0.000	0.000
	APR	39.2	3.223	3.467	3.134	136.904	43.245	0.000	0.000
	MAY	248.6	19.163	1.425	2.324	137.589	57.700	0.000	0.000
	JUN	177.4	57.000	12.384	2.250	138.953	97.216	0.000	0.000
	JUL	155.8	73.392	0.829	4.240	139.500	117.107	41.021	0.000
	AUG	178.3	119.200	0.268	4.276	139.500	117.107	110.634	0.000
	SEP	313.6	163.305	0.259	4.598	139.500	117.107	142.764	0.000
	OCT	149.7	131.994	1.405	4.635	139.500	117.107	126.262	0.000
	NOV	30.4	27.160	2.561	6.188	139.472	116.027	20.556	0.000
	DEC	21.5	7.167	14.805	7.721	139.042	100.309	0.000	0.000
	ANNUAL	1460.8	614.927	89.429	54.992			441.238	0.000
1977	JAN	0.0	5.597	17.532	6.633	138.466	81.456	0.000	0.000
	FEB	0.0	3.159	19.072	5.044	137.699	60.342	0.000	0.000
	MAR	43.4	2.767	14.550	4.460	136.942	43.961	0.000	0.000
	APR	48.7	2.245	6.014	3.133	136.534	36.947	0.000	0.000
	MAY	110.5	2.186	2.633	2.617	136.319	33.774	0.000	0.000
	JUN	127.7	2.058	16.653	1.695	134.820	17.381	0.000	0.000
	JUL	131.2	3.237	28.027	0.553	134.350	12.468	0.000	-20.592
	AUG	166.0	16.323	27.424	0.521	135.638	25.938	0.000	-25.907
	SEP	302.2	184.569	0.259	3.351	139.500	117.107	80.562	0.000
	OCT	31.2	28.127	18.018	6.418	139.032	99.964	19.429	0.000
	NOV	6.0	4.971	2.990	6.337	138.898	95.360	0.000	0.000
	DEC	1.2	3.305	18.059	6.215	138.221	74.227	0.000	0.000
	ANNUAL	968.1	258.544	171.230	46.975			99.990	-46.499
1978	JAN	0.0	2.439	17.532	4.836	137.437	54.176	0.000	0.000
	FEB	0.0	1.840	19.072	3.368	136.298	33.485	0.000	0.000
	MAR	64.7	1.794	12.014	2.169	135.166	21.007	0.000	0.000
	APR	149.3	4.426	4.928	1.426	134.961	18.858	0.000	0.000
	MAY	180.5	9.209	1.425	1.187	135.548	24.994	0.000	0.000
	JUN	142.0	11.443	42.729	0.913	134.576	14.836	0.000	-22.613
	JUL	175.4	57.019	49.987	0.602	136.515	36.662	0.000	-18.247
	AUG	247.8	180.279	0.826	3.733	139.500	117.107	86.261	0.000
	SEP	295.6	169.148	3.444	4.357	139.500	117.107	152.892	0.000
	OCT	88.4	75.095	42.370	6.154	139.265	108.287	31.637	0.000
	NOV	60.7	22.533	1.998	7.133	139.460	115.582	4.982	0.000
	DEC	0.0	6.891	17.428	7.809	138.943	96.892	0.000	0.000
	ANNUAL	1404.4	542.116	213.752	43.687			275.772	-40.860
1979	JAN	0.0	4.248	17.532	6.368	138.317	77.019	0.000	0.000
	FEB	0.0	2.466	19.072	4.753	137.497	55.537	0.000	0.000
	MAR	0.0	2.026	17.543	4.132	136.458	35.787	0.000	0.000
	APR	66.5	1.628	3.480	2.596	136.128	31.258	0.000	0.000
	MAY	188.9	9.319	2.049	1.728	136.494	36.333	0.000	0.000
	JUN	293.7	50.912	3.915	1.529	138.393	79.256	0.000	0.000
	JUL	106.5	81.212	17.461	6.244	139.064	101.076	31.627	0.000
	AUG	222.9	111.089	13.090	4.740	139.500	117.107	71.675	0.000
	SEP	331.4	151.943	27.309	4.441	139.500	117.107	112.596	0.000
	OCT	21.5	61.038	2.786	7.632	139.463	115.678	48.999	0.000
	NOV	0.0	6.339	4.311	7.682	139.304	109.707	0.000	0.000
	DEC	0.0	4.025	17.428	7.327	138.699	88.776	0.000	0.000
	ANNUAL	1231.4	486.243	145.973	59.173			264.897	0.000

YEAR	MONTH	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV LOSS	END OF MONTH W.L.	END OF MONTH STORAGE	SPILLAGE	SHORTAGE	(6/8)
		mm	MCM	MCM	MCM	m	MCM	MCM	MCM	
1980	JAN	0.0	2.546	17.532	5.778	137.992	67.886	0.000	0.000	
	FEB	5.6	1.819	19.080	4.214	137.065	46.319	0.000	0.000	
	MAR	0.0	1.537	18.000	3.448	135.675	26.331	0.000	0.000	
	APR	82.1	1.161	3.392	2.168	135.249	21.874	0.000	0.000	
	MAY	182.0	5.963	2.628	1.205	135.425	23.707	0.000	0.000	
	JUN	176.0	14.221	7.905	1.034	135.862	28.277	0.000	0.000	
	JUL	159.1	26.977	0.884	1.780	137.304	51.240	0.000	0.000	
	AUG	104.6	11.469	13.375	2.649	137.054	46.112	0.000	0.000	
	SEP	320.7	219.060	0.259	3.695	139.500	117.107	128.991	0.000	
	OCT	210.3	135.205	1.453	5.788	139.500	117.107	125.018	0.000	
	NOV	46.2	14.896	2.581	7.067	139.447	115.076	6.891	0.000	
	DEC	0.0	5.603	17.420	7.739	138.895	95.240	0.000	0.000	
	ANNUAL	1286.6	440.458	104.510	46.567			260.900	0.000	
1981	JAN	0.0	3.159	17.532	6.227	138.230	74.495	0.000	0.000	
	FEB	4.3	1.684	19.072	4.403	137.367	52.620	0.000	0.000	
	MAR	0.1	1.294	17.543	3.835	136.223	32.472	0.000	0.000	
	APR	94.5	0.881	3.072	2.113	135.338	22.797	0.000	0.000	
	MAY	153.7	3.222	2.598	1.122	134.788	17.048	0.000	0.000	
	JUN	226.1	46.123	4.260	1.367	137.387	53.069	0.000	0.000	
	JUL	180.7	54.857	1.415	3.358	139.045	100.410	0.000	0.000	
	AUG	175.9	69.465	0.268	4.295	139.500	117.107	44.733	0.000	
	SEP	159.7	70.841	0.873	5.081	139.500	117.107	61.347	0.000	
	OCT	130.9	51.443	2.482	6.356	139.500	117.107	40.036	0.000	
	NOV	44.2	15.978	2.554	6.607	139.446	115.044	8.082	0.000	
	DEC	0.0	4.910	18.067	7.689	138.856	93.953	0.000	0.000	
	ANNUAL	1170.1	323.858	89.734	52.453			154.198	0.000	
1982	JAN	0.0	2.679	17.532	6.124	138.172	72.830	0.000	0.000	
	FEB	6.5	1.448	19.072	4.297	137.285	50.837	0.000	0.000	
	MAR	19.2	1.158	15.352	3.561	136.264	33.024	0.000	0.000	
	APR	122.2	0.934	3.449	2.441	135.837	28.020	0.000	0.000	
	MAY	174.2	4.151	3.161	1.893	135.731	26.909	0.000	0.000	
	JUN	199.1	21.101	2.048	1.794	136.897	43.113	0.000	0.000	
	JUL	114.5	16.135	0.841	2.310	137.486	55.289	0.000	0.000	
	AUG	174.6	50.096	0.268	2.999	139.022	99.614	0.000	0.000	
	SEP	483.8	331.229	0.259	3.830	139.500	117.107	293.088	0.000	
	OCT	110.5	98.026	1.936	5.782	139.500	117.107	85.409	0.000	
	NOV	82.4	29.501	2.546	6.190	139.480	116.357	20.042	0.000	
	DEC	2.5	6.717	17.420	7.570	138.968	97.747	0.000	0.000	
	ANNUAL	1489.5	563.173	83.885	48.791			398.539	0.000	
1983	JAN	0.0	4.286	17.532	6.426	138.346	77.854	0.000	0.000	
	FEB	6.5	2.022	19.072	4.695	137.517	56.008	0.000	0.000	
	MAR	0.1	1.440	17.543	4.063	136.457	35.770	0.000	0.000	
	APR	12.4	0.950	4.016	2.769	136.014	29.888	0.000	0.000	
	MAY	202.5	2.989	2.613	1.703	135.874	28.412	0.000	0.000	
	JUN	241.8	31.970	1.897	1.613	137.485	55.273	0.000	0.000	
	JUL	151.0	42.354	1.961	3.707	138.732	89.841	0.000	0.000	
	AUG	203.8	104.871	0.841	4.461	139.500	117.107	67.061	0.000	
	SEP	345.9	149.988	67.812	4.152	139.500	117.107	70.525	0.000	
	OCT	182.4	204.878	0.867	5.065	139.500	117.107	188.705	0.000	
	NOV	0.0	13.217	3.122	7.915	139.422	114.128	4.499	0.000	
	DEC	0.0	5.748	17.420	7.683	138.872	94.486	0.000	0.000	
	ANNUAL	1346.4	564.713	154.696	54.251			330.790	0.000	

