No. 52

JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)
THE DEPARTMENT OF IRRIGATION,
THE MINISTRY OF WATER RESOURCES
HIS MAJESTY'S GOVERNMENT OF NEPAL

THE MASTER PLAN STUDY
ON
THE TERAI GROUNDWATER RESOURCES
EVALUATION AND DEVELOPMENT PROJECT
FOR IRRIGATION

FINAL REPORT

VOLUME III: APPENDICES

MARCH, 1995

SANYU CONSULTANTS INC.

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PREFACE

This report summarizes the results of the "Master Plan Study on Terai Groundwater Resources Evaluation and Development Project for Irrigation," conducted by the Japan International Cooperation Agency (hereafter JICA) and requested by His Majesty's Government of Nepal (HMGN).

The major objectives of this study include the evaluation of deep groundwater resources and the formulation of an irrigation master plan using deep tubewells (DTW) in Jhapa District, in the eastern part of Terai Plain, which is the granary of Nepal, as well as Mahottari District in central Terai and Banke District in western Terai.

The study have been conducted in "Phase I" and "Phase II." The objective of the "Phase I" study is to select irrigable areas by deep tubewell as well as a representative area with the highest groundwater potential among the three study districts. As a result, the southeastern part of Jhapa District has been selected as the representative area.

After an intensive survey and study of the representative area, the objectives of the "Phase II" study include an evaluation of groundwater resources, formulations of a DTW irrigation master plan, and DTW irrigation guidelines. This Study includes the establishment of a monitoring network and observation related to meteorology, hydrology, groundwater, geophysical prospecting, the drilling of 20 exploratory wells, well testing, groundwater surveys, toposurvey of sample area, a socio-economic and agricultural study. Based on results of the said field survey, a groundwater resource evaluation and a DTW irrigation master plan and guidelines have been made for the representative area and the other two areas. As well, a groundwater monitoring system, a meteorological, hydrological, and hydrogeological database, and a groundwater management system have been constructed.

Through the study period, technical transfers have been conducted for the counterpart personnel of Department of Irrigation (DOI) in the On-The-Job basis and the training in Japan.

The "Phase I" study was conducted between October 1991 to March 1992, and "Phase II" was conducted between September 1992 to September 1994, for a total study period of 36 months.

This report is volume three of three volumes.

Volume One	:	Main Report
Volume Two	:	Sector Report
Volume Three	:	Appendices

The Study Team wishes to express its deep appreciation to the officers of the Department of Irrigation of the Ministry of Water Resources, particularly to the counterpart personnel and the officers of related agencies of Japan.

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Abbreviation

ADB	:	Asian Development Bank
ADB/N	:	Agricultural Development Bank/Nepal
AIC	:	Agricultural Inputs Corporation
AMD	:	Agricultural Marketing Division
AO	:	Association Organizer
ASD	:	Agricultural Statistics Division
BNP	:	Program for Fulfillment of Basic Needs
CBS	:	Central Bureau of Statistics
CDO	:	Chief District Officer
CDR	:	Central Development Region
DMH	:	Department of Meteorology and Hydrology
DOA	:	Department of Agriculture
DOI	:	Department of Irrigation
DTW	:	Deep Tubewell
DTWIP	:	Deep Tubewell Irrigation Project
EIRR	:	Economic Internal Rate of Return
ESE	:	East-south-east
E-W	:	East-west
GCA	:	Gross Command Area
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
GOJ	:	Government of Japan
GWRDB	:	Ground Water Resources Development Board
GWRDP	:	Ground Water Resources Development
HMGN	:	His Majesty's Government of Nepal
HYV	:	High Yielding Variety
IAP	:	Intensive Irrigation and Agriculture Program
IDA	:	International Development Association
JADP	:	Janakpur Zone Agricultural Development Project
JICA	:	Japan International Cooperation Agency
JTA	:	Junior Technical assistants
LLDC	:	Least Level Development Country
MOA	:	Ministry of Agriculture
MOWR	:	Ministry of Water Resources
MPID	:	Mater Plan for Irrigation Development in Nepal
MSL	:	Mean Sea Level
NCA	:	Net Command Area
NNE	:	North-north-east
O&M	:	Operation and Maintenance
PVC	:	Polyvinyl Chloride
SSW	:	South-south-west
STW	:	Shallow Tubewell
STWIP	:	Shallow Tubewell Irrigation Program
SWL	:	Static Water Level
TIATSP	:	Tubewell Irrigation Agriculture Training and Services Project
UNDP	:	United Nation Development Program
UPVC	:	Unplastixised Polyvinyl Chloride
ASAID	:	United State Agency for International Development
WNW	:	West-north-west
WUA	:	Water Users Association
WUG	:	Water Users Group

Glossary

a	:	Annum
av.	:	Average
bgl	:	Below ground level
mags	:	Meter above ground surface
masl	:	Meter above sea level
m	:	Meter(s)
mm	:	Milli-meter(s)
km	:	Kilo-meter(s)
km2	:	Square kilometer(s)
sq.km	:	Square kilometer(s)
m3	:	Cubic meter(s)
cu.m	:	Cubic meter(s)
MCM	:	Million cubic meter(s)
t	:	Ton(s)
Mt	:	Metric ton(s)
kg	:	Kilogram(s)
ha	:	Hectare(s)
°C	:	Degree centigrade
%	:	Percent
yr	:	Year(s)
hr	:	Hour(s)
min	:	Minute(s)
sec	:	Second(s)
l	:	Liter(s)
S/cm	:	Siemens per centimeter(s)
in	:	Inch(es)
"	:	Inch(es)
kw	:	Kilowatt(s)
KVA	:	Kilo-volt-ampere
Rs	:	Nepal Rupee(s)
MRs	:	Million Rupee(s)
¥	:	Japanese Yen
M¥	:	Million Yen
US$	:	US Dollar
M$	:	Million Dollar
EC	:	Electric Conductivity
k	:	Permeability (Water Conductivity)
pH	:	Potential of Hydrogen
S	:	Storage Coefficient
T	:	Transmissivity
ND	:	Nominal Diameter
ID	:	Internal Diameter
OD	:	Outer Diameter
MAX.	:	Maximum
MIN.	:	Minimum

APPENDIX - ONE

GUIDELINES FOR

DEEP TUBEWELL IRRIGATION

APPENDIX ONE: GUIDELINES FOR DTW IRRIGATION

1.1 LFCA and LFWY

The purpose of studying guidelines for DTW irrigation projects is to study the least feasible command area (LFCA) irrigated by one DTW, and to grasp the least feasible well yield (LFWY) in order to offer the materials for evaluating the economic feasibility of DTW irrigation projects in the future.

LFCA is considered the least feasible command area irrigated by one DTW under variable conditions, such as natural conditions, socio-economy, and agriculture in the project areas. After deciding LCFA, LFWY can be estimated automatically as the water requirement necessary for LCFA.

An economic analysis is carried out based on the same conditions used in 6.9 Project Evaluation in the main report, and the priority area of Jhapa District has been selected for the study. Conditions used in the study are shown below.

Command area by one DTW	100 ha
Cropping intensity without project	126%
Cropping intensity with project	200%
Cropping patterns	refer to Figure 1
Farmgate Prices	refer to Table 1
Production Costs	refer to Table 2
Project Life	50 years
Construction Period	1 year
Replacement	
DTW	20 years
Pumps	15 years
OM Equipments	10 years

The following three cases are analyzed regarding the yield of DTWs and the number of pump stations.

	Yield of DTW	Pump Stations
Case-1	90 lit/sec	1 place
Case-2	45	2
Case-3	30	3

Project costs for each case are estimated per 100 ha in the case of a) irrigated by one DTW, b) irrigated by two DTWs, and c) irrigated by three DTWs. These cost estimations are based on the topo-map survey in the sample area which was conducted in the Phase II study.

When estimating economic project costs, the land acquisition cost and price escalation cost are excluded as transfer expenditures, and local portions in the financial project cost are converted to border prices by multiplying the SCF.

The economic project costs and O & M costs per 100 ha are shown in the following three cases:

Project Costs

(Unit: Rs1,000/100 ha)

	Case-1	Case-2	Case-3
LC	5,129	5,727	6,358
FC	8,901	10,956	13,308
Total	14,030	16,683	19,666

(Unit: Rs1,000/100 ha)

O & M Costs	Case-1	Case-2	Case-3
LC	200	287	344
FC	25	35	42
Total	225	322	386

The incremental agricultural benefits are estimated as shown in Table 3.

The results of the study of the EIRR and B/C ratio in the three cases are shown below:

a) Jhapa

	Case-1	Case-2	Case-3
EIRR(%)	16.77	13.94	11.75
B/C	1.53	1.26	1.07

b) Mahottari

	Case-1	Case-2	Case-3
EIRR(%)	15.51	12.69	10.53
B/C	1.38	1.14	0.97

c) Banke

	Case-1	Case-2	Case-3
EIRR(%)	15.59	12.81	10.67
B/C	1.40	1.15	0.98

Base on the economic analysis, the following remarks can be made:

- number of pump stations can be reduced when the well yield is higher
- annual O & M cost will be higher when the well yield is small and the number of pump stations is high
- total length of the buried pipelines will be longer when the well yield is high and the number of pump stations is low
- EIRR and B/C ratios will be higher when the well yield is high and lower when the DTW yield is low (refer to Figure 2)
- the ratio of B/C will be less than 1.0 when the well yield is approximately 30 lit/sec
- therefore, LFCA irrigated by approximately 30 lit/sec is estimated at approximately 30 ha
- LFWY will be approximately 30 lit/sec.

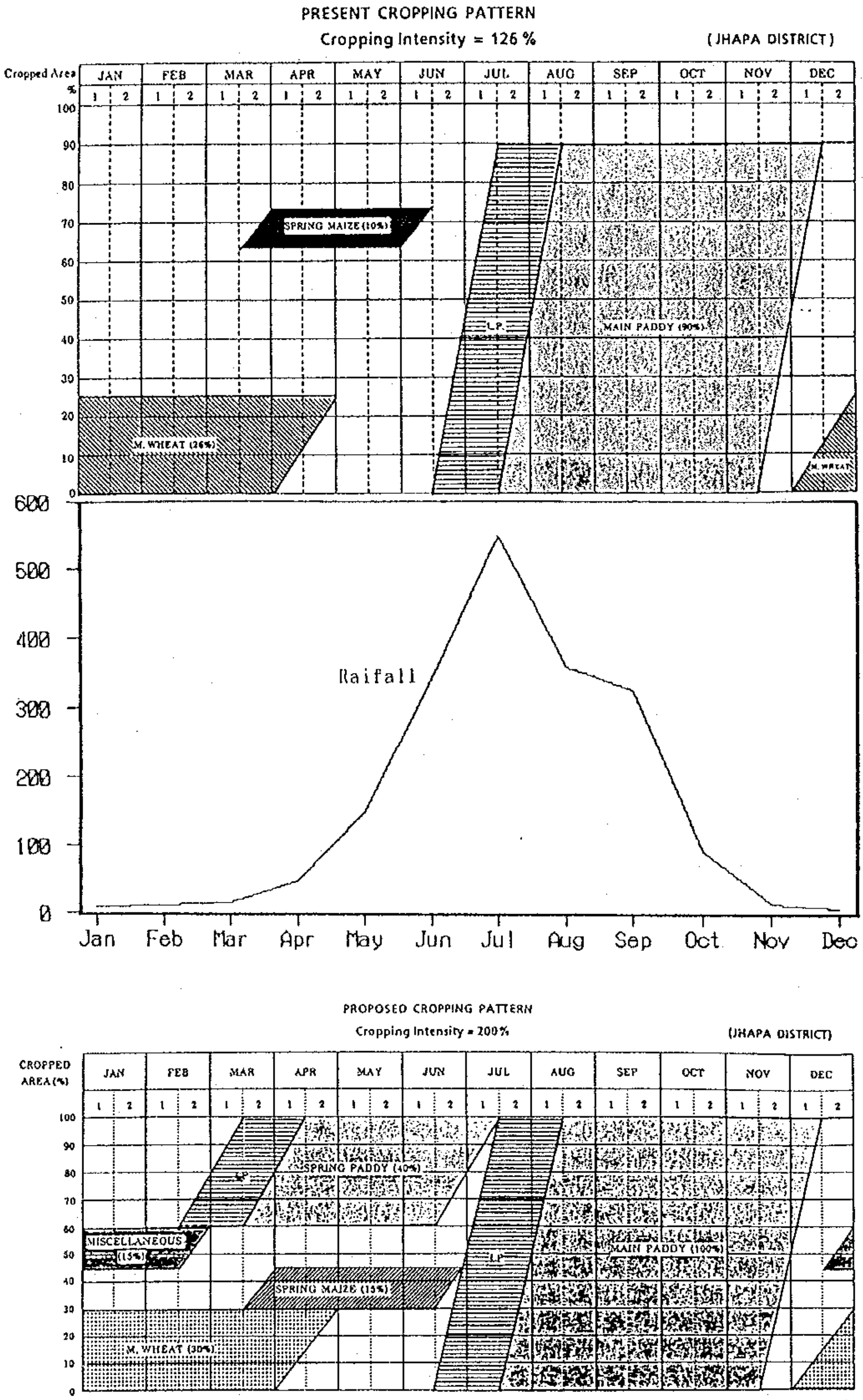


Figure 1.1.1(1) Present and Proposed Cropping Pattrens in Jhapa District

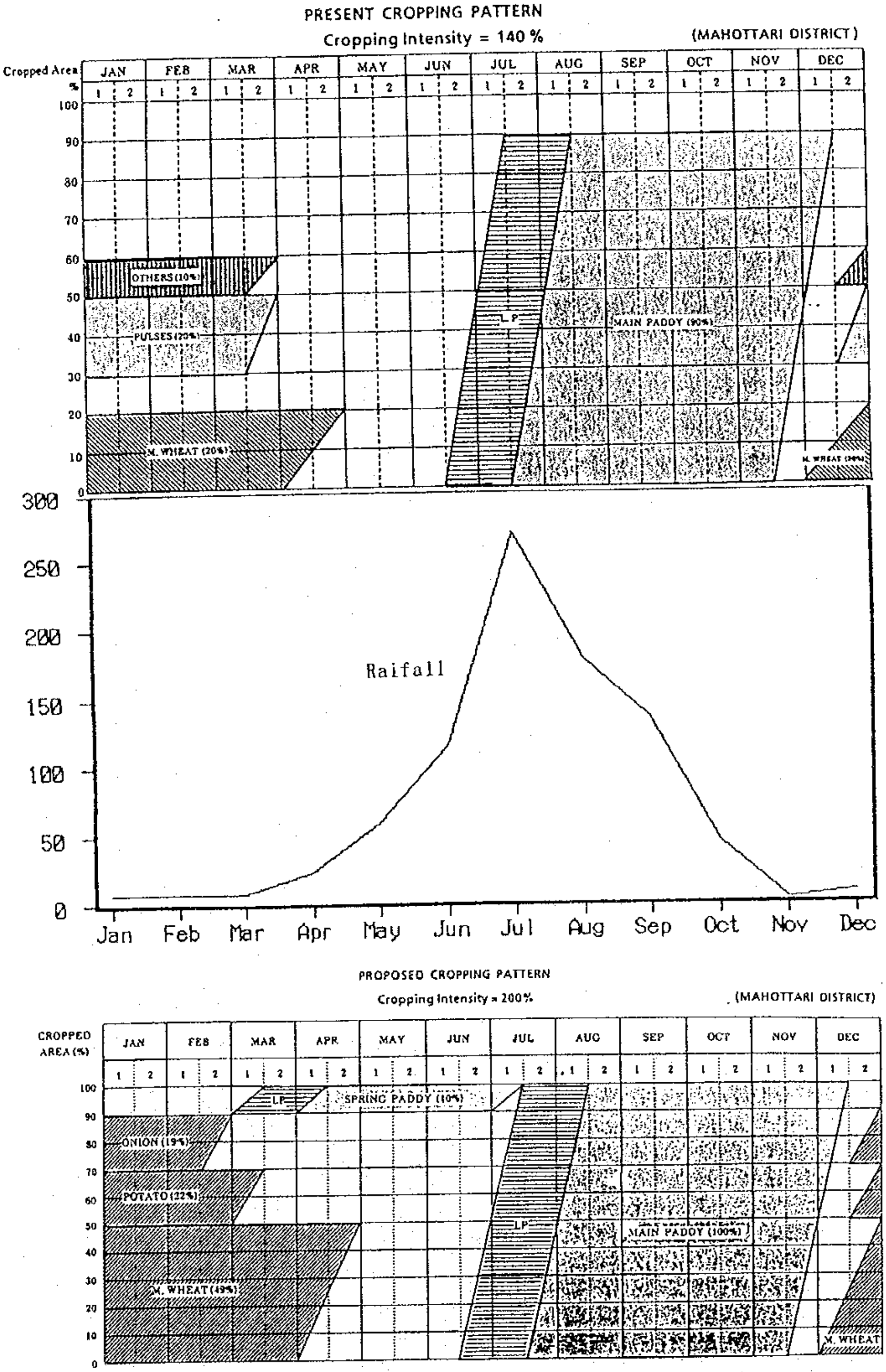


Figure 1.1.1(2) Present and Proposed Cropping Pattrens in Mahottari District

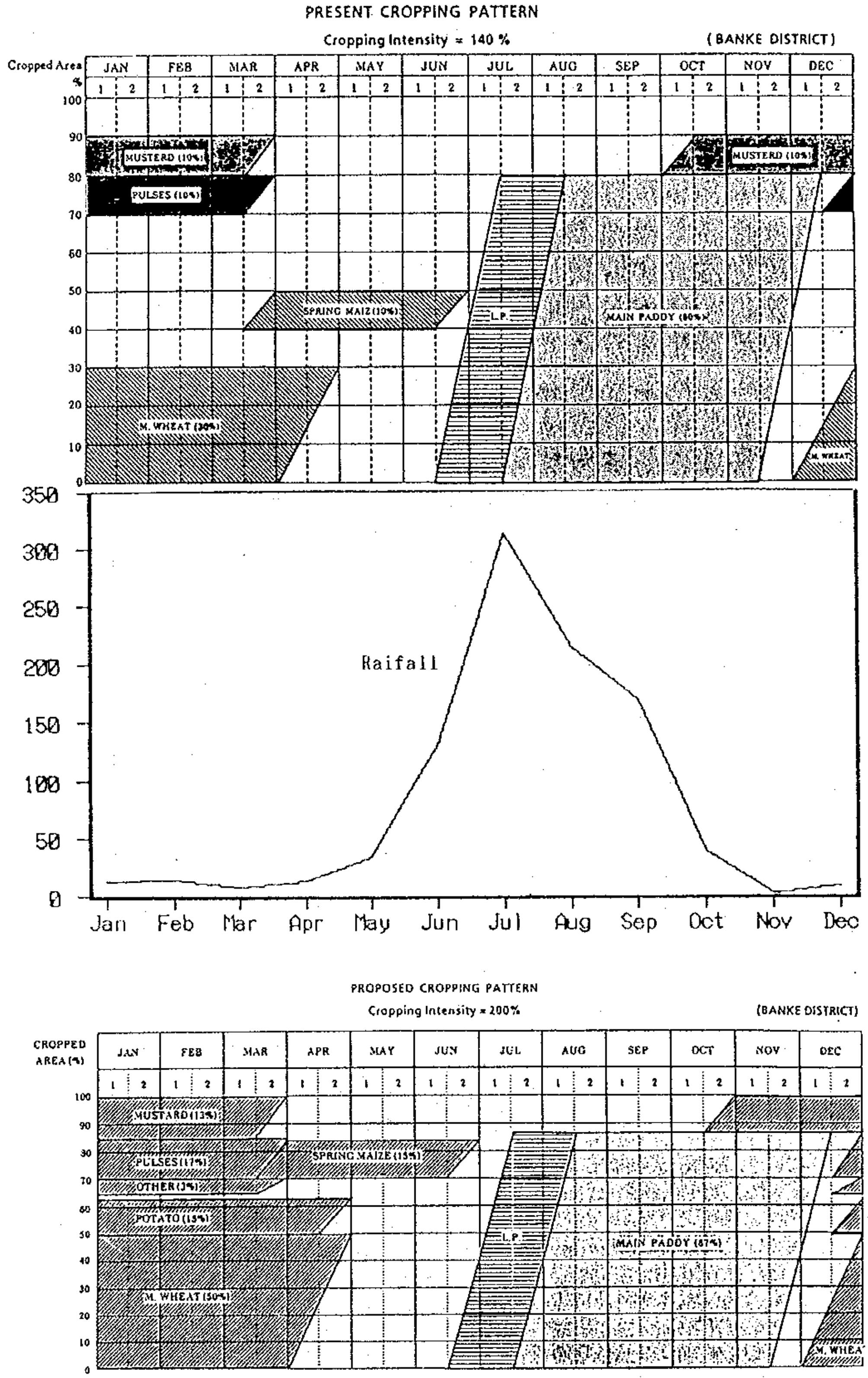


Figure 1.1.1(3) Present and Proposed Cropping Pattrens in Banke District

Table 1.1.1(1) Financial and Economic Price of the Commodities(Jhapa)

	Unit	Price Financial	Price Economic	Remarks
1. Seeds				
Paddy	Rs/kg	10.00	10.61	
Wheat	Rs/kg	11.65	23.90	
Maize	Rs/kg	14.20	25.12	
Mustard	Rs/kg	23.00	21.95	
Pigeon Peas	Rs/kg	16.00	14.58	
Lentil	Rs/kg	18.00	16.40	
Cauliflower	Rs/kg	300.00	273.30	
Potato	Rs/kg	10.00	9.11	
Onion	Rs/kg	225.00	204.97	
Vegetables(cabbage)	Rs/kg	305.00	277.86	
2. Crops				
Paddy	Rs/ton	4790	10106	
Wheat	Rs/ton	4250	12312	
Maize	Rs/ton	4590	9567	
Mustard(oilseeds)	Rs/ton	23110	23110	
Pigeon Peas	Rs/ton	17190	17190	
Lentil	Rs/ton	14940	14940	
Cauliflower	Rs/ton	7690	7690	
Potato	Rs/ton	3880	3880	
Onion	Rs/ton	8940	8940	
Vegetables(cabbage)	Rs/ton	6740	6740	
3. By-products				
Paddy Straw	Rs/kg	0.40	0.36	
Wheat Straw	Rs/kg	0.25	0.23	
Maize Stalks	Rs/kg	0.20	0.18	
Lentil Stalks	Rs/kg	0.25	0.23	
Mustard Stalks	Rs/kg	0.20	0.18	
4. Fertilizer				
Nitrogen	Rs/kg	12.17	26.32	
Phosphate	Rs/kg	17.39	24.68	
Potash	Rs/kg	14.17	17.35	
Barnyard Manure	Rs/ton	200.00	182.00	
5. Agri-Chemicals				
Parathion	Rs/kg	338.5	308.4	
BHC Dust	Rs/kg	5.9	5.4	
Malathion Dust	Rs/kg	12.6	11.5	
Hinosan	Rs/lit.	463.0	421.8	
2-4D	Rs/kg	203.8	185.7	
6. Farm Labor				
Hired Labor	Rs/day	32	22	
Hired Bullock with Labour	Rs/day	100	68	

Table 1.1.1(2) Financial and Economic Price of the Commodities (Mahottari)

	Unit	Price Financial	Price Economic	Remarks
1. Seeds				
Paddy	Rs/kg	8.50	9.01	
Wheat	Rs/kg	10.50	21.50	
Maize	Rs/kg	15.00	26.51	
Mustard	Rs/kg	22.00	20.04	
Pigeon Peas	Rs/kg	16.00	14.58	
Lentil	Rs/kg	18.00	16.39	
Cauliflower	Rs/kg	300.00	273.30	
Potato	Rs/kg	8.00	7.29	
Onion	Rs/kg	225.00	204.97	
Vegetables (cabbage)	Rs/kg	300.00	273.30	
2. Crops				
Paddy	Rs/ton	6070	10361	
Wheat	Rs/ton	6010	12704	
Maize	Rs/ton	4920	9959	
Mustard (oilseeds)	Rs/ton	23480	23480	
Pigeon Peas	Rs/ton	15420	15420	
Lentil	Rs/ton	14940	14940	
Cauliflower	Rs/ton	6000	6000	
Potato	Rs/ton	4530	4530	
Onion	Rs/ton	4140	4140	
Vegetables (cabbage)	Rs/ton	3430	3430	
3. By-products				
Paddy Straw	Rs/kg	0.50	0.46	
Wheat Straw	Rs/kg	0.30	0.27	
Maize Stalks	Rs/kg	0.20	0.18	
Lentil Stalks	Rs/kg	0.25	0.23	
Mustard Stalks	Rs/kg	0.20	0.18	
4. Fertilizer				
Nitrogen	Rs/kg	11.22	27.17	
Phosphate	Rs/kg	17.39	25.35	
Potash	Rs/kg	13.58	18.00	
Barnyard Manure	Rs/ton	200.00	182.00	
5. Agri-Chemicals				
Parathion	Rs/kg	338.5	308.4	
BHC Dust	Rs/kg	5.9	5.4	
Malathion Dust	Rs/kg	12.6	11.5	
Hinosan	Rs/lit.	463.0	421.8	
2-4D	Rs/kg	203.8	185.7	
6. Farm Labor				
Hired Labor	Rs/day	35	24	
Hired Bullock with Labour	Rs/day	100	68	

Table 1.1.1(3) Financial and Economic Price of the Commodities (Banke)

	Unit	Price		Remarks
		Financial	Economic	
1. Seeds				
Paddy	Rs/kg	9.05	9.59	
Wheat	Rs/kg	11.65	23.90	
Maize	Rs/kg	14.90	26.37	
Mustard	Rs/kg	30.00	27.33	
Pigeon Peas	Rs/kg	20.00	18.22	
Lentil	Rs/kg	18.50	16.85	
Cauliflower	Rs/kg	550.00	501.05	
Potato	Rs/kg	8.00	7.29	
Onion	Rs/kg	225.00	204.97	
Vegetables (cabbage)	Rs/kg	340.00	309.74	
2. Crops				
Paddy	Rs/ton	5270	10584	
Wheat	Rs/ton	6310	13049	
Maize	Rs/ton	5570	10302	
Mustard (oilseeds)	Rs/ton	20330	20330	
Pigeon Peas	Rs/ton	24230	24230	
Lentil	Rs/ton	21600	21600	
Cauliflower	Rs/ton	7000	7000	
Potato	Rs/ton	3600	3600	
Onion	Rs/ton	8940	8940	
Vegetables (cabbage)	Rs/ton	12060	12060	
3. By-products				
Paddy Straw	Rs/kg	0.50	0.46	
Wheat Straw	Rs/kg	0.25	0.23	
Maize Stalks	Rs/kg	0.25	0.23	
Lentil Stalks	Rs/kg	0.25	0.23	
Mustard Stalks	Rs/kg	0.20	0.18	
4. Fertilizer				
Nitrogen	Rs/kg	12.17	27.91	
Phosphate	Rs/kg	18.08	26.28	
Potash	Rs/kg	14.16	18.57	
Barnyard Manure	Rs/ton	200.00	182.00	
5. Agri-Chemicals				
Parathion	Rs/kg	338.5	308.4	
BHC Dust	Rs/kg	5.9	5.4	
Malathion Dust	Rs/kg	12.6	11.5	
Hinosan	Rs/lit.	463.0	421.8	
2-4D	Rs/kg	203.8	185.7	
6. Farm Labor				
Hired Labor	Rs/day	37	25	
Hired Bullock with Labour	Rs/day	100	68	

Table 1.1.2(1) Cost and Return of Crops(Economic)-Jhapa

District:Jhapa
Crop:Rainfed Paddy-Monsoon

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	22	172	3784	185	4070
Bullock Labor	day	68	41	2788	44	2992
Sub-total				6572		7062
b.Input Cost						
Seed	kg	10.61	62	658	62	658
Manure	kg	0.18	900	162	900	162
Fertilizer						
N	kg	26.32	30	790	40	1053
P	kg	24.68	10	247	20	494
K	kg	17.35	0	0	15	260
Agri-Chemicals	kg		0	60		150
Sub-total				1916		2776
Miscellaneous(5% of total)				447		518
Total Costs				8935		10356
2. Gross Income				24321		36559
a. Main Product	ton	10106	2.33	23547	3.50	35371
b. By-product	ton	360	2.15	774	3.30	1188
3. Net Profit	Rs			15386		26203

District:Jhapa
Crop:Irrigated Paddy(HYV)-Monsson

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	22	179	3938	197	4334
Bullock Labor		68	43	2924	49	3332
Sub-total				6862		7666
b.Input Cost						
Seed	kg	10.61	56	594	56	594
Manure	ton	0.18	1650	297	1650	297
Fertilizer						
N	kg	26.32	46	1211	80	2106
P	kg	24.68	15	370	40	987
K	kg	17.35	10	174	20	347
Agri-Chemicals	kg		0	75		200
Sub-total				2721		4531
Miscellaneous(5% of total)				504		642
Total Costs				10087		12839
2. Gross Income				27781		42152
a. Main Product	ton	10106	2.64	26629	4.00	40424
b. By-product	ton	360	3.20	1152	4.80	1728
3. Net Profit	Rs			17694		29313

District:Jhapa
Crop:Irrigated Paddy(HYV)-Spring Paddy

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1. Production Cost						
a. Labor Cost						
Labor	day	22	100	2200	114	2508
Bullock Labor	day	68	42	2856	47	3196
Sub-total				5056		5704
b. Input Cost						
Seed	kg	10.61	69	732	69	732
Manure	kg	0.18	1090	196	1090	196
Fertilizer						
N	kg	26.32	40	1053	70	1842
P	kg	24.68	15	370	30	740
K	kg	17.35	10	174	20	347
Agri-Chemicals	kg		0	75		200
Sub-total				2600		4058
Miscellaneous(5% of total)				403		514
Total Costs				8059		10276
2. Gross Income				14847		39987
a. Main Product	ton	10106	1.41	14199	3.80	38403
b. By-product	ton	360	1.80	648	4.40	1584
3. Net Profit	Rs			6788		29711

