Table E.3.5 Economic Irrigation Benefit

Description		Area	Gross Income		Production Cost		Net Return	
		ha	NRs/ha	Total	NRs/ha	Total	NRs/ha	Total
A. Without Project				1000NRs		1000NRs		1000NRs
Paddy	Partially Irrigated	837	21,252	17,788	6,489	5,431	14,763	12,357
	Non-irrigated	854	13,717	11,714	6,131	5,236	7,586	6,478
	Total	1,691		29,502		10,667		18,835
Wheat	Partially Irrigated	306	23,987	7,340	6,537	2,000	17,450	5,340
	Non-irrigated	116	13,828	1,604	6,282	729	7,546	875
	Total	422		8,944		2,729		6,215
Maize	Partially Irrigated	25	17,905	448	4,610	115	13,295	332
Pulses	Partially Irrigated	78	8,356	652	4,301	335	4,054	316
	Non-irrigated	195	7,090	1,383	3,929	766	3,161	616
	Total	273		2,034		1,102		933
Oilseeds	Partially Irrigated	77	10,586	815	3,817	294	6,769	521
	Non-irrigated	29	6,859	199	3,546	103	3,312	96
	Total	106		1,014		397		617
Vegetabl	Partially Irrigated	50	17,248	862	9,962	498	7,286	364
Total		2,567		42,805		15,508		27,297
B. With Project								
Paddy	Full Irrigated	1,800	43,470	78,246	10,672	19,210	32,798	59,036
Wheat	Full Irrigated	680	42,330	28,784	11,425	7,769	30,905	21,015
Oilseeds	Full Irrigated	225	17,892	4,026	7,781	1,751	10,112	2,275
Vegetabl	Full Irrigated	325	53,760	17,472	15,217	4,946	38,543	12,526
Total		3,030		128,528		33,675		94,853
C. Increment								
Paddy		109		48,744		8,542		40,201
Wheat		258		19,840		5,040		14,800
Maize		-25		-448		-115		-332
Pulses		-273		-2,034		-1,102		-933
Oilseeds		119		3,012		1,354		1,658
Vegetables		275		16,610		4,447		12,162
Total		463		85,723		18,167		67,557

Table E.3.6 Farm Budget under the Without and With Project Conditions (1/3)