YEAR	MONTH	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV LOSS	END OF MONTH W.L.	END OF MONTH STORAGE	SPILLAGE	SHORTAGE
		mm	MCM	MCM	MCM	m	MCM	MCM	MCM
1984	JAN	0.0	2.970	17.532	6.170	138.199	73.597	0.000	0.000
	FEB	0.0	1.585	19.080	4.664	137.309	51.359	0.000	0.000
	MAR	25.3	1.121	14.952	3.438	136.337	34.034	0.000	0.000
	APR	138.3	1.470	5.271	2.195	135.832	27.964	0.000	0.000
	MAY	192.2	9.137	1.496	1.512	136.309	33.636	0.000	0.000
	JUN	196.7	42.552	50.702	1.589	135.239	21.770	0.000	0.000
	JUL	69.0	36.288	25.450	1.888	135.922	28.906	0.000	0.000
	AUG	424.1	229.652	21.389	2.082	139.500	117.107	91.034	-0.512
	SEP	429.2	402.607	0.259	4.018	139.500	117.107	387.999	0.000
	OCT	382.9	344.820	1.385	5.214	139.500	117.107	325.768	0.000
	NOV	21.5	19.717	2.589	6.639	139.481	116.371	11.634	0.000
	DEC	0.0	8.932	17.420	7.936	139.019	99.501	0.000	0.000
	ANNUAL	1879.2	1100.850	177.525	47.344			816.434	-0.512
1985	JAN	0.0	7.391	17.532	6.639	138.495	82.353	0.000	0.000
	FEB	6.1	4.324	19.072	4.923	137.784	62.465	0.000	0.000
	MAR	7.8	3.798	15.352	4.294	137.070	46.427	0.000	0.000
	APR	171.7	5.930	4.723	2.657	136.980	44.680	0.000	0.000
	MAY	217.2	43.718	1.440	2.352	138.497	82.420	0.000	0.000
	JUN	130.0	42.915	8.866	3.919	139.323	110.404	0.000	0.000
	JUL	166.2	55.999	18.330	4.819	139.305	109.738	30.717	0.000
	AUG	125.9	75.613	0.268	4.399	139.500	117.107	59.799	0.000
	SEP	279.6	164.975	0.830	4.237	139.500	117.107	151.662	0.000
	OCT	105.1	57.976	27.793	6.056	139.454	115.361	22.976	0.000
	NOV	11.3	9.473	2.715	6.679	139.444	114.966	0.000	0.000
	DEC	0.0	7.406	18.054	7.772	138.922	96.176	0.000	0.000
	ANNUAL	1220.9	479.518	134.975	58.746			265.154	0.000
1986	JAN	0.0	5.043	17.532	6.339	138.320	77.088	0.000	0.000
	FEB	0.0	3.677	19.072	4.790	137.548	56.720	0.000	0.000
	MAR	35.1	3.576	15.352	4.102	136.759	40.663	0.000	0.000
	APR	38.2	3.235	5.901	2.789	136.408	35.046	0.000	0.000
	MAY	246.3	25.153	1.999	1.827	137.478	55.116	0.000	0.000
	JUN	180.4	30.348	3.910	2.260	138.343	77.777	0.000	0.000
	JUL	290.5	143.714	0.841	4.266	139.500	117.107	92.092	0.000
	AUG	269.6	170.789	0.831	4.287	139.500	117.107	157.134	0.000
	SEP	269.0	179.287	0.858	5.081	139.500	117.107	164.387	0.000
	OCT	115.4	85.484	1.423	6.213	139.500	117.107	73.577	0.000
	NOV	53.3	15.409	2.644	7.075	139.489	116.665	5.362	0.000
	DEC	11.7	8.895	18.059	7.642	139.016	99.415	0.000	0.000
	ANNUAL	1509.5	674.611	88.423	56.668			492.553	0.000
1987	JAN	0.0	6.513	17.532	6.602	138.466	81.451	0.000	0.000
	FEB	0.0	4.177	19.072	5.072	137.736	61.275	0.000	0.000
	MAR	11.0	3.805	15.392	4.351	137.005	45.148	0.000	0.000
	APR	19.9	3.319	6.556	3.031	136.644	38.714	0.000	0.000
	MAY	143.0	4.087	2.598	2.250	136.584	37.749	0.000	0.000
	JUN	310.3	65.983	7.443	2.325	138.757	90.665	0.000	0.000
	JUL	173.4	83.807	0.884	4.324	139.500	117.107	47.968	0.000
	AUG	197.0	74.314	0.826	5.202	139.500	117.107	64.572	0.000
	SEP	360.7	289.043	0.259	4.116	139.500	117.107	270.218	0.000
	OCT	106.4	73.743	1.943	5.782	139.500	117.107	62.333	0.000
	NOV	183.2	92.832	1.406	5.001	139.500	117.107	81.785	0.000
	DEC	0.0	11.128	17.428	8.066	139.096	102.185	0.000	0.000
	ANNUAL	1504.9	712.752	91.339	56.123			526.876	0.000

YEAR	MONTH	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV LOSS	END OF MONTH W.L.	END OF MONTH STORAGE	SPILLAGE	SHORTAGE
		mm	MCM	MCM	MCM	m	MCM	MCM	MCM
1988	JAN	0.0	7.926	17.532	6.829	138.592	85.369	0.000	0.000
	FEB	0.0	4.884	19.080	5.512	137.899	65.416	0.000	0.000
	MAR	7.4	4.067	18.000	4.738	137.076	46.542	0.000	0.000
	APR	133.2	3.646	2.345	2.850	136.987	44.811	0.000	0.000
	MAY	413.1	85.933	1.425	2.617	139.500	117.107	0.000	0.000
	JUN	232.4	221.334	1.006	4.534	139.500	117.107	208.886	0.000
	JUL	82.9	21.310	28.718	5.161	138.825	92.922	11.694	0.000
	AUG	183.6	78.051	13.657	4.254	139.271	108.521	40.640	0.000
	SEP	332.3	163.560	43.919	4.630	139.500	117.107	93.714	0.000
	OCT	197.9	175.028	14.839	5.644	139.500	117.107	149.503	0.000
	NOV	0.0	15.250	3.125	7.968	139.474	116.100	5.229	0.000
	DEC	0.0	9.058	17.500	7.926	139.013	99.278	0.000	0.000
	ANNUAL	1582.8	790.047	181.148	62.663			509.666	0.000
1989	JAN	0.0	6.210	17.532	6.583	138.453	81.078	0.000	0.000
	FEB	0.0	4.427	19.072	5.057	137.732	61.155	0.000	0.000
	MAR	69.5	4.326	13.079	4.203	137.148	47.983	0.000	0.000
	APR	86.9	4.072	2.964	2.922	137.047	45.965	0.000	0.000
	MAY	166.1	10.690	2.507	2.034	137.320	51.580	0.000	0.000
	JUN	63.8	4.932	9.929	2.080	136.958	44.257	0.000	0.000
	JUL	213.0	37.655	1.989	2.414	138.270	75.626	0.000	0.000
	AUG	236.9	155.230	1.943	4.104	139.500	117.107	99.942	0.000
	SEP	335.7	210.774	7.831	3.754	139.500	117.107	188.652	0.000
	OCT	79.5	84.284	17.502	5.780	139.500	117.107	56.790	0.000
	NOV	9.4	10.092	3.115	7.205	139.473	116.067	0.308	0.000
	DEC	0.0	8.113	18.059	7.869	138.971	97.846	0.000	0.000
	ANNUAL	1260.8	540.806	115.523	54.005			345.692	0.000
1990	JAN	0.0	5.700	17.532	6.468	138.393	79.258	0.000	0.000
	FEB	5.8	4.298	19.072	4.836	137.661	59.433	0.000	0.000
	MAR	152.0	10.230	9.665	3.854	137.501	55.633	0.000	0.000
	APR	13.1	4.184	3.527	3.962	137.344	52.119	0.000	0.000
	MAY	371.6	72.097	1.450	2.739	139.482	116.422	0.000	0.000
	JUN	215.3	123.669	6.869	4.095	139.500	117.107	105.839	0.000
	JUL	272.4	123.007	0.268	4.778	139.500	117.107	111.813	0.000
	AUG	234.7	174.037	1.385	4.943	139.500	117.107	159.010	0.000
	SEP	304.7	199.669	0.259	4.719	139.500	117.107	184.710	0.000
	OCT	253.7	239.191	1.984	5.208	139.500	117.107	220.042	0.000
	NOV	66.6	39.676	2.594	6.783	139.496	116.936	28.487	0.000
	DEC	0.0	11.867	17.428	8.058	139.111	102.724	0.000	0.000
	ANNUAL	1889.9	1007.625	82.033	60.443			809.901	0.000

(8/8)

FIGURE B-4 WATER BALANCE STUDY (1/3)

Cropping Pattern Type-1

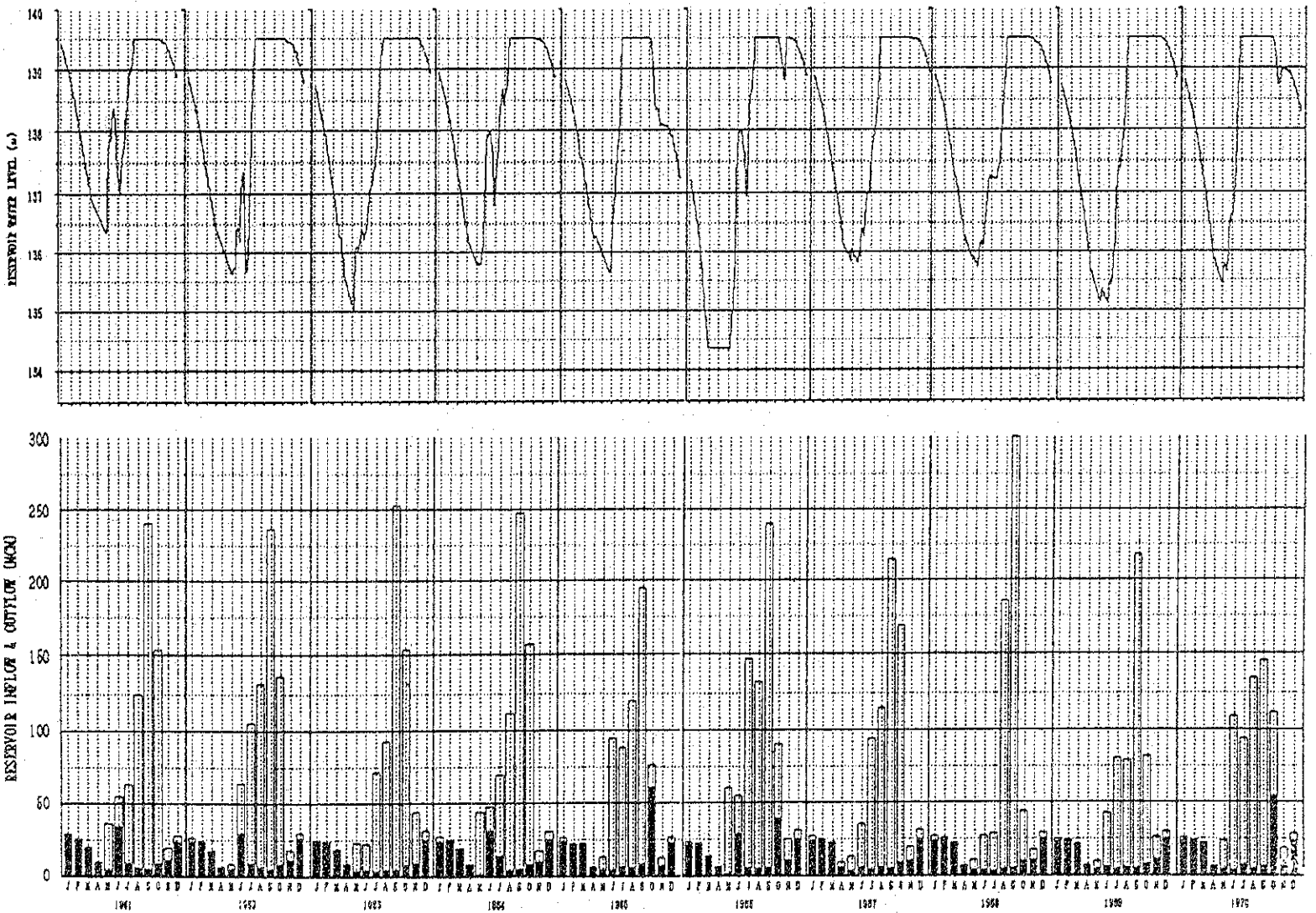


FIGURE B-4 WATER BALANCE STUDY (2/3)