District:Jhapa
Crop:Maize

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1. Production Cost						
a. Labor Cost						
Labor	day	22	133	2926	160	3511
Bullock Labor		68	29	1972	34	2312
Sub-total				4898		5823
b. Input Cost						
Seed	kg	25.12	25	628	25	628
Manure	kg	0.18	2880	518	2880	518
Fertilizer						
N	kg	26.32	25	658	80	2106
P	kg	24.68	10	247	40	987
K	kg	17.35	0	0	20	347
Agri-Chemicals	kg			50		200
Sub-total				2101		4786
Miscellaneous(5% of total)				368		558
Total Costs				7368		11168
2. Gross Income				12815		26412
a. Main Product	kg	9567	1.31	12533	2.70	25831
b. By-product	kg	180	1.57	283	3.23	581
3. Net Profit	Rs			5448		15245

District:Jhapa
Crop:Wheat

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	22	119	2618	140	3080
Bullock Labor	day	68	40	2720	47	3196
Sub-total				5338		6276
b.Input Cost						
Seed	kg	23.9	120	2868	120	2868
Manure	kg	0.18	1700	306	1700	306
Fertilizer						
N	kg	26.32	40	1053	50	1316
P	kg	24.68	18	444	40	987
K	kg	17.35	0	0	20	347
Agri-Chemicals	kg		0	50		150
Sub-total				4721		5974
Miscellaneous(5% of total)				529		645
Total Costs				10588		12895
2. Gross Income				19951		33880
a. Main Product	ton	12312	1.59	19576	2.70	33242
b. By-product	ton	230	1.63	375	2.77	637
3. Net Profit	Rs			9363		20985

District:Jhapa
Crop:Lentil & Pulses

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	22	72	1584	83	1826
Bullock Labor		68	11	748	13	898
Sub-total				2332	0	2724
b.Input Cost						
Seed	kg	16.4	22	361	22	361
Manure	kg	0.18	300	54	300	54
Fertilizer						
N	kg	26.32	15	395	25	658
P	kg	24.68	20	494	40	987
K	kg	17.35	0	0	0	0
Agri-Chemicals	kg		0	0		65
Sub-total				1303		2125
Miscellaneous(5% of total)				191		255
Total Costs				3827		5104
2. Gross Income				9086		16657
a. Main Product	ton	14940	0.60	8964	1.10	16434
b. By-product	ton	230	0.53	122	0.97	223
3. Net Profit	Rs			5259		11553

District:Jhapa
Crop:Mustard(Oilcrops)

	Unit	Unit Price (Rs)	Without Project Quantity	Without Project Value (Rs)	With Project Quantity	With Project Value (Rs)
1. Production Cost						
a. Labor Cost						
Labor	day	22	83	1826	98	2156
Bullock Labor		68	34	2312	38	2584
Sub-total				4138		4740
b. Input Cost						
Seed	kg	21.95	20	439	20	439
Manure	kg	0.18	2500	450	2500	450
Fertilizer						
N	kg	26.32	35	921	50	1316
P	kg	24.68	10	247	40	987
K	kg	17.35	0	0	30	521
Agri-Chemicals	kg		0	0		150
Sub-total				2057		3863
Miscellaneous(5% of total)				326		453
Total Costs				6521		9055
2. Gross Income				14239		18673
a. Main Product	ton	23110	0.61	14097	0.80	18488
b. By-product	ton	180	0.79	142	1.03	185
3. Net Profit	Rs			7718		9618

District:Jhapa
Crop:Potato

	Unit	Unit Price (Rs)	Without Project Quantity	Without Project Value (Rs)	With Project Quantity	With Project Value (Rs)
1. Production Cost						
a. Labor Cost						
Labor	day	22	311	6842	338	7436
Bullock Labor		68	27	1836	31	2108
Sub-total				8678		9544
b. Input Cost						
Seed	kg	9.11	950	8655	950	8655
Manure	kg	0.18	11500	2070	11500	2070
Fertilizer						
N	kg	26.32	300	7896	330	8686
P	kg	24.68	100	2468	110	2715
K	kg	17.35	25	434	28	477
Agri-Chemicals	kg		0	150		300
Sub-total				21672		22902
Miscellaneous(5% of total)				1597		1708
Total Costs				31948		34154
2. Gross Income				35269		46560
a. Main Product	ton	3880	9.09	35269	12.00	46560
b. By-product	ton	0	0	0	0	0
3. Net Profit	Rs			3322		12406

District:Jhapa
Crop:Vegetables(Cauliflower)

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	22	345	7590	385	8470
Bullock Labor		68	25	1700	29	1972
Sub-total				9290		10442
b.Input Cost						
Seed	kg	273.3	0.5	137	0.5	137
Manure	kg	0.18	15000	2700	15000	2700
Fertilizer						
N	kg	26.32	50	1316	100	2632
P	kg	24.68	48	1185	80	1974
K	kg	17.35	25	434	50	868
Agri-Chemicals	kg			150		300
Sub-total				5921		8611
Miscellaneous(5% of total)				801		1003
Total Costs				16012		20055
2. Gross Income				47524		84590
a. Main Product	ton	7690	6.18	47524	11.00	84590
b. By-product	ton	0	0.30	0	0.50	0
3. Net Profit	Rs			31513		64535

Table 1.1.2(2) Cost and Return of Crops(Economic)-Mahottari

District:Mahottari
Crop:Rainfed Paddy-Monsoon

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1. Production Cost						
a. Labor Cost						
Labor	day	24	164	3936	175	4200
Bullock Labor	day	68	44	2992	47	3196
Sub-total				6928		7396
b. Input Cost						
Seed	kg	9.01	64	577	64	577
Manure	kg	0.18	900	162	900	162
Fertilizer						
N	kg	27.17	35	951	40	1087
P	kg	25.35	10	254	20	507
K	kg	18.00	0	0	15	270
Agri-Chemicals			0	0		200
Sub-total				1943		2802
Miscellaneous(5% of total)				467		537
Total Costs				9338		10735
2. Gross Income				24733		30322
a. Main Product	ton	10361	2.29	23675	2.80	29011
b. By-product	ton	460	2.30	1058	2.85	1311
3. Net Profit				15395		19587

District:Mahottari
Crop:Irrigated Paddy(HYV)-Monsson

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1. Production Cost						
a. Labor Cost						
Labor	day	24	159	3816	175	4200
Bullock Labor	day	68	41	2788	47	3196
Sub-total				6604		7396
b. Input Cost						
Seed	kg	9.01	60	541	60	541
Manure	kg	0.18	2100	378	2100	378
Fertilizer						
N	kg	27.17	62	1685	80	2174
P	kg	25.35	20	507	40	1014
K	kg	18.00	10	180	20	360
Agri-Chemicals			0	0		200
Sub-total				3290		4666
Miscellaneous(5% of total)				521		635
Total Costs				10415		12697
2. Gross Income				29231		36837
a. Main Product	ton	10361	2.70	28016	3.40	35227
b. By-product	ton	460	2.64	1214	3.50	1610
3. Net Profit				18816		24140

District:Mahottari

Crop:Irrigated Paddy(HYV)-Spring Paddy

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	24	100	2400	114	2736
Bullock Labor	day	68	42	2856	47	3196
Sub-total				5256		5932
b.Input Cost						
Seed	kg	9.01	60	541	60	541
Manure	kg	0.18	2000	360	2000	360
Fertilizer						
N	kg	27.17	50	1359	70	1902
P	kg	25.35	15	380	30	761
K	kg	18.00	10	180	20	360
Agri-Chemicals			0	0		200
Sub-total				2819		4123
Miscellaneous(5% of total)				425		529
Total Costs				8500		10584
2. Gross Income				32967		38983
a. Main Product	kg	10361	3.05	31601	3.60	37300
b. By-product	kg	460	2.97	1366	3.66	1684
3. Net Profit				24467		28399

District:Mahottari

Crop:Maize

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	24	125	3000	150	3600
Bullock Labor	day	68	32	2176	38	2611
Sub-total				5176		6211
b.Input Cost						
Seed	kg	26.51	28	742	28	742
Manure	kg	0.18	2100	378	2100	378
Fertilizer						
N	kg	27.17	60	1630	80	2174
P	kg	25.35	10	254	30	761
K	kg	18.00	0	0	20	360
Agri-Chemicals				25		200
Sub-total				3029		4614
Miscellaneous(5% of total)				432		570
Total Costs				8637		11395
2. Gross Income				19839		26469
a. Main Product	ton	9959	1.95	19420	2.60	25893
b. By-product	ton	180	2.33	419	3.20	576
3. Net Profit				11203		15074

District:Mahottari
Crop:Wheat

	Unit	Unit Price (Rs)	Without Project Quantity	Without Project Value (Rs)	With Project Quantity	With Project Value (Rs)
1. Production Cost						
a. Labor Cost						
Labor	day	24	98	2352	116	2784
Bullock Labor	day	68	47	3196	55	3740
Sub-total				5548		6524
b. Input Cost						
Seed	kg	21.5	120	2580	120	2580
Manure	kg	0.18	1800	324	1800	324
Fertilizer						
N	kg	27.17	65	1766	70	1902
P	kg	25.35	20	507	40	1014
K	kg	18.00	10	180	20	360
Agri-Chemicals			0	0		200
Sub-total				5357		6380
Miscellaneous(5% of total)				574		679
Total Costs				11479		13583
2. Gross Income				19212		33751
a. Main Product	ton	12704	1.48	18802	2.60	33030
b. By-product	ton	270	1.52	410	2.67	721
3. Net Profit				7733		20168

District:Mahottari
Crop:Lentil & Pulses

	Unit	Unit Price (Rs)	Without Project Quantity	Without Project Value (Rs)	With Project Quantity	With Project Value (Rs)
1. Production Cost						
a. Labor Cost						
Labor	day	24	60	1440	71	1704
Bullock Labor	day	68	12	816	12	816
Sub-total				2256		2520
b. Input Cost						
Seed	kg	16.39	35	574	35	574
Manure	kg	0.18	1200	216	1200	216
Fertilizer						
N	kg	27.17	7	190	25	679
P	kg	25.35	10	254	40	1014
K	kg	18.00	0	0	0	0
Agri-Chemicals	kg		0	0		200
Sub-total				1233		2683
Miscellaneous(5% of total)				184		274
Total Costs				3673		5477
2. Gross Income				9086		16657
a. Main Product	kg	14940	0.60	8964	1.10	16434
b. By-product	kg	230	0.53	122	0.97	223
3. Net Profit				5413		11180

District:Mahottari
Crop:Mustard(Oilcrops)

	Unit	Unit Price (Rs)	Without Project Quantity	Without Project Value (Rs)	With Project Quantity	With Project Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	24	86	2064	112	2688
Bullock Labor	day	68	30	2040	35	2380
Sub-total				4104		5068
b.Input Cost						
Seed	kg	20.04	20	401	20	401
Manure	kg	0.18	2500	450	2500	450
Fertilizer						
N	kg	27.17	35	951	50	1359
P	kg	25.35	10	254	30	761
K	kg	18.00	0	0	30	540
Agri-Chemicals			0	0		200
Sub-total				2055		3710
Miscellaneous(5% of total)				324		462
Total Costs				6483		9240
2. Gross Income				12805		18969
a. Main Product	kg	23480	0.54	12679	0.80	18784
b. By-product	kg	180	0.70	126	1.03	185
3. Net Profit				6322		9730

District:Mahottari
Crop:Potato

	Unit	Unit Price (Rs)	Without Project Quantity	Without Project Value (Rs)	With Project Quantity	With Project Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	24	316	7584	342	8208
Bullock Labor	day	68	42	2856	48	3264
Sub-total				10440		11472
b.Input Cost						
Seed	kg	7.29	990	7217	990	7217
Manure	kg	0.18	15100	2718	15100	2718
Fertilizer						
N	kg	27.17	300	8151	310	8423
P	kg	25.35	100	2535	110	2789
K	kg	18.00	50	900	50	900
Agri-Chemicals			0	0		300
Sub-total				21521		22346
Miscellaneous(5% of total)				1682		1780
Total Costs				33643		35598
2. Gross Income				45662		54360
a. Main Product	ton	4530	10.08	45662	12.00	54360
b. By-product	ton	0	0	0	0	0
3. Net Profit				12019		18762

District:Mahottari
Crop:Vegetables(Cauliflower)

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1. Production Cost						
a. Labor Cost						
Labor	day	24	330	7920	368	8832
Bullock Labor	day	68	23	1564	27	1836
Sub-total				9484		10668
b. Input Cost						
Seed	kg	273.3	0.5	137	0.5	137
Manure	kg	0.18	14500	2610	14500	2610
Fertilizer						
N	kg	27.17	50	1359	100	2717
P	kg	25.35	48	1217	80	2028
K	kg	18.00	25	450	50	900
Agri-Chemicals				300		500
Sub-total				6072		8892
Miscellaneous(5% of total)				819		1029
Total Costs				16375		20589
2. Gross Income				60000		72000
a. Main Product	ton	6000	10.00	60000	12.00	72000
b. By-product	ton	0	0.30	0	0.50	0
3. Net Profit				43625		51411

District:Mahottari
Crop:Onion

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1. Production Cost						
a. Labor Cost						
Labor	day	24	430	10320	480	11520
Bullock Labor	day	68	29	1972	29	1972
Sub-total				12292		13492
b. Input Cost						
Seed	kg	204.9	8.0	1640	8.0	1640
Manure	kg	0.18	30000	5400	30000	5400
Fertilizer						
N	kg	27.17	55	1494	66	1793
P	kg	25.35	45	1141	54	1369
K	kg	18.00	60	1080	70	1260
Agri-Chemicals				500		600
Sub-total				11255		12062
Miscellaneous(5% of total)				1239		1345
Total Costs				24786		26899
2. Gross Income				41400		53820
a. Main Product	ton	4140	10.00	41400	13.00	53820
b. By-product	ton	0	0.00	0	0.50	0
3. Net Profit				16614		26921

Table 1.1.2(3) Cost and Return of Crops (Economic) -Banke

District:Banke
Crop:Rainfed Paddy-Monsoon

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	25	156	3900	165	4125
Bullock Labor	day	68	44	2992	48	3264
Sub-total				6892		7389
b.Input Cost						
Seed	kg	9.59	65	623	65	623
Manure	kg	0.18	570	103	800	144
Fertilizer						
N	kg	27.91	45	1256	40	1116
P	kg	26.28	10	263	20	526
K	kg	18.57	0	0	15	279
Agri-Chemicals			0	0		200
Sub-total				2245		2888
Miscellaneous(5% of total)				481		541
Total Costs				9618		10818
2. Gross Income				21552		28806
a. Main Product	ton	10584	1.95	20586	2.60	27518
b. By-product	ton	460	2.10	966	2.80	1288
3. Net Profit				11934		17989

District:Banke
Crop:Irrigated Paddy(HYV)-Monsson

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	25	162	4050	179	4475
Bullock Labor	day	68	46	3128	55	3740
Sub-total				7178		8215
b.Input Cost						
Seed	kg	9.59	64	614	64	614
Manure	kg	0.18	400	72	400	72
Fertilizer						
N	kg	27.91	50	1396	80	2233
P	kg	26.28	15	394	40	1051
K	kg	18.57	10	186	20	371
Agri-Chemicals			0	0		200
Sub-total				2661		4541
Miscellaneous(5% of total)				518		671
Total Costs				10357		13428
2. Gross Income				23367		38608
a. Main Product	ton	10584	2.12	22438	3.50	37044
b. By-product	ton	460	2.02	929	3.40	1564
3. Net Profit				13010		25180

District:Banke
Crop:Irrigated Paddy(HYV)-Spring Paddy

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1. Production Cost						
a. Labor Cost						
Labor	day					
Bullock Labor	day					
Sub-total						
b. Input Cost						
Seed	kg					
Manure	kg					
Fertilizer						
N	kg					
P	kg					
K	kg					
Agri-Chemicals						
Sub-total						
Miscellaneous(5% of total)						
Total Costs						
2. Gross Income						
a. Main Product	ton					
b. By-product	ton					
3. Net Profit						

District:Banke
Crop:Maize

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1. Production Cost						
a. Labor Cost						
Labor	day	25	132	3300	156	3900
Hired Labor	day	68	39	2652	46	3128
Sub-total				5952		7028
b. Input Cost						
Seed	kg	26.37	26	686	26	686
Manure	kg	0.18	5640	1015	5640	1015
Fertilizer						
N	kg	27.91	10	279	70	1954
P	kg	26.28	10	263	40	1051
K	kg	18.57	0	0	20	371
Agri-Chemicals				0		300
Sub-total				2243		5377
Miscellaneous(5% of total)				431		653
Total Costs				8626		13058
2. Gross Income				17030		27498
a. Main Product	ton	10302	1.61	16586	2.60	26785
b. By-product	ton	230	1.93	444	3.10	713
3. Net Profit				8404		14440

District:Banke
Crop:Wheat

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	25	120	3000	143	3575
Bullock Labor	day	68	39	2652	45	3060
Sub-total				5652		6635
b.Input Cost						
Seed	kg	23.9	125	2988	125	2988
Manure	kg	0.18	975	176	975	176
Fertilizer						
N	kg	27.91	30	837	50	1396
P	kg	26.28	15	394	40	1051
K	kg	18.57	0	0	20	371
Agri-Chemicals			0	0		200
Sub-total				4395		6181
Miscellaneous(5% of total)				529		675
Total Costs				10575		13491
2. Gross Income				18598		27897
a. Main Product	ton	13049	1.40	18269	2.10	27403
b. By-product	ton	230	1.43	329	2.15	495
3. Net Profit				8022		14407

District:Banke
Crop:Lentil & Pulses

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	25	75	1875	90	2250
Bullock Labor	day	68	14	952	16	1088
Sub-total				2827	0	3338
b.Input Cost						
Seed	kg	16.85	23	388	23	388
Manure	kg	0.18	450	81	450	81
Fertilizer						
N	kg	27.91	10	279	25	698
P	kg	26.28	0	0	40	1051
K	kg	18.57	0	0	0	0
Agri-Chemicals			0	0		200
Sub-total				748		2418
Miscellaneous(5% of total)				188		303
Total Costs				3763		6058
2. Gross Income				14826		21807
a. Main Product	ton	21600	0.68	14688	1.00	21600
b. By-product	ton	230	0.60	138	0.90	207
3. Net Profit				11063		15749

District:Banke
Crop:Mustard(Oilcrops)

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	25	110	2750	132	3300
Bullock Labor	day	68	30	2040	36	2448
Sub-total				4790		5748
b.Input Cost						
Seed	kg	27.33	20	547	20	547
Manure	kg	0.18	3600	648	3600	648
Fertilizer						
N	kg	27.91	10	279	50	1396
P	kg	26.28	0	0	40	1051
K	kg	18.57	0	0	30	557
Agri-Chemicals			0	0		200
Sub-total				1474		4398
Miscellaneous(5% of total)				330		534
Total Costs				6593		10680
2. Gross Income				11309		16417
a. Main Product	ton	20330	0.55	11182	0.80	16264
b. By-product	ton	180	0.71	128	0.85	153
3. Net Profit				4716		5737

District:Banke
Crop:Potato

	Unit	Unit Price (Rs)	Without Project Quant-ity	Without Project Value (Rs)	With Project Quant-ity	With Project Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	25	367	9175	390	9750
Bullock Labor	day	68	50	3400	59	4012
Sub-total				12575		13762
b.Input Cost						
Seed	kg	7.29	560	4082	560	4082
Manure	kg	0.18	8000	1440	8000	1440
Fertilizer						
N	kg	27.91	40	1116	45	1256
P	kg	26.28	20	526	22	578
K	kg	18.57	0	0	0	0
Agri-Chemicals			0	0		300
Sub-total				7164		7657
Miscellaneous(5% of total)				1039		1127
Total Costs				20778		22546
2. Gross Income				43128		50400
a. Main Product	ton	3600	11.98	43128	14.00	50400
b. By-product	ton	0	0	0	0	0
3. Net Profit				22350		27854

District:Banke
Crop:Vegetables(Cauliflower)

	Unit	Unit Price (Rs)	Without Project		With Project	
			Quant-ity	Value (Rs)	Quant-ity	Value (Rs)
1.Production Cost						
a.Labor Cost						
Labor	day	25	320	8000	356	8900
Bullock Labor	day	68	25	1700	29	1972
Sub-total				9700		10872
b.Input Cost						
Seed	kg	501	0.5	251	0.5	251
Manure	kg	0.18	15000	2700	15000	2700
Fertilizer				0		
N	kg	27.91	50	1396	80	2233
P	kg	26.28	48	1261	70	1840
K	kg	18.57	25	464	40	743
Agri-Chemicals				500		300
Sub-total				6572		8066
Miscellaneous(5% of total)				856		997
Total Costs				17128		19934
2. Gross Income				62020		77000
a. Main Product	ton	7000	8.86	62020	11.00	77000
b. By-product	ton	0	0.50	0	0.80	0
3. Net Profit				44892		57066

Table 1.1.3(1) Incremental Agricultural Benefit(Jhapa)

	M. Paddy Rainfed	M.Paddy Irrigated	S.Paddy Irrigated	Maize	Wheat	Miscellaneous (Mustard)	Total
Without Project							
Yield(ton/ha)	2.33	-	-	1.31	1.59	-	
Price(Rs/ton)	10,106	-	-	9,567	12,312	-	
GPV(RS/ha)	24,321	-	-	12,815	19,951	-	
Production Cost(Rs/ha)	8,935	-	-	7,368	10,588	-	
NPV(Rs/ha)	15,386	-	-	5,447	9,363	-	
Cropping Area(ha)	90	-	-	10	26	-	126
Total NPV(RS1000)	1,385	-	-	54	243	-	1,683
With Project							
Yield(ton/ha)	-	4.00	3.80	2.70	2.70	0.80	
Price(Rs/ton)	-	10,106	10,106	9,567	12,312	23,110	
GPV(RS/ha)	-	42,152	39,987	26,412	33,880	18,673	
Production Cost(Rs/ha)	-	12,839	10,276	11,168	12,895	9,055	
NPV(Rs/ha)	-	29,313	29,711	15,244	20,985	9,618	
Cropping Area(ha)	-	100	40	15	30	15	200
Total NPV(RS1000)	-	2,931	1,188	229	630	144	5,122
Incremental NPV(Rs1000)	-1,385	2,931	1,188	174	386	144	3,440

Note:GVP includes income from by-products

Table 1.1.3(2) Incremental Agricultural Benefit(Mahottari)

	M.Paddy Rainfed	M.Paddy Irrigated	S.Paddy Irrigated	Wheat	Pulses (Lentil)	Onion	Potato	Others (Oilseeds)	Total
Without Project									
Yield(ton/ha)	2.29	-	-	1.48	0.60	-	-	0.54	
Price(Rs/ton)	10,361	-	-	12,704	14,940	-	-	23,480	
GPV(RS/ha)	24,733	-	-	19,212	9,086	-	-	12,805	
Production Cost(Rs/ha)	9,338	-	-	11,479	3,673	-	-	6,483	
NPV(Rs/ha)	15,395	-	-	7,733	5,413	-	-	6,322	
Cropping Area(ha)	90	-	-	20	20	-	-	10	140
Total NPV(RS1000)	1,386	-	-	155	108	-	-	63	1,712
With Project									
Yield(ton/ha)	-	3.40	3.60	2.60	-	13.00	12.00	-	
Price(Rs/ton)	-	10,361	10,361	12,704	-	4,140	4,530	-	
GPV(RS/ha)	-	36,837	38,983	33,751	-	53,820	54,360	-	
Production Cost(Rs/ha)	-	12,697	10,584	13,583	-	26,899	35,598	-	
NPV(Rs/ha)	-	24,140	28,399	20,168	-	26,921	18,762	-	
Cropping Area(ha)	-	100	10	49	-	19	22	-	200
Total NPV(RS1000)	-	2,414	284	988	-	511	413	-	4,610
Incremental NPV(Rs1000)	-1,386	2,414	284	834	-108	511	413	-63	2,899

Note:GVP includes income from by-products

Table 1.1.3(3) Incremental Agricultural Benefit(Banke)

	M.Paddy Rainfed	M.Paddy Irrigated	Maize	Mustard	Wheat	Pulses (Lentil)	Potato	Others (Cauliflower)	Total
Without Project									
Yield(ton/ha)	1.95	-	1.61	0.55	1.40	0.68	-	-	
Price(Rs/ton)	10,584	-	10,302	20,330	13,049	21,600	-	-	
GPV(RS/ha)	21,552	-	17,030	11,309	18,598	14,826	-	-	
Production Cost(Rs/ha)	9,618	-	8,626	6,593	10,575	3,763	-	-	
NPV(Rs/ha)	11,934	-	8,404	4,716	8,023	11,063	-	-	
Cropping Area(ha)	80	-	10	10	30	10	-	-	140
Total NPV(RS1000)	955	-	84	47	241	111	-	-	1,437
With Project									
Yield(ton/ha)	-	3.50	2.60	0.8	2.10	1.00	14.00	11.00	
Price(Rs/ton)	-	10,584	10,302	20,330	13,049	21,600	5,420	7,000	
GPV(RS/ha)	-	38,608	27,498	16,417	27,897	21,807	75,880	77,000	
Production Cost(Rs/ha)	-	13,428	13,058	10,680	13,491	6,058	22,546	19,934	
NPV(Rs/ha)	-	25,180	14,440	5,737	14,406	15,749	53,334	57,066	
Cropping Area(ha)	-	87	15	13	50	17	15	3	200
Total NPV(RS1000)	-	2,191	217	75	720	268	800	171	4,441
Incremental NPV(Rs1000)	-955	2,191	133	27	480	157	800	171	3,004

Note:GVP includes income from by-products

Table 1.1.4(1)

Calculation of EIRR-Jhapa Representative Area-Case-1(90 lit/sec)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV		NPV		NPV	
						Int.= 0.1		Int.= 0.2		Int.= 0.25	
						Cost	Benefit	Cost	Benefit	Cost	Benefit
1	14030	0	14030	0	-14030	14030.0	0.0	14030.0	0.0	14030.0	0.0
2	0	225	225	1514	1289	186.0	1250.9	156.3	1051.1	144.0	968.7
3	0	225	225	1823	1598	169.0	1369.8	130.2	1055.1	115.2	933.5
4	0	225	225	2236	2011	153.7	1527.2	108.5	1078.3	92.2	915.9
5	0	225	225	2546	2321	139.7	1580.6	90.4	1023.0	73.7	834.1
6	0	225	225	2786	2561	127.0	1572.9	75.4	933.2	59.0	730.4
7	0	225	225	2993	2768	115.5	1535.8	62.8	835.2	47.2	627.6
8	0	225	225	3130	2905	105.0	1460.4	52.3	728.0	37.7	525.2
9	0	225	225	3234	3009	95.4	1371.4	43.6	626.7	30.2	434.0
10	484	225	709	3302	2593	273.4	1273.2	114.5	533.4	76.1	354.6
11	0	225	225	3354	3129	78.9	1175.6	30.3	451.4	19.3	288.1
12	0	225	225	3378	3153	71.7	1076.4	25.2	378.9	15.5	232.1
13	0	225	225	3440	3215	65.2	996.4	21.0	321.5	12.4	189.1
14	0	225	225	3440	3215	59.2	905.9	17.5	267.9	9.9	151.3
15	1290	225	1515	3440	1925	362.7	823.5	98.3	223.3	53.3	121.0
16	0	225	225	3440	3215	49.0	748.6	12.2	186.1	6.3	96.8
17	0	225	225	3440	3215	44.5	680.6	10.1	155.1	5.1	77.5
18	0	225	225	3440	3215	40.5	618.7	8.5	129.2	4.1	62.0
19	0	225	225	3440	3215	36.8	562.5	7.0	107.7	3.2	49.6
20	1157	225	1382	3440	2058	205.4	511.3	36.0	89.7	15.9	39.7
21	0	225	225	3440	3215	30.4	464.8	4.9	74.8	2.1	31.7
22	0	225	225	3440	3215	27.6	422.6	4.1	62.3	1.7	25.4
23	0	225	225	3440	3215	25.1	384.2	3.4	51.9	1.3	20.3
24	0	225	225	3440	3215	22.8	349.2	2.8	43.3	1.1	16.2
25	0	225	225	3440	3215	20.8	317.5	2.4	36.1	0.9	13.0
26	0	225	225	3440	3215	18.9	288.6	2.0	30.1	0.7	10.4
27	0	225	225	3440	3215	17.2	262.4	1.6	25.0	0.5	8.3
28	0	225	225	3440	3215	15.6	238.5	1.4	20.9	0.4	6.7
29	0	225	225	3440	3215	14.2	216.9	1.1	17.4	0.3	5.3
30	1774	225	1999	3440	1441	114.6	197.1	8.4	14.5	2.5	4.3
31	0	225	225	3440	3215	11.7	179.2	0.8	12.1	0.2	3.4
32	0	225	225	3440	3215	10.7	162.9	0.7	10.1	0.2	2.7
33	0	225	225	3440	3215	9.7	148.1	0.5	8.4	0.1	2.2
34	0	225	225	3440	3215	8.8	134.7	0.5	7.0	0.1	1.7
35	0	225	225	3440	3215	8.0	122.4	0.4	5.8	0.1	1.4
36	0	225	225	3440	3215	7.3	111.3	0.3	4.9	0.1	1.1
37	0	225	225	3440	3215	6.6	101.2	0.3	4.0	0.1	0.9
38	0	225	225	3440	3215	6.0	92.0	0.2	3.4	0.0	0.7
39	0	225	225	3440	3215	5.5	83.6	0.2	2.8	0.0	0.6
40	1157	225	1382	3440	2058	30.5	76.0	0.9	2.3	0.2	0.5
41	0	225	225	3440	3215	4.5	69.1	0.1	2.0	0.0	0.4
42	0	225	225	3440	3215	4.1	62.8	0.1	1.6	0.0	0.3
43	0	225	225	3440	3215	3.7	57.1	0.1	1.4	0.0	0.2
44	0	225	225	3440	3215	3.4	51.9	0.1	1.1	0.0	0.2
45	1290	225	1515	3440	1925	20.8	47.2	0.4	0.9	0.1	0.1
46	0	225	225	3440	3215	2.8	42.9	0.1	0.8	0.0	0.1
47	0	225	225	3440	3215	2.6	39.0	0.0	0.7	0.0	0.1
48	0	225	225	3440	3215	2.3	35.5	0.0	0.5	0.0	0.1
49	0	225	225	3440	3215	2.1	32.2	0.0	0.5	0.0	0.1
50	484	225	709	3440	2731	6.0	29.3	0.1	0.4	0.0	0.0
Total						16872.7	25861.9	15168.1	10621.5	14863.1	7789.7

EIRR = 16.77

B/C at 10%= 1.53

Calculation of EIRR-Jhapa Representative Area-Case-2(45 lit/sec)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV Int. = 0.1		NPV Int. = 0.2		NPV Int. = 0.25	
						Cost	Benefit	Cost	Benefit	Cost	Benefit
1	16683	0	16683	0	-16683	16683.0	0.0	16683.0	0.0	16683.0	0.0
2	0	322	322	1514	1192	266.1	1250.9	223.6	1051.1	206.1	968.7
3	0	322	322	1823	1501	241.9	1369.8	186.3	1055.1	164.9	933.5
4	0	322	322	2236	1914	219.9	1527.2	155.3	1078.3	131.9	915.9
5	0	322	322	2546	2224	199.9	1580.6	129.4	1023.0	105.5	834.1
6	0	322	322	2786	2464	181.8	1572.9	107.8	933.2	84.4	730.4
7	0	322	322	2993	2671	165.2	1535.8	89.9	835.2	67.5	627.6
8	0	322	322	3130	2808	150.2	1460.4	74.9	728.0	54.0	525.2
9	0	322	322	3234	2912	136.6	1371.4	62.4	626.7	43.2	434.0
10	484	322	806	3302	2496	310.7	1273.2	130.2	533.4	86.5	354.6
11	0	322	322	3354	3032	112.9	1175.6	43.3	451.4	27.7	288.1
12	0	322	322	3378	3056	102.6	1076.4	36.1	378.9	22.1	232.1
13	0	322	322	3440	3118	93.3	996.4	30.1	321.5	17.7	189.1
14	0	322	322	3440	3118	84.8	905.9	25.1	267.9	14.2	151.3
15	1313	322	1635	3440	1805	391.4	823.5	106.1	223.3	57.5	121.0
16	0	322	322	3440	3118	70.1	748.6	17.4	186.1	9.1	96.8
17	0	322	322	3440	3118	63.7	680.6	14.5	155.1	7.3	77.5
18	0	322	322	3440	3118	57.9	618.7	12.1	129.2	5.8	62.0
19	0	322	322	3440	3118	52.6	562.5	10.1	107.7	4.6	49.6
20	1561	322	1883	3440	1557	279.9	511.3	49.1	89.7	21.7	39.7
21	0	322	322	3440	3118	43.5	464.8	7.0	74.8	3.0	31.7
22	0	322	322	3440	3118	39.6	422.6	5.8	62.3	2.4	25.4
23	0	322	322	3440	3118	36.0	384.2	4.9	51.9	1.9	20.3
24	0	322	322	3440	3118	32.7	349.2	4.1	43.3	1.5	16.2
25	0	322	322	3440	3118	29.7	317.5	3.4	36.1	1.2	13.0
26	0	322	322	3440	3118	27.0	288.6	2.8	30.1	1.0	10.4
27	0	322	322	3440	3118	24.6	262.4	2.3	25.0	0.8	8.3
28	0	322	322	3440	3118	22.3	238.5	2.0	20.9	0.6	6.7
29	0	322	322	3440	3118	20.3	216.9	1.6	17.4	0.5	5.3
30	1797	322	2119	3440	1321	121.4	197.1	8.9	14.5	2.6	4.3
31	0	322	322	3440	3118	16.8	179.2	1.1	12.1	0.3	3.4
32	0	322	322	3440	3118	15.3	162.9	0.9	10.1	0.3	2.7
33	0	322	322	3440	3118	13.9	148.1	0.8	8.4	0.2	2.2
34	0	322	322	3440	3118	12.6	134.7	0.7	7.0	0.2	1.7
35	0	322	322	3440	3118	11.5	122.4	0.5	5.8	0.1	1.4
36	0	322	322	3440	3118	10.4	111.3	0.5	4.9	0.1	1.1
37	0	322	322	3440	3118	9.5	101.2	0.4	4.0	0.1	0.9
38	0	322	322	3440	3118	8.6	92.0	0.3	3.4	0.1	0.7
39	0	322	322	3440	3118	7.8	83.6	0.3	2.8	0.1	0.6
40	1561	322	1883	3440	1557	41.6	76.0	1.3	2.3	0.3	0.5
41	0	322	322	3440	3118	6.5	69.1	0.2	2.0	0.0	0.4
42	0	322	322	3440	3118	5.9	62.8	0.2	1.6	0.0	0.3
43	0	322	322	3440	3118	5.3	57.1	0.1	1.4	0.0	0.2
44	0	322	322	3440	3118	4.9	51.9	0.1	1.1	0.0	0.2
45	1313	322	1635	3440	1805	22.4	47.2	0.4	0.9	0.1	0.1
46	0	322	322	3440	3118	4.0	42.9	0.1	0.8	0.0	0.1
47	0	322	322	3440	3118	3.7	39.0	0.1	0.7	0.0	0.1
48	0	322	322	3440	3118	3.3	35.5	0.1	0.5	0.0	0.1
49	0	322	322	3440	3118	3.0	32.2	0.0	0.5	0.0	0.1
50	484	322	806	3440	2634	6.9	29.3	0.1	0.4	0.0	0.0
Total						20475.4	25861.9	18237.6	10621.5	17832.0	7789.7

EIRR = 13.94

B/C at 10%= 1.26

Calculation of EIRR-Jhapa Representative Area-Case-3(30 lit/sec)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV Int.= 0.1		NPV Int.= 0.2		NPV Int.= 0.25	
						Cost	Benefit	Cost	Benefit	Cost	Benefit
1	19666	0	19666	0	-19666	19666.0	0.0	19666.0	0.0	19666.0	0.0
2	0	386	386	1514	1128	319.0	1250.9	268.1	1051.1	247.0	968.7
3	0	386	386	1823	1437	290.0	1369.8	223.4	1055.1	197.6	933.5
4	0	386	386	2236	1850	263.6	1527.2	186.1	1078.3	158.1	915.9
5	0	386	386	2546	2160	239.7	1580.6	155.1	1023.0	126.5	834.1
6	0	386	386	2786	2400	217.9	1572.9	129.3	933.2	101.2	730.4
7	0	386	386	2993	2607	198.1	1535.8	107.7	835.2	81.0	627.6
8	0	386	386	3130	2744	180.1	1460.4	89.8	728.0	64.8	525.2
9	0	386	386	3234	2848	163.7	1371.4	74.8	626.7	51.8	434.0
10	484	386	870	3302	2432	335.4	1273.2	140.5	533.4	93.4	354.6
11	0	386	386	3354	2968	135.3	1175.6	52.0	451.4	33.2	288.1
12	0	386	386	3378	2992	123.0	1076.4	43.3	378.9	26.5	232.1
13	0	386	386	3440	3054	111.8	996.4	36.1	321.5	21.2	189.1
14	0	386	386	3440	3054	101.6	905.9	30.1	267.9	17.0	151.3
15	1313	386	1699	3440	1741	406.7	823.5	110.3	223.3	59.8	121.0
16	0	386	386	3440	3054	84.0	748.6	20.9	186.1	10.9	96.8
17	0	386	386	3440	3054	76.4	680.6	17.4	155.1	8.7	77.5
18	0	386	386	3440	3054	69.4	618.7	14.5	129.2	7.0	62.0
19	0	386	386	3440	3054	63.1	562.5	12.1	107.7	5.6	49.6
20	2099	386	2485	3440	955	369.4	511.3	64.8	89.7	28.7	39.7
21	0	386	386	3440	3054	52.2	464.8	8.4	74.8	3.6	31.7
22	0	386	386	3440	3054	47.4	422.6	7.0	62.3	2.8	25.4
23	0	386	386	3440	3054	43.1	384.2	5.8	51.9	2.3	20.3
24	0	386	386	3440	3054	39.2	349.2	4.9	43.3	1.8	16.2
25	0	386	386	3440	3054	35.6	317.5	4.0	36.1	1.5	13.0
26	0	386	386	3440	3054	32.4	288.6	3.4	30.1	1.2	10.4
27	0	386	386	3440	3054	29.4	262.4	2.8	25.0	0.9	8.3
28	0	386	386	3440	3054	26.8	238.5	2.3	20.9	0.7	6.7
29	0	386	386	3440	3054	24.3	216.9	2.0	17.4	0.6	5.3
30	1797	386	2183	3440	1257	125.1	197.1	9.2	14.5	2.7	4.3
31	0	386	386	3440	3054	20.1	179.2	1.4	12.1	0.4	3.4
32	0	386	386	3440	3054	18.3	162.9	1.1	10.1	0.3	2.7
33	0	386	386	3440	3054	16.6	148.1	0.9	8.4	0.2	2.2
34	0	386	386	3440	3054	15.1	134.7	0.8	7.0	0.2	1.7
35	0	386	386	3440	3054	13.7	122.4	0.7	5.8	0.2	1.4
36	0	386	386	3440	3054	12.5	111.3	0.5	4.9	0.1	1.1
37	0	386	386	3440	3054	11.4	101.2	0.5	4.0	0.1	0.9
38	0	386	386	3440	3054	10.3	92.0	0.4	3.4	0.1	0.7
39	0	386	386	3440	3054	9.4	83.6	0.3	2.8	0.1	0.6
40	2099	386	2485	3440	955	54.9	76.0	1.7	2.3	0.3	0.5
41	0	386	386	3440	3054	7.8	69.1	0.2	2.0	0.0	0.4
42	0	386	386	3440	3054	7.0	62.8	0.2	1.6	0.0	0.3
43	0	386	386	3440	3054	6.4	57.1	0.2	1.4	0.0	0.2
44	0	386	386	3440	3054	5.8	51.9	0.1	1.1	0.0	0.2
45	1313	386	1699	3440	1741	23.3	47.2	0.5	0.9	0.1	0.1
46	0	386	386	3440	3054	4.8	42.9	0.1	0.8	0.0	0.1
47	0	386	386	3440	3054	4.4	39.0	0.1	0.7	0.0	0.1
48	0	386	386	3440	3054	4.0	35.5	0.1	0.5	0.0	0.1
49	0	386	386	3440	3054	3.6	32.2	0.1	0.5	0.0	0.1
50	484	386	870	3440	2570	7.4	29.3	0.1	0.4	0.0	0.0
Total						24126.6	25861.9	21501.7	10621.5	21026.1	7789.7

EIRR = 11.75

B/C at 10%= 1.07

Table 1.1.4(2)
Calculation of EIRR-Mahottari-Case-1(90 lit/sec)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV Int.= 0.1		NPV Int.= 0.2		NPV Int.= 0.25	
						Cost	Benefit	Cost	Benefit	Cost	Benefit
1	14030	0	14030	0	-14030	14030.0	0.0	14030.0	0.0	14030.0	0.0
2	0	225	225	1305	1080	186.0	1078.1	156.3	905.9	144.0	834.9
3	0	225	225	1884	1659	169.0	1415.7	130.2	1090.5	115.2	964.8
4	0	225	225	2319	2094	153.7	1584.0	108.5	1118.4	92.2	949.9
5	0	225	225	2609	2384	139.7	1620.0	90.4	1048.5	73.7	854.9
6	0	225	225	2754	2529	127.0	1554.6	75.4	922.3	59.0	722.0
7	0	225	225	2827	2602	115.5	1450.5	62.8	788.8	47.2	592.8
8	0	225	225	2899	2674	105.0	1352.4	52.3	674.2	37.7	486.4
9	0	225	225	2899	2674	95.4	1229.5	43.6	561.8	30.2	389.1
10	484	225	709	2899	2190	273.4	1117.7	114.5	468.2	76.1	311.3
11	0	225	225	2899	2674	78.9	1016.1	30.3	390.2	19.3	249.0
12	0	225	225	2899	2674	71.7	923.7	25.2	325.1	15.5	199.2
13	0	225	225	2899	2674	65.2	839.7	21.0	271.0	12.4	159.4
14	0	225	225	2899	2674	59.2	763.4	17.5	225.8	9.9	127.5
15	1290	225	1515	2899	1384	362.7	694.0	98.3	188.2	53.3	102.0
16	0	225	225	2899	2674	49.0	630.9	12.2	156.8	6.3	81.6
17	0	225	225	2899	2674	44.5	573.6	10.1	130.7	5.1	65.3
18	0	225	225	2899	2674	40.5	521.4	8.5	108.9	4.1	52.2
19	0	225	225	2899	2674	36.8	474.0	7.0	90.7	3.2	41.8
20	1157	225	1382	2899	1517	205.4	430.9	36.0	75.6	15.9	33.4
21	0	225	225	2899	2674	30.4	391.7	4.9	63.0	2.1	26.7
22	0	225	225	2899	2674	27.6	356.1	4.1	52.5	1.7	21.4
23	0	225	225	2899	2674	25.1	323.8	3.4	43.8	1.3	17.1
24	0	225	225	2899	2674	22.8	294.3	2.8	36.5	1.1	13.7
25	0	225	225	2899	2674	20.8	267.6	2.4	30.4	0.9	11.0
26	0	225	225	2899	2674	18.9	243.2	2.0	25.3	0.7	8.8
27	0	225	225	2899	2674	17.2	221.1	1.6	21.1	0.5	7.0
28	0	225	225	2899	2674	15.6	201.0	1.4	17.6	0.4	5.6
29	0	225	225	2899	2674	14.2	182.8	1.1	14.7	0.3	4.5
30	1774	225	1999	2899	900	114.6	166.1	8.4	12.2	2.5	3.6
31	0	225	225	2899	2674	11.7	151.0	0.8	10.2	0.2	2.9
32	0	225	225	2899	2674	10.7	137.3	0.7	8.5	0.2	2.3
33	0	225	225	2899	2674	9.7	124.8	0.5	7.1	0.1	1.8
34	0	225	225	2899	2674	8.8	113.5	0.5	5.9	0.1	1.5
35	0	225	225	2899	2674	8.0	103.2	0.4	4.9	0.1	1.2
36	0	225	225	2899	2674	7.3	93.8	0.3	4.1	0.1	0.9
37	0	225	225	2899	2674	6.6	85.3	0.3	3.4	0.1	0.8
38	0	225	225	2899	2674	6.0	77.5	0.2	2.8	0.0	0.6
39	0	225	225	2899	2674	5.5	70.5	0.2	2.4	0.0	0.5
40	1157	225	1382	2899	1517	30.5	64.1	0.9	2.0	0.2	0.4
41	0	225	225	2899	2674	4.5	58.2	0.1	1.6	0.0	0.3
42	0	225	225	2899	2674	4.1	52.9	0.1	1.4	0.0	0.2
43	0	225	225	2899	2674	3.7	48.1	0.1	1.1	0.0	0.2
44	0	225	225	2899	2674	3.4	43.7	0.1	1.0	0.0	0.2
45	1290	225	1515	2899	1384	20.8	39.8	0.4	0.8	0.1	0.1
46	0	225	225	2899	2674	2.8	36.2	0.1	0.7	0.0	0.1
47	0	225	225	2899	2674	2.6	32.9	0.0	0.6	0.0	0.1
48	0	225	225	2899	2674	2.3	29.9	0.0	0.5	0.0	0.1
49	0	225	225	2899	2674	2.1	27.2	0.0	0.4	0.0	0.1
50	484	225	709	2899	2190	6.0	24.7	0.1	0.3	0.0	0.0
Total						16872.7	23332.5	15168.1	9918.3	14863.1	7351.0

EIRR = 15.51

B/C at 10%= 1.38

Calculation of EIRR-Mahottari-Case-2(45 lit/sec)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV Int.= 0.1		NPV Int.= 0.2		NPV Int.= 0.25	
						Cost	Benefit	Cost	Benefit	Cost	Benefit
1	16683	0	16683	0	-16683	16683.0	0.0	16683.0	0.0	16683.0	0.0
2	0	322	322	1305	983	266.1	1078.1	223.6	905.9	206.1	834.9
3	0	322	322	1884	1562	241.9	1415.7	186.3	1090.5	164.9	964.8
4	0	322	322	2319	1997	219.9	1584.0	155.3	1118.4	131.9	949.9
5	0	322	322	2609	2287	199.9	1620.0	129.4	1048.5	105.5	854.9
6	0	322	322	2754	2432	181.8	1554.6	107.8	922.3	84.4	722.0
7	0	322	322	2827	2505	165.2	1450.5	89.9	788.8	67.5	592.8
8	0	322	322	2899	2577	150.2	1352.4	74.9	674.2	54.0	486.4
9	0	322	322	2899	2577	136.6	1229.5	62.4	561.8	43.2	389.1
10	484	322	806	2899	2093	310.7	1117.7	130.2	468.2	86.5	311.3
11	0	322	322	2899	2577	112.9	1016.1	43.3	390.2	27.7	249.0
12	0	322	322	2899	2577	102.6	923.7	36.1	325.1	22.1	199.2
13	0	322	322	2899	2577	93.3	839.7	30.1	271.0	17.7	159.4
14	0	322	322	2899	2577	84.8	763.4	25.1	225.8	14.2	127.5
15	1313	322	1635	2899	1264	391.4	694.0	106.1	188.2	57.5	102.0
16	0	322	322	2899	2577	70.1	630.9	17.4	156.8	9.1	81.6
17	0	322	322	2899	2577	63.7	573.6	14.5	130.7	7.3	65.3
18	0	322	322	2899	2577	57.9	521.4	12.1	108.9	5.8	52.2
19	0	322	322	2899	2577	52.6	474.0	10.1	90.7	4.6	41.8
20	1561	322	1883	2899	1016	279.9	430.9	49.1	75.6	21.7	33.4
21	0	322	322	2899	2577	43.5	391.7	7.0	63.0	3.0	26.7
22	0	322	322	2899	2577	39.6	356.1	5.8	52.5	2.4	21.4
23	0	322	322	2899	2577	36.0	323.8	4.9	43.8	1.9	17.1
24	0	322	322	2899	2577	32.7	294.3	4.1	36.5	1.5	13.7
25	0	322	322	2899	2577	29.7	267.6	3.4	30.4	1.2	11.0
26	0	322	322	2899	2577	27.0	243.2	2.8	25.3	1.0	8.8
27	0	322	322	2899	2577	24.6	221.1	2.3	21.1	0.8	7.0
28	0	322	322	2899	2577	22.3	201.0	2.0	17.6	0.6	5.6
29	0	322	322	2899	2577	20.3	182.8	1.6	14.7	0.5	4.5
30	1797	322	2119	2899	780	121.4	166.1	8.9	12.2	2.6	3.6
31	0	322	322	2899	2577	16.8	151.0	1.1	10.2	0.3	2.9
32	0	322	322	2899	2577	15.3	137.3	0.9	8.5	0.3	2.3
33	0	322	322	2899	2577	13.9	124.8	0.8	7.1	0.2	1.8
34	0	322	322	2899	2577	12.6	113.5	0.7	5.9	0.2	1.5
35	0	322	322	2899	2577	11.5	103.2	0.5	4.9	0.1	1.2
36	0	322	322	2899	2577	10.4	93.8	0.5	4.1	0.1	0.9
37	0	322	322	2899	2577	9.5	85.3	0.4	3.4	0.1	0.8
38	0	322	322	2899	2577	8.6	77.5	0.3	2.8	0.1	0.6
39	0	322	322	2899	2577	7.8	70.5	0.3	2.4	0.1	0.5
40	1561	322	1883	2899	1016	41.6	64.1	1.3	2.0	0.3	0.4
41	0	322	322	2899	2577	6.5	58.2	0.2	1.6	0.0	0.3
42	0	322	322	2899	2577	5.9	52.9	0.2	1.4	0.0	0.2
43	0	322	322	2899	2577	5.3	48.1	0.1	1.1	0.0	0.2
44	0	322	322	2899	2577	4.9	43.7	0.1	1.0	0.0	0.2
45	1313	322	1635	2899	1264	22.4	39.8	0.4	0.8	0.1	0.1
46	0	322	322	2899	2577	4.0	36.2	0.1	0.7	0.0	0.1
47	0	322	322	2899	2577	3.7	32.9	0.1	0.6	0.0	0.1
48	0	322	322	2899	2577	3.3	29.9	0.1	0.5	0.0	0.1
49	0	322	322	2899	2577	3.0	27.2	0.0	0.4	0.0	0.1
50	484	322	806	2899	2093	6.9	24.7	0.1	0.3	0.0	0.0
Total						20475.4	23332.5	18237.6	9918.3	17832.0	7351.0

EIRR = 12.69

B/C at 10%= 1.14

Calculation of EIRR-Mahottari-Case-3(30 lit/sec)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV		NPV		NPV	
						Int.=	0.1	Int.=	0.2	Int.=	0.25
						Cost	Benefit	Cost	Benefit	Cost	Benefit
1	19666	0	19666	0	-19666	19666.0	0.0	19666.0	0.0	19666.0	0.0
2	0	386	386	1305	919	319.0	1078.1	268.1	905.9	247.0	834.9
3	0	386	386	1884	1498	290.0	1415.7	223.4	1090.5	197.6	964.8
4	0	386	386	2319	1933	263.6	1584.0	186.1	1118.4	158.1	949.9
5	0	386	386	2609	2223	239.7	1620.0	155.1	1048.5	126.5	854.9
6	0	386	386	2754	2368	217.9	1554.6	129.3	922.3	101.2	722.0
7	0	386	386	2827	2441	198.1	1450.5	107.7	788.8	81.0	592.8
8	0	386	386	2899	2513	180.1	1352.4	89.8	674.2	64.8	486.4
9	0	386	386	2899	2513	163.7	1229.5	74.8	561.8	51.8	389.1
10	484	386	870	2899	2029	335.4	1117.7	140.5	468.2	93.4	311.3
11	0	386	386	2899	2513	135.3	1016.1	52.0	390.2	33.2	249.0
12	0	386	386	2899	2513	123.0	923.7	43.3	325.1	26.5	199.2
13	0	386	386	2899	2513	111.8	839.7	36.1	271.0	21.2	159.4
14	0	386	386	2899	2513	101.6	763.4	30.1	225.8	17.0	127.5
15	1313	386	1699	2899	1200	406.7	694.0	110.3	188.2	59.8	102.0
16	0	386	386	2899	2513	84.0	630.9	20.9	156.8	10.9	81.6
17	0	386	386	2899	2513	76.4	573.6	17.4	130.7	8.7	65.3
18	0	386	386	2899	2513	69.4	521.4	14.5	108.9	7.0	52.2
19	0	386	386	2899	2513	63.1	474.0	12.1	90.7	5.6	41.8
20	2099	386	2485	2899	414	369.4	430.9	64.8	75.6	28.7	33.4
21	0	386	386	2899	2513	52.2	391.7	8.4	63.0	3.6	26.7
22	0	386	386	2899	2513	47.4	356.1	7.0	52.5	2.8	21.4
23	0	386	386	2899	2513	43.1	323.8	5.8	43.8	2.3	17.1
24	0	386	386	2899	2513	39.2	294.3	4.9	36.5	1.8	13.7
25	0	386	386	2899	2513	35.6	267.6	4.0	30.4	1.5	11.0
26	0	386	386	2899	2513	32.4	243.2	3.4	25.3	1.2	8.8
27	0	386	386	2899	2513	29.4	221.1	2.8	21.1	0.9	7.0
28	0	386	386	2899	2513	26.8	201.0	2.3	17.6	0.7	5.6
29	0	386	386	2899	2513	24.3	182.8	2.0	14.7	0.6	4.5
30	1797	386	2183	2899	716	125.1	166.1	9.2	12.2	2.7	3.6
31	0	386	386	2899	2513	20.1	151.0	1.4	10.2	0.4	2.9
32	0	386	386	2899	2513	18.3	137.3	1.1	8.5	0.3	2.3
33	0	386	386	2899	2513	16.6	124.8	0.9	7.1	0.2	1.8
34	0	386	386	2899	2513	15.1	113.5	0.8	5.9	0.2	1.5
35	0	386	386	2899	2513	13.7	103.2	0.7	4.9	0.2	1.2
36	0	386	386	2899	2513	12.5	93.8	0.5	4.1	0.1	0.9
37	0	386	386	2899	2513	11.4	85.3	0.5	3.4	0.1	0.8
38	0	386	386	2899	2513	10.3	77.5	0.4	2.8	0.1	0.6
39	0	386	386	2899	2513	9.4	70.5	0.3	2.4	0.1	0.5
40	2099	386	2485	2899	414	54.9	64.1	1.7	2.0	0.3	0.4
41	0	386	386	2899	2513	7.8	58.2	0.2	1.6	0.0	0.3
42	0	386	386	2899	2513	7.0	52.9	0.2	1.4	0.0	0.2
43	0	386	386	2899	2513	6.4	48.1	0.2	1.1	0.0	0.2
44	0	386	386	2899	2513	5.8	43.7	0.1	1.0	0.0	0.2
45	1313	386	1699	2899	1200	23.3	39.8	0.5	0.8	0.1	0.1
46	0	386	386	2899	2513	4.8	36.2	0.1	0.7	0.0	0.1
47	0	386	386	2899	2513	4.4	32.9	0.1	0.6	0.0	0.1
48	0	386	386	2899	2513	4.0	29.9	0.1	0.5	0.0	0.1
49	0	386	386	2899	2513	3.6	27.2	0.1	0.4	0.0	0.1
50	484	386	870	2899	2029	7.4	24.7	0.1	0.3	0.0	0.0
Total						24126.6	23332.5	21501.7	9918.3	21026.1	7351.0

EIRR = 10.53

B/C at 10%= 0.97

Table 1.1.4(3)

Calculation of EIRR-Banke-Case-1(90 lit/sec)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV Int.= 0.1 Cost	NPV Int.= 0.1 Benefit	NPV Int.= 0.2 Cost	NPV Int.= 0.2 Benefit	NPV Int.= 0.25 Cost	NPV Int.= 0.25 Benefit
1	14030	0	14030	0	-14030	14030.0	0.0	14030.0	0.0	14030.0	0.0
2	0	225	225	1352	1127	186.0	1117.2	156.3	938.8	144.0	865.2
3	0	225	225	1802	1577	169.0	1354.2	130.2	1043.1	115.2	922.8
4	0	225	225	2253	2028	153.7	1538.8	108.5	1086.5	92.2	922.8
5	0	225	225	2493	2268	139.7	1548.2	90.4	1002.0	73.7	817.0
6	0	225	225	2704	2479	127.0	1526.1	75.4	905.4	59.0	708.7
7	0	225	225	2824	2599	115.5	1449.0	62.8	788.1	47.2	592.2
8	0	225	225	2914	2689	105.0	1359.3	52.3	677.7	37.7	488.9
9	0	225	225	2944	2719	95.4	1248.5	43.6	570.6	30.2	395.1
10	484	225	709	3004	2295	273.4	1158.2	114.5	485.2	76.1	322.6
11	0	225	225	3004	2779	78.9	1052.9	30.3	404.3	19.3	258.0
12	0	225	225	3004	2779	71.7	957.2	25.2	336.9	15.5	206.4
13	0	225	225	3004	2779	65.2	870.2	21.0	280.8	12.4	165.1
14	0	225	225	3004	2779	59.2	791.0	17.5	234.0	9.9	132.1
15	1290	225	1515	3004	1489	362.7	719.1	98.3	195.0	53.3	105.7
16	0	225	225	3004	2779	49.0	653.8	12.2	162.5	6.3	84.6
17	0	225	225	3004	2779	44.5	594.3	10.1	135.4	5.1	67.6
18	0	225	225	3004	2779	40.5	540.3	8.5	112.8	4.1	54.1
19	0	225	225	3004	2779	36.8	491.2	7.0	94.0	3.2	43.3
20	1157	225	1382	3004	1622	205.4	446.5	36.0	78.4	15.9	34.6
21	0	225	225	3004	2779	30.4	405.9	4.9	65.3	2.1	27.7
22	0	225	225	3004	2779	27.6	369.0	4.1	54.4	1.7	22.2
23	0	225	225	3004	2779	25.1	335.5	3.4	45.3	1.3	17.7
24	0	225	225	3004	2779	22.8	305.0	2.8	37.8	1.1	14.2
25	0	225	225	3004	2779	20.8	277.3	2.4	31.5	0.9	11.3
26	0	225	225	3004	2779	18.9	252.1	2.0	26.2	0.7	9.1
27	0	225	225	3004	2779	17.2	229.1	1.6	21.9	0.5	7.3
28	0	225	225	3004	2779	15.6	208.3	1.4	18.2	0.4	5.8
29	0	225	225	3004	2779	14.2	189.4	1.1	15.2	0.3	4.6
30	1774	225	1999	3004	1005	114.6	172.2	8.4	12.7	2.5	3.7
31	0	225	225	3004	2779	11.7	156.5	0.8	10.5	0.2	3.0
32	0	225	225	3004	2779	10.7	142.3	0.7	8.8	0.2	2.4
33	0	225	225	3004	2779	9.7	129.3	0.5	7.3	0.1	1.9
34	0	225	225	3004	2779	8.8	117.6	0.5	6.1	0.1	1.5
35	0	225	225	3004	2779	8.0	106.9	0.4	5.1	0.1	1.2
36	0	225	225	3004	2779	7.3	97.2	0.3	4.2	0.1	1.0
37	0	225	225	3004	2779	6.6	88.3	0.3	3.5	0.1	0.8
38	0	225	225	3004	2779	6.0	80.3	0.2	2.9	0.0	0.6
39	0	225	225	3004	2779	5.5	73.0	0.2	2.5	0.0	0.5
40	1157	225	1382	3004	1622	30.5	66.4	0.9	2.0	0.2	0.4
41	0	225	225	3004	2779	4.5	60.3	0.1	1.7	0.0	0.3
42	0	225	225	3004	2779	4.1	54.9	0.1	1.4	0.0	0.3
43	0	225	225	3004	2779	3.7	49.9	0.1	1.2	0.0	0.2
44	0	225	225	3004	2779	3.4	45.3	0.1	1.0	0.0	0.2
45	1290	225	1515	3004	1489	20.8	41.2	0.4	0.8	0.1	0.1
46	0	225	225	3004	2779	2.8	37.5	0.1	0.7	0.0	0.1
47	0	225	225	3004	2779	2.6	34.1	0.0	0.6	0.0	0.1
48	0	225	225	3004	2779	2.3	31.0	0.0	0.5	0.0	0.1
49	0	225	225	3004	2779	2.1	28.1	0.0	0.4	0.0	0.1
50	484	225	709	3004	2295	6.0	25.6	0.1	0.3	0.0	0.0
Total						16872.7	23625.3	15168.1	9921.4	14863.1	7325.3