Cropping Pattern Type-1

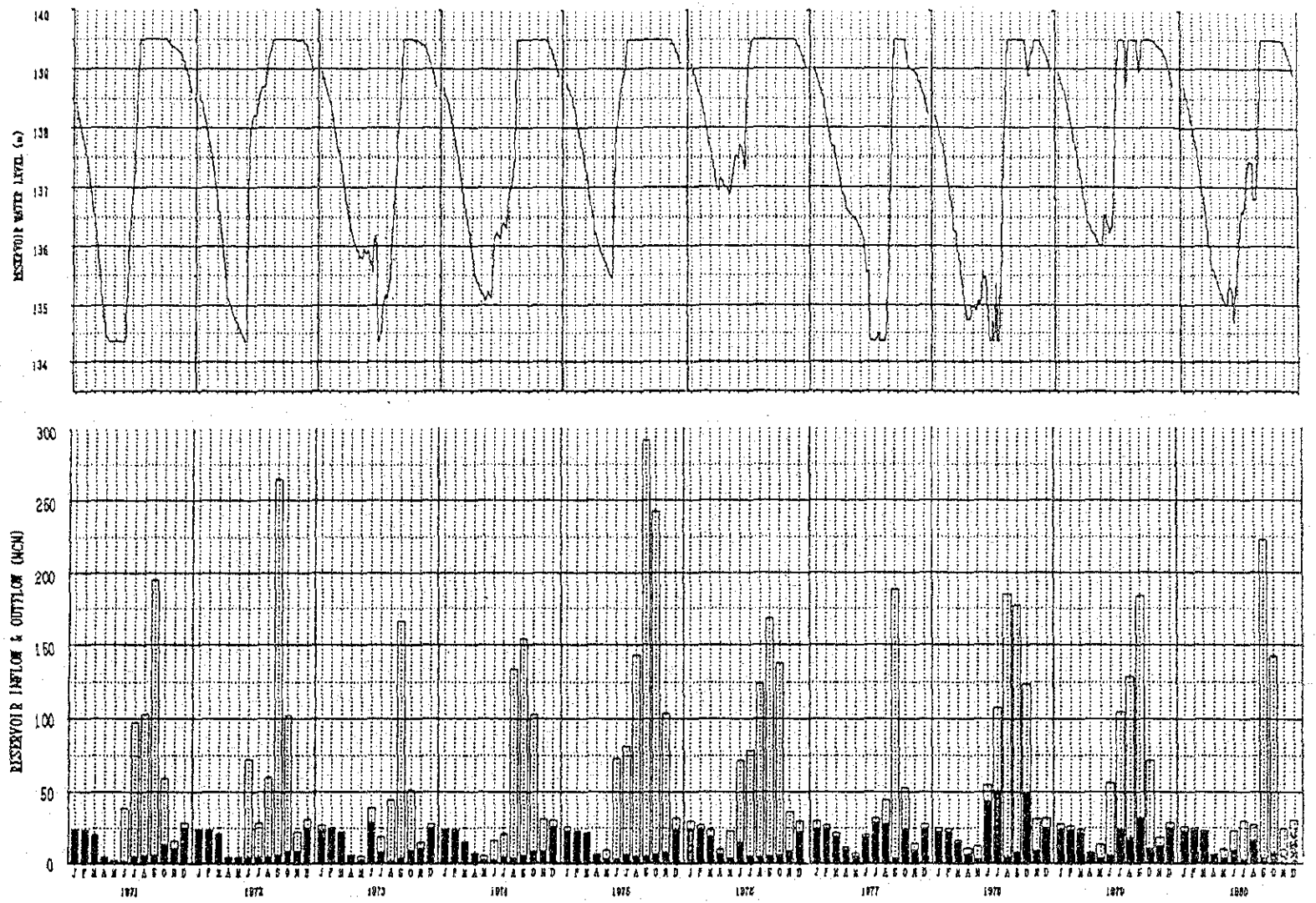


FIGURE B-4 WATER BALANCE STUDY (3/3)

Cropping Pattern Type-1

TABLE B-6 RESULTS OF WATER BALANCE STUDY (CROPPING PATTERN TYPE-2) (1/8)

PROJECT SITE : : D-28
DRAINAGE AREA : : 1246.8sq.km

IRRIGATION AREA
CROPPING PATTERN TYPE-II
PADDY : 31700 ha
UPLAND CROP (WET): 1050 ha
UPLAND CROP (DRY): 5440 ha
PERENNIAL CROP : 1250 ha

RESERVOIR CAPACITY
TOTAL : 117.107 MCM
EFFEC. : 104.639 MCM
DEAD : 12.468 MCM
RESERVOIR WATER LEVEL
N.W.L. : 139.500 m
DEAD : 134.350 m

YEAR	MONTH	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV. LOSS	END OF MONTH W.L.	END OF MONTH STORAGE	SPILLAGE	SHORTAGE
		mm	MCM	MCM	MCM	m	MCM	MCM	MCM
1961	JAN	0.0	1.717	21.058	7.452	138.744	90.228	0.000	0.000
	FEB	0.0	0.713	20.261	5.515	137.888	65.130	0.000	0.000
	MAR	3.4	0.338	15.887	4.471	137.002	45.093	0.000	0.000
	APR	91.0	0.019	6.699	2.994	136.433	35.418	0.000	0.000
	MAY	248.9	31.882	2.004	2.320	137.741	61.382	0.000	0.000
	JUN	148.4	20.947	31.528	3.364	137.069	46.391	0.000	0.000
	JUL	211.1	53.863	7.140	2.835	138.662	87.586	0.000	0.000
	AUG	224.0	118.774	1.804	4.626	139.500	117.107	76.885	0.000
	SEP	366.0	235.463	0.740	4.357	139.500	117.107	218.595	0.000
	OCT	155.2	145.166	1.943	6.786	139.500	117.107	129.181	0.000
	NOV	0.0	8.416	3.112	7.877	139.406	113.509	0.604	0.000
	DEC	7.5	4.901	16.260	7.440	138.872	94.465	0.000	0.000
	ANNUAL	1455.5	622.199	128.435	60.038			425.265	0.000
1962	JAN	0.0	2.298	18.445	6.123	138.146	72.092	0.000	0.000
	FEB	21.7	0.913	20.131	4.300	137.175	48.528	0.000	0.000
	MAR	29.6	0.529	13.573	3.642	136.172	31.816	0.000	0.000
	APR	94.4	0.263	3.399	2.412	135.668	26.255	0.000	0.000
	MAY	211.8	4.020	2.638	1.606	135.628	25.829	0.000	0.000
	JUN	146.1	34.856	28.046	2.068	135.914	28.828	0.000	0.000
	JUL	248.1	96.634	6.768	2.101	139.359	111.761	0.000	0.000
	AUG	216.3	125.958	1.183	5.592	139.500	117.107	107.541	0.000
	SEP	402.1	230.785	0.259	4.840	139.500	117.107	214.150	0.000
	OCT	102.6	127.982	1.943	6.498	139.497	117.009	113.241	0.000
	NOV	0.0	6.872	3.115	7.831	139.381	112.591	0.000	0.000
	DEC	0.0	4.396	19.043	7.491	138.744	90.233	0.000	0.000
	ANNUAL	1472.7	635.505	118.543	54.506			434.932	0.000
1963	JAN	0.0	1.889	18.445	5.830	137.987	67.758	0.000	0.000
	FEB	0.0	0.843	20.131	4.115	136.961	44.312	0.000	0.000
	MAR	55.7	0.478	15.953	3.123	135.614	25.689	0.000	0.000
	APR	1.8	0.180	6.554	2.000	134.812	17.305	0.000	0.000
	MAY	261.8	19.234	2.049	1.642	136.178	31.886	0.000	0.000
	JUN	188.9	17.956	3.174	1.912	136.937	43.859	0.000	0.000
	JUL	194.1	67.919	1.162	3.130	139.149	104.091	0.000	0.000
	AUG	195.8	87.514	0.786	3.967	139.500	117.107	65.372	0.000
	SEP	347.1	248.082	0.259	3.996	139.500	117.107	231.426	0.000
	OCT	163.0	145.479	1.943	6.069	139.500	117.107	130.195	0.000
	NOV	87.9	34.490	1.980	7.072	139.462	115.637	25.186	0.000
	DEC	0.0	6.314	18.404	7.771	138.901	95.461	0.000	0.000
	ANNUAL	1496.1	630.378	90.842	50.625			452.178	0.000

YEAR	MONTH	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV. LOSS	END OF MONTH W.L.	END OF MONTH STORAGE	SPILLAGE	SHORTAGE
		mm	MCM	MCM	MCM	m	MCM	MCM	MCM
1964	JAN	0.0	3.580	18.445	6.230	138.219	74.181	0.000	0.000
	FEB	0.0	1.418	20.140	4.664	137.280	50.725	0.000	0.000
	MAR	16.3	0.682	15.900	3.558	136.180	31.914	0.000	0.000
	APR	57.7	0.415	5.646	2.127	135.504	24.535	0.000	0.000
	MAY	308.7	41.727	0.268	1.384	137.786	62.523	0.000	0.000
	JUN	144.5	15.535	29.346	2.744	137.007	45.192	0.000	0.000
	JUL	156.4	55.100	11.524	3.900	138.487	82.113	0.000	0.000
	AUG	212.1	107.258	0.698	4.055	139.500	117.107	58.083	0.000
	SEP	345.6	241.652	1.378	4.478	139.500	117.107	221.133	0.000
	OCT	170.7	148.898	1.943	6.360	139.485	116.531	140.379	0.000
	NOV	34.8	7.701	2.554	7.317	139.418	113.977	0.000	0.000
	DEC	0.0	5.538	18.404	7.636	138.834	93.198	0.000	0.000
	ANNUAL	1446.8	629.504	126.246	54.452			419.595	0.000
1965	JAN	0.4	2.802	18.445	5.943	138.124	71.479	0.000	0.000
	FEB	52.5	1.375	17.417	4.123	137.304	51.246	0.000	0.000
	MAR	2.5	1.039	18.300	3.619	136.050	30.313	0.000	0.000
	APR	157.7	1.339	2.858	2.324	135.682	26.403	0.000	0.000
	MAY	182.8	9.078	2.610	1.574	136.094	30.844	0.000	0.000
	JUN	280.2	90.236	2.601	2.010	139.364	111.957	0.000	0.000
	JUL	169.9	81.904	3.198	5.052	139.500	117.107	64.410	0.000
	AUG	156.4	114.359	2.203	4.680	139.500	117.107	101.761	0.000
	SEP	280.8	186.435	4.225	4.478	139.491	116.768	168.752	0.000
	OCT	33.5	15.402	53.509	5.513	138.156	72.377	0.000	0.000
	NOV	5.8	5.680	2.564	4.837	138.084	70.373	0.000	0.000
	DEC	15.4	3.694	19.043	4.587	137.258	50.252	0.000	0.000
	ANNUAL	1337.9	513.342	146.973	48.740			334.923	0.000
1966	JAN	0.0	2.036	18.445	3.308	136.061	30.444	0.000	0.000
	FEB	0.0	1.156	20.131	1.764	134.352	12.493	0.000	-2.846
	MAR	60.1	0.899	13.000	0.690	134.350	12.468	0.000	-12.812
	APR	98.7	0.746	5.584	0.528	134.350	12.468	0.000	-5.403
	MAY	352.3	59.081	0.268	1.254	137.962	67.088	0.000	-0.015
	JUN	176.6	26.109	26.756	3.090	137.767	62.045	0.000	0.000
	JUL	226.5	141.479	1.763	4.486	139.500	117.107	73.096	0.000
	AUG	185.6	127.691	0.770	4.549	139.500	117.107	115.990	0.000
	SEP	335.8	233.431	1.342	5.201	139.500	117.107	215.219	0.000
	OCT	158.1	51.069	32.123	6.174	139.500	117.107	10.219	0.000
	NOV	3.3	14.298	3.115	7.765	139.430	114.421	5.390	0.000
	DEC	9.5	5.855	19.043	7.110	138.853	93.830	0.000	0.000
	ANNUAL	1606.5	663.850	142.339	45.920			419.913	-21.076
1967	JAN	0.0	3.345	18.445	6.115	138.159	72.458	0.000	0.000
	FEB	0.0	1.767	20.131	4.426	137.226	49.579	0.000	0.000
	MAR	0.0	1.275	18.449	3.680	135.898	28.662	0.000	0.000
	APR	177.5	3.552	3.492	2.053	135.691	26.491	0.000	0.000
	MAY	176.8	9.200	2.006	1.660	136.152	31.565	0.000	0.000
	JUN	203.7	30.121	4.783	1.986	137.403	53.412	0.000	0.000
	JUL	222.1	89.101	1.768	3.238	139.500	117.107	15.945	0.000
	AUG	213.8	109.357	1.263	5.074	139.500	117.107	97.554	0.000
	SEP	303.3	209.481	0.259	5.081	139.500	117.107	193.670	0.000
	OCT	181.2	160.146	1.928	7.073	139.500	117.107	143.140	0.000
	NOV	56.9	8.871	3.110	7.479	139.443	114.939	0.006	0.000
	DEC	0.0	6.402	18.484	7.732	138.882	94.805	0.000	0.000
	ANNUAL	1535.3	632.620	94.120	55.598			450.315	0.000