EIRR = 15.59

B/C at 10%= 1.40

Calculation of EIRR-Banke-Case-2(45 lit/sec)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV Int.= 0.1 Cost	NPV Int.= 0.1 Benefit	NPV Int.= 0.2 Cost	NPV Int.= 0.2 Benefit	NPV Int.= 0.25 Cost	NPV Int.= 0.25 Benefit
1	16683	0	16683	0	-16683	16683.0	0.0	16683.0	0.0	16683.0	0.0
2	0	322	322	1352	1030	266.1	1117.2	223.6	938.8	206.1	865.2
3	0	322	322	1802	1480	241.9	1354.2	186.3	1043.1	164.9	922.8
4	0	322	322	2253	1931	219.9	1538.8	155.3	1086.5	131.9	922.8
5	0	322	322	2493	2171	199.9	1548.2	129.4	1002.0	105.5	817.0
6	0	322	322	2704	2382	181.8	1526.1	107.8	905.4	84.4	708.7
7	0	322	322	2824	2502	165.2	1449.0	89.9	788.1	67.5	592.2
8	0	322	322	2914	2592	150.2	1359.3	74.9	677.7	54.0	488.9
9	0	322	322	2944	2622	136.6	1248.5	62.4	570.6	43.2	395.1
10	484	322	806	3004	2198	310.7	1158.2	130.2	485.2	86.5	322.6
11	0	322	322	3004	2682	112.9	1052.9	43.3	404.3	27.7	258.0
12	0	322	322	3004	2682	102.6	957.2	36.1	336.9	22.1	206.4
13	0	322	322	3004	2682	93.3	870.2	30.1	280.8	17.7	165.1
14	0	322	322	3004	2682	84.8	791.0	25.1	234.0	14.2	132.1
15	1313	322	1635	3004	1369	391.4	719.1	106.1	195.0	57.5	105.7
16	0	322	322	3004	2682	70.1	653.8	17.4	162.5	9.1	84.6
17	0	322	322	3004	2682	63.7	594.3	14.5	135.4	7.3	67.6
18	0	322	322	3004	2682	57.9	540.3	12.1	112.8	5.8	54.1
19	0	322	322	3004	2682	52.6	491.2	10.1	94.0	4.6	43.3
20	1561	322	1883	3004	1121	279.9	446.5	49.1	78.4	21.7	34.6
21	0	322	322	3004	2682	43.5	405.9	7.0	65.3	3.0	27.7
22	0	322	322	3004	2682	39.6	369.0	5.8	54.4	2.4	22.2
23	0	322	322	3004	2682	36.0	335.5	4.9	45.3	1.9	17.7
24	0	322	322	3004	2682	32.7	305.0	4.1	37.8	1.5	14.2
25	0	322	322	3004	2682	29.7	277.3	3.4	31.5	1.2	11.3
26	0	322	322	3004	2682	27.0	252.1	2.8	26.2	1.0	9.1
27	0	322	322	3004	2682	24.6	229.1	2.3	21.9	0.8	7.3
28	0	322	322	3004	2682	22.3	208.3	2.0	18.2	0.6	5.8
29	0	322	322	3004	2682	20.3	189.4	1.6	15.2	0.5	4.6
30	1797	322	2119	3004	885	121.4	172.2	8.9	12.7	2.6	3.7
31	0	322	322	3004	2682	16.8	156.5	1.1	10.5	0.3	3.0
32	0	322	322	3004	2682	15.3	142.3	0.9	8.8	0.3	2.4
33	0	322	322	3004	2682	13.9	129.3	0.8	7.3	0.2	1.9
34	0	322	322	3004	2682	12.6	117.6	0.7	6.1	0.2	1.5
35	0	322	322	3004	2682	11.5	106.9	0.5	5.1	0.1	1.2
36	0	322	322	3004	2682	10.4	97.2	0.5	4.2	0.1	1.0
37	0	322	322	3004	2682	9.5	88.3	0.4	3.5	0.1	0.8
38	0	322	322	3004	2682	8.6	80.3	0.3	2.9	0.1	0.6
39	0	322	322	3004	2682	7.8	73.0	0.3	2.5	0.1	0.5
40	1561	322	1883	3004	1121	41.6	66.4	1.3	2.0	0.3	0.4
41	0	322	322	3004	2682	6.5	60.3	0.2	1.7	0.0	0.3
42	0	322	322	3004	2682	5.9	54.9	0.2	1.4	0.0	0.3
43	0	322	322	3004	2682	5.3	49.9	0.1	1.2	0.0	0.2
44	0	322	322	3004	2682	4.9	45.3	0.1	1.0	0.0	0.2
45	1313	322	1635	3004	1369	22.4	41.2	0.4	0.8	0.1	0.1
46	0	322	322	3004	2682	4.0	37.5	0.1	0.7	0.0	0.1
47	0	322	322	3004	2682	3.7	34.1	0.1	0.6	0.0	0.1
48	0	322	322	3004	2682	3.3	31.0	0.1	0.5	0.0	0.1
49	0	322	322	3004	2682	3.0	28.1	0.0	0.4	0.0	0.1
50	484	322	806	3004	2198	6.9	25.6	0.1	0.3	0.0	0.0
Total						20475.4	23625.3	18237.6	9921.4	17832.0	7325.3

EIRR = 12.81

B/C at 10%= 1.15

Calculation of EIRR-Banke-Case-3(30 lit/sec)

(Unit:Rs.1,000)

Year	Capital Cost	O & M Cost	Total	Benefit	Return	NPV Int.= 0.1		NPV Int.= 0.2		NPV Int.= 0.25	
						Cost	Benefit	Cost	Benefit	Cost	Benefit
1	19666	0	19666	0	-19666	19666.0	0.0	19666.0	0.0	19666.0	0.0
2	0	386	386	1352	966	319.0	1117.2	268.1	938.8	247.0	865.2
3	0	386	386	1802	1416	290.0	1354.2	223.4	1043.1	197.6	922.8
4	0	386	386	2253	1867	263.6	1538.8	186.1	1086.5	158.1	922.8
5	0	386	386	2493	2107	239.7	1548.2	155.1	1002.0	126.5	817.0
6	0	386	386	2704	2318	217.9	1526.1	129.3	905.4	101.2	708.7
7	0	386	386	2824	2438	198.1	1449.0	107.7	788.1	81.0	592.2
8	0	386	386	2914	2528	180.1	1359.3	89.8	677.7	64.8	488.9
9	0	386	386	2944	2558	163.7	1248.5	74.8	570.6	51.8	395.1
10	484	386	870	3004	2134	335.4	1158.2	140.5	485.2	93.4	322.6
11	0	386	386	3004	2618	135.3	1052.9	52.0	404.3	33.2	258.0
12	0	386	386	3004	2618	123.0	957.2	43.3	336.9	26.5	206.4
13	0	386	386	3004	2618	111.8	870.2	36.1	280.8	21.2	165.1
14	0	386	386	3004	2618	101.6	791.0	30.1	234.0	17.0	132.1
15	1313	386	1699	3004	1305	406.7	719.1	110.3	195.0	59.8	105.7
16	0	386	386	3004	2618	84.0	653.8	20.9	162.5	10.9	84.6
17	0	386	386	3004	2618	76.4	594.3	17.4	135.4	8.7	67.6
18	0	386	386	3004	2618	69.4	540.3	14.5	112.8	7.0	54.1
19	0	386	386	3004	2618	63.1	491.2	12.1	94.0	5.6	43.3
20	2099	386	2485	3004	519	369.4	446.5	64.8	78.4	28.7	34.6
21	0	386	386	3004	2618	52.2	405.9	8.4	65.3	3.6	27.7
22	0	386	386	3004	2618	47.4	369.0	7.0	54.4	2.8	22.2
23	0	386	386	3004	2618	43.1	335.5	5.8	45.3	2.3	17.7
24	0	386	386	3004	2618	39.2	305.0	4.9	37.8	1.8	14.2
25	0	386	386	3004	2618	35.6	277.3	4.0	31.5	1.5	11.3
26	0	386	386	3004	2618	32.4	252.1	3.4	26.2	1.2	9.1
27	0	386	386	3004	2618	29.4	229.1	2.8	21.9	0.9	7.3
28	0	386	386	3004	2618	26.8	208.3	2.3	18.2	0.7	5.8
29	0	386	386	3004	2618	24.3	189.4	2.0	15.2	0.6	4.6
30	1797	386	2183	3004	821	125.1	172.2	9.2	12.7	2.7	3.7
31	0	386	386	3004	2618	20.1	156.5	1.4	10.5	0.4	3.0
32	0	386	386	3004	2618	18.3	142.3	1.1	8.8	0.3	2.4
33	0	386	386	3004	2618	16.6	129.3	0.9	7.3	0.2	1.9
34	0	386	386	3004	2618	15.1	117.6	0.8	6.1	0.2	1.5
35	0	386	386	3004	2618	13.7	106.9	0.7	5.1	0.2	1.2
36	0	386	386	3004	2618	12.5	97.2	0.5	4.2	0.1	1.0
37	0	386	386	3004	2618	11.4	88.3	0.5	3.5	0.1	0.8
38	0	386	386	3004	2618	10.3	80.3	0.4	2.9	0.1	0.6
39	0	386	386	3004	2618	9.4	73.0	0.3	2.5	0.1	0.5
40	2099	386	2485	3004	519	54.9	66.4	1.7	2.0	0.3	0.4
41	0	386	386	3004	2618	7.8	60.3	0.2	1.7	0.0	0.3
42	0	386	386	3004	2618	7.0	54.9	0.2	1.4	0.0	0.3
43	0	386	386	3004	2618	6.4	49.9	0.2	1.2	0.0	0.2
44	0	386	386	3004	2618	5.8	45.3	0.1	1.0	0.0	0.2
45	1313	386	1699	3004	1305	23.3	41.2	0.5	0.8	0.1	0.1
46	0	386	386	3004	2618	4.8	37.5	0.1	0.7	0.0	0.1
47	0	386	386	3004	2618	4.4	34.1	0.1	0.6	0.0	0.1
48	0	386	386	3004	2618	4.0	31.0	0.1	0.5	0.0	0.1
49	0	386	386	3004	2618	3.6	28.1	0.1	0.4	0.0	0.1
50	484	386	870	3004	2134	7.4	25.6	0.1	0.3	0.0	0.0
Total						24126.6	23625.3	21501.7	9921.4	21026.1	7325.3

EIRR = 10.67

B/C at 10%= 0.98

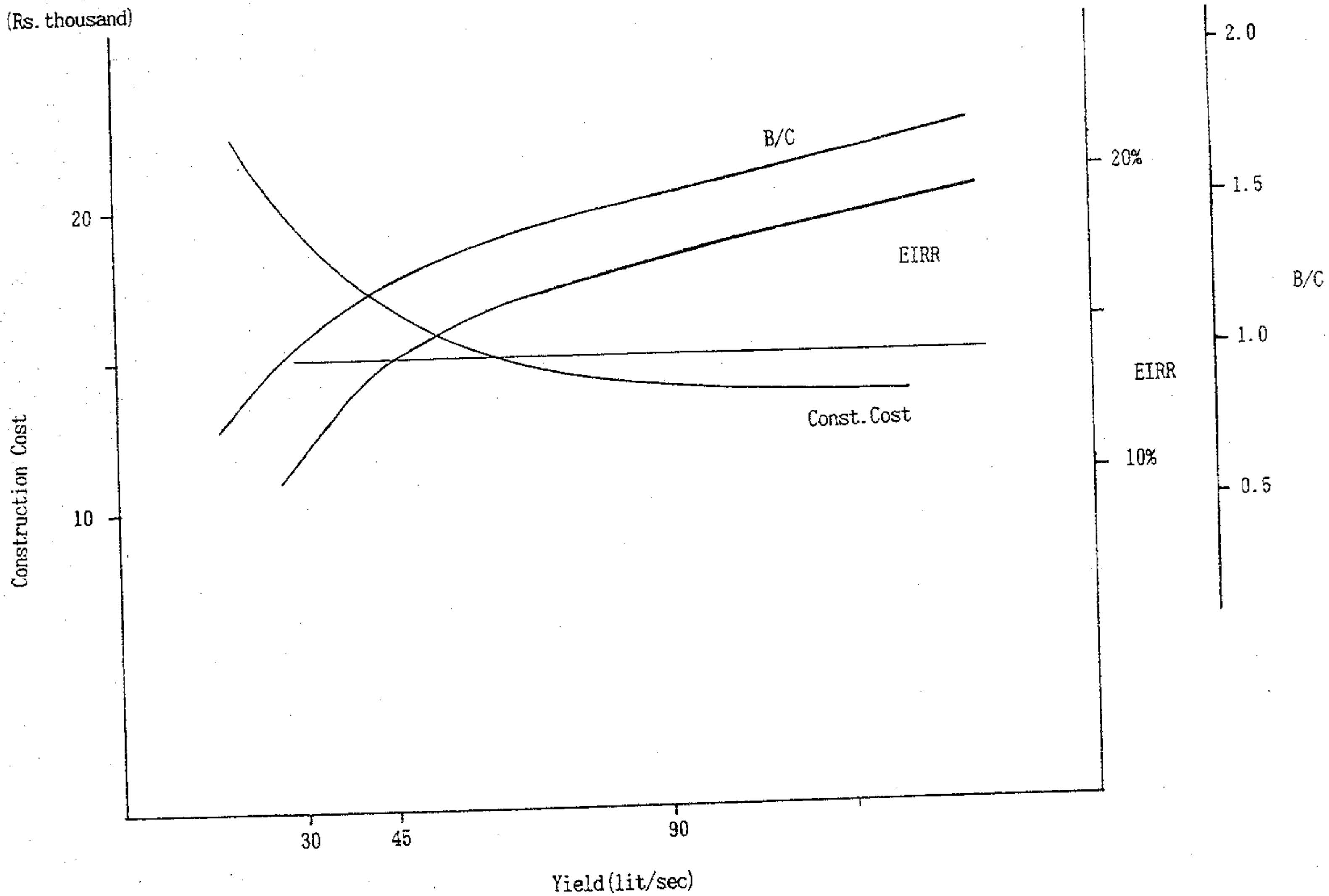


Figure 1.1.2(1) LFCA and LFWY (Jhapa)

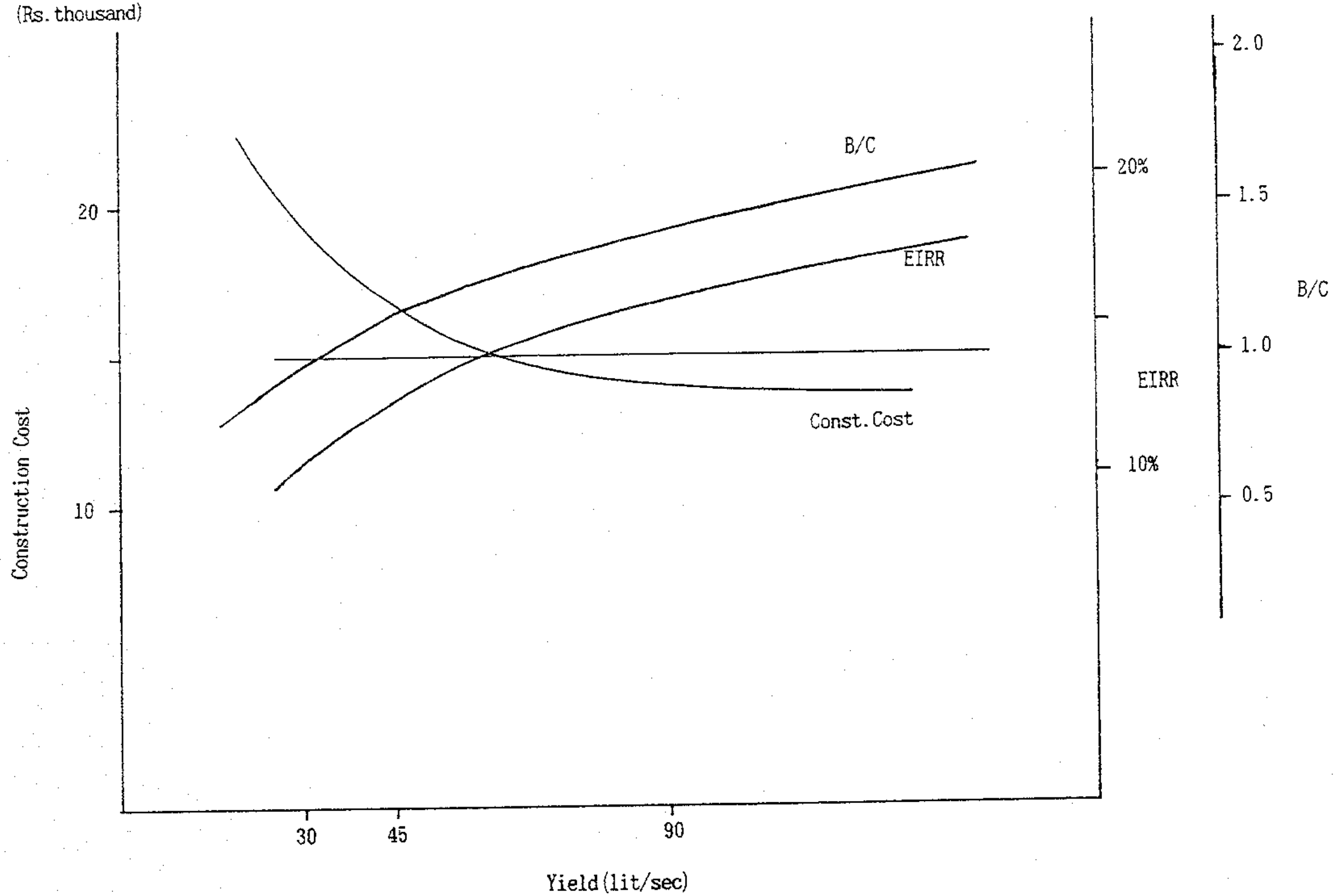


Figure 1.1.2(2) LFCA and LFWY (Mahottari)

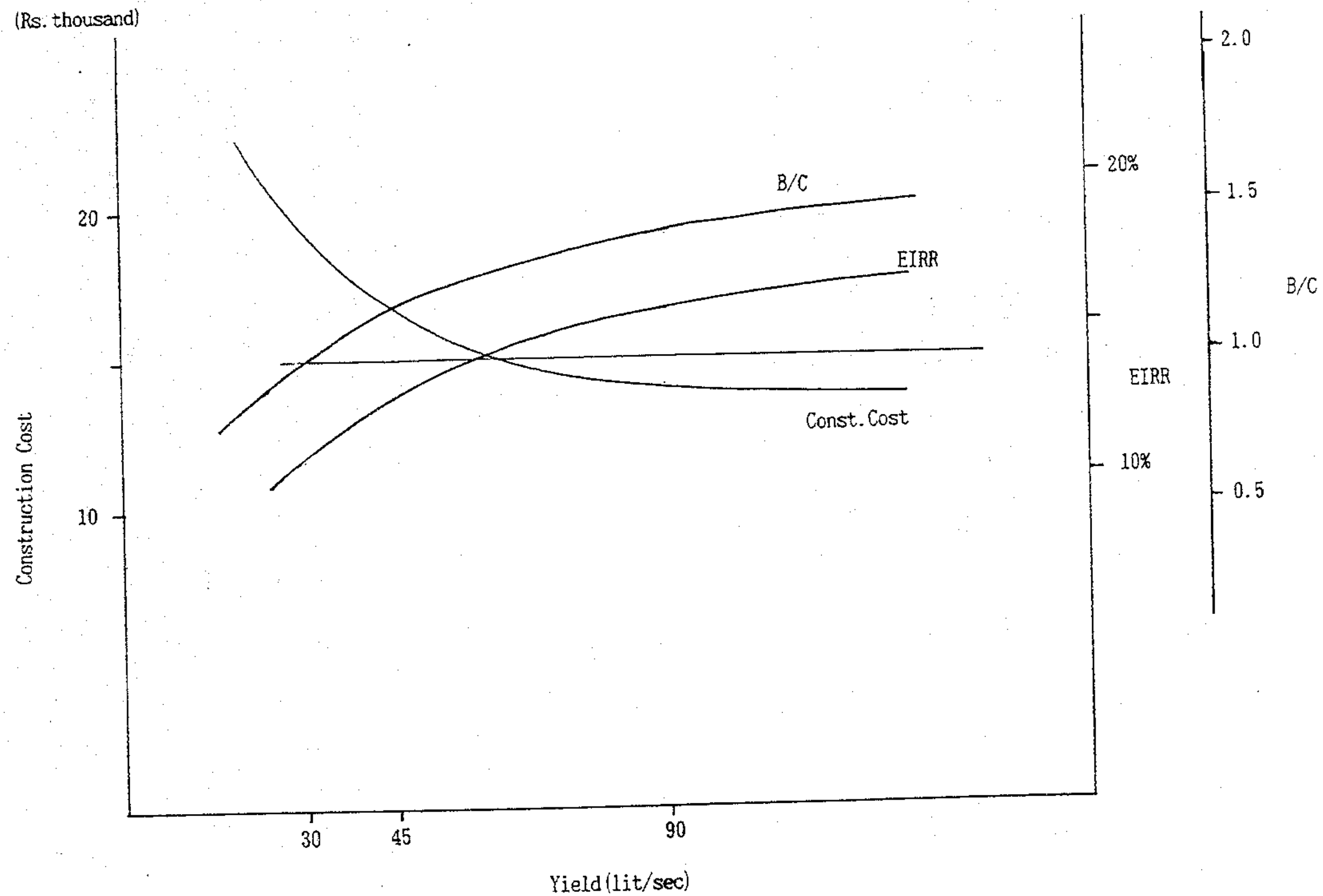


Figure 1.1.2(3) LFCA and LFWY (Banke)

1.2 Evaluation of Aquifer Potential

The evaluation of aquifer potential is of particular importance to the groundwater irrigation project. The first consideration is to interpret the lithologic well logs and data of borehole loggings in order to establish the hydrogeological units. Particular attention should be paid to the presence of the Churia Group in shallow depths, based on the regional geological studies. In general, the Terai Plain is underlain by a thin series of alternating clay and sand and gravel beds, and possible yields are estimated at 60 to 120 l/s. Potential problems may arise in certain areas where the consolidated Churia Formation with finer materials underlies the shallow parts. For instance, north of Nepalganj, a formation underlies the central part of the alluvial plain; it is composed of a thick series of alternating fine sand and silt, with many siltstone fragments, and it has been established in previous studies as alluvial. The composition rate of the permeable beds and the transmissivity in this formation are less than 15% and 200 m^2/day, respectively, which are much smaller compared with neighboring alluvial formations. These geological conditions can be easily confirmed through a study of the regional geology and a careful interpretation of the borehole lithologic logs and aerial photographs.

1.3 Construction of Production Well

1.3.1 Design of Production Well

(1) Depth and Diameter

The diameter must be chosen to satisfy the water requirement. For this connection the entrance velocity of water into the screen must be calculated based on the design yield. It has been proposed, based on field experience and laboratory tests, that the average entrance velocity of water moving into the screen should not exceed 3.0 cm/s to the avoid extraction of formation material (Driscoll, 1987).
According to calculations based on well diameters of 150 mm, 200 mm, and 250 mm with a 30 m screen length, the velocity by a 120 l/s discharge is 3.4 cm/s, 2.5 cm/s, and 2.0 cm/s, respectively. Therefore, the recommended well diameter is 250 mm in the Terai Plain. The necessary length of screen selected is shown in Table 1.3.1. The length is calculated based on a screen with an opening rate of 25%, and the required velocity is calculated by the 30 m screen length.

Table 1.3.1 Length of Screen and Entrance Velocity by Yields

Well Yield (l/s)	Necessary Length of Screen		Required Velocity (cm/sec)
	Velocity=2.0 cm/s	Velocity=3.0 cm/s	
60	15.6	10.2	1.0
80	20.7	13.6	1.4
100	25.9	17.0	1.7
120	31.1	20.3	2.0

The optimum length of screen for four different yields in Jhapa, Mahottari, and Bank can be calculated by using the optimum screen velocity derived from the representative transmissivity (Walton, 1962). The actual depth of well is the sum of the lengths of housing (=50 m), the total length of beds including permeable and impermeable beds, several clearances for seasonal fluctuation (=10 m), and others. Results are tabulated in Table 1.3.2.

Table 1.3.2 Calculation of Necessary Well Depth

District /Area	T(m2/d) /k(m/d)	Cal. S.L. Yield(l/s)				Rate of Sand & Grav(%)	F.L Yield(l/s)				Total W.L. (m)
		60	80	100	120		60	80	100	120	
<u>Jhapa</u>											
North Alv.	1,130/49	13	18	20	26	61	21	30	33	43	98
Kankai Alv.	1,740/76	10	14	17	20	76	13	18	22	26	81
Gangetic Alv.	2,490/108	9	11	14	17	77	12	14	18	22	77
Terrace	1,000/43	16	21	26	31	66	24	32	40	50	105
<u>Mahottari</u>											
Bhabar	4,800/218	6	7	9	11	60	10	12	15	18	73
Gangetic Alv.	520/24	20	27	34	41	52	38	52	65	79	134
<u>Banke</u>											
Bhabar	700/90	9	13	16	19	30	30	43	53	63	118
Central Alv.	210/27	18	24	29	35	15	120	160	193	233	288
South Alv.	1,010/129	8	10	13	15	50	16	20	26	30	85

Remarks: T=transmissivity k=permeability, derived by T with aquifer lengths of 23 m in Jhapa, 22 m in Mahottari, and 7.8 m in Banke
Cal.S.L.=calculated screen length F.L.=length of necessary beds
Total W.L.=necessary total well length

1.3.2 Completion of Production Well

(1) Well Drilling Method

Selection of the drilling method depends on the geologic conditions. The percussion drilling method is the proper technique in the Bhabar Zone where the stratum is composed mainly of large gravel; the rotary drilling method is more efficient in the southern Terai because the sand and gravel size decreases southward. Taking regional geological conditions into consideration, the most economical method should be adopted for the project drilling.

(2) Density of Drilling Fluid

Selection and maintenance of the proper drilling fluid density will prevent the collapse or the flow of water into a borehole. Water-based drilling fluids include (1) clean, fresh water, (2) water with clay additives, (3) water with polymeric additives and (4) water with clay and polymeric additives. Water-based drilling fluid systems with clay or polymeric additives are typically used in unconsolidated formations, therefore items (2) and (4) are recommended drilling fluids for the Terai Plain.

Control of the drilling fluid density is a fundamental factor in successful water well drilling. To maintain an open hole, the pressure exerted by the drilling fluid column must exceed the pore pressure in the aquifer. Typically, a minimum excess pressure of 34.5 kPa is desirable, though the pressure requirement may be higher when pressure from confined formations is encountered.

Ordinarily, the water pressure within a freshwater aquifer is 9.8 kPa/m, unless the total dissolved solids are abnormally high. Therefore, at a depth of 10 m the pressure is 98 kPa. Under confined conditions, the potentiometric surface is above the top of the aquifer, therefore, the pore pressure at any thickness always exceeds the normal hydraulic pressure of 9.8 kPa of aquifer thickness.

A simple equation for determining the hydrostatic pressure exerted by the drilling fluid in a borehole is as follows:

Hydrostatic pressure(g/cm^2)
= fluid density (g/cm^3) x height of fluid column (cm)

To control the flow of water into the borehole, it is necessary to increase the density of the drilling fluid before reaching the confined formation. The additional drilling fluid density required to equalize the confined pressure is determined by the follow:

Additional drilling fluid density
= weight of water x (height of water above ground level/depth to top of confined aquifer)

The calculated additional density at site EX-8 in Jhapa is 0.45 where the height of the artesian pressure and the depth to the top of aquifer are 9 m and 60 m, respectively. Based on the above formula, the required density of drilling fluid is calculated as shown below.

Table 1.3.3 Required density of Drilling Fluid

Aquifer	S.W.L (mags)	Pore Pressure (kPa)	Excess P. (kPa)	Total P. (kPa)	Add. Density	Total F.Density
Unconfined	0	60x9.8=96.6	34.5	131	-	1.3
Confined	9	60x9.8=96.6	34.5	131	0.45	1.75

Remark: S.W.L.=static water level Excess P.=excess pressure
Total P. =total pressure Add. Density=additional density
F.Density=fluid density

It is not necessary to increase the fluid density for unconfined aquifers because the weight of ordinal bentonite is estimated at 1,320 kg/m^3; however, drilling in confined aquifers requires the control of the fluid density. An excessive increase in the density can affect the drilling and well completion process in the following ways:

- Large volumes of drilling fluid and cuttings can be forced into the aquifer during drilling. Removal of the drilling fluid and cuttings during development can be extremely difficult, especially if clay additives are used.
- Material cost increase due to high fluid losses.
- Rate of penetration is reduced.
- Sample collection is more difficult and less reliable as cuttings do not separate from the drilling fluid at the surface.

Polymers are ordinarily used to control viscosity. Even the addition of small volumes of polymers to the drilling fluid can have significant effects on viscosity. In general, high-viscosity drilling fluids are required to lift coarse sand or gravel, whereas lower viscosity drilling fluids are adequate to lift fine sand and silt. In most cases, continuous monitoring of the drilling fluid is necessary to achieve the best results.