YEAR	MONTH	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV. LOSS	END OF MONTH W.L.	END OF MONTH STORAGE	SPILLAGE	SHORTAGE	(3/8)
		mm	MCM	MCM	MCM	m	MCM	MCM	MCM	
1968	JAN	0.0	3.699	18.445	6.190	138.202	73.693	0.000	0.000	
	FEB	0.0	2.029	20.140	4.651	137.285	50.829	0.000	0.000	
	MAR	9.6	1.496	18.086	3.702	136.063	30.463	0.000	0.000	
	APR	61.2	1.029	3.500	2.381	135.602	25.559	0.000	0.000	
	MAY	172.8	6.638	1.916	1.756	135.854	28.193	0.000	0.000	
	JUN	184.1	23.310	2.896	2.017	137.019	45.424	0.000	0.000	
	JUL	157.3	25.508	1.162	2.328	137.928	66.168	0.000	0.000	
	AUG	288.5	180.924	0.708	4.306	139.500	117.107	114.440	0.000	
	SEP	429.5	314.444	0.259	4.862	139.500	117.107	291.187	0.000	
	OCT	44.0	34.184	2.585	7.214	139.468	115.866	27.820	0.000	
	NOV	0.0	6.719	3.125	7.786	139.348	111.337	0.000	0.000	
	DEC	0.0	4.173	18.484	7.424	138.718	89.393	0.000	0.000	
	ANNUAL	1347.0	604.153	91.306	54.619			433.447	0.000	
1969	JAN	2.5	2.223	18.445	5.562	137.978	67.497	0.000	0.000	
	FEB	0.0	1.324	20.131	4.112	136.971	44.512	0.000	0.000	
	MAR	4.6	1.046	18.449	3.123	135.446	23.933	0.000	0.000	
	APR	53.9	0.585	4.016	2.021	134.922	18.452	0.000	0.000	
	MAY	228.3	5.998	2.527	1.296	135.101	20.327	0.000	0.000	
	JUN	201.5	36.951	4.373	1.587	137.220	49.471	0.000	0.000	
	JUL	203.0	75.798	2.769	2.849	139.467	115.861	0.000	0.000	
	AUG	121.3	73.177	2.127	5.073	139.500	117.107	61.075	0.000	
	SEP	362.6	213.195	0.259	4.840	139.500	117.107	197.439	0.000	
	OCT	150.9	74.057	1.418	6.069	139.500	117.107	62.870	0.000	
	NOV	0.0	15.807	3.095	7.906	139.410	113.683	7.441	0.000	
	DEC	0.0	5.113	18.404	7.602	138.814	92.534	0.000	0.000	
	ANNUAL	1328.6	505.276	96.012	52.040			328.825	0.000	
1970	JAN	0.0	2.497	18.445	6.002	138.087	70.467	0.000	0.000	
	FEB	0.0	1.203	20.131	4.289	137.109	47.189	0.000	0.000	
	MAR	0.0	0.763	18.449	3.504	135.640	25.961	0.000	0.000	
	APR	102.9	0.424	3.530	1.927	135.157	20.907	0.000	0.000	
	MAY	236.6	19.072	2.535	1.652	136.394	34.839	0.000	0.000	
	JUN	282.2	105.520	0.663	2.756	139.500	117.107	14.558	0.000	
	JUL	173.4	86.981	2.151	6.068	139.500	117.107	74.414	0.000	
	AUG	256.7	129.363	0.689	4.812	139.500	117.107	117.396	0.000	
	SEP	267.4	138.967	1.378	5.322	139.500	117.107	125.321	0.000	
	OCT	73.8	57.130	47.012	5.960	138.977	98.065	20.344	0.000	
	NOV	0.0	9.009	3.120	6.765	138.939	96.740	0.000	0.000	
	DEC	8.6	4.828	18.411	6.219	138.306	76.696	0.000	0.000	
	ANNUAL	1401.6	555.757	136.514	55.274			352.034	0.000	
1971	JAN	0.0	2.153	18.445	4.966	137.487	55.321	0.000	0.000	
	FEB	0.0	0.926	20.131	3.384	136.239	32.685	0.000	0.000	
	MAR	1.8	0.484	18.449	2.341	134.350	12.468	0.000	-0.113	
	APR	95.9	0.130	3.492	0.000	134.350	12.468	0.000	-3.369	
	MAY	164.8	0.797	1.425	0.219	134.350	12.468	0.000	-0.888	
	JUN	239.4	37.211	0.864	0.902	137.073	46.468	0.000	-0.416	
	JUL	191.0	92.345	2.164	4.061	139.500	117.107	10.865	0.000	
	AUG	220.7	97.263	1.273	4.549	139.500	117.107	86.580	0.000	
	SEP	282.3	189.487	0.858	4.598	139.500	117.107	174.559	0.000	
	OCT	46.5	45.618	5.884	7.155	139.390	112.926	34.480	0.000	
	NOV	0.0	5.559	3.115	7.532	139.245	107.560	0.000	0.000	
	DEC	0.0	3.312	19.043	7.119	138.566	84.544	0.000	0.000	
	ANNUAL	1242.4	475.285	95.145	46.827			306.484	-4.786	

YEAR	MONTH	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV. LOSS	END OF MONTH W.L.	END OF MONTH STORAGE	SPILLAGE	SHORTAGE
		mm	MCM	MCM	MCM	m	MCM	MCM	MCM
1972	JAN	0.0	1.360	18.445	5.443	137.764	61.957	0.000	0.000
	FEB	6.0	0.593	20.140	3.721	136.641	38.660	0.000	0.000
	MAR	1.0	0.242	18.896	2.756	134.806	17.238	0.000	0.000
	APR	69.8	0.000	3.047	1.221	134.398	12.970	0.000	0.000
	MAY	92.5	0.000	3.134	0.174	134.350	12.468	0.000	-2.797
	JUN	284.7	68.598	2.667	2.614	138.188	73.302	0.000	-0.956
	JUL	202.0	24.232	2.652	3.334	138.747	90.336	0.000	0.000
	AUG	139.8	55.227	1.746	3.645	139.500	117.107	17.527	0.000
	SEP	371.4	258.419	1.353	4.960	139.500	117.107	237.841	0.000
	OCT	161.5	93.567	1.385	6.935	139.500	117.107	84.102	0.000
	NOV	84.7	13.846	2.592	5.891	139.500	117.107	5.065	0.000
	DEC	0.0	5.881	18.411	7.852	138.930	96.430	0.200	0.000
	ANNUAL	1413.4	521.965	94.468	48.546			344.735	-3.753
1973	JAN	1.0	3.571	18.445	6.179	138.255	75.208	0.000	0.000
	FEB	0.0	1.350	20.131	4.581	137.329	51.779	0.000	0.000
	MAR	1.1	0.618	18.449	3.729	136.040	30.188	0.000	0.000
	APR	60.1	0.266	3.427	2.184	135.532	24.829	0.000	0.000
	MAY	186.2	3.174	0.789	1.289	135.622	25.767	0.000	0.000
	JUN	125.6	10.348	28.609	1.137	134.350	12.468	0.000	-6.616
	JUL	152.7	11.006	7.808	0.741	135.110	20.419	0.000	-6.045
	AUG	177.7	43.118	0.698	1.305	137.659	59.378	0.000	0.000
	SEP	256.9	162.692	0.259	3.266	139.500	117.107	93.304	0.000
	OCT	69.2	41.895	2.552	6.921	139.497	117.005	30.431	0.000
	NOV	7.2	4.631	3.165	7.198	139.340	111.041	0.000	0.000
	DEC	0.2	2.851	19.035	7.206	138.660	87.508	0.000	0.000
	ANNUAL	1037.9	285.521	123.367	45.737			123.735	-12.661
1974	JAN	3.7	1.138	18.445	5.531	137.869	64.630	0.000	0.000
	FEB	0.0	0.471	20.131	3.917	136.780	41.029	0.000	0.000
	MAR	52.8	0.180	13.185	2.793	135.570	25.223	0.000	0.000
	APR	73.1	0.019	5.544	1.433	134.904	18.264	0.000	0.000
	MAY	209.4	2.794	1.425	1.022	134.924	18.471	0.000	0.000
	JUN	152.9	13.761	2.713	1.193	135.800	27.638	0.000	0.000
	JUL	132.4	16.975	4.271	1.763	136.583	37.730	0.000	0.000
	AUG	254.9	130.031	1.128	3.111	139.500	117.107	39.914	0.000
	SEP	252.9	148.425	1.417	4.478	139.500	117.107	135.112	0.000
	OCT	128.2	93.732	2.009	6.499	139.482	116.406	81.241	0.000
	NOV	91.6	22.947	1.960	6.606	139.446	115.056	14.585	0.000
	DEC	3.8	4.854	19.043	7.390	138.835	93.234	0.000	0.000
	ANNUAL	1355.7	435.328	91.270	45.736			270.852	0.000
1975	JAN	11.9	2.748	17.976	5.779	138.146	72.095	0.000	0.000
	FEB	43.6	1.155	18.246	4.209	137.280	50.737	0.000	0.000
	MAR	35.5	0.716	18.297	3.429	135.997	29.691	0.000	0.000
	APR	38.7	0.320	3.935	2.201	135.439	23.860	0.000	0.000
	MAY	215.4	5.885	1.986	1.070	135.682	26.394	0.000	0.000
	JUN	210.7	69.827	0.864	2.081	138.730	89.785	0.000	0.000
	JUL	160.5	74.403	4.684	4.476	139.494	116.858	34.451	0.000
	AUG	295.7	138.356	1.686	4.024	139.500	117.107	125.481	0.000
	SEP	335.1	286.420	0.808	4.237	139.500	117.107	267.057	0.000
	OCT	280.8	235.830	1.433	5.208	139.500	117.107	217.400	0.000
	NOV	165.4	95.118	1.973	6.042	139.500	117.107	82.350	0.000
	DEC	15.4	8.544	16.586	7.648	139.062	100.990	0.000	0.000
	ANNUAL	1808.7	919.322	88.474	50.403			726.739	0.000