(3) Casing and Screen

a) Casing

Standard design procedures involve choosing the casing diameter and material, estimating well depth, selecting the length, diameter, and material for the screen, determining the screen slot size, and choosing the completion method. In regard to the material for the casing and screen, an assessment of the water quality is essential to prevent corrosion and incrustation. A general idea of the chemical combinations and the limit of concentrations which cause corrosion and incrustation are listed in Table 1.3.4.

Table 1.3.4 Quality Limitation for Corrosion and Incrusting in mg/l

	pH	CO2	Fe	Mn	Hard's	DO	TDS	Cl
Corrosion	7.0>	50<	-	-	-	2.0<	1,000>	500<
Incrusting	7.5<	-	0.5<	0.2<	300<	-	-	-

The table shows that there are no problems related to quality in the exploratory wells in Jhapa, except in the Kankai alluvial plain. It is advisable to use stainless if Fe and Mn concentrations exceed the limit.

b) Screen

A type of continuous slot wire-wound screen is adequate for irrigation purposes because of its large slot opening. The required opening must be greater than 25%, as stated in 1.3.1 (1).

Three factors, including water quality and strength requirements, govern the choice of materials used to fabricate well screens. High concentrations of Fe and Mn should also be taken into consideration for Terai groundwater.

The three loads, or forces, imposed on a screen include the column load (vertical compression), tensile load (extending forces), and collapse pressure (horizontal force). While a borehole is open during the installation of the screen and pipe, a screen attached directly to the casing may have to support the entire weight of the pipe. This burden exerts a column load on the screen. A tensile load is exerted on the screen when long screen and casing sections are installed. After the borehole material sloughs against the screen, the earth pressure exerts a horizontal stress on the screen, especially during development. The screen must have adequate collapse resistance to withstand both the earth and hydraulic pressures. The screen's resistance to both column and tensile loading is directly proportional to the yield strength of the material used to fabricate the screen, whereas the collapse resistance is proportional to the material's modulus of elasticity.

The necessary resistance is calculated using the following standard well:

Housing

Diameter: 400 mm Length:50 m Material: steel (w=80 kg/m)

Casing

Diameter: 250 mm Material: stainless steel (w=45 kg/m)

Location: 70-140 mbgs (total 70 m)

Screen

Type: continuous slot wire Material=stainless steel (w=30 kg/m)

Location: 60-70, 140-150 mbgs (total 20 m)

Fresh water in the borehole

Load exerts to screen under above conditions

Tensile load: (450 kg x 70m)+(10kg x 30m)=3,450 kg .... 67kg/cm^2

Column load: (80kg x 50m)+((10kg x 10m)+(45kg x 70m)=7,250 kg .. 40 kg/cm^2

Max collapse load: k x γ x H — 0.5 x 2.0 x 150 m=150 t/m^2 .... 15 kg/cm^2

k = coefficient of earth pressure at rest

γ = unit weight of sand and gravel

H = depth to bottom of screen

Some degree of safety should be considered in selection of screen material, for example, 150% to 200% of the calculated load.

Table 1.3.5 Required Strength of Casing

Casing	Dia. (mm)	Thick. (mm)	Tensile (kg/cm2)	Column (kg/cm2)	Collapse (kg/cm2)
Required Strength	250	6.6	134	280	30
Tested Strength	250	6.6	2,000	-	40

Table 1.3.6 Required Strength of Screen

Screen	Dia. (mm)	Opening (%)	Slot Size (mm)	Tensile (t)	Collapse (kg/cm2)
Required Strength	250	-	-	7	15
Tested Strength	250				
Ordinal		39	1.5	50	19.6
Reinforced by					
Ring base		39	1.5	28	50.5
Wire base		-	1.5	22	25.4

Remarks: ordinal=continuous slot wire-wound screen

The table shows that the strength of the casing is within the required limits; however, the strength of the screen, especially the collapse, indicates a critical value to the required strength. Therefore, it is strongly recommended that reinforced screens be used if the well depth exceeds 100 m.

1.4 Back Data on Project and O&M Costs for the Case Study using a Diesel Engine as a Power Source

1. Subject

   To calculate the Project Cost and O&M Cost for the Case Study on LFCA and LFWY when a Diesel Engine is applied for the power source of pump, instead of electristic power supply system.

2. Methodology

   Just same with the calculation methodology applied in the draft final report.

3. Cost of Diesel Engine

   Referred to the recent estimation for the imported diesel engine from India.

4. Other basical costs

   Same with the ones used in the draft final report.

5. Break down on "Pump Set" (for Case-I)

   estimated cost of Vertical Shaft Turbine Pump: 450 (40 kW)

   estimated cost of Diesel Engine: 548 (95 HP)

   estimated cost of Appurtenance: 30 % of main body

		L/C (10 %)	F/C (90 %)	Total (100 %)	Remarks
(1)	Vertical Shaft Turbine Pump 47 kW/40 kW = 1.18	59	472	531	450x1.18
(2)	Diesel Engine 67HP/95HP = 0.74	93	313	406	548x0.74
(3)	Appurtenance 30 % of above	28	94	122	406x0.3
(4)	Discharge Pipes, Valve, Flow-meter, etc.	69	230	299	253x1.18
	Sub-total (1)~(4)	249	1,109	1,358	
(5)	Spare-Parts above S•T x 0.3	41	366	407	
	Total	290	1,475	1,765	

6. Costs for Case-II and Case-III

(1) Case-II

L/C: 290 x 0.6 x 2 = 348 (x 1,000 NRs)

F/C: 1,475 x 0.6 x = 1,770

Total 2,118

(2) Case-III

L/C: 290 x 0.4 x 3 = 348 (x 1,000 NRs)

F/C:1,475 x 0.4 x 3 = 1,770

Total 2,118

Thus, the Project Cost using Diesel Engine was summarized as Table-A at next page.

7. O&M Costs

	L/C (90 %)	F/C (10 %)	Total (100 %)	Remarks
Case I	5,580	620	6,200	620,600 NR/100 ha
Case II	7,520	830	8,350	834,200 NR/100 ha
Case III	8,780	970	9,750	974,300 NR/100 ha

Table-A Summary of Project Cost Estimate (using Diesel Engine)

(1,000 NR)

No	Work Items \ Case Study / Currency	Case I (90 l/s) L/C	Case I (90 l/s) F/C	Case I (90 l/s) T•C	Case II (45 l/s) L/C	Case II (45 l/s) F/C	Case II (45 l/s) T•C	Case III (30 l/s) L/C	Case III (30 l/s) F/C	Case III (30 l/s) T•C	Remarks
1	Well Development										
	Sub-total	219	1,297	1,516	350	2,076	2,426	525	3,113	3,638	Same with the case using motor
2	Pump Station										
	Pump Sets	290	1,475	1,765	348\3	1,770	2,118	348	1,770	2,118	
	Pump House	198	116	314	96	232	628	594	348	942	
	Control Chamber	116	140	256	232	280	512	348	420	768	
	Power Supply	-	-	-	-	-	-	-	-	-	
	Sub-total	604	1,731	2,335	976	2,282	3,258	1,290	2,538	3,828	
3	Irrigation Canal										
	Sub-total	863	632	1,495	756	506	1,262	681	416	1,097	
4	Drainage System										
	Sub-total	253	58	311	298	68	366	320	73	393	
5	Farm Road System	1,023	682	1,705	1,023	682	1,705	1,023	682	1,705	
6	Procurement of O&M and Office Equipment	26	460	486	26	460	486	26	460	486	
7	Technical Support	950	2,680	3,630	950	2,680	3,630	950	2,680	3,630	
8	Project Administration	950	-	950	950	-	950	950	-	950	
9	Land Acquisition	1,410	-	1,410	1,740	-	1,740	1,890	-	1,890	
	Sub-total (5~9)	4,359	3,822	8,181	4,689	3,822	8,511	4,839	3,822	8,661	
10	Total Investment Cost	6,298	7,540	13,838	7,069	8,754	15,823	7,655	9,962	17,617	
	Cost/ha	63.0	75,4	138.4	70.7	87.5	158,2	76.6	99.6	176.2	10^3 NR
11	Physical Contingency	630	754	1,384	707	875	1,582	766	996	1,762	10% for T.C
12	Prince Escalation	630	151	781	707	175	882	766	199	965	L/C 10% F/C 2%
13	TOTAL PROJECT COST	7,558	8,445	16,003	8,483	9,804	18,287	9,187	11,157	20,344	

8. Break down of O&M Cost

8-1 Case Study I (A = 100 ha, Q = 90 l/s, 70 HP of DE, y = well)

(1) O&M Equipment Cost

Motorcycle	1 unit	36,000/5 years	=	7,200 NR
Bicycle	2 units	4,000 x 2/5 years	=	1,600 NR
Tool set (mechanics)		50,000/20 years	=	2,500 NR
Sub-total				11,300 NR

(2) Operation Cost

Fuel for DE	1 LS*see 9.	=	541,700 NR
Operator	1 x 2,000 x 12	=	24,000 NR
Asst. Operator	2 x 1,400 x 12	=	33,600 NR
Sub-total			599,300 NR

(3) Maintenance

Mechanics	1 LS	10,000 NR
Sub-total		10,000 NR
Total		620,600 NR

620,600 ÷ 100 ≒ 6,200 NR/ha

8-2 Case Study II (A = 100 ha, Q = 45 l/s, 40 HP of DE, 2 wells)

(1) O&M Equipment Cost

Case I x 2 set	11,300 x 2	=	22,600 NR
Sub-total			22,600 NR

(2) Operation Cost

Fuel for DE	1 LS*see 9.	=	681,400 NR
Operators (Case-I x 2)	57,600 x 2	=	115,200 NR
Sub-total			496,600 NR

(3) Maintenance

Case-I x 1.5	10,000 x 1.5	=	15,000 NR
Sub-total			15,000 NR
Total			834,200 NR

834,200 ÷ 100 ≒ 8,350 NR/ha

8-3 Case Study-III (A = 100 ha, Q = 30 l/s, 28 HP of DE, 3 wells)

(1) O&M Equipment Cost

Case-I x 3 set	11,300 x 3	= 33,900 NR
Sub-total		33,900 NR

(2) Operation Cost

Fuel for DE	1 LS*see 9.	= 747,600 NR
Operators (Case-I x 2)	57,600 x 3	= 172,800 NR
Sub-total		920,400 NR

(3) Maintenance

Case-I x 2.0	10,000 x 2.0	= 20,000 NR
Sub-total		20,000 NR
Total		974,300 NR

974,300 ÷ 100 ≒ 9,750 NR/ha

9. Fuel Cost of Diesel Engine

(1) Conditions

Operation time: 2,200 hours/year

Consumption: 100~300 HP 0.22 kg/h/ps ≒ 0.22/0.85 ≒ 0.26 l/h/ps

less than 100 HP 0.25 kg/h/ps ≒ 0.25/0.85 ≒ 0.29 l/h/ps

→ applied 0.29 l/h/ps

(2) Fuel Cost for each case

- Case-I Power Output: 70 HP

Operating time: 2,200 hour

Fuel consumption: 0.29 l/h x 70 HP x 2,200 h = 44,600 l/year

Oil consumption: 0.1 % of Fuel

44,660 l x 0.001 ≒ 45 l/year

Fuel Cost:	44,660 l x 12 NR = 535,920 ≒	536,000 NR
	45 l x 125 NR = 5,625 ≒	5,700 NR
Total		541,700 NR

- Case-II Power Output:40 HP (70/2 + 5)

Operating time:	2,200 hour	
Fuel consumption:	1.10 of fuel efficiency	
	(0.29 x 70 x 2,200) x 1.10 x 2 = 56,144 ≒ 56,200 l/year	
Oil consumption:	0.1 % of Fuel	
	56,200 l x 0.001 = 56.2 ≒ 56 l/year	
Fuel Cost:	56,200 l x 12 NR =	674,400 NR
	56 l x 125 NR =	7,000 NR
Total		681,400 NR

- Case-III Power Output:28 HP (70/3 + 5)

Operating time:	2,200 hour	
Fuel consumption:	1.15 of fuel efficiency	
	(0.29 x 28 x 2,200) x 1.15 x 3 = 61,631 ≒ 61,650 l/year	
Oil consumption:	0.1 % of Fuel	
	61,650 l x 0.001 ≒ 62 l/year	
Fuel Cost:	61,650 l x 125 NR =	439,800 NR
	62 l x 125 NR =	7,750 NR
Total		747,550 NR ≒ 747,600 NR

APPENDIX - TWO

OPERATIONAL MANUAL FOR GROUNDWATER MONITORING

[illegible]

[illegible]

APPENDIX TWO: OPERATION MANUAL FOR GROUNDWATER MONITORING

2.1 Introduction

For groundwater development projects, the analysis of the groundwater balance, including surface water, and the forecasting of groundwater movements under pumping conditions, are the most important studies in terms of the planning and implementation stages.

The Synthetic Storage Model (STML) has been developed to implement the above simulation studies on a practical basis.

STML is a mathematical model which deals with basin-wide hydrological balance analyses for both surface and subsurface systems, simultaneously in an unsteady and quasi three-dimensional state. In regard to groundwater systems, it also performs water balance and hydraulic analyses of multi-aquifer systems, including aquicludes. Therefore, the model can be applied to solve phenomena such as multi-phase density flow, land subsidence, substance balance, and so forth.

The program for the synthetic storage model is written by FORTRAN-IV. Originally it was prepared for a main frame computer but was transferred to a desk-top computer by the Study Team during the study period. In the Project, both surface water and groundwater balances are analyzed by the program, and groundwater behavior under pumping conditions is simulated through the program. In the future the groundwater in the area should be controlled through water balance studies using this program as well as data obtained by a proper groundwater monitoring system.

The Manual provides the simulation program with the associated subroutine programs, its structure, required input data or parameters, program operation instructions, and further maintenance. A full set of the program sources are attached in the Appendix, together with a floppy disk containing the latest version of the program.

2.2 Program

2.2.1 Language

The major programs, which are provided by JICA, are written by MS-FORTRAN, version 5.1, and are already installed into the desk-top computer, which is also provided by JICA under the Project. Some programs related to the plotter are written by MS-BASIC, version 7.1 because of the ease in handling the plotter or digitizer. MS-BASIC is also provided simultaneously and is already installed.

2.2.2 Program Component

The STML program consists of a main program, "STML.FOR," and ten subroutine programs. These include,

STML.FOR	...	Main routine
BLOCK.FOR	...	Data initialize subroutine
DATARD.FOR	...	Data reading subroutine
DATAWR.FOR	...	Data write out subroutine
OPEGRA.FOR	...	Subroutine for preparing a graphic condition
PRESET.FOR	...	Preparing the yearly data and variables
PRESET2.FOR	...	Preparing the monthly data and variables
SURF.FOR	...	Calculation for surface system
SUBSURF.FOR	...	Calculation for subsurface system
GPLOT.FOR	...	Graphic display subroutine
AFTTRET.FOR	...	After treatment on a monthly basis

Besides the main program, it associated several subordinate but isolated programs for data handling or plotting. These include,

DPSWR.FOR	...	Program to print out the data calculated by the main routine.
SELECT.FOR	...	Program to rearrange the data which is calculated by the main routine into separated sub-basin data.
SELECDRW.FOR	...	Rearranging the data resulting from SELECT.FOR into a data form by the BASIC plotting program.

As the BASIC program, following two programs are provided:

PLOT2.BAS	...	Plotting routine for the Plotter.
PLOTDRW.BAS	...	Same as above but for results under pumping condition.

2.2.3 Program Structure

The flow chart of the program is illustrated in Figure 2.1, and the program source is shown in List 1. The program structure is explained based on the step numbers in the list.

Line No. 3 to 78 are declarations on the graphic display, common data, and data format. Among the declarations, line No. 3 and No. 5 are the special treatments for MS-FORTRAN to enable graphic displays on the CRT.

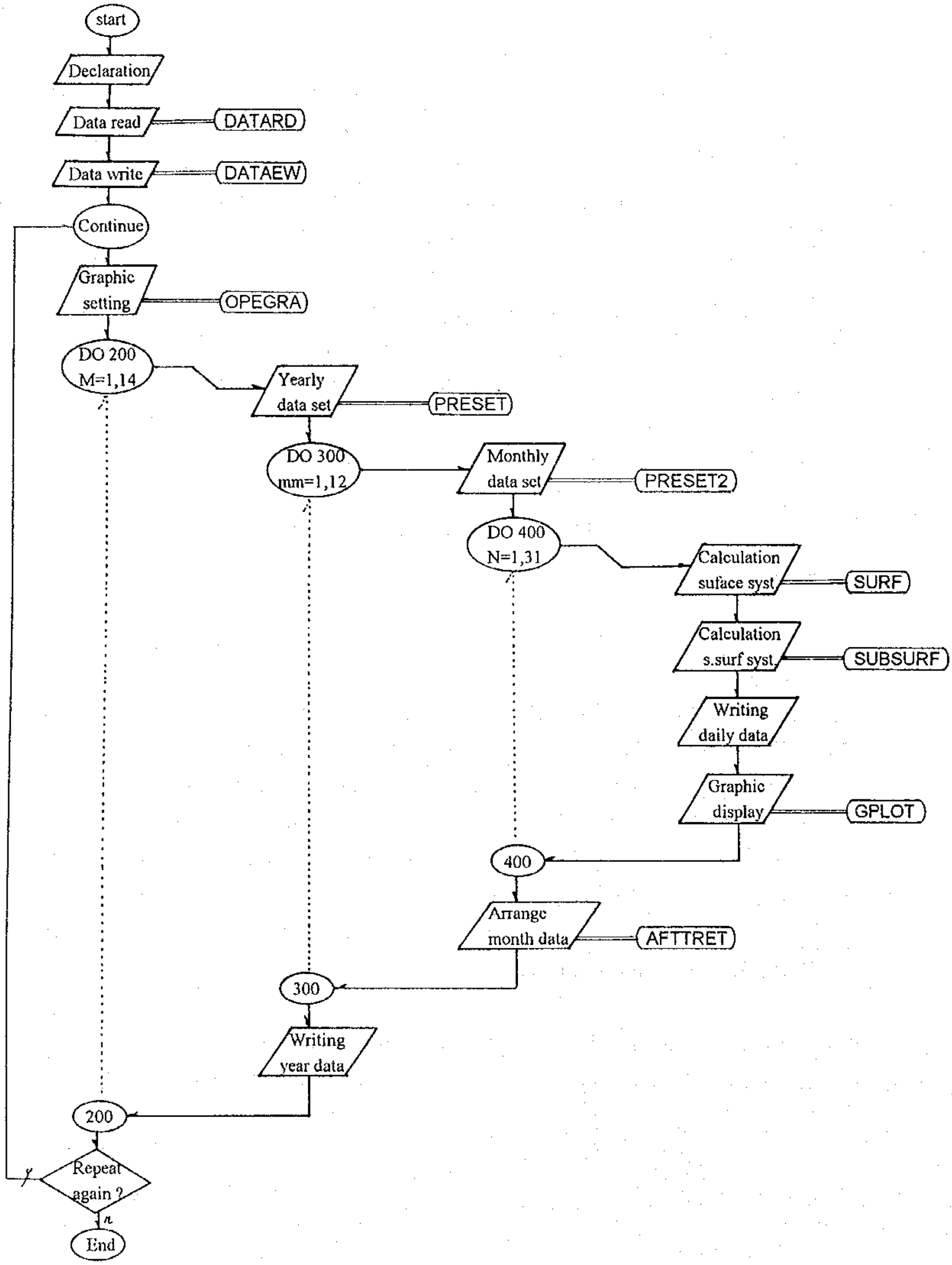
After setting the basic variables, subroutines of data reading and printout are called (lines 80 to 93), and then the data files on draft, rain, and verification are opened along with the files for installing results. Lines 120 to 122 are set at the graphic mode.

The major routine starts from line 126 by inputting the target sub-basin number which is displayed on screen for tracing. Lines 129 to 148 set the graphic constants or variables and calls the OPGRA subroutine at line 150, which arranges the graphic screen.

The yearly iteration starts from line 154, including the monthly iteration from line 170 and the daily iteration from line 179. At the beginning of yearly iteration, PRESET subroutine prepares the draft data and clears all yearly variables. In the monthly iteration, PRESET 2 prepares the rain and verification data and clears the monthly variables. The major calculations on the surface and subsurface systems are carried out in the daily iteration routine by SURF and SUBSURF subroutines. Results of the calculations are immediately written into the result file, and GPLOT is then called for display on screen. After the daily iteration, AFTTRET is called to arrange the daily data into a monthly and yearly data form; and at the end of yearly iteration, the monthly and yearly data arranged by AFTTRET are written in the result file.

Lines 336 to 353 are the closing routine. If another sub-basin is to be analyzed, the program resumes from line 96 and the program ends at line 355.

Figure 2.2.1 Flowchart of STML



2.3 Input and Output Data

2.3.1 Input Data

The program needs following input data arranged into data files:

Data	Data File	Called at
model parameter	GENERAL.DAT	DATARD
E.transpiration	"	"
basin parameter	BASIN.DAT	"
drafting	DRF.DAT	PRESET
rainfall	RAIN.DAT	PRESET2
G.hydrograph	DV.DAT	"
River runoff	"	"
Add. draft	DRWBAS.DAT	(SUBSURF)

2.3.2 Output Data

Output data and files are as follows:

Data	Data File	Written at
SW.hydrograph	RESSUR.DAT	Daily iteration
G.hydrograph	RES1-26.DAT	"
SW.balance	YEARLY.DAT	Yearly iteration
G. balance	"	"
draft amount	DRWUP.DAT	(AFTTRET)
unable amount	UNDRW.DAT	(")

2.4 Data Structure

Because the main memory capacity is limited by MS-DOS, all of the input data has to be prepared in monthly bases, or partitioned month by month. This make the data structure rather complicated, therefore each data structure is explained below.

2.4.1 GENERAL.DAT

The name of the study basin, case number, basin number, treatment years, fixed water heads at the dummy basin, total area, existence of verification data, monthly evapotranspiration, and the number of data basin (basins having verification data) are contained in GENERAL.DAT. The data structure is described in List-2.

2.4.2 BASIN.DAT

This data file is the most basic and most significant: It contains all of the sub-basin parameters including the initial heads. Data structures of surface basins, groundwater basins, and dummy basins are different because of the subsurface structure which is associated or not associated.

The data structures of three kinds of sub-basins are shown in List 3, (a) to (c), accompanied with explanations.

2.4.3 DV.DAT

The data file is one of the most complicated among the data files required. It includes the verification data of the groundwater hydrograph and the river runoff in the same level, and these two are distinguished by the parameter "IPV" in the SURF and SUBSURF subroutines.

The data is grouped completely into yearly data. In the yearly group, the data is separated into monthly subgroups, and further divided into each verification data in monthly bases. List 4 indicates the part of the DV.DAT used in the Project.

2.4.4 RAIN.DAT

Daily rainfall data is simply arranged in a monthly order under a yearly order, as shown in List 5.

2.4.5 DRF.DAT

In this program formulation, DRF.DAT contains only the current draft amount of all of the sub-basins in monthly bases. List 6 shows a portion of an actually used DRF.DAT.

2.5 Operation

2.5.1 Current Groundwater Balance

The STML program already has a full set of input data and verification data under the current situation, so the program can be run as it is. For running the program, working in the PWB (Programmers Work Bench) circumstance under MS-FORTRAN is much easier than working in a stand-alone condition. The ".MAK" and ".SRS" files required for working in PWB are also included in the attached floppy disk.

Operation procedures are as follows:

a) Change directory into \FORTRAN, set path route required.
b) Copy all files from the floppy (A:*.*) to the directory.
c) Start up PWB under MS-FORTRAN (pwb.exe).
d) Set STML.MAK as make file.
e) Run STML.
f) Answer the target basin number (1 - 27)
g) Input the number more than 28 when ending the program.

Through the above procedure, the groundwater hydrograph for the target sub-basin for 14 years is displayed on the screen, together with the verification data if it exists. When the operator wants to revise any parameters, the data file (usually BASIN.DAT) is opened under PWB, the data modified, saved, and run again. Therefore, the operator can modify the model until the simulated hydrograph became satisfactory or as intended.

A hard copy of the calculation results can be obtain through running of associated program "DPSWR.FOR" after completion of the main program. The program reads out the result file "YEARLY.DAT" created by the main program, and sends it to the printer along with the predetermined format.

2.5.2 Simulation Under Pumping Conditions

(1) General Procedure

For the simulation study under pumping conditions, another program named "STML-D.FOR", which is a version including additional draft routines, is required, as well as the associated subroutine programs of "PRESET D.FOR," "SUBSUR-D.FOR," and "AFTTRE-D.FOR," instead of the subroutine programs mentioned above. These versions of the program are also contained in the floppy disk. This requires some data such as the amount of additional draft on a monthly basis, sharing ratio of draft for the relevant sub-basins, and the control level of the draft. The first one is read from DRWBAS.DAT, and the others are given in the PRESET-D and SUBSUR-D subroutines directly.

The procedures for running the program are the same as the ones explained above; the only different is the setting of STML-D.MAK instead of STML.MAK in the PWB circumstance.

(2) Setting the Draft Amount and the Target Sub-basin

Initially set the draft amount for each sub-basin to be withdrawn in monthly unit draft (mm/day), as shown in Table 5.2.1. The table indicates the sample applied in the Study for simulation under shallow aquifer drafting conditions. In this case, the target sub-basins are from No. 14 to No. 27, except for No.18, No. 22, and No. 24. Among them, sub-basins No. 21, No. 23, and No. 27 target only deep aquifer drafting, and sub-basins No.15, No.16, No. 20, and No.26 target both shallow and deep aquifers.

Next set the target aquifer to be extracted in subroutine PRESET-D (refer to the program list of "PRESET-D.FOR"). When there is more than one aquifers to be withdrawn, for example sub-basin No.15, No.16. and so on, the draft amount is shared for each aquifer as the total becomes 1.0.

Table 2.5.1 Sample of "DRWBAS.DAT"

1:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14:	0.370	0.683	2.169	3.767	3.145	1.609	2.873	6.257	4.673	4.512	2.400	0.319
15:	0.347	0.640	2.033	3.533	2.949	1.509	2.693	5.866	4.381	4.230	2.250	0.298
16:	0.324	0.597	1.898	3.297	2.752	1.408	2.514	5.475	4.089	3.948	2.100	0.279
17:	0.370	0.683	2.169	3.768	3.145	1.609	2.873	6.257	4.673	4.512	2.400	0.319
18:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19:	0.370	0.683	2.169	3.768	3.145	1.609	2.873	6.257	4.673	4.512	2.400	0.319
20:	0.393	0.725	2.304	4.003	3.342	1.710	3.052	6.648	4.966	4.784	2.550	0.339
21:	0.296	0.555	1.762	3.062	2.556	1.307	2.335	5.084	3.797	3.666	1.950	0.258
22:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23:	0.114	0.213	0.678	1.177	0.983	0.503	0.898	1.955	1.460	1.410	0.750	0.099
24:	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25:	0.370	0.683	2.169	3.768	3.145	1.609	2.873	6.257	4.673	4.512	2.400	0.319
26:	0.393	0.725	2.304	4.003	3.342	1.710	3.052	6.648	4.966	4.794	2.550	0.339
27:	0.364	0.683	2.169	3.768	3.145	1.609	2.873	6.257	4.674	4.512	2.400	0.318

Therefore, the unit draft amount must be set to the total volume to be withdrawn from the sub-basin.

Further, an additional draft parameter for each sub-basin is defined in the subroutine SUBSUR-D to simulate other draft conditions, ie., to check the maximum draft potential. When simulating the hydrologic balance under irrigation water demand, set the parameters as 1.00, and set the target sub-basins to seven sub-basins just concerned. Lines 186 to 219 in the program list of SUBSUR-D are the definition routine for unconfined aquifers. If only confined aquifers are the target, this routine is voided and the routine from lines 368 to 402 in the same program is used instead.

After completion of these preparation, run STML-D carefully checking the drawdown displayed on screen. During this procedure, line 199 in the program list of STML-D is effective because it can make the run-time much shorter. At the end of this procedure, line 199 is voided for complete function of the program.

2.5.3 Plotting

Before drawing out the results by the plotter, the results are rearranged into a favorable format for the plotting routine through SELECT.FOR and SELECDRW.FOR. The former separates the daily results of water heads and runoff into each sub-basin, and the latter distinguishes the amount of draft and unable draft, which are then arranged into sub-basin unit data.

SELECT program creates 27 data files, named RAT-1 to RAT-27.DAT, which occupy a total of 12.2 MB of memory space in Hard Disk; therefore it is necessary to check the HD space prior to running this program.

The program needs a long run-time, depending upon the clock speed of CPU and the existence of co-processor. For the program, a co-processor for floating calculations is indispensable.

The plotting routine is written by BASIC language. The programs are PLOT2.BAS and PLOTDRW.BAS; the former is for normal water balance and the latter is for water balance under pumping conditions. The running procedure is as follows:

a) Change directory to \BASIC, and set required path.
b) Copy all BASIC file (*.BAS) to the directory.
c) Start up Quick-basic (qbx.exe),

d) Set the program PLOT2.BAS or PLOTDRW.BAS under QB conditions.
e) Prepare the Plotter (A3 paper size).
f) Run program.
g) Answer the target sub-basin to be drawing.
h) Answer the number greater than 28 when go to end.

Before running the program, setting the data file name in the routine from lines 84 to 139 as well as editing on lines 269 and 272 for the title line are required.

2.6 Improvement and Maintenance

Though the program has been debugged and is stable as is, it is recommended that the following aspects of program be improved:

a) To unify the STML.FOR and STML-D.FOR.
b) To include SELECT.FOR and SELECDRW.FOR into the main routine.
c) To make clear the common data to omit unnecessary variables.
d) To translate the BASIC program into the FORTRAN program, and to unify all of the program into FORTRAN.
e) And so forth.

For periodical maintenance, the verification data must be revised on a monthly basis if possible. Carefully run the program to determine whether or not the model parameters still meet the actual water balance. When the calculated hydrograph or runoff no longer fits the new verification data, the model parameter(s) should be modified, and the water balance already carried out should be reviewed again. Therefore, the storage model of the area becomes even more precise, month by month, and year by year.

2.7 Appendix

A floppy disk (3.5", 1.44 MB format) is attached as the appendix which contains all of the fortran programs (.FOR), make files (.MAK), and input data files (.DAT).

List-1 Program Source of STML


```
C******************     PROGRAM STML, MAIN ROUTINE ************
C
      INCLUDE 'FGRAPH.FI'
      PROGRAM STML
      INCLUDE 'FGRAPH.FD'
C
C --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- ---
C
      PARAMETER (MB=37,MBC=37,MA=4,MT=3,MS=2,MY=14,MAS=MA-1)
C
      COMMON /NAME/AREANM,BASNAM,ICASE
      COMMON /DTE/NYR,KYR,KMN,NREGB
      COMMON /MONTH/MON(12)
      COMMON /BASIN/NBASIN,NAQFR,AREA(MBC),CAREA(MBC),IBASN(MY)
      COMMON /BASIN2/ET(12),STMX(MB)
      COMMON /BLK1/IPQ(MB,MY),IPV(6,MB),IPG(MB),NTK(MB)
      COMMON /BLK2/MBCT(MB),NGCT(4,MBC),NPCT(4,MBC),NOSN(MB),RET(MT,MB)
      COMMON /BLK3/RTRN(MB),NOUT(4,MT,MB)
      COMMON /BLK4/GSL(MBC),XL(MBC),YL(MBC),ZL(MA,MBC),GZZ(MA,MB)
      COMMON /BLK5/XA(MT,MB),HA(4,MT,MB),ALF(4,MT,MB)
      COMMON /BLK6/GALF(4,MA,MB),GLEK(MAS,MB),GHA(4,MB),
     +           GBTK(MA,MB),BDSH(MAS,MB)
      COMMON /BLK7/GXA(32,MA,MBC),GSTR(32,MA,MB),GQZ(MA,MB)
      COMMON /BLK8/RAIN(31),DRF(12,MA,MB),IDRF(MB),NDRF(MB),PDRF(MB),
     +       DRFT(31,MA,MB)
      COMMON /BLK9/BRAIN(31,MB),DV(31,6,MB),EET(31,MB)
      COMMON /BLK10/RINF(32,MBC),OVFL(31,MB),RNOF(32,MB),GRCH(31,MB),
     +         GLK(31,MA,MB),GRNF(31,MA,MB),GINF(32,MA,MBC),NOF(MB)
      COMMON /OTH1/EXROF(MB),EXBIN(MB),EXGST(MA,MB),EXGXA(MA,MB),
     +           EXGIN(MA,MB)
      COMMON /OTH2/AAMAX,BBMAX(MB),BBMIN(MB),EEMAX,EEMIN
      COMMON /OTH3/GHH(MS,MB),GQQ(MS,MB),HH(MS),QQ(MS)
      COMMON /OTH4/SSSR(MY),SSSE(MY),SSSI(MY),SSSD(MY),SSSG(MY),
     +           SSRM(MY),SSSY(MY),SINF(MY),SOUT(MY)
      COMMON /OTH5/SSRE(MB),SSRN(MB),SSEE(MB),SSIN(MB),SSFF(MB),
     +           SSLK(MA,MB),SSGR(MA,MB),SSDF(MA,MB)
      COMMON /OTH6/SRN(12,MB),SEE(12,MB),SIN(12,MB),SFF(12,MB),
     +           SRE(12,MB),SLK(MA,12,MB),SGR(MA,12,MB),SDF(MA,12,MB)
      COMMON /OTH7/ARE(MB),ARN(MB),AEE(MB),AIN(MB),AFF(MB),ALK(MA,MB),
     +           AGR(MA,MB),ADF(MA,MB),AGF(MB),AAD(MB),SHD(MA,12,MB)
      COMMON /DUM/GRDMY(6,MA),XDUMY(MA),NDUMY
      COMMON /GRAP/UBA(MB),PBA(MB),GWB(MB),RAT(27),COH(27)
      COMMON /PLOT/AQ1Y,AQ2Y,AQ3Y,AQ4Y,AQ1N,AQ2N,AQ3N,AQ4N
      COMMON /RCHG/CONGRCH(31,9)
      COMMON /DRAW/DRTIO(MB),DRMON(12,27),AQRAT(4,27),DRWN(31,4,27),
     +           REQE(MB),UNDRW(31,27)
C
      CHARACTER*20 AREANM
      CHARACTER*16 BASNAM
      CHARACTER*1  ANS
      INTEGER*2  status, xleft, yleft, yright, xrightE
      INTEGER*2  AQ1Y,AQ2Y,AQ3Y,AQ4Y,AQ1N,AQ2N,AQ3N,AQ4N,RN0,RN1
      RECORD / xycoord /     xy
      RECORD / videoconfig / screen
      RECORD / rccoord / S
C
C ------------------------------------------------------------------
    1 FORMAT(' MONTH=',I2,6X,'MX1    MX2    MX3',9X,'XA1',4X,'XA2',
     + 4X,'XA3',9X,'Q31',3X,'Q32   Q33   Q22   Q12   Q13   Q14',6X,
     + 'RNOF',9X,'Q21   Q11')
    2 FORMAT(2I2)
    5 FORMAT(I2,6F8.2)
    3 FORMAT(I2)
    4 FORMAT(I5)
    6 FORMAT('+', 'BASIN=',I2,'  TERM=',I2)
    7 FORMAT(2X,5F8.2)
    8 FORMAT(I2,3F8.2)
    9 FORMAT(14F9.1)
   10 FORMAT(12F6.3)
   14 FORMAT(8F8.1)
   79 FORMAT(I2,I3,I5,F8.2)
   80 FORMAT(12F8.2,2F8.2)
   81 FORMAT(I2)
   82 FORMAT(12F8.2)
   83 FORMAT(A20,I3,I4)
   84 FORMAT(I4,8F8.1)
   85 FORMAT(12F8.2,F8.0,F8.1)
   90 FORMAT(A1)
C------------------------------------------------------------------
C
      NREGB = 27
      NTERN = 0
      IDAYINT = 5
C
      OPEN(1,FILE='PRN')
C
C****** GENERAL DATA READING ******
C
      CALL DATARD
C
C****** PRINT OUT BASIC DATA ******
C
      CALL DATAWR
C
C******* OPRN DATA FILES **********
   50 continue
C******************************************************************
C****** START ITERATIVE CALCULATION FOR TREATING YEAR ******
C******************************************************************
C
C                 ---------- OPEN DATA FILES ----------------
C
      OPEN(2,FILE='C:\FORTRAN\DRF.DAT',STATUS='OLD')
      OPEN(3,FILE='C:\FORTRAN\RAIN.DAT',STATUS='OLD')
      OPEN(4,FILE='C:\FORTRAN\DV.DAT',STATUS='OLD')
      OPEN(5,FILE='C:\FORTRAN\YEARLY.DAT',STATUS='UNKNOWN')
C
      OPEN(6,FILE='C:\FORTRAN\RESSUR.DAT',STATUS='UNKNOWN')
      OPEN(7,FILE='C:\FORTRAN\RES5.DAT',STATUS='UNKNOWN')
      OPEN(8,FILE='C:\FORTRAN\RES8.DAT',STATUS='UNKNOWN')
      OPEN(9,FILE='C:\FORTRAN\RES11.DAT',STATUS='UNKNOWN')
      OPEN(10,FILE='C:\FORTRAN\RES14.DAT',STATUS='UNKNOWN')
      OPEN(11,FILE='C:\FORTRAN\RES17.DAT',STATUS='UNKNOWN')
      OPEN(12,FILE='C:\FORTRAN\RES20.DAT',STATUS='UNKNOWN')
      OPEN(13,FILE='C:\FORTRAN\RES23.DAT',STATUS='UNKNOWN')
      OPEN(14,FILE='C:\FORTRAN\RES26.DAT',STATUS='UNKNOWN')
C
C**************** Find graphics mode. **********************
C
      IF( setvideomode( 18 ) .EQ. 0 )
     +    STOP 'Error:  cannot set graphics mode'
      CALL getvideoconfig( screen )
C
C**************** TARGET BASIN INPUT ***************
C
      WRITE(*,*) ' INPUT TARGET BASIN NUMBER (I2)'
      READ(*,81) NTG
C
      RN0=340
      RN1=340
      xleft = 40
      yleft = 40
      xrightE=631
      yright = 440
      AQX = xleft
      UBASE=UBA(NTG)
      AREA2=AREA(NTG)/CAREA(NTG)
         AQ1Y=40+INT((UBASE-GXA(1,1,NTG))*10.)
         AQ2Y=40+INT((UBASE-GXA(1,2,NTG))*10.)
         AQ3Y=40+INT((UBASE-GXA(1,3,NTG))*10.)
         AQ4Y=40+INT((UBASE-GXA(1,4,NTG))*10.)
C
      SSRM(M)=0.0
      SSSY(M)=0.0
      TRAIN = 0.
      IACUM = 0
      LST = 0
      RM3AIN = 0.
C
      CALL OPGRA(NTG)
C
C***************** YEARLY ITERATION ***************
C
      DO 200 MM=1, 14
C
        LMS=KMN
        LMN=12
        IYR=KYR-1+MM
        NREP=1
C
        CALL PRESET(MM,NREP)
        IF(NREP.EQ.0) GO TO 990
        DO I=1, 9
          NF = I + 5
          WRITE(NF,4) IYR
        END DO
C
C ************** MONTHLY ITERATION *****************
C
        DO 300 M=LMS, LMN
C
          JMO=MON(M)
          IF(MOD(IYR,4).EQ.0.AND.M.EQ.2) JMO=29
C
          CALL PRESET2(MM,M,JMO)
C
C ************** DAILY ITERATION *****************
C
          DO 400 N=1, JMO
C
```

```
            IACUM = IACUM + 1
            RAI = RAIN(N)
C
            CALL SURF(N,M,JMO,MM)
C
            CALL SUBSURF(I,AQ1N,AQ2N,AQ3N,AQ4N,NTG)
C
C         go to 399
C ------------------------------ WRITING TO SURFACE DATA FILE -------
C
            WRITE(6,2) M, N
            DO K=1, 4
              CC1=RNOF(N,K)*AREA(K)/CAREA(K)
              WRITE(6,8) K, CC1, DV(N,6,K), RAI
            END DO
C
C -------------------------- WRITING TO SUB-S DATA FILE (5 - 27) ----
            WRITE(7,2) M, N
            DO K=5, 7
              CC1=RNOF(N,K)*AREA(K)/CAREA(K)
              WRITE(7,5) K, (GXA(N,L,K),L=1,4), CC1, RAI
              WRITE(7,7) (DV(N,L,K),L=1,4),DV(N,6,K)
            END DO
            WRITE(8,2) M, N
            DO K=8, 10
              CC1=RNOF(N,K)*AREA(K)/CAREA(K)
              WRITE(8,5) K, (GXA(N,L,K),L=1,4), CC1, RAI
              WRITE(8,7) (DV(N,L,K),L=1,4),DV(N,6,K)
            END DO
            WRITE(9,2) M, N
            DO K=11, 13
              CC1=RNOF(N,K)*AREA(K)/CAREA(K)
              WRITE(9,5) K, (GXA(N,L,K),L=1,4), CC1, RAI
              WRITE(9,7) (DV(N,L,K),L=1,4),DV(N,6,K)
            END DO
            WRITE(10,2) M, N
            DO K=14, 16
              CC1=RNOF(N,K)*AREA(K)/CAREA(K)
              WRITE(10,5) K, (GXA(N,L,K),L=1,4), CC1, RAI
              WRITE(10,7) (DV(N,L,K),L=1,4),DV(N,6,K)
            END DO
            WRITE(11,2) M, N
            DO K=17, 19
              CC1=RNOF(N,K)*AREA(K)/CAREA(K)
              WRITE(11,5) K, (GXA(N,L,K),L=1,4), CC1, RAI
              WRITE(11,7) (DV(N,L,K),L=1,4),DV(N,6,K)
            END DO
            WRITE(12,2) M, N
            DO K=20, 22
              CC1=RNOF(N,K)*AREA(K)/CAREA(K)
              WRITE(12,5) K, (GXA(N,L,K),L=1,4), CC1, RAI
              WRITE(12,7) (DV(N,L,K),L=1,4),DV(N,6,K)
            END DO
            WRITE(13,2) M, N
            DO K=23, 25
              CC1=RNOF(N,K)*AREA(K)/CAREA(K)
              WRITE(13,5) K, (GXA(N,L,K),L=1,4), CC1, RAI
              WRITE(13,7) (DV(N,L,K),L=1,4),DV(N,6,K)
            END DO
            WRITE(14,2) M, N
            DO K=26, 27
              CC1=RNOF(N,K)*AREA(K)/CAREA(K)
              WRITE(14,5) K, (GXA(N,L,K),L=1,4), CC1, RAI
              WRITE(14,7) (DV(N,L,K),L=1,4),DV(N,6,K)
            END DO
C
C ------------------------------------ PLOTTING ROUTINE -------------
  399     continue
C
            TRAIN = TRAIN + RAI
            IF(IACUM.EQ.IDAYINT) THEN
              CALL GPLOT(N,MM,NTG,AQX,yright,AREA2,RN0,RN1,MTERN,TRAIN)
              IACUM = 0
              TRAIN = 0.
              AQX = AQX + 1
              IF(AQX.GT.xrightE) THEN
                AQX=xleft
                MTERN = MTERN + 1
                CALL settextposition(1,6,S)
                WRITE(*,6) NTG,MTERN+1
              END IF
            END IF
C
  400     CONTINUE
C
C --------------------- (END OF DAILY ITERATION) --------------------
C
          IF(MTERN.EQ.0) THEN
            dummy = setcolor(7)
          ELSE
            dummy = setcolor(5)
          END IF
          CALL moveto(AQX,yright,xy)
          STATUS = lineto(AQX,yright+10)
C
          CALL AFTTRET(MM,M,JMO)
C
  300   CONTINUE
C
C ---------------------- (END OF MONTHLY ITERATION) -----------------
C
          IF(MTERN.EQ.0) THEN
            dummy = setcolor(7)
          ELSE
            dummy = setcolor(5)
          END IF
          AQX = AQX + 1
          CALL moveto(AQX,yleft,xy)
          STATUS = lineto(AQX,yright)
          IF(AQX.GT.xrightE) THEN
            AQX = xleft
            MTERN = MTERN + 1
            CALL settextposition(1,6,S)
            WRITE(*,6) NTG,MTERN+1
          END IF
C                          --------- recording to HD ----------
C
         DO 750  KK=1,NRECB
C
          WRITE(5,79) KK,ICASE,IYR,AREA(KK)
C
          WRITE(5,80) (SRN(M,KK),M=1,12),SSRN(KK),ARN(KK)
          WRITE(5,85) (SIN(M,KK),M=1,12),SSIN(KK),AIN(KK)
          WRITE(5,80) (SEE(M,KK),M=1,12),SSEE(KK),AEE(KK)
          WRITE(5,85) (SFF(M,KK),M=1,12),SSFF(KK),AFF(KK)
          WRITE(5,80) (SRE(M,KK),M=1,12),SSRE(KK),ARE(KK)
          IF(IPG(KK).GT.0) GO TO 750
C
          DO 745 L=1, NAQFR
            WRITE(5,81) L
            WRITE(5,80) (SLK(L,M,KK),M=1,12),SSLK(L,KK),ALK(L,KK)
            WRITE(5,80) (SGR(L,M,KK),M=1,12),SSGR(L,KK),AGR(L,KK)
            WRITE(5,80) (SDF(L,M,KK),M=1,12),SSDF(L,KK),ADF(L,KK)
            WRITE(5,82) (SHD(L,M,KK),M=1,12)
  745     CONTINUE
C
  750   CONTINUE
C
        WRITE(5,83) AREANM, ICASE, IYR
        DO 735 KK=1, NRECB
          WRITE(5,84) KK,AREA(KK),ARN(KK),AIN(KK),AEE(KK),AFF(KK),
     1                ARE(KK),AGF(KK),AAD(KK)
  735   CONTINUE
        WRITE(5,14) CAREA(NBASIN),SSSR(MM),SINF(MM),SSSE(MM),
     1              SOUT(MM),SSSI(MM),SSSG(MM),SSSD(MM)
C
  707   SSSY(MM)=SOUT(MM)-SINF(MM)
        SSRM(MM)=SSSG(MM)
C
  200 CONTINUE
C ******************** (END OF YEARLY ITERATION) ********************
C
      WRITE(5,9) (SSSY(M),M=1,14)
      WRITE(5,9) (SSRM(M),M=1,14)
C
  991 WRITE(*,*) ' PLOT OTHER BASIN ? .....  Y or N'
      READ (*,90) ANS
      IF(ANS.EQ.'N'.OR.ANS.EQ.'n') GO TO 999
      DO NF=2, 14
        CLOSE(NF)
      END DO
      MTERN = 0
      GO TO 50
C
C ************************** ENDING ************************
C
  990 STOP 'ERROR DATA'
      WRITE(*,*) 'END OF PROGRAM'
C
  999 CONTINUE
      DO 1000 N=1,14
        CLOSE(N)
 1000 CONTINUE
C
      END
C*********************************************************************
```

List-2 GENERAL.DAT

```
JHAPA DISTRICT
   1   37    4
  14 1980    1
 58.  60.  60.  62.  0.
 2549.1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 1 0 0 1 1 1 0 0 1 1 1 1 0 1 1 1 0 1 1 1 1 1
  1.5  3.0  4.0  6.0  6.0  5.5  4.5  5.0  5.0  4.0  3.0  2.0
    0    0    0    0    0    0    0    1    1    1    1    0    0   17   17
```

- Name of District (A20)
- Case No., Sub-basin No., Aquifer No. (3I5)
- Treating years, Begining year, Begining month (3I5)
- Fixed g.water heads of Dummy Basin (5F5.2)
- Total area of the model (F8.2)
- IPQ(37,14) Existence of verification data at each year (30I2)
- Monthly Evapotranspiration (12F5.1)
- No. of sub-basins having verification data (16I5)

List-3 (a) BASIN.DAT (Surface Basin)

```
SUBBASIN NO.1
1181.5421181.542   0.000
       8       3       8       0
    0.00    1.20    0.00
       0       0       0       0       0       1
    0.70    0.55    0.00
     0.0    50.0   210.0
   0.030   0.018   0.080   0.350
   0.018   0.045   0.000   0.000
   0.001   0.002   0.005   0.000
     0.0    20.0   110.0   200.0
     0.0    50.0   0.000   0.000
     0.0     0.0   160.0     0.0
       0       8       8       8
       0       8       8       8
       8       8       8       8
```

- Basin Name (A16)
- AREA(K),CAREA(K),DRTIO(K) (3F8.3) Area, Cumulated area, unused variable
- NBCT(K), NTK(K), IPG(K), IDRF(K) (4I8) Surface connection, No.of Tank, existence of groundwater system, draft or not
- RDRF(K), RTRN(K), PDRF(K) (3F8.3) Coefficients on Draft, Rain, and Additional draft
- IPV(IL,K) (6I8) Existence of verification data on each aquifer and runoff
- RET(I,K) (3F8.3) Coefficients on evapotranspiration on each tank
- XA(I,K) (3F8.3) Initial water heads in each tank
- ALF(I,J,K) (4F8.5) Runoff coefficients on each tnak and each outlet
- HA(I,J,K) (4F8.2) Orifice heights on each tank, each outlet
- NOUT(I,J,K) (4I8) Destinations of each outlet in each tank

List-3 (b) BASIN.DAT (Groundwater Basin)

```
SUBBASIN NO.5
  58.984 219.369   0.000
       9       2       0       0
     0.0     1.0     0.0
       0       0       0       0       0       0
    0.70    0.55    0.00
     0.0    20.0
   0.030   0.010   0.300   0.000   0.000
  -0.060   0.005   0.000   0.600   0.000
     0.0    15.0   100.0   0.000   0.000
     0.0     0.0    30.0    13.0   0.000
       0       9       9       9
       0       9       0       9
  7150.0  8250.0   152.0       2
    22.0     1.0    23.5    70.0
   130.0   128.5   100.0   -20.0
     0.5     5.0    50.0
       0       9       6       0
       1       1       6       6
 0.05000 0.00050 0.00050   0.001
     0.0   5.000   1.500     0.0
     0.0   0.500   1.000     0.0
     0.0   0.200   1.000     0.0
     0.0   0.100   0.300     0.0
   500.0   2.000   1.300
     0.0   100.0   136.0     0.0
   150.1   150.4   150.5   151.0
   130.0   152.0
    0.00 1297.65
    1.00
```

(Surface System)

- Basin Name (A16)
- AREA(K),CAREA(K),DRTIO(K) (3F8.3
  Area, Cumulated area, unused variable
- NBCT(K), NTK(K), IPG(K), IDRF(K) (4I8)
  Surface connection, No.of Tank, existence of groundwater system, draft or not
- RDRF(K), RTRN(K), PDRF(K) (3F8.3)
  Coefficients on Draft, Rain, and Additional draft
- IPV(IL,K) (6I8)
  Existence of verification data on each aquifer and runoff
- RET(I,K) (3F8.3)
  Coefficients on evapotranspiration on each tank
- XA(I,K) (3F8.3)
  Initial water heads in each tank
- ALF(I,J,K) (4F8.5)
  Runoff coefficients on each tnak and each outlet
- HA(I,J,K) (4F8.2)
  Orifice heights on each tank, each outlet
- NOUT(I,J,K) (4I8)
  Destinations of each outlet in each tank

(Subsurface System)

- XL(K), YL(K), GSL(K), NOSN(K) (3F8.1,I8)
  X and Y lengths, Ground elevation, No. of H-Q curve (unused)
- ZL(I,K) (5F8.1)
  Thickness of each aquifer
- GZZ(I,K) (5F8.1)
  Base elevation of each aquifer
- BDSH(I,K) (4F8.2)
  Thickness of each aquiclude
- NGCT(J,K) (4I8)
  Subsurface connection to up, down, left, and right
- NPCT(I,K) (4I8) — unused
- GBTK(J,K) (5F8.5)
  Specific yield of each aquifer
- GALF(J,L,K) (4F8.5)
  Permeability for up, down, left, and right directions for each aquifer
- GLEK(L,K) (3F8.5)
  Leakance (a part)
- GHA(I,K) (4F8.2)
  Height of outlet to up, down, left and right dirc.
- GXA(1,J,K) (5F8.1)
  Initial g.water head of each aquifer
- Dummy variables (2F8.2)
  (originally heads and volumes on H-Q curve)
- RAT(K) (F8.2)
  Coefficient on quadratic for permeability

List-3 (c) BASIN.DAT (Dummy Basin)

```
SUBBASIN NO.28
   33.63
 9440.0  3560.0   183.0       0
   27.0    20.0    25.0    70.0
      0       0       0       7
      4       4       4       4
  490.0   110.0   156.0   156.0
  175.0   175.0   175.0   170.0
```

- Basin name (A16)
- AREA(K)
- X and Y lengths, Ground elevation, No. of H-Q curve (unused)
- ZL(I,K) (5F8.1) Thickness of each aquifer
- NGCT(J,K) (4I8) Subsurface connection to up, down, left, and right
- NPCT(I,K) (4I8) --- unused
- GHA(I,K) (4F8.2) Height of outlet to up, down, left and right dirc.
- GXA(1,J,K) (5F8.1) Initial g.water head of each aquifer

List-4 DV.DAT

```
1991
1992
1993
st13/1   154.50   154.48
 154.51   154.46
st16/1   106.75   106.76   106.80
   106.72   107.69
jp10/1   107.44   107.50   107.52
   107.47   107.46
ex9/1
st11/1   123.70   123.61   123.68
   123.56   123.54
st4/1   71.93   71.93   71.94
   71.90   71.89
ex14/1
ex3/1
jp9/1   93.75   93.76
 93.72   93.69
ex7/1
ex2/1
st17/1   108.12   108.13   108.15
   108.08   108.04
ex15/1
ex10/1
st19/1   90.48   90.53   90.58
   90.48   90.44
jp12/1   80.90   80.89   80.87
   80.85
st2/1   82.35   82.30   82.32
   82.30
riv2/1
 0.53  0.52  0.51  0.52  0.55  0.52  0.55  0.55  0.58  0.57  0.52
st1/1 91.66   91.49   91.58   91.30
 91.40
ex5/1
stj5/1   75.25   75.25   75.24
   75.21
jp13/1   76.17   76.13   76.18
   76.17
stj1/1   77.30   77.27   77.27
   77.25
ex4/1
st3/1   68.46   68.48   68.44
   68.42
ex12/1
ex1/1
stj2/1   71.27   71.28   71.27
   71.24
```

- One well one month data (6X,10F6.2,/,6X,10F6.2,/,11F6.2)
- One river runoff one month data (6x,10F6.2,/,6X,10F6.2,/,11F6.2)
- One year data

List-4 DV.DAT (cont.)

```
ex13/1

riv3/1

        0.03  0.06  0.03  0.03  0.01  0.01  0.11  0.02  0.02  0.02  0.36
st13/2154.42                                    154.38
                                                154.34
                              154.32
st16/2                                    106.65
                        106.67
      106.68                                    106.64
jp10/2                                    107.41
                        107.42
      107.42                                    107.39
```

```
ex5/12                               77.23
                   77.27                                     77.17
                                           77.14
stj512                         75.75
             75.66                                     75.56
                                     75.48
jp1312                         76.37
             76.30                                     76.25
                                     76.22
stj112 77.80                                     77.73
                               77.65
             77.59                                     77.58
ob2/12 71.71 71.70 71.69 71.68 71.67 71.65 71.65 71.64 71.64 71.63
       71.62 71.62 71.61 71.60 71.59 71.57 71.57 71.56 71.56 71.56
       71.55 71.53 71.52 71.52 71.52 71.52 71.51 71.51 71.50 71.49 71.49
st3/12 68.90                                     68.90
                               68.68
             68.68                                     68.63
ex1212 68.51                                     68.44
                               68.39
             68.33                                     68.29
ob1/12 65.73 65.72 65.72 65.71 65.70 65.69 65.69 65.69 65.69 65.68
       65.68 65.68 65.67 65.67 65.65 65.64 65.64 65.63 65.63 65.63
       65.62 65.61 65.59 65.59 65.60 65.60 65.59 65.59 65.58 65.58 65.57
stj212                         71.89
             71.72                                     71.58
                                     71.43
ex1312                         65.62
             65.60                                     65.45
                                     65.40
riv312  0.04  0.07  0.07  0.08  0.05  0.55  0.07  0.06  0.05  0.05
        0.04  0.05  0.08  0.02  0.04  0.03  0.03  0.03  0.06  0.04
        0.03  0.03  0.05  0.05  0.02  0.03  0.01  0.05  0.04  0.03  1.26
  1994
st13/1                        154.54
            154.60                                    154.68
                                    154.65
st16/1            106.70                                    106.69
                                          106.96
                              106.90                              106.82
jp10/1            107.47                                    107.46
                                          107.62
                        107.62
ex-9/1            112.01                                    111.98
                                          111.98
                        111.97                                    111.95
st11/1                        123.54
            123.64                                    123.79
                                    123.72
stw4/1                   71.97
       71.94                                     71.97
                               71.96
```

- One month data
- Next month data
- One well one month data (6X,10F6.2/,6X,10F6.2/,11F6.2)
- One river runoff one month data (6x,10F6.2/,6X,10F6.2/,11F6.2)
- Next year data

List-5 RAIN.DAT

```
 1980
   /1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   /2    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0   11   14    0    0    0    0    0    0    0    0    0    3    0
   /3    0    0    0    6    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    2    0
   /4    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0   13    0    0    0    0    0    0    0    0    0   14
   /5    0    0   41    0    0   15    0    0   14    0   40    0    0    0    3
    0    0    0    0    0    0    0    0    0    0   11    2    5    0    8    0
   /6    0    0    2    0    0    7    3   16   25    0    0    0    0   22    0
   11   48   60   81    0    5    0    0    8    0    0    0    0   18   11
   /7    3    0   30   30    0    0    0    0    5    9   20    0    0    4    8
   29   33   38   11   91   51   15    0    0    0   30   22   12    5   15   85
   /8   90    3    0    0  100   22   80   40    0    0   15   11   23   55   80
   91   50   15    0    0    0    5    2    0    0    0   15    8   20    0   17
   /9   31   40   45   50   12    0    0   50   27    0    0   85   90   95    0
    2   22   25    7    0    0   36    0   50    0    0    2    0    0    0
  /10    0    0    0    0    0   25   28    0    0    0    0    0    0    0    0
    0    0    0   15   13    0    5    0   40    0    0    0    0    0    0
  /11    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  /12    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
 1981
   /1    0    0    0    0    0    0    0    5    2    0    0    0    0    0    0
    0    0    0    0    0    0    0    6   13    0    0    0    0    0    0    0
   /2    0    0    0    0    0    0    0    0    0    0    4    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0
   /3    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0   35    0
   /4    0    0    0    0    0    0    0    0    0    0    0    8    0    0   35
    0    6    2    0    0    0    6    0    2    0    0    8    0    0   58
   /5    0    3    9   13    0    0    0    0    0    0    0   44   22    6   16
   26    0    0    0    0    0    0    0    0    0    5    0    0    0    0    0
   /6    0    0    0    0    0    0    2    0    0    4   15    0    0    0    0
    0    0    0    0    0    0    5   40   31   15    3   22   51   80   66
   /7    5   13    0    0    3    0    0    0    0    0    0    7   18   77   35
   81   85   66    0    0    0    0  230    0   40  160  180  140    0    0   18
   /8   19    0    0    5   17    0   22  120   82   55    0    0    0   57   13
    0   65   25   28   29   40    5   25    0    0    0    0    0    0    0    0
   /9    0   60   25    0    0    5    0    0    0    0   22    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  /10    0    0    0    0    0    0    0    5    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  /11    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  /12    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
 1982
   /1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   /2    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0
   /3    0    0    0    0    0    8    0    0    0    0    0    0    0    0    0
    0    0    0    0    4    0    0    0    0    0    0    0    0    0    0    0
   /4    0    0    0    0    0    0    0    0    0    0    0    0    0   10   20
    0    2    0    0    0    0    0    0    5    0   20    0    0    0    0
   /5    0    0    0    0    0    0    0    0    0    0    0    0    6   41    5
    0    0    0    0    0    0    0    0    0    0    0   55   42   48   60   56
   /6    0   10    0   33    0    0    0   60    0    0    0    0    0    0   45
    3   48   80   38    0    0    0    0    0   50   56    0    0   35   20
   /7   38   80   50   22    9   55   86    5  110  130  122   10  130  122   19
   18   18   40   43   66   65   70   80    0    0   38    5   17    0   55    0
   /8    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0   11    8    0    0    0    0    0    5    4    0    0    0    0    0    0
   /9    0    0    0    0    0    0    0    0    5    4    9   22   60   28   17
   13   40   35   18   48   50   60   11    0    0    0    0    0    0    0
  /10    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0   10    3    6    6    0    0    0    0    0    0    0
  /11    0    0    0    0    0    0    0    0    7    3    4    0    0    0    0
    0    0    0    0    0    0    0   12    0    0    0    0    0    0    0
  /12    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
 1983
   /1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    5    0    0    0
   /2    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0   15    0    0    0
   /3    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    2    5    0    9    0    0    0    0    0    0    0    0
   /4    0    0    0    0    0    0    0    0    0    0    2    0    0    0    0
    0    0    0   17    0    0    0    0    0    0    0    0    0    6    5
   /5    0    0    0
```

Daily rainfall for one month (5X,15F5.0,/,16F5.0)

One year data

Next year data

Daily rainfall for one month (5X,15F5.0,/,16F5.0)

List-6 DRF.DAT

```
1980
 144  144  144  144  144  144  144  144  144  144  144  144
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
 300  300  300  300  300  300  300  300  300  300  300  300
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
 324  324  324  324  324  324  324  324  324  324  324  324
   0    0    0    0    0    0    0    0    0    0    0    0
1160 1160 1160 1160 1160 1160 1160 1160 1160 1160 1160 1160
   0    0    0    0    0    0    0    0    0    0    0    0
 226  226  226  226  226  226  226  226  226  226  226  226
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
 693  693  693  693  693  693  693  693  693  693  693  693
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
1076 1076 1076 1076 1076 1076 1076 1076 1076 1076 1076 1076
   0    0    0    0    0    0    0    0    0    0    0    0
1100 1100 1100 1100 1100 1100 1100 1100 1100 1100 1100 1100
   0    0    0    0    0    0    0    0    0    0    0    0
 370  370  370  370  370  370  370  370  370  370  370  370
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
 530  530  530  530  530  530  530  530  530  530  530  530
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
 197  197  197  197  197  197  197  197  197  197  197  197
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
1981
 144  144  144  144  144  144  144  144  144  144  144  144
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
 300  300  300  300  300  300  300  300  300  300  300  300
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
 324  324  324  324  324  324  324  324  324  324  324  324
   0    0    0    0    0    0    0    0    0    0    0    0
1160 1160 1160 1160 1160 1160 1160 1160 1160 1160 1160 1160
   0    0    0    0    0    0    0    0    0    0    0    0
 226  226  226  226  226  226  226  226  226  226  226  226
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
 693  693  693  693  693  693  693  693  693  693  693  693
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
1076 1076 1076 1076 1076 1076 1076 1076 1076 1076 1076 1076
   0    0    0    0    0    0    0    0    0    0    0    0
1100 1100 1100 1100 1100 1100 1100 1100 1100 1100 1100 1100
   0    0    0    0    0    0    0    0    0    0    0    0
 370  370  370  370  370  370  370  370  370  370  370  370
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
 530  530  530  530  530  530  530  530  530  530  530  530
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
 197  197  197  197  197  197  197  197  197  197  197  197
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0
```

For one sub-basin, 12 months (12F5.0) on each aquifer

For one sub-basin, 12 months (12F5.0) on each aquifer

One year data

For one sub-basin, 12 months (12F5.0)

Next year data

APPENDIX - THREE

DATA BASE SYSTEM AND ITS OPERATION

APPENDIX THREE: DATA BASE SYSTEM AND ITS OPERATION

3.1 Introduction

A large amount of data has been collected and processed for the purpose of this Study. Data consists of rainfall, river discharge, groundwater heads as well as an inventory of the gauging stations.