YEAR	MONTH	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV. LOSS	END OF MONTH W.L.	END OF MONTH STORAGE	SPILLAGE	SHORTAGE
		mm	MCM	MCM	MCM	m	MCM	MCM	MCM
1976	JAN	0.0	5.839	18.538	6.594	138.464	81.418	0.000	0.000
	FEB	0.4	2.613	20.496	4.994	137.619	58.411	0.000	0.000
	MAR	145.9	4.871	15.731	3.637	136.927	43.671	0.000	0.000
	APR	39.2	3.223	3.467	2.965	136.738	40.301	0.000	0.000
	MAY	248.6	19.163	1.425	2.205	137.468	54.875	0.000	0.000
	JUN	177.4	57.000	13.487	2.138	138.840	93.400	0.000	0.000
	JUL	155.8	73.392	2.595	4.163	139.500	117.107	35.517	0.000
	AUG	178.3	119.200	1.122	4.276	139.500	117.107	109.781	0.000
	SEP	313.6	163.305	0.259	4.598	139.500	117.107	142.764	0.000
	OCT	149.7	131.994	1.405	4.635	139.500	117.107	126.262	0.000
	NOV	30.4	27.160	2.561	6.188	139.472	116.027	20.556	0.000
	DEC	21.5	7.167	15.614	7.693	139.020	99.528	0.000	0.000
	ANNUAL	1460.8	614.927	96.701	54.085			434.880	0.000
1977	JAN	0.0	5.597	18.445	6.556	138.413	79.853	0.000	0.000
	FEB	0.0	3.159	20.131	4.915	137.594	57.808	0.000	0.000
	MAR	43.4	2.767	15.296	4.268	136.771	40.872	0.000	0.000
	APR	48.7	2.245	6.182	2.950	136.326	33.873	0.000	0.000
	MAY	110.5	2.186	2.633	2.455	136.096	30.861	0.000	0.000
	JUN	127.7	2.058	17.554	1.525	134.471	13.738	0.000	0.000
	JUL	131.2	3.237	28.940	0.494	134.350	12.468	0.000	-25.089
	AUG	166.0	16.323	27.952	0.482	135.597	25.509	0.000	-25.968
	SEP	302.2	184.569	0.259	3.345	139.500	117.107	80.140	0.000
	OCT	31.2	28.127	17.536	6.424	139.046	100.440	19.429	0.000
	NOV	6.0	4.971	2.976	6.366	138.912	95.821	0.000	0.000
	DEC	1.2	3.305	19.043	6.216	138.203	73.702	0.000	0.000
	ANNUAL	968.1	258.544	176.947	45.996			99.569	-51.058
1978	JAN	0.0	2.439	18.445	4.778	137.376	52.808	0.000	0.000
	FEB	0.0	1.840	20.131	3.262	136.120	31.164	0.000	0.000
	MAR	64.7	1.794	12.597	2.000	134.905	18.270	0.000	0.000
	APR	149.3	4.426	5.093	1.242	134.701	16.141	0.000	0.000
	MAY	180.5	9.209	1.425	1.045	135.301	22.419	0.000	0.000
	JUN	142.0	11.443	42.399	0.755	134.576	14.836	0.000	-24.700
	JUL	175.4	57.019	50.209	0.599	136.486	36.217	0.000	-18.022
	AUG	247.8	180.279	1.748	3.727	139.500	117.107	84.902	0.000
	SEP	295.6	169.148	3.342	4.357	139.500	117.107	152.995	0.000
	OCT	88.4	75.095	41.087	6.188	139.295	109.395	31.779	0.000
	NOV	60.7	22.533	1.998	7.149	139.460	115.582	6.073	0.000
	DEC	0.0	6.891	18.411	7.779	138.915	95.938	0.000	0.000
	ANNUAL	1404.4	542.116	216.885	42.880			275.748	-42.722
1979	JAN	0.0	4.248	18.445	6.280	138.256	75.241	0.000	0.000
	FEB	0.0	2.466	20.131	4.614	137.377	52.838	0.000	0.000
	MAR	0.0	2.026	18.449	3.921	136.217	32.393	0.000	0.000
	APR	66.5	1.628	3.480	2.414	135.839	28.046	0.000	0.000
	MAY	188.9	9.319	2.049	1.585	136.282	33.265	0.000	0.000
	JUN	293.7	50.912	4.343	1.408	138.278	75.880	0.000	0.000
	JUL	106.5	81.212	19.676	6.203	139.058	100.855	26.299	0.000
	AUG	222.9	111.089	14.506	4.737	139.500	117.107	70.041	0.000
	SEP	331.4	151.943	26.969	4.446	139.500	117.107	112.931	0.000
	OCT	21.5	61.038	2.780	7.632	139.463	115.684	48.999	0.000
	NOV	0.0	6.339	4.272	7.685	139.305	109.749	0.000	0.000
	DEC	0.0	4.025	18.411	7.300	138.671	87.861	0.000	0.000
	ANNUAL	1231.4	486.243	153.511	58.224			258.270	0.000

YEAR	MONTH	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV. LOSS	END OF MONTH W.L.	END OF MONTH STORAGE	SPILLAGE	SHORTAGE	(6/8)
		mm	MCM	MCM	MCM	m	MCM	MCM	MCM	
1980	JAN	0.0	2.546	18.445	5.694	137.927	66.157	0.000	0.000	
	FEB	5.6	1.819	20.140	4.078	136.927	43.667	0.000	0.000	
	MAR	0.0	1.537	18.896	3.229	135.357	23.003	0.000	0.000	
	APR	82.1	1.161	3.392	1.919	134.955	18.795	0.000	0.000	
	MAY	182.0	5.963	2.628	1.049	135.145	20.784	0.000	0.000	
	JUN	176.0	14.267	8.206	0.892	135.571	25.239	0.000	0.000	
	JUL	159.1	26.977	1.808	1.636	137.120	47.423	0.000	0.000	
	AUG	104.6	11.469	15.598	2.407	136.739	40.314	0.000	0.000	
	SEP	320.7	219.060	0.259	3.605	139.500	117.107	123.284	0.000	
	OCT	210.3	135.205	1.453	5.788	139.500	117.107	125.018	0.000	
	NOV	46.2	14.896	2.581	7.067	139.447	115.076	6.891	0.000	
	DEC	0.0	5.603	18.404	7.709	138.866	94.286	0.000	0.000	
	ANNUAL	1286.6	440.504	111.809	45.072			255.193	0.000	
1981	JAN	0.0	3.159	18.445	6.137	138.167	72.696	0.000	0.000	
	FEB	4.3	1.684	20.131	4.271	137.241	49.894	0.000	0.000	
	MAR	0.1	1.294	18.449	3.629	135.893	28.607	0.000	0.000	
	APR	94.5	0.881	3.072	1.700	134.815	17.333	0.000	0.000	
	MAY	153.7	3.729	2.598	0.921	134.616	15.249	0.000	0.000	
	JUN	226.1	47.254	5.087	1.319	137.321	51.603	0.000	0.000	
	JUL	180.7	54.857	2.381	3.281	138.977	98.055	0.000	0.000	
	AUG	175.9	69.465	1.128	4.267	139.500	117.107	41.547	0.000	
	SEP	159.7	70.841	1.383	5.080	139.500	117.107	60.837	0.000	
	OCT	130.9	51.443	2.482	6.356	139.500	117.107	40.036	0.000	
	NOV	44.2	15.978	2.554	6.607	139.446	115.044	8.082	0.000	
	DEC	0.0	4.910	19.051	7.659	138.828	92.999	0.000	0.000	
	ANNUAL	1170.1	325.496	96.760	51.229			150.502	0.000	
1982	JAN	0.0	2.679	18.445	6.037	138.109	71.070	0.000	0.000	
	FEB	6.5	1.448	20.131	4.167	137.156	48.147	0.000	0.000	
	MAR	19.2	1.158	16.112	3.367	136.004	29.768	0.000	0.000	
	APR	122.2	0.934	3.449	2.235	135.545	24.971	0.000	0.000	
	MAY	174.2	4.151	3.161	1.704	135.457	24.048	0.000	0.000	
	JUN	199.1	21.101	2.977	1.651	136.689	39.465	0.000	0.000	
	JUL	114.5	16.135	2.269	2.122	137.265	50.402	0.000	0.000	
	AUG	174.6	50.096	0.698	2.800	138.873	94.496	0.000	0.000	
	SEP	483.8	331.229	0.259	3.807	139.500	117.107	287.992	0.000	
	OCT	110.5	98.026	1.936	5.782	139.500	117.107	85.409	0.000	
	NOV	82.4	29.501	2.546	6.190	139.480	116.357	20.042	0.000	
	DEC	2.5	6.717	18.404	7.540	138.940	96.793	0.000	0.000	
	ANNUAL	1489.5	563.173	90.389	47.402			393.443	0.000	
1983	JAN	0.0	4.286	18.445	6.337	138.285	76.072	0.000	0.000	
	FEB	6.5	2.022	20.131	4.560	137.398	53.302	0.000	0.000	
	MAR	0.1	1.440	18.449	3.855	136.215	32.365	0.000	0.000	
	APR	12.4	0.950	4.016	2.565	135.710	26.687	0.000	0.000	
	MAY	202.5	2.989	2.613	1.530	135.585	25.384	0.000	0.000	
	JUN	241.8	31.970	3.379	1.455	137.289	50.922	0.000	0.000	
	JUL	151.0	42.354	4.659	3.444	138.518	83.056	0.000	0.000	
	AUG	203.8	104.871	1.699	4.373	139.500	117.107	59.505	0.000	
	SEP	345.9	149.988	66.147	4.160	139.500	117.107	72.182	0.000	
	OCT	182.4	204.878	0.867	5.065	139.500	117.107	188.705	0.000	
	NOV	0.0	13.217	3.122	7.915	139.422	114.128	4.499	0.000	
	DEC	0.0	5.748	18.404	7.653	138.844	93.532	0.000	0.000	
	ANNUAL	1346.4	564.713	161.930	52.911			324.891	0.000	