For the purpose of processing and managing the related data, some conventional software have been supplied from JICA, and a database program has been developed by the Study Team. The names of the programs are shown below.

Conventional Software (available in market)

LOTUS123 (Ver. 3.1) :	for data processing
LOGGER (Rockworks) :	for managing bore hole lithology
GEOBASE 6.0 :	for dealing with geological data

Developed Software for this Study

JDBASE :	for managing meteorological, hydrological, and geological data simultaneously

3.2 Conventional Software

Lotus 123 is used for the purpose of data managing and processing. The software has been employed to manage such data as daily rainfall, river discharge, groundwater head, and the inventory of gauging stations for this Study. All data processed by Lotus has been saved on floppy(s), submitted with this report, and a portion of the data has been printed and attached in Appendix 4.

Logger is a software developed by RockWare Inc., which can produce lithological logs with the aid of a graphic screen. Geobase is a database software managing geological and geo-hydrological data such as lithology, groundwater chemistry, pumping tests, water levels, and so on.

Geobase was developed by Earthware of California. Logger and Geobase have already been installed in the desk-top computer provided by JICA.

3.3 Developed Software (JDBASE)

A database program named JDBASE has been developed in order to manage meteorological and hydrological data. The program also deals with groundwater data, and the relationship between rainfall, river runoff, and groundwater heads can be graphically shown. The program is written by MS-Basic and the source program is presented so that the user can further improve the program. All data used in JDBASE must be prepared by LOTUS and finally converted into a text file (ASC file), as exampled by the floppy containing the program.

3.3.1 Program Component

The configuration of the program is shown in Figure 3.1.1. The program consists of a main program and nine sub-programs as shown below, which are brought into the computer memory through chain-functions. The main program, JDBASE, must be loaded into the memory by using the load-function of Ms-basic, or in otherwords, JDBASE is run under the condition that Ms-basic is in the memory.

Main	JDBASE
SUB	JDB510: to generate inventory screen for graphic
	JDB511: to generate inventory screens for data reference
	JDB516: to generate inventory screens for graph overwrite
	JDB520: to screen data selected for a period of one year
	JDB521: to screen data selected for a period of three years
	JDB522: to screen data selected for a period of five years
	JDB523: to screen data selected for a period of ten years
	JDB550: to calibrate the graph screened
	JDB570: to tabulate the data selected

3.3.2 Operation

Ms-basic is first loaded into computer memory and then the main program, JDBASE. As JDBASE begins to operate, the menu screen in Figure 3.2.1 is generated. When data reference is needed, 01, 02, or 03 is input in case of groundwater level, river discharge, and rainfall, respectively. When data graphics are needed, 11, 22, or 33 is input in the case of the same mentioned above. When the function key F10 is pressed, the program is terminated and returns to Ms-basic.

Following the menu screen, inventory screen appears as shown in Figure 3.2.2. The screen is an example for well inventory. If the drive containing the data file is required to be changed, press F8 key. F9 key terminates the current screen and returns the operation to the menu screen. To select well on the screen, move the rectangle by the arrow keys.

When detailed information is required for well enclosed the rectangle, press F6 key. The F6 key generates the screen showing detailed information such as exact well location, well constants and remarks. An example is shown on Figure 3.2.3.

When the well to be referred is identified, press the enter key. The chronological table appears on the right square, as shown in Figure 3.2.4. Function key F1, F2, F3, and F4 supplies selectable periods of 1, 3, 5, and 10 years, respectively. In the case of data reference, the screen shown in Figure 3.2.5 appears instead of one in Figure 3.2.4. The screen in Figure 3.2.5 supplies only one year because the data reference is made on a yearly basis.

A graph follows according to the period selected, as shown in Figure 3.2.6. When additional data is required to be overwritten, function key F1, F2, or F3 key supplies so. After F1, F2, or F3 key is pressed, the inventory screen shown in Figure 3.2.2 appears again. The selected data on the inventory screen is overwritten (see Figure 3.2.6). Calibration for the graph in Figure 3.2.6 is supplied by pressing function key F8. An example of calibration is shown in Figure 3.2.7.

Figure 3.2.8 is a screen for data reference. The screen follows after the year to be referred is identified in the screen shown in Figure 3.2.5.

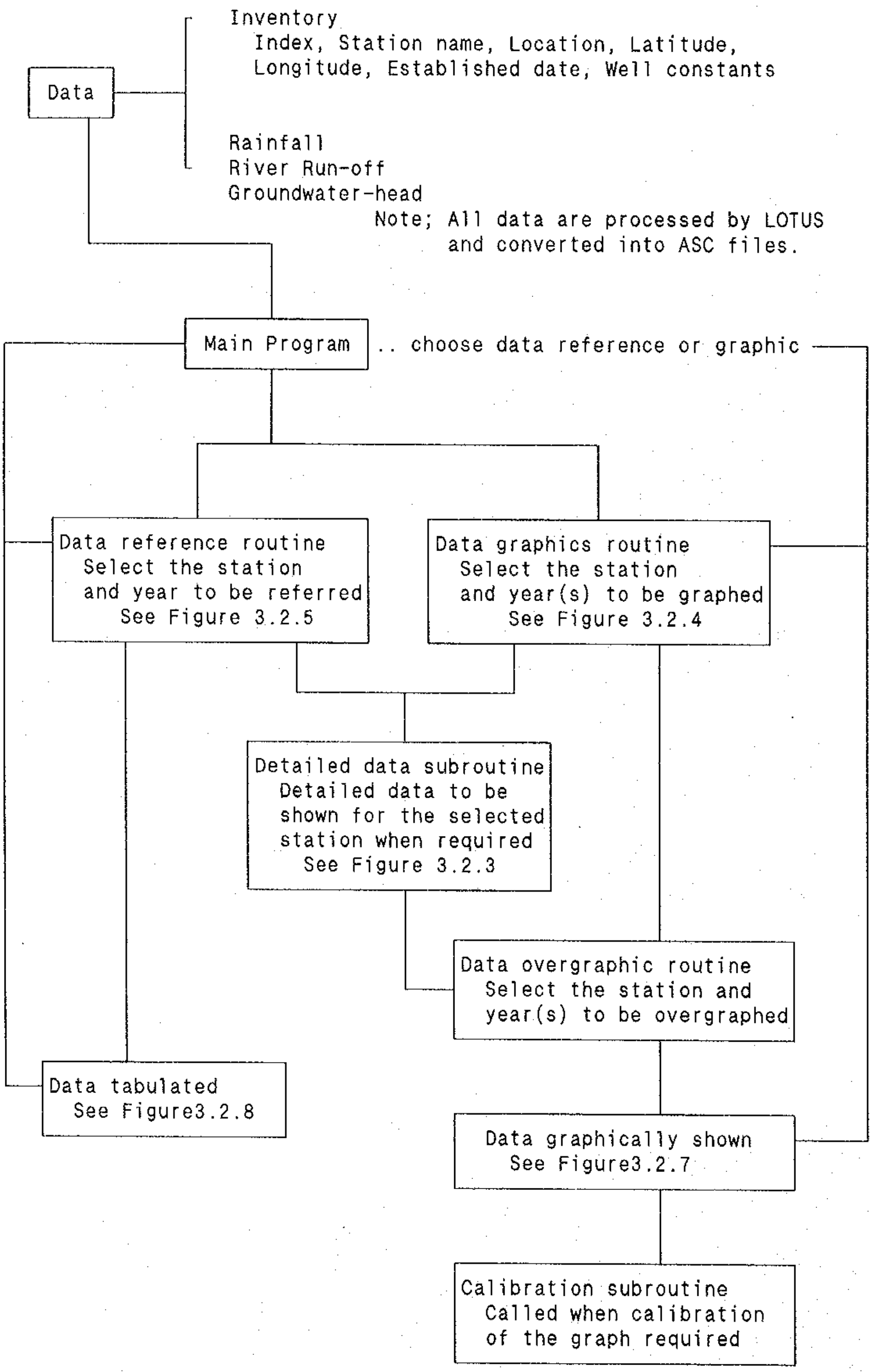


Figure 3.1.1 Configuration of Database Program

```
MENU SCREEN ON METEO-HYDROLOGICAL & GROUNDWATER DATABASE

DATA REFERENCE                      DATA GRAPHICS

   01;Groundwater Level(Daily)         11;Groundwater Level(Daily)
   02;River Discharge(Daily)           22;River Discharge(Daily)
   03;Rainfall(Daily)                  33;Rainfall(Daily)

Please enter the number you want, and hit Enter key !!

Note; All data is basically processed by LOTUS.

     File names shall be \GRWTR\INVEN.PRN for inventry of item 1 above
                         \RIVER\INVEN.PRN for inventry of item 2 above
                         \RAINF\INVEN.PRN for inventry of item 3 above

                         \GRWTR\*****.PRN for data of item 1 above
                         \RIVER\*****.PRN for data of item 2 above
                         \RAINF\*****.PRN for data of item 3 above

     Where ; ***** is the INDEX No. corresponding to the station

                                                                   DS
```

Figure 3.2.1 Menu Screen Generated by JDBASE

Grounwater level

Index	Well	Location	Drilled
EX-1	EX-1	Sunadhi Patharia	SEP.1993
EX-2	EX-2	Harchana Garamuni	OCT.1992
EX-3	EX-3	Dangebari	AUG.1993
EX-4	EX-4	Bhagdubba Rajbarh	SEP.1992
EX-5	EX-5	Sitachauk Prithvinag	NOV.1992
EX-6	EX-6	Dangagaun Balubari	JAN.1993
EX-7	EX-7	Hamumanbir Halidibari	JAN.1993
EX-8	EX-8	Bhimnager Prithvinag	OCT.1992
EX-9	EX-9	Birtabazar Anarmani	FEB.1993
EX-10	EX-10	Balubathan Sarnamati	DEC.1992
EX-11	EX-11	Balua Jalthal	DEC.1992
EX-12	EX-12	Gherabari Gherabari	FEB.1993
EX-13	EX-13	Dangabari Pathamar	OCT 1992
EX-14	EX-14	Tulshibari Surunga	FEB.1993
EX-15	EX-15	Laijhora Jamirgarhi	NOV.1992
JP-1	JP-1	Sunadih Patharia	MAR.1970
JP-2	JP-2	Bhagdubba Rajgarh	OCT.1992
JP-3	JP-3	Hanumanbir Haldibari	OCT.1992

Please insert the data floppy of [JP-1]
in Drive[F], then hit Enter key !!

INFO RETN DRIV MENU DS

Figure 3.2.2 Inventory Screen for Wells Presented by Database Program

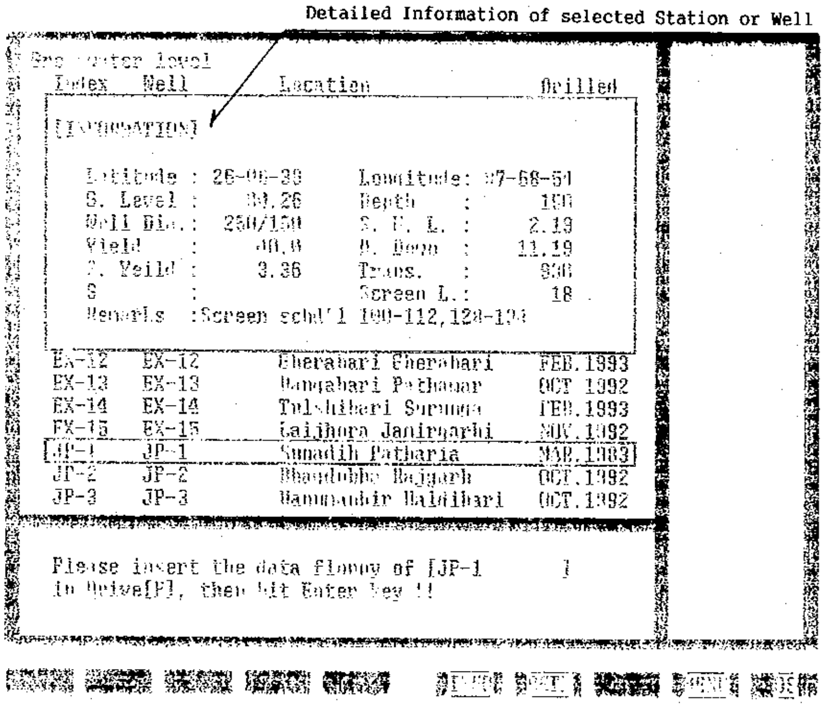


Figure 3.2.3 Screen Showing Detailed Information in an Inventory Screen

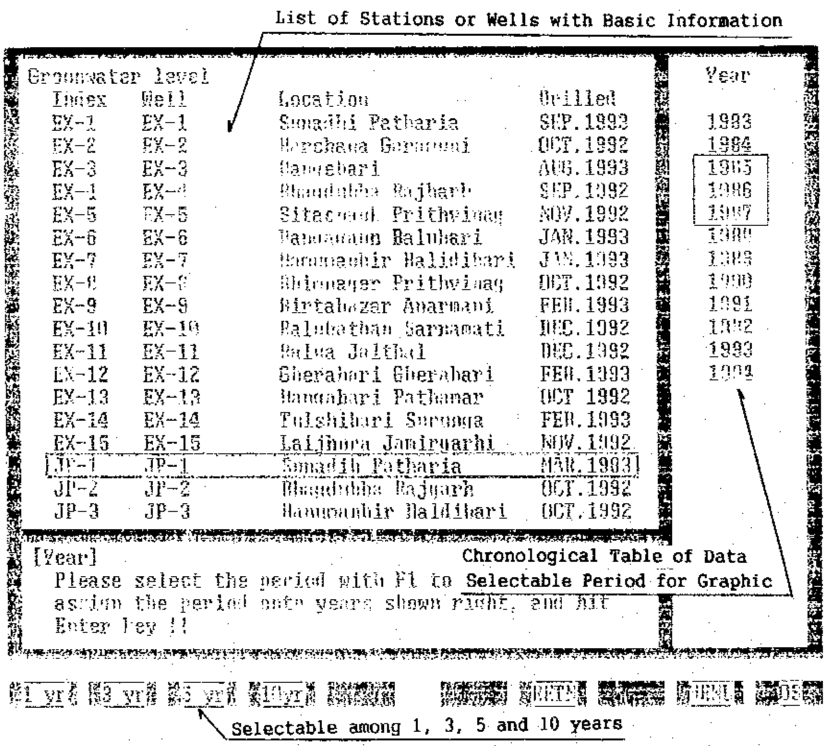
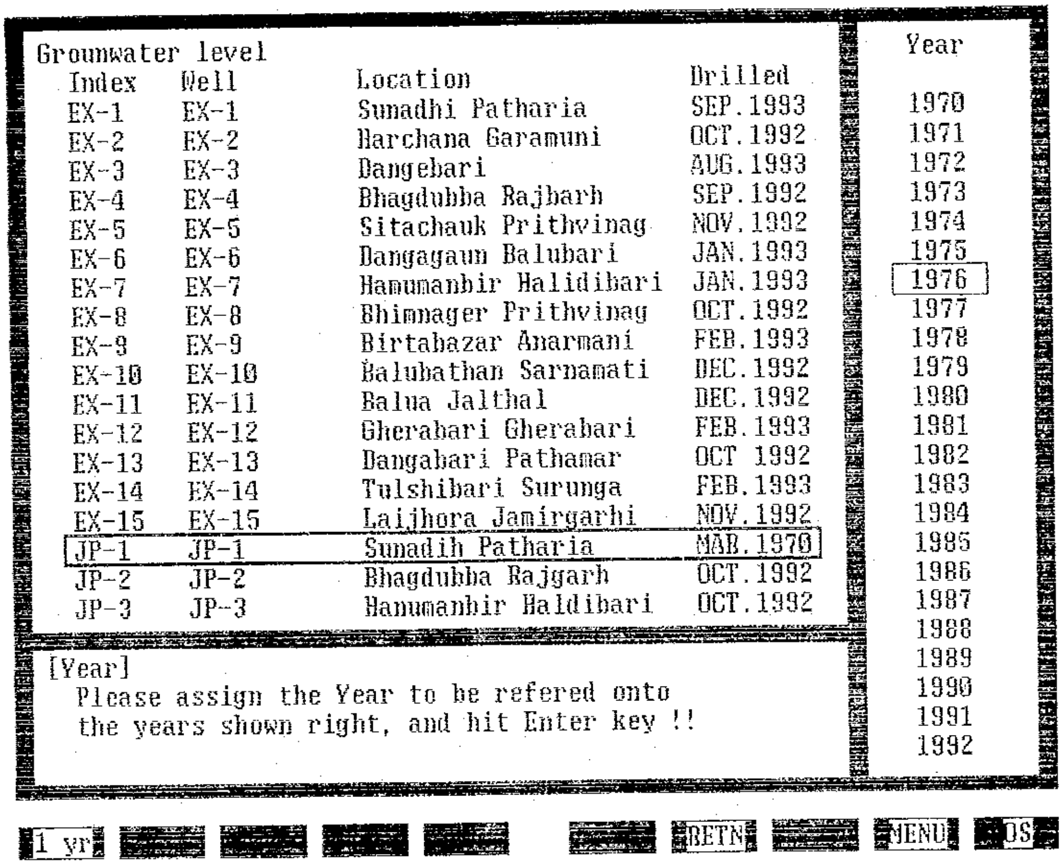


Figure 3.2.4 Inventory Screen for Selected Well with its Chronological Table



Grounwater level

Index	Well	Location	Drilled
EX-1	EX-1	Sunadhi Patharia	SEP.1993
EX-2	EX-2	Harchana Garamuni	OCT.1992
EX-3	EX-3	Dangebari	AUG.1993
EX-4	EX-4	Bhagdubba Rajbarh	SEP.1992
EX-5	EX-5	Sitachauk Prithvinag	NOV.1992
EX-6	EX-6	Dangagaun Balubari	JAN.1993
EX-7	EX-7	Hamumanbir Halidibari	JAN.1993
EX-8	EX-8	Bhimnager Prithvinag	OCT.1992
EX-9	EX-9	Birtabazar Anarmani	FEB.1993
EX-10	EX-10	Balubathan Sarnamati	DEC.1992
EX-11	EX-11	Balua Jalthal	DEC.1992
EX-12	EX-12	Gherabari Gherabari	FEB.1993
EX-13	EX-13	Dangabari Pathamar	OCT 1992
EX-14	EX-14	Tulshibari Surunga	FEB.1993
EX-15	EX-15	Laijhora Jamirgarhi	NOV.1992
JP-1	JP-1	Sunadih Patharia	MAR.1970
JP-2	JP-2	Bhagdubba Rajgarh	OCT.1992
JP-3	JP-3	Hanumanbir Haldibari	OCT.1992

[Year]
Please assign the Year to be refered onto
the years shown right, and hit Enter key !!

Year: 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992

1 yr | RETN | MENU | OS

Figure 3.2.5 Inventory Screen for Selected Well in Case of Data Reference

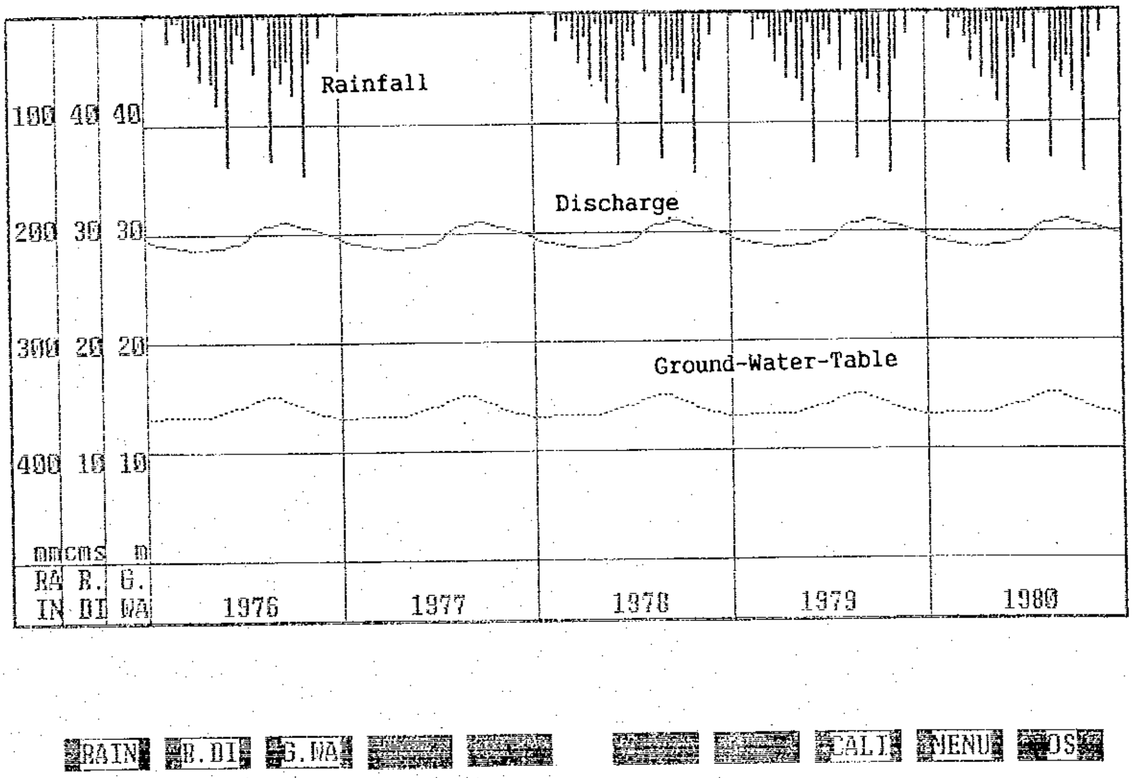


Figure 3.2.6 An Example between Rainfall, River discharge and Groundwater Table

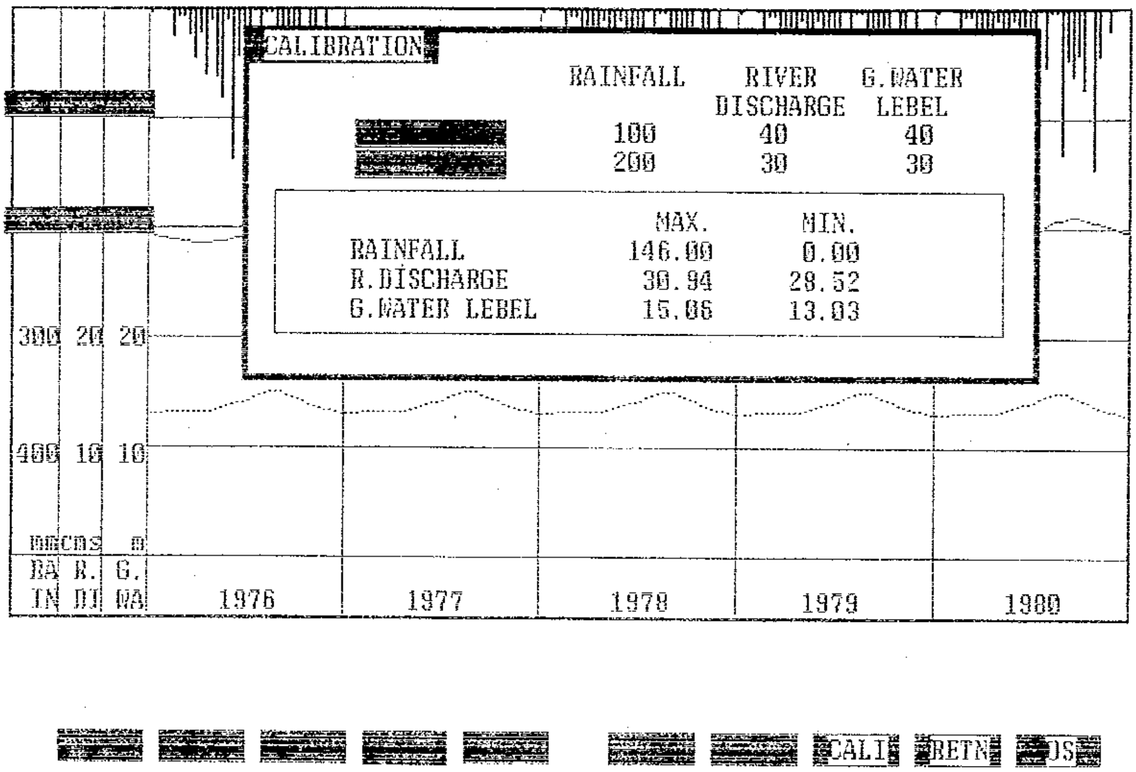


Figure 3.2.7 An Example for Calibration

Index	: JP-1	Latitude	: 26-06-39
Well	: JP-1	Longitude	: 87-68-54
Location	: Sunadih Patharia	Drilled	:MAR.1970

1975	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1	13.17	13.11	13.14	13.15	13.24	13.78	14.16	14.81	14.96	14.42
2	13.14	13.09	13.16	13.12	13.26	13.79	14.17	14.83	14.98	14.36
3	13.10	13.11	13.16	13.11	13.28	13.81	14.17	14.84	14.97	14.36
4	13.08	13.08	13.14	13.11	13.28	13.83	14.17	14.85	14.96	14.38
5	13.04	13.11	13.14	13.11	13.30	13.83	14.17	14.86	14.95	14.35
6	13.03	13.10	13.14	13.10	13.30	13.83	14.17	14.91	14.96	14.37
7	13.01	13.10	13.16	13.11	13.31	13.85	14.17	14.95	14.94	14.36
8	13.02	13.10	13.16	13.13	13.28	13.87	14.19	14.98	14.92	14.34
9	13.02	13.10	13.16	13.13	13.32	13.89	14.21	15.00	14.87	14.27
10	13.01	13.10	13.14	13.12	13.35	13.89	14.24	15.01	14.85	14.26
11	13.01	13.10	13.15	13.11	13.37	13.90	14.30	15.02	14.84	14.25
12	13.02	13.12	13.16	13.12	13.37	13.91	14.35	15.04	14.82	14.23
13	13.01	13.12	13.16	13.11	13.39	13.93	14.39	15.05	14.78	14.21
14	13.02	13.12	13.16	13.11	13.42	13.93	14.44	15.06	14.76	14.18
15	13.03	13.14	13.12	13.12	13.43	13.93	14.49	15.07	14.75	14.16
16	13.04	13.13	13.13	13.12	13.46	13.92	14.54	15.08	14.74	14.14
17	13.04	13.12	13.13	13.10	13.49	13.93	14.58	15.07	14.72	14.11
18	13.04	13.11	13.14	13.12	13.44	13.93	14.62	15.06	14.71	14.09