YEAR	MONTH	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV. LOSS	END OF MONTH W.L.	END OF MONTH STORAGE	SPILLAGE	SHORTAGE
		mm	MCM	MCM	MCM	m	MCM	MCM	MCM
1984	JAN	0.0	2.970	18.445	6.082	138.136	71.834	0.000	0.000
	FEB	0.0	1.585	20.140	4.521	137.182	48.678	0.000	0.000
	MAR	25.3	1.121	15.687	3.250	136.091	30.806	0.000	0.000
	APR	138.3	1.470	5.432	1.994	135.527	24.777	0.000	0.000
	MAY	192.2	9.137	1.496	1.370	136.074	30.591	0.000	0.000
	JUN	196.7	42.552	50.606	1.459	134.970	18.950	0.000	0.000
	JUL	69.0	36.288	27.363	1.716	135.486	24.345	0.000	0.000
	AUG	424.1	229.652	21.582	2.021	139.500	117.107	91.034	-5.205
	SEP	429.2	402.607	0.259	4.018	139.500	117.107	387.999	0.000
	OCT	382.9	344.820	1.385	5.214	139.500	117.107	325.768	0.000
	NOV	21.5	19.717	2.589	6.639	139.481	116.371	11.634	0.000
	DEC	0.0	8.932	18.404	7.906	138.991	98.547	0.000	0.000
	ANNUAL	1879.2	1100.850	183.387	46.190			816.434	-5.205
1985	JAN	0.0	7.391	18.445	6.549	138.436	80.560	0.000	0.000
	FEB	6.1	4.324	20.131	4.789	137.674	59.747	0.000	0.000
	MAR	7.8	3.798	16.112	4.091	136.899	43.152	0.000	0.000
	APR	171.7	5.930	4.882	2.492	136.802	41.412	0.000	0.000
	MAY	217.2	43.718	1.440	2.230	138.393	79.273	0.000	0.000
	JUN	130.0	42.915	10.054	3.765	139.208	106.224	0.000	0.000
	JUL	166.2	55.999	19.109	4.791	139.307	109.827	25.697	0.000
	AUG	125.9	75.613	0.698	4.399	139.500	117.107	59.458	0.000
	SEP	279.6	164.975	1.328	4.237	139.500	117.107	151.165	0.000
	OCT	105.1	57.976	26.980	6.064	139.458	115.481	23.661	0.000
	NOV	11.3	9.473	2.691	6.687	139.448	115.103	0.000	0.000
	DEC	0.0	7.406	19.038	7.751	138.898	95.349	0.000	0.000
	ANNUAL	1220.9	479.518	140.909	57.843			259.980	0.000
1986	JAN	0.0	5.043	18.445	6.259	138.263	75.441	0.000	0.000
	FEB	0.0	3.677	20.131	4.659	137.436	54.144	0.000	0.000
	MAR	35.1	3.576	16.112	3.904	136.570	37.524	0.000	0.000
	APR	38.2	3.235	6.066	2.613	136.180	31.919	0.000	0.000
	MAY	246.3	25.153	1.999	1.706	137.344	52.109	0.000	0.000
	JUN	180.4	30.348	4.338	2.140	138.229	74.462	0.000	0.000
	JUL	290.5	143.714	1.722	4.183	139.500	117.107	87.979	0.000
	AUG	269.6	170.789	2.149	4.287	139.500	117.107	155.817	0.000
	SEP	269.0	179.287	1.330	5.081	139.500	117.107	163.914	0.000
	OCT	115.4	85.484	1.423	6.213	139.500	117.107	73.577	0.000
	NOV	53.3	15.409	2.644	7.075	139.489	116.665	5.362	0.000
	DEC	11.7	8.895	19.043	7.612	138.989	98.460	0.000	0.000
	ANNUAL	1509.5	674.611	95.402	55.732			486.649	0.000
1987	JAN	0.0	6.513	18.445	6.514	138.407	79.692	0.000	0.000
	FEB	0.0	4.177	20.131	4.934	137.627	58.594	0.000	0.000
	MAR	11.0	3.805	16.157	4.148	136.830	41.903	0.000	0.000
	APR	19.9	3.319	6.720	2.844	136.438	35.492	0.000	0.000
	MAY	143.0	4.087	2.598	2.102	136.382	34.675	0.000	0.000
	JUN	310.3	65.983	8.148	2.205	138.644	87.006	0.000	0.000
	JUL	173.4	83.807	1.772	4.282	139.500	117.107	43.464	0.000
	AUG	197.0	74.314	2.157	5.198	139.500	117.107	63.245	0.000
	SEP	360.7	289.043	0.259	4.116	139.500	117.107	270.218	0.000
	OCT	106.4	73.743	1.943	5.782	139.500	117.107	62.333	0.000
	NOV	183.2	92.832	1.406	5.001	139.500	117.107	81.785	0.000
	DEC	0.0	11.128	18.411	8.036	139.068	101.231	0.000	0.000
	ANNUAL	1504.9	712.752	98.148	55.163			521.046	0.000

YEAR	MONTH	RAINFALL	INFLOW	IRRIG. DEMAND	RESERV. LOSS	END OF MONTH W.L.	END OF MONTH STORAGE	SPILLAGE	SHORTAGE
		mm	MCM	MCM	MCM	m	MCM	MCM	MCM
1988	JAN	0.0	7.926	18.445	6.738	138.534	83.561	0.000	0.000
	FEB	0.0	4.884	20.140	5.363	137.793	62.697	0.000	0.000
	MAR	7.4	4.067	18.896	4.518	136.898	43.146	0.000	0.000
	APR	133.2	3.646	2.345	2.678	136.812	41.586	0.000	0.000
	MAY	413.1	85.933	1.425	2.494	139.500	117.107	0.000	0.000
	JUN	232.4	221.334	1.908	4.534	139.500	117.107	205.340	0.000
	JUL	82.9	21.310	30.111	5.157	138.822	92.793	9.978	0.000
	AUG	183.6	78.051	14.544	4.252	139.275	108.646	39.500	0.000
	SEP	332.3	163.560	43.048	4.637	139.500	117.107	94.584	0.000
	OCT	197.9	175.028	14.406	5.644	139.500	117.107	150.054	0.000
	NOV	0.0	15.250	3.125	7.968	139.474	116.100	5.229	0.000
	DEC	0.0	9.058	18.484	7.896	138.985	98.324	0.000	0.000
	ANNUAL	1582.8	790.047	186.878	61.880			504.687	0.000
1989	JAN	0.0	6.210	18.445	6.493	138.394	79.286	0.000	0.000
	FEB	0.0	4.427	20.131	4.917	137.620	58.444	0.000	0.000
	MAR	69.5	4.326	13.688	4.008	136.990	44.858	0.000	0.000
	APR	86.9	4.072	2.964	2.764	136.890	42.999	0.000	0.000
	MAY	166.1	10.690	2.507	1.921	137.184	48.727	0.000	0.000
	JUN	63.8	4.932	11.548	1.940	136.716	39.925	0.000	0.000
	JUL	213.0	37.655	3.776	2.208	138.060	69.713	0.000	0.000
	AUG	236.9	155.230	3.234	4.052	139.500	117.107	92.791	0.000
	SEP	335.7	210.774	8.131	3.754	139.500	117.107	188.353	0.000
	OCT	79.5	84.284	16.947	5.780	139.500	117.107	57.344	0.000
	NOV	9.4	10.092	3.115	7.205	139.473	116.067	0.308	0.000
	DEC	0.0	8.113	19.043	7.839	138.943	96.892	0.000	0.000
	ANNUAL	1260.8	540.806	123.529	52.881			338.796	0.000
1990	JAN	0.0	5.700	18.445	6.379	138.333	77.475	0.000	0.000
	FEB	5.8	4.298	20.131	4.699	137.548	56.727	0.000	0.000
	MAR	152.0	10.230	10.132	3.687	137.367	52.627	0.000	0.000
	APR	13.1	4.184	3.527	3.780	137.212	49.294	0.000	0.000
	MAY	371.6	72.097	1.450	2.624	139.411	113.712	0.000	0.000
	JUN	215.3	123.669	7.202	4.088	139.500	117.107	102.803	0.000
	JUL	272.4	123.007	1.583	4.778	139.500	117.107	110.498	0.000
	AUG	234.7	174.037	2.245	4.943	139.500	117.107	158.150	0.000
	SEP	304.7	199.669	0.259	4.719	139.500	117.107	184.710	0.000
	OCT	253.7	239.191	1.984	5.208	139.500	117.107	220.042	0.000
	NOV	66.6	39.676	2.594	6.783	139.496	116.936	28.487	0.000
	DEC	0.0	11.867	18.411	8.028	139.084	101.770	0.000	0.000
	ANNUAL	1889.9	1007.625	87.965	59.716			804.690	0.000

FIGURE B-5 WATER BALANCE STUDY (1/3)

Cropping Pattern Type-2

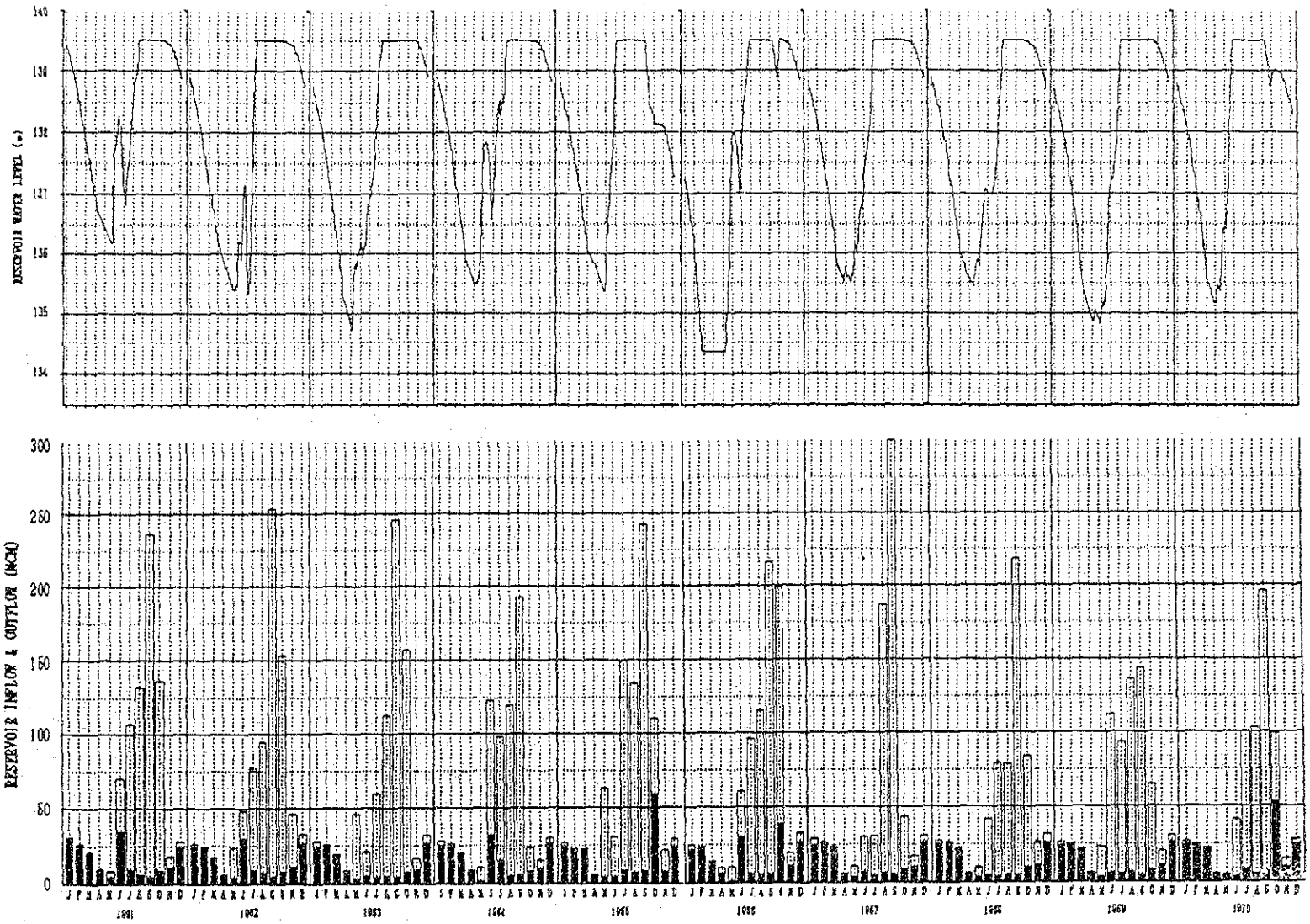


FIGURE B-5 WATER BALANCE STUDY (2/3)

Cropping Pattern Type-2

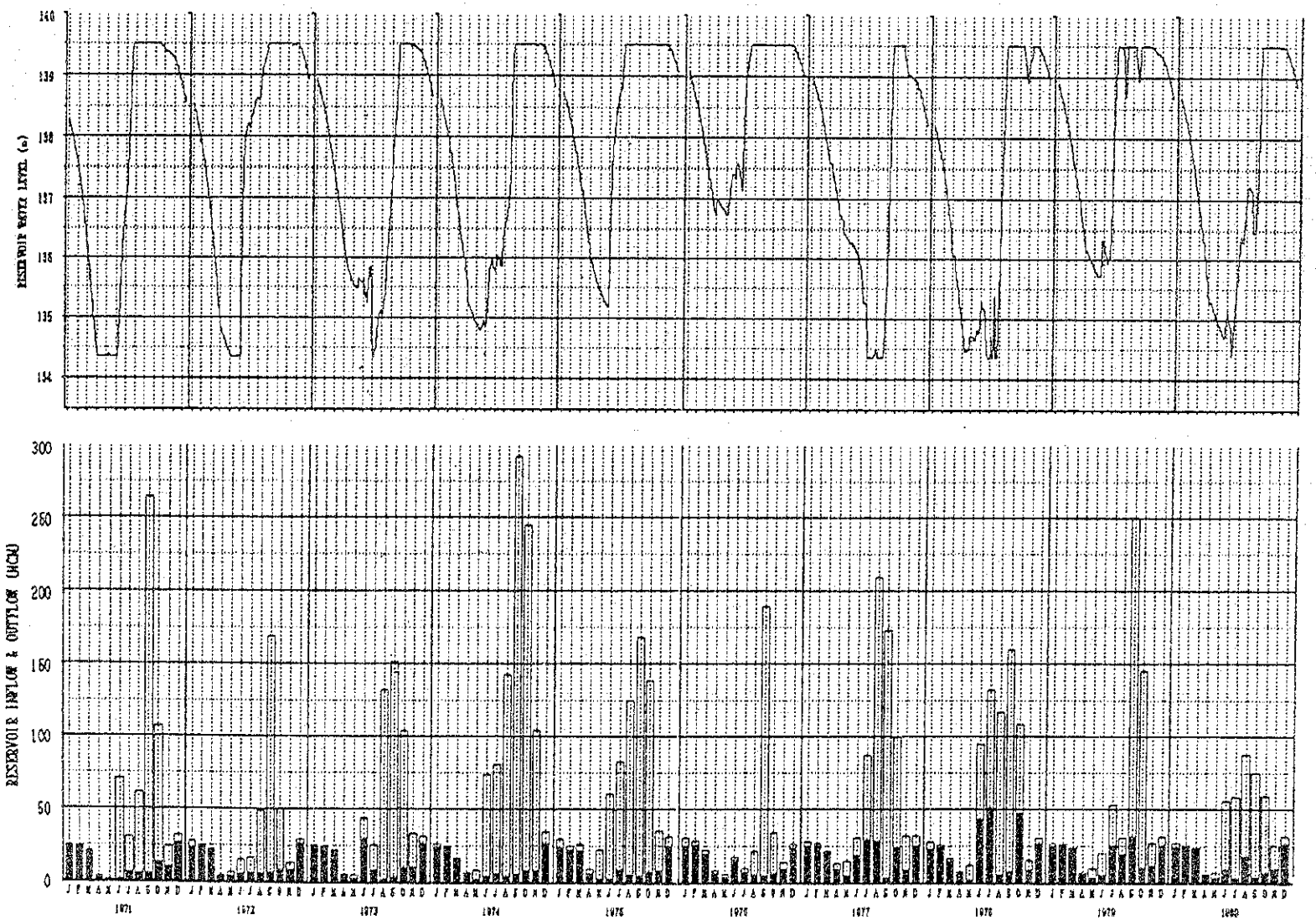
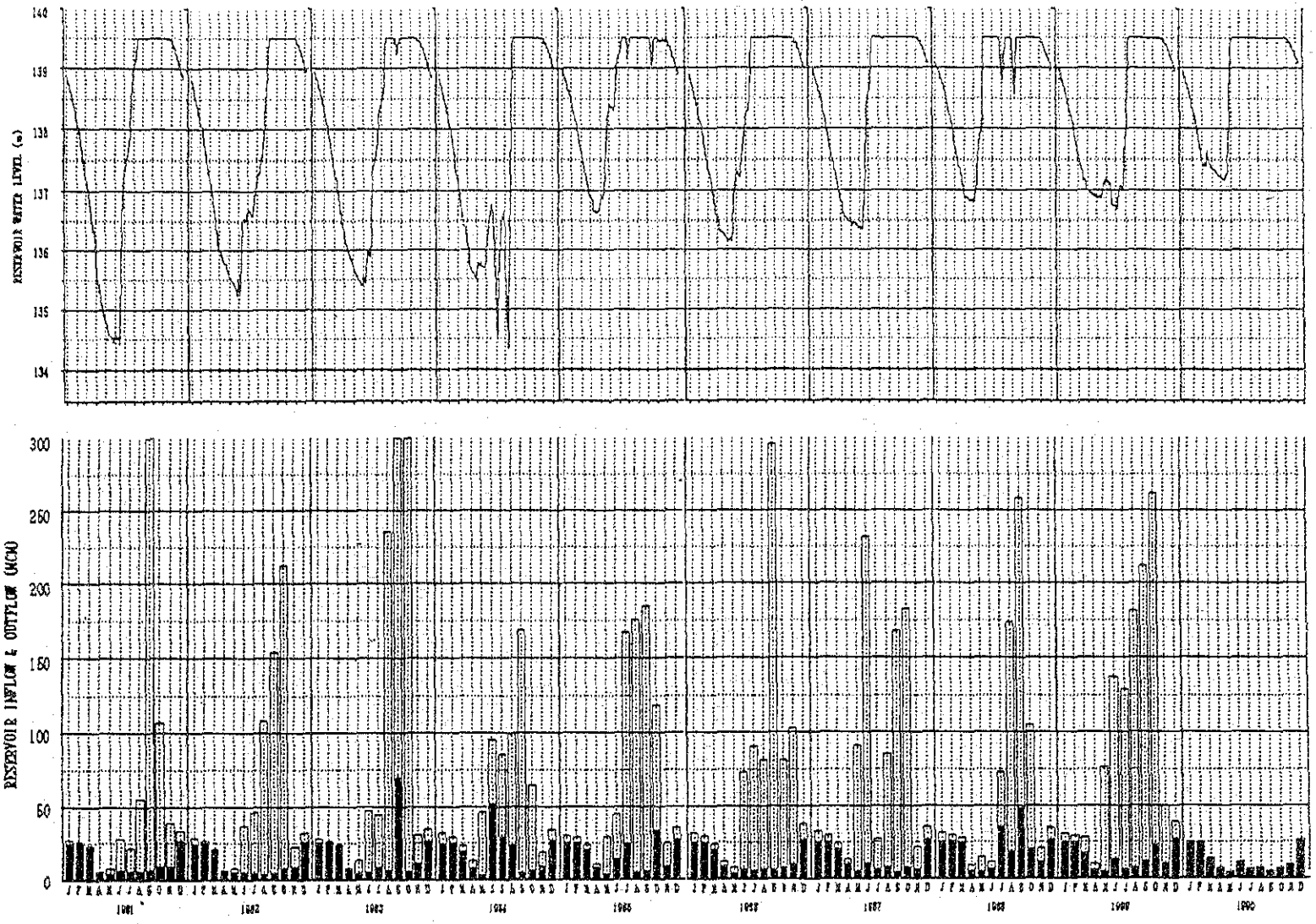


FIGURE B-5 WATER BALANCE STUDY (3/3)

Cropping Pattern Type-2



ANNEX C. SOIL AND LAND USE

ANNEX C. SOIL AND LAND USE

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PART - I (OVERALL BASIN STUDY)

CHAPTER I. SOIL

The present soil study aims at identifying major soil group and their distribution in the area of Lam Dom Yai Basin Irrigation Project to evaluate the endowed land resources through the review of the past soil studies and supplementary investigations.

Based on a detailed reconnaissance soil map of Ubon Ratchathani Province (1 : 100,000), Report of Soil Survey of Changwat Ubon Ratchathani (1971), Land Use Planning of North-eastern Thailand (1984) prepared by Department of Land Development and soil survey in the Phase-1 Study, the detail description of soil characteristics, land classification and land use of the basin can be given as follows.

1. 1 Parent Material of Soil and Landforms

Most soils of the basin are formed from alluvial sediments derived from sandstone and conglomerate. There are some basalt outcrops in hills south-west of Amphoe Det Udom and these hills have undoubtedly contributed some sediments locally. The alluvium has been deposited by rivers that have meandered over the landscape. As these rivers moved over the landscape, they truncated the bedrock ridges and deposited thick layers of alluvium over the area. The present surface materials are very low in plant nutrients and contain few easily weatherable minerals, because of the intense weathering, leaching, and repeated cycles of geological erosion and deposition. Only on mountains are there soils which developed from materials not transported by water. However, the parent material of most of these soils is not true residuum, because the unconsolidated material over the bedrock has moved downhill and these materials are mainly colluvium.