NOTE: Move by [ROLL-UP], [ROLL-DOWN] and arrow keys

RETN MENU OS

Figure 3.2.8 An Example for Data Reference

APPENDIX - FOUR

REFERENCE DATA

[illegible]

[illegible]

4.1 Meteorology and Hydrology

4.1.1. Relationship between River Discharge and Rainfall

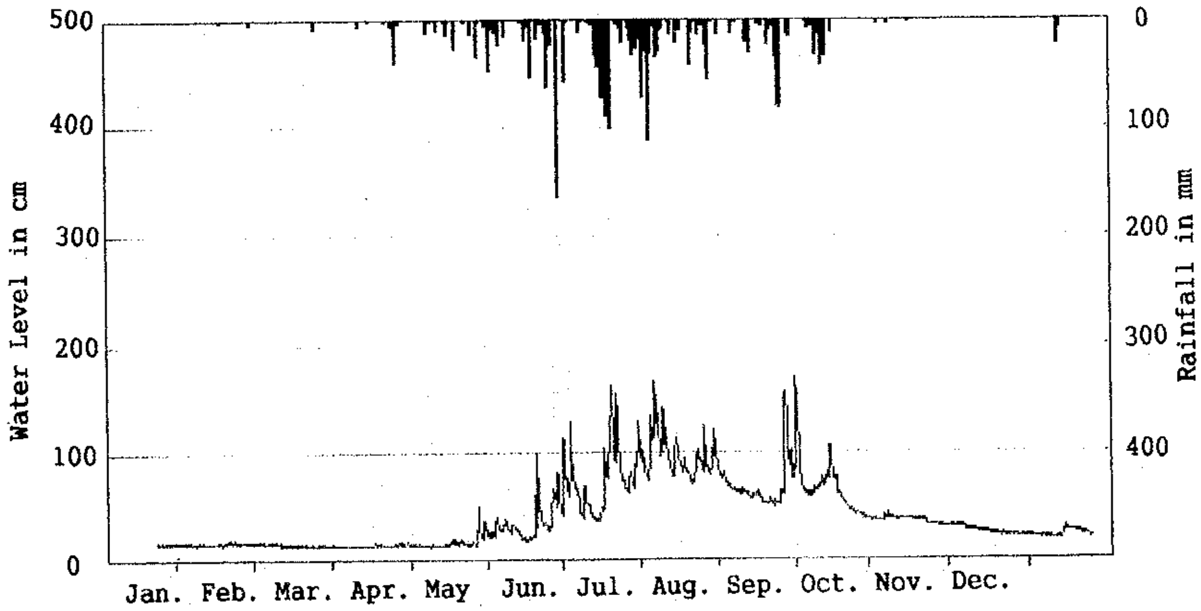


Figure 4.1.1

Relationship between Water Level for FG-1 and Chandragadhi Rainfall

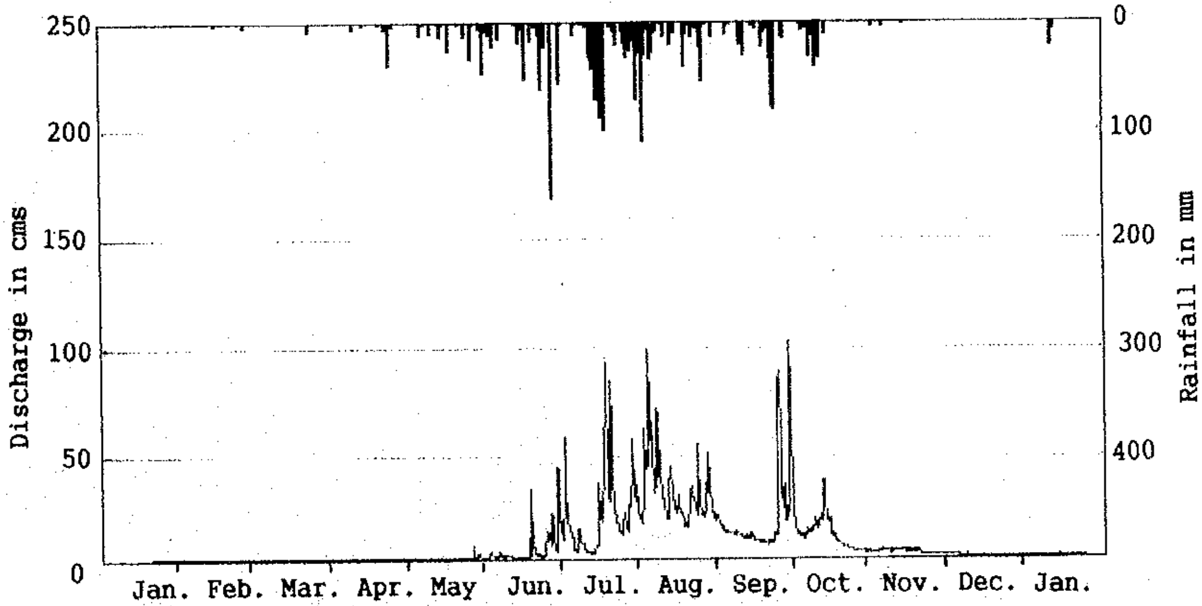


Figure 4.1.2

Relationship between Deoniya Discharge at FG-1 and Chandragadhi Rainfall

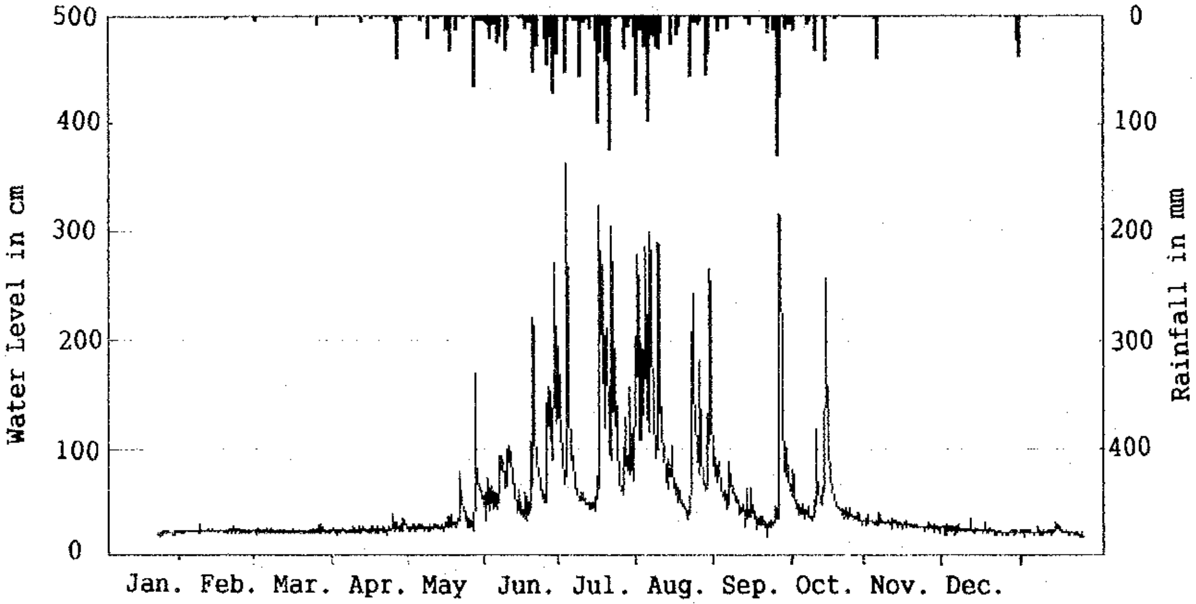


Figure 4.1.3

Relationship between Water Level for FG-2 and Chandragadhi Rainfall

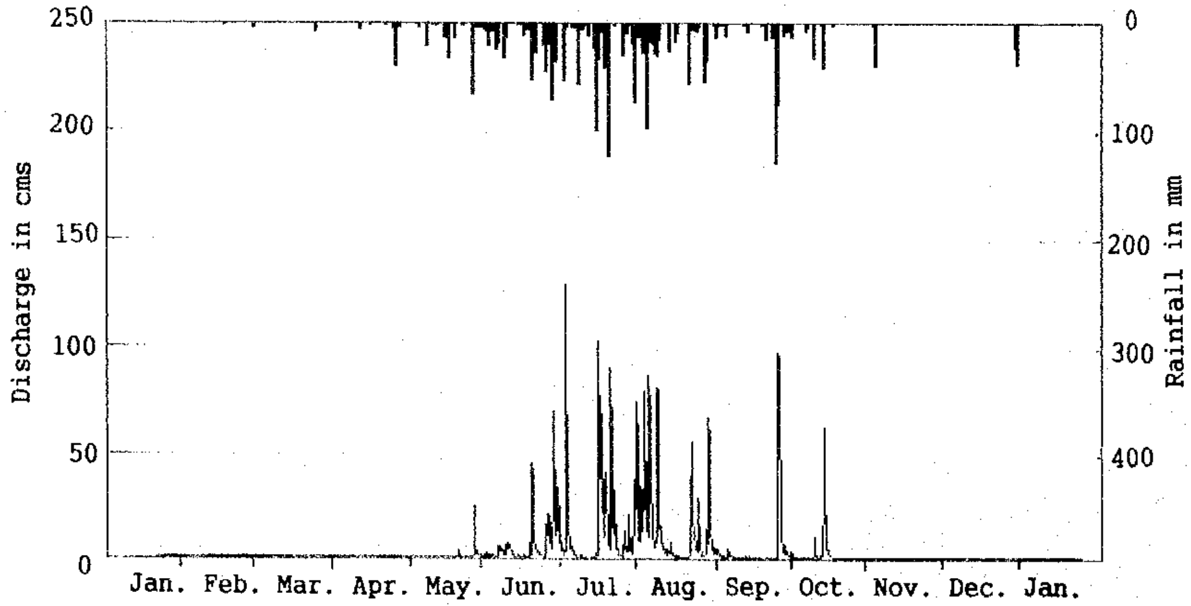


Figure 4.1.4

Relationship between Budhajhora Discharge at FG-2 and Chandragadhi Rainfall

4.1.2. Rating Curves

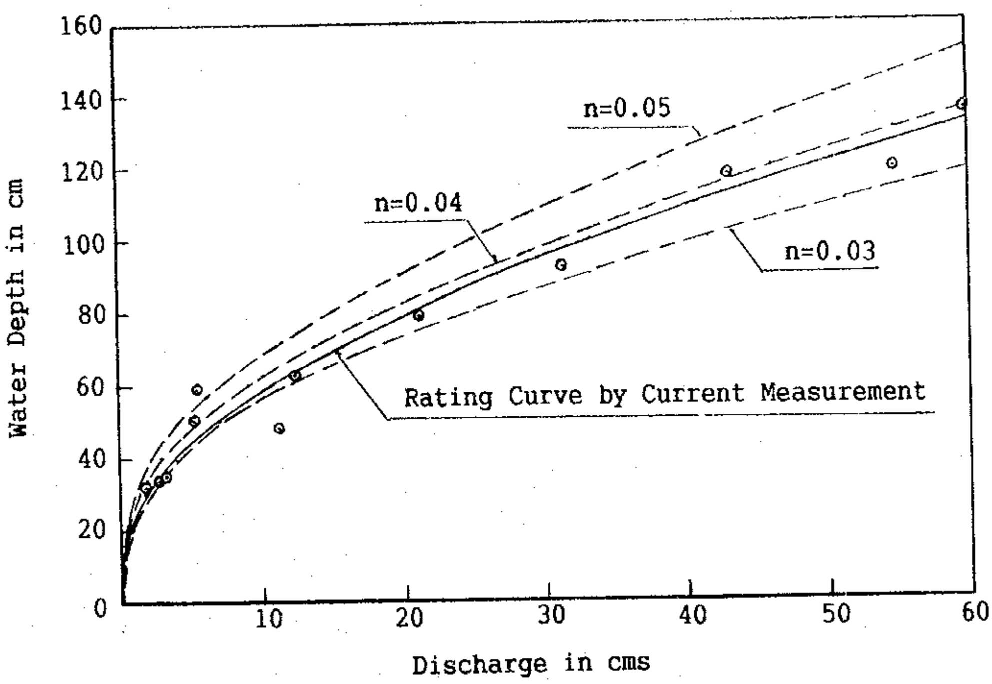


Figure 4.1.5 Rating Curve at FG-1 for Deoniya River

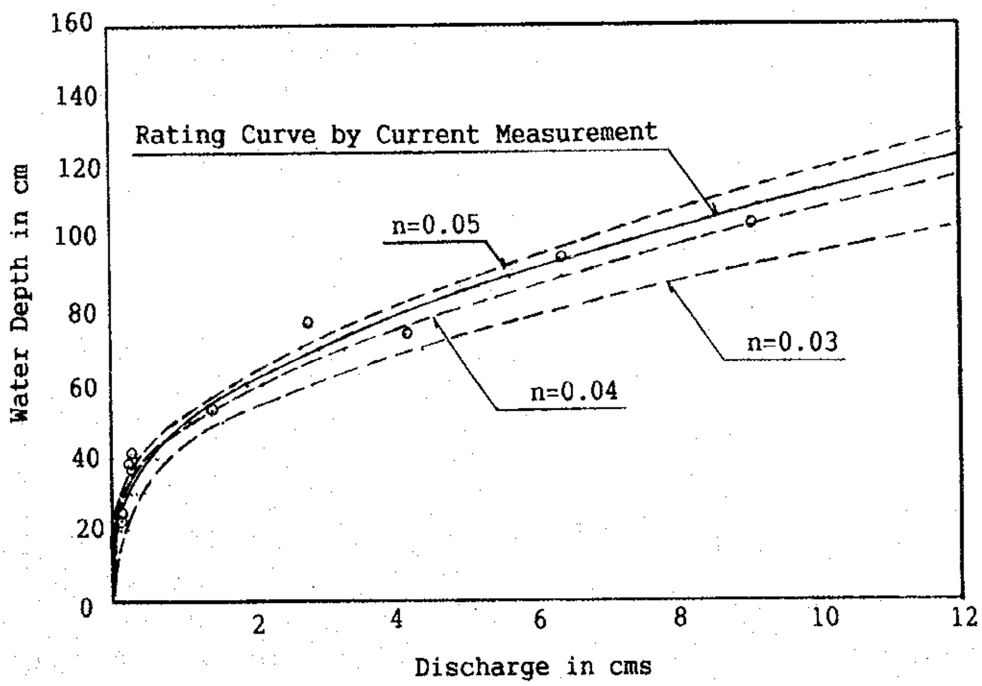


Figure 4.1.6 Rating Curve at FG-2 for Budhajhora River

4.1.3. Return Period by Gumbel Plot

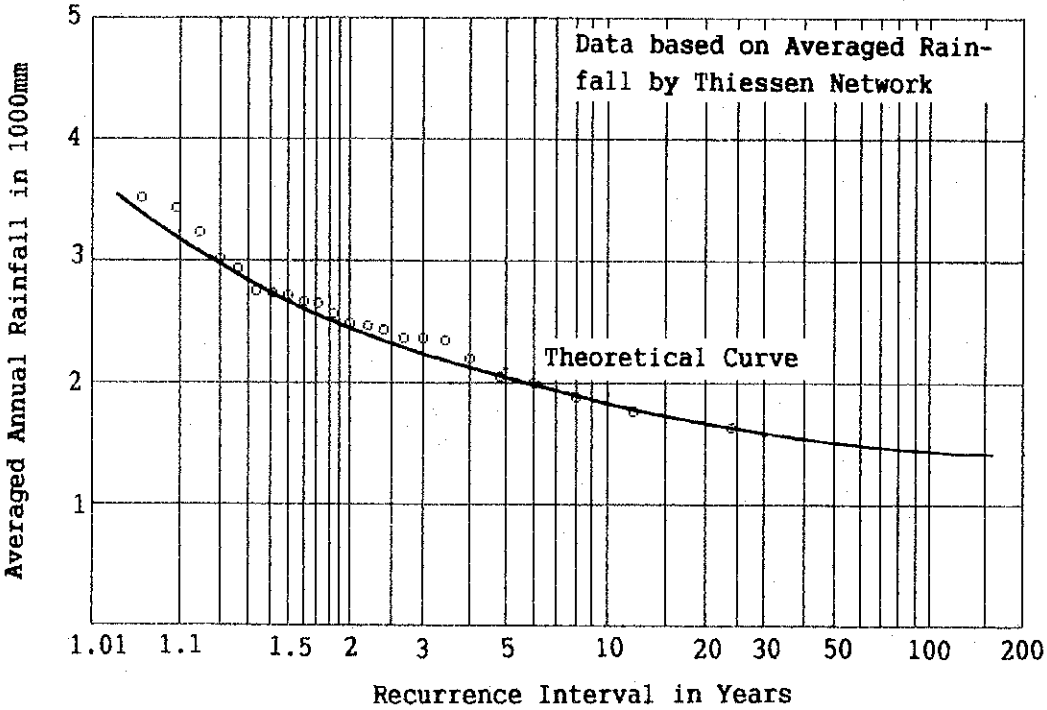


Figure 4.1.7
Non-Exceedance Gumbel Plot for Averaged Annual Rainfall in Jhapa District

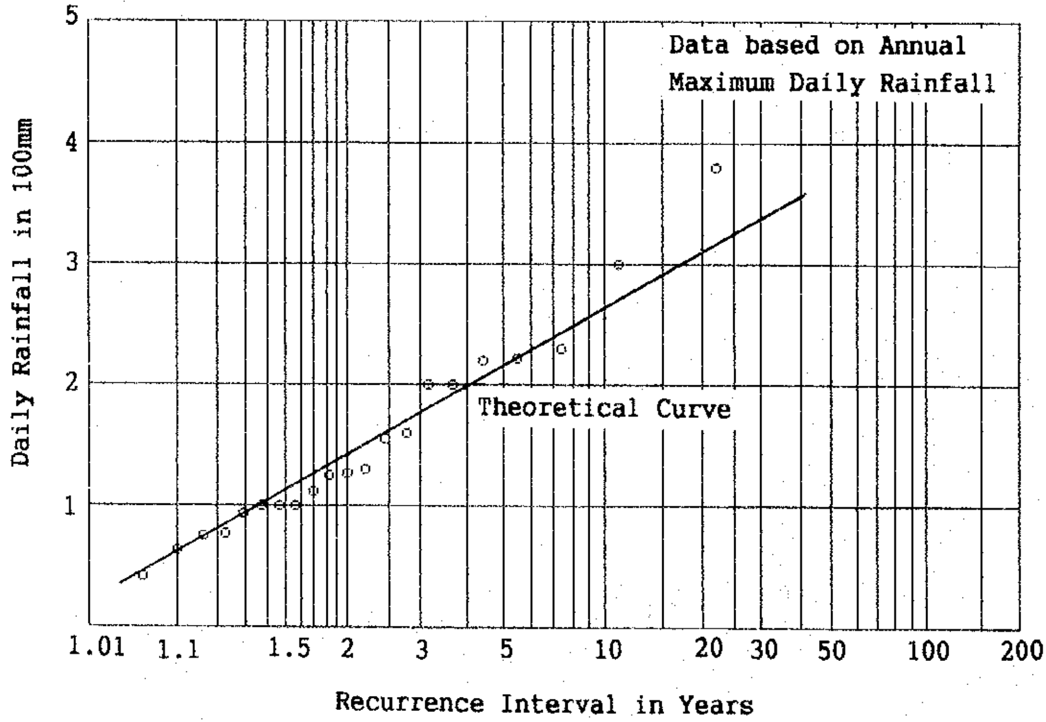


Figure 4.1.8
Exceedance Gumbel Plot for Annual Maximum Daily Rainfall at Chandragadhi

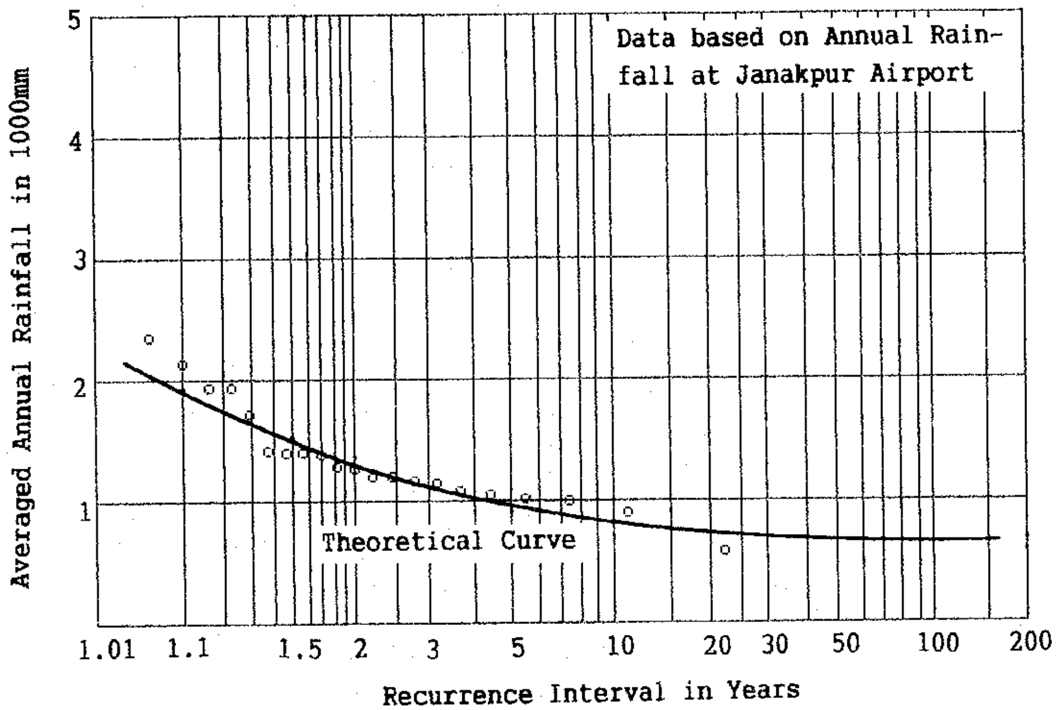


Figure 4.1.9
Non-Exceedance Gumbel Plot for Annual Rainfall at Janakpur Airport

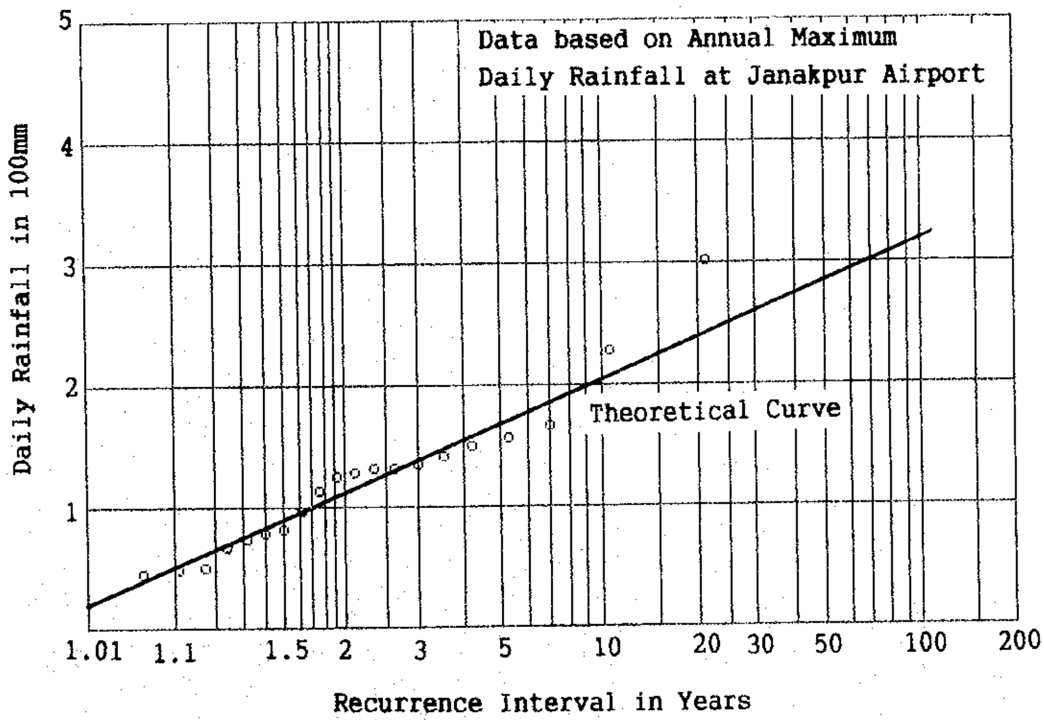


Figure 4.1.10
Exceedance Gumbel Plot for Annual Maximum Daily Rainfall at Janakpur Airport

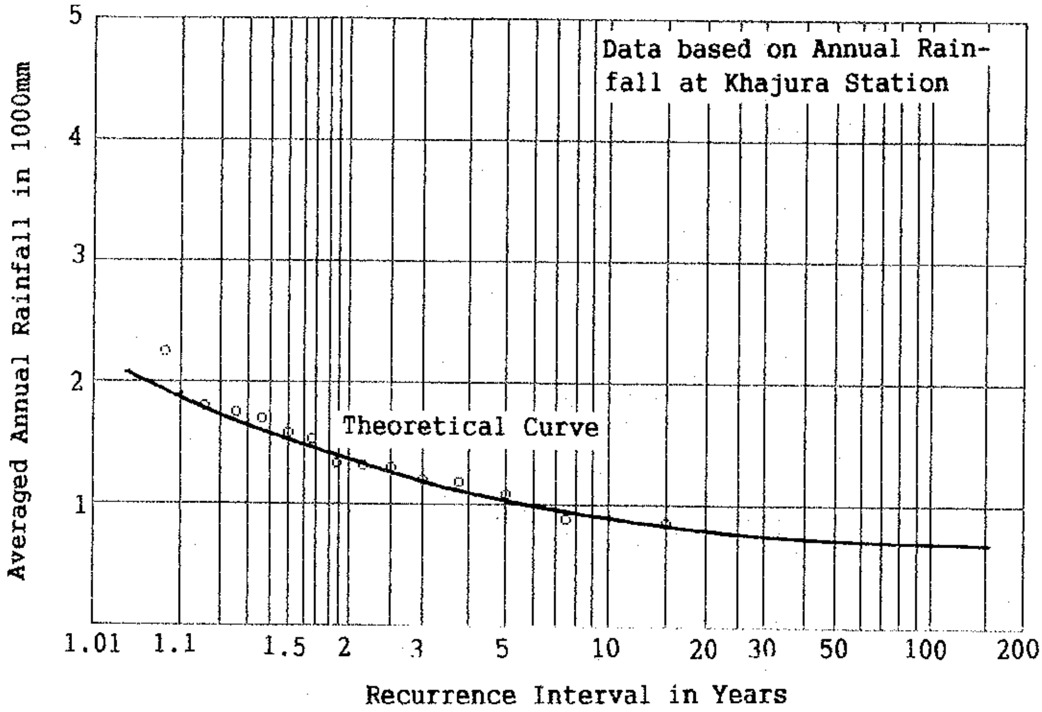


Figure 4.1.11
Non-Exceedance Gumbel Plot for Annual Rainfall at Khajura

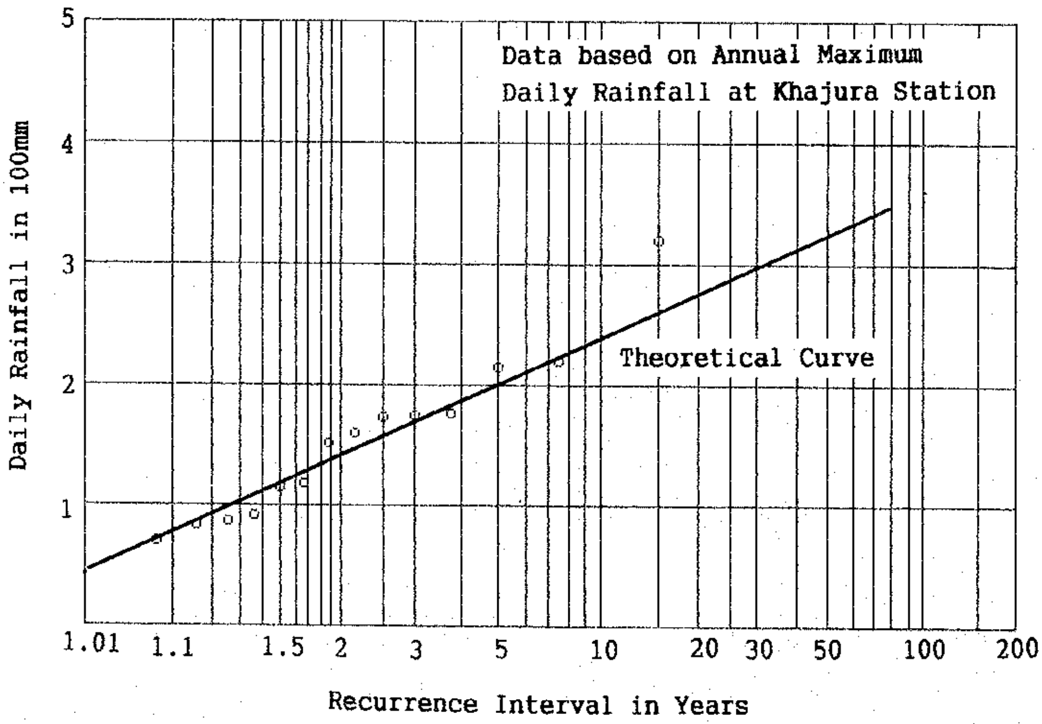


Figure 4.1.12
Exceedance Gumbel Plot for Annual Maximum Daily Rainfall at Khajura