From a physiographic point of view, the land forms in the basin are classified into four categories: alluvial plains, low terraces, middle terraces and hills.

Alluvial plains occur in a narrow strip along both sides of Lam Dom Yai. River levees are the higher parts of the flood plain adjacent to main river channels. The main geomorphological landforms are the natural river levees and back swamps. The range in texture of the materials of the levees is usually silt loam to loam at the surface and loam, clay loam or silty clay in the sub-soils. Finer materials normally occupy the lower parts of the basin. The soils that occupy the basin and old stream beds are Phimai and Kalasin.

The Phimai soils are mainly used for paddy rice. The Kalasin soils are flooded and are seldom used for crop cultivation.

Low terraces are extensive in the west, western, south-western, and the central portions of the basin. The low terraces make up about 15 percent of the whole area. The topography is flat to nearly flat and rises gradually above the alluvial plains. Most rice lands are on these terraces.

Soils on these terraces are sandy to loamy in the surface. They have finer textured subsurface layers, some of which contain laterite gravel as cemented sheets or as concretion imbedded in a layer of clay. The higher parts of these terraces are sand at a depth of 50 cm or more. A small percentage of the soils are saline and these soils occur in small areas. The major soil series on these terraces are Roi Et, Ubon, and On series.

Middle terraces occur in large bodies in the basin, especially in the south, where it occupies 60 percent of the area. Soils on these terraces usually have laterite as more-or-less cemented sheets or as concretions imbedded in a layer of clay. The laterite is at a depth of 50 to 100 cm. However, in some places it is at the surface. Geologic and man-made erosions are moderate to severe on these terraces.

The terraces consist of sandy sediments with slightly less clay content in the surface layers than the subsurface layers. Strongly mottled gray clay is usually found below the laterite. On the higher part of these terraces, the depth of clay is less.

Soils of these terraces are mainly used for upland crops, particularly kenaf. Some areas are covered by a dry dipterocarp forest and a mixed

deciduous forest. The major soils on these terraces belong to the Korat, Nam Phong, Phon Phi Say, and Buntharik series.

Hills of the Phya Dongrak escarpment is in the southern part of the basin. The bedrocks are mostly sandstones and conglomerates, but there is some basalt. All belong to the geologic Korat series. Soils that are shallow to sandstone bedrocks are common in these areas and sandstone outcrops are common on the footslopes. The hill soils are mapped as Slope Complex soils. Most on these soils are in forest, but some small areas are cleared and used for shifting cultivation.

1. 2 Soil Classification and Characteristics

The soil survey report of the Department of Land Development revealed that Ubon Ratchathani Province is occupied by 30 soil series and only 24 soil series appear in the basin. The soil series in the area can be grouped into 15 soil subgroups as follows:

SOIL GROUP

Subgroup	Symbol of Soil Series
Oxic Paleustult	Kt, Suk, Kt-h
Aeric Paleaquult	Re, Bt, Re-1
Ustoxic Quartzipsamment	Ng
Typic Plinthustult	Pp
Aquic Quartzipsamment	Ub
Typic Plinthaquult	Pn
Typic Haplustox	Ci
Spodix Quartzipsamment	Dt
Aeric Plinthic Paleaquult	Rn
Vertic Tropaquept	Pm
Oxic Plinthaquult	On
Petro Ferric Haplustult	Sk
Ustoxic Dystropept	Kn
Rhodic Paleustalf	Su
Aquic Plinthustult	Bb

Date source: Guide Line to Soil Series and Classification of Thailand, DLD (1981).

Distributions of each soils series in the basin are as follow:

DISTRIBUTION OF SOIL SERIES

Soil Name	Area	Percent
	(ha)	(%)
1. Korat (Kt)	176,578	36.0
2. Slope Complex (Sc)	70,141	14.3
3. Korat-Phon Phisai Association (Kt/Pp)	67,688	13.8
4. Roi Et (Re)	48,559	9.9
5. Nam Phong (Ng)	39,240	8.0
6. Phon Phisai (Pp)	20,601	4.2
7. Roi Et-On Association (Re/On)	11,515	2.3
8. Roi Et-Phen Association (Re/Pn)	11,281	2.3
9. Ubon (Ub)	9,300	1.9
10. Buntharik (Bt)	9,286	1.9
11. Phen (Pn)	6,037	1.2
12. Chok Chai (Ci)	5,900	1.2
13. Alluvial Complex (Ac)	4,653	0.9
14. Dong Takien (Dt)	2,103	0.4
15. Renu (Rn)	1,650	0.3
16. Roi Et, loamy phase (Re-1)	1,500	0.3
17. Satuk (Suk)	1,459	0.3
18. Phimai (Pm)	981	0.2
19. On (On)	682	0.1
20. Korat, high phase (Kt-h)	571	0.1
21. Sakon (Sk)	428	0.1
22. Kalasin (Kn)	196	0.04
23. Surin (Su)	98	0.02
24. Borabu (Bb)	52	0.01
Total	490,499	100.0

The distribution of identified soil series are shown in Figure C-1. The soil map was compiled on the basis of the detailed reconnaissance soil map (1 : 100,000) prepared by DLD, and was confirmed through field observations.

The major characteristics of the soil series are described as follow:

a) Korat Series (Kt)

The Korat series consists of well drained, sandy or loamy soils formed in old alluvium on the gently undulating to rolling parts of middle terraces and to a less extent on the higher parts of low terraces. This series appears in all parts of the basin.

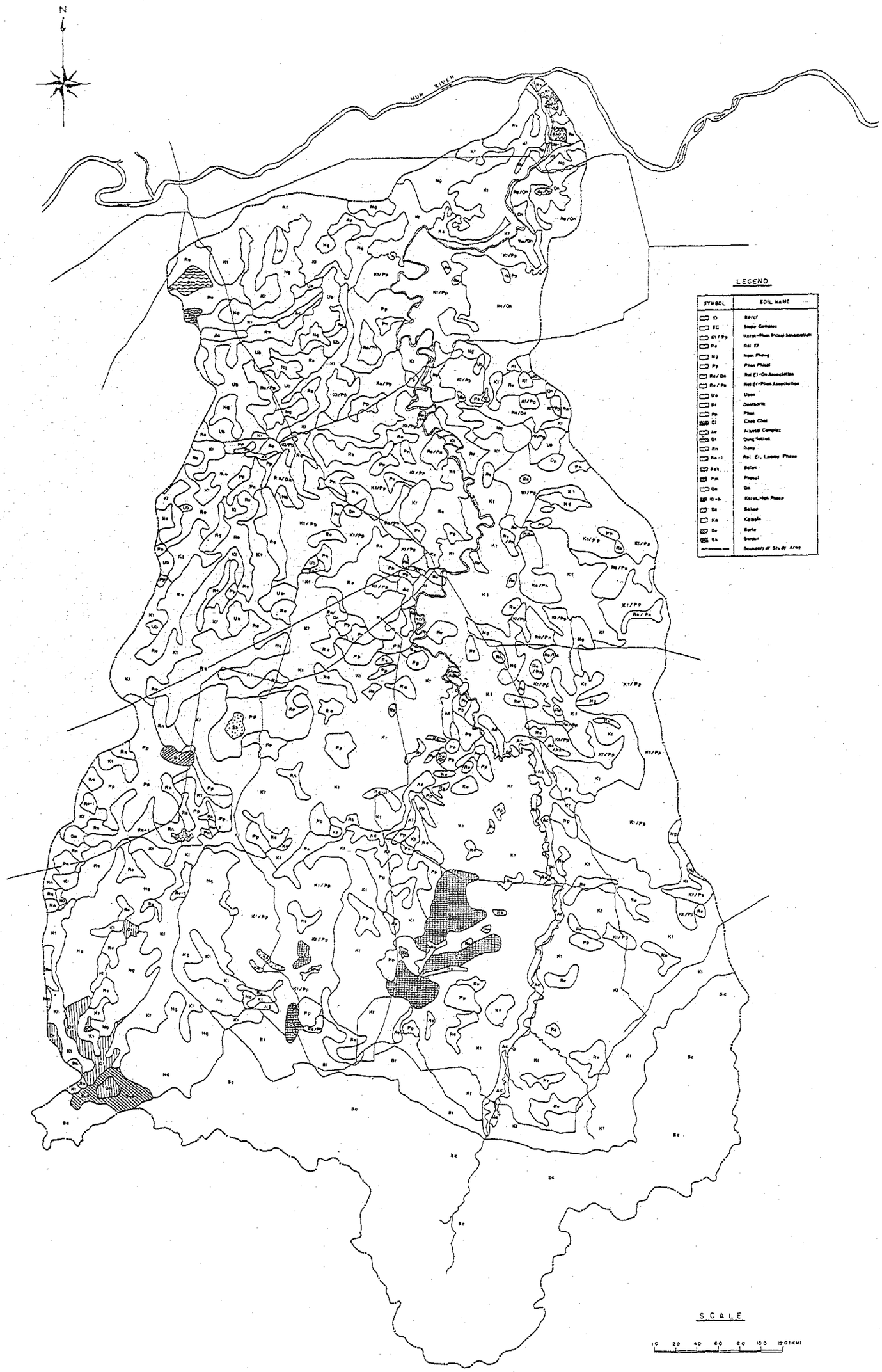

FIGURE C-1 SOIL MAP IN THE BASIN

Soil profile of Korat series is as folows:

Ap ... The surface horizon is light grayish brown or grayish brown loamy sand or sandy loam about 20 cm thick. The surface is light gray when dry. Organic matter content is near one percent.

A2 ... The upper subsoil is light brownish gray loamy sand or sandy loam 20 to 35 cm thick. This horizon contains many bleached sand grains.

B2t ... The low subsoil is brown or pale brown sandy loam, loam or sandy clay loam, commonly more than one meter thick. This layer may contain yellowish brown mottles and it may contain laterite in the lower parts.

The range in pH of these soils is commonly from 4.5 to 6.0 in the surface and upper subsoil, and 4.5 to 5.0 in the lower subsoil.

b) Slope Complex Soils (Sc)

This unit consists of steep soils, many of which are shallow to sandstone bedrock and contain stones and/or bedrock outcrops. The most uniform characteristic of soils in this unit is that the predominant slope gradient is over 12 percent. In terms of the soil survey manual, this is an undifferentiated unit. Each area does not necessarily contain all the soils included in any one area. This unit contains soils of many series, but the series was not determined in the survey and it is probable that the unit contains soils of unnamed series. Large areas of this unit are in the southern part of the basin.

c) Korat/Phon Phi Sai Association (Kt/Pp)

This unit is composed of soils of the Korat series and the Phon Phi Sai series that occur side by side. Every delineation of this unit contains approximately 60 percent of Korat soils and 40 percent of Phon Phi Sai soils. These soils are on the higher parts of the middle terraces. They are in large bodies in eastern, northern, south-western and the middle part of the basin.