Description	Unit Yield (ton/ha)		Large Farmer			Medium Farmer			Small Farmer			Marginal Farmer			Average Farmer		
	Without	With	Without Project	With Project	Increment	Without Project	With Project	Increment	Without Project	With Project	Increment	Without Project	With Project	Increment	Without Project	With Project	Increment
A. Average Paddy Size (ha)			6.81	6.67	-0.14	3.05	2.99	-0.06	1.32	1.29	-0.03	0.34	0.33	-0.01	0.84	0.82	-0.02
B. Cropped Area (ha)																	
Paddy(N.I)			3.22		-3.22	1.44		-1.44	0.62		-0.62	0.16		-0.16	0.40		-0.40
Paddy(P.I)			3.07		-3.07	1.38		-1.38	0.60		-0.60	0.15		-0.15	0.38		-0.38
Paddy(F.I)				6.67	6.67		2.99	2.99		1.29	1.29		0.33	0.33		0.83	0.83
Wheat(N.I)			0.94		-0.94	0.42		-0.42	0.18		-0.18	0.05		-0.05	0.12		-0.12
Wheat(P.I)			0.74		-0.74	0.33		-0.33	0.14		-0.14	0.04		-0.04	0.09		-0.09
Wheat(F.I)				3.29	3.29		1.24	1.24		0.49	0.49		0.09	0.09		0.31	0.31
Maize(P.I)			0.09		-0.09	0.04		-0.04	0.02		-0.02	0.01		-0.01	0.01		-0.01
Pulses(N.I)			0.57		-0.57	0.26		-0.26	0.11		-0.11	0.03		-0.03	0.07		-0.07
Pulses(P.I)			0.13		-0.13	0.06		-0.06	0.03		-0.03	0.01		-0.01	0.02		-0.02
Oilseed(N.I)			0.41		-0.41	0.18		-0.18	0.08		-0.08	0.02		-0.02	0.05		-0.05
Oilseed(P.I)			0.17		-0.17	0.08		-0.08	0.03		-0.03	0.01		-0.01	0.02		-0.02
Oilseed(F.I)				0.83	0.83		0.37	0.37		0.16	0.16		0.04	0.04		0.10	0.10
Vegetables(PI)			0.19		-0.19	0.08		-0.08	0.04		-0.04	0.01		-0.01	0.02		-0.02
Vegetables(FI)				0.43	0.43		0.43	0.43		0.23	0.23		0.09	0.09		0.15	0.15
Total			9.53	11.23	1.69	4.27	5.03	0.76	1.85	2.17	0.33	0.48	0.56	0.08	1.18	1.40	0.22
C. Crop Production (ton)																	
Paddy(N.I)	1.42		4.57			2.05			0.89			0.23			0.56		
Paddy(P.I)	2.20		6.76			3.03			1.31			0.34			0.83		
Paddy(F.I)		4.50		30.02			13.46			5.81			1.49			3.74	
Paddy Total			11.33	30.02	18.68	5.07	13.46	8.38	2.20	5.81	3.61	0.57	1.49	0.92	1.40	3.74	2.34
Wheat(N.I)	0.98		0.93			0.41			0.18			0.05			0.11		
Wheat(P.I)	1.70		1.26			0.56			0.24			0.06			0.15		
Wheat(F.I)		3.00		9.88			3.72			1.46			0.27			0.94	
Wheat Total			2.18	9.88	7.69	0.98	3.72	2.74	0.42	1.46	1.04	0.11	0.27	0.16	0.27	0.94	0.67
Maize(P.I)	1.72		0.16		-0.16	0.07		-0.07	0.03		-0.03	0.01		-0.01	0.02		-0.02
Pulses(N.I)	0.56		0.32			0.14			0.06			0.02			0.04		
Pulses(P.I)	0.66		0.09			0.04			0.02			0.00			0.01		
Pulses Total			0.41		-0.41	0.18		-0.18	0.08		-0.08	0.02		-0.02	0.05		-0.05
Oilseed(N.I)	0.46		0.19			0.08			0.04			0.01			0.02		
Oilseed(P.I)	0.71		0.12			0.05			0.02			0.01			0.01		
Oilseed(FI)		1.20		1.00			0.45			0.19			0.05			0.12	
Oilseed Total			0.31	1.00	0.70	0.14	0.45	0.31	0.06	0.19	0.13	0.01	0.05	0.03	0.04	0.12	0.09
Vegetables(PI)	3.85		0.71			0.32			0.14			0.03			0.09		
Vegetables(FI)		12.00		5.16			5.16			2.80			1.13			1.80	
Vegetables Total			0.71	5.16	4.45	0.32	5.16	4.84	0.14	2.80	2.66	0.03	1.13	1.09	0.09	1.80	1.71

(To be Contained)

Table E.3.6 Farm Budget under the Without and With Project Conditions (2/3)

Description	Unit Price (NRs/kg)	Production Cost (NRs/ha)					Large Farmer			Medium Farmer			Small Farmer			Marginal Farmer			Average Farmer		
		Large	Medium	Small	Marginal	Average	Without Project	With Project	Increment	Without Project	With Project	Increment	Without Project	With Project	Increment	Without Project	With Project	Increment	Without Project	With Project	Increment
D. Gross Income (NRs)																					
Paddy(N.I)	5.25						24,005			10,750			4,652			1,200			2,960		
Paddy(P.I)	5.25						35,482			15,893			6,872			1,767			4,377		
Paddy(F.I)	5.25							157,579			70,639			30,476			7,796			19,609	
Wheat(N.I)	6.00						5,551			2,487			1,076			276			682		
Wheat(P.I)	6.00						7,548			3,386			1,459			377			928		
Wheat(F.I)	6.00							59,256			22,302			8,766			1,620			5,652	
Maize(P.I)	6.00						960			423			186			52			114		
Pulses(N.I)	14.00						4,500			2,015			870			227			557		
Pulses(P.I)	14.00						1,201			536			231			55			148		
Oilseed(N.I)	16.25						3,042			1,360			591			150			374		
Oilseed(P.I)	16.25						1,927			865			369			92			242		
Oilseed(FI)	16.25							16,263			7,293			3,140			800			2,028	
Vegetables(PI)	5.00						3,561			1,598			693			173			443		
Vegetables(FI)	5.00							25,800			25,800			13,980			5,640			9,000	
							87,777	258,898	171,121	39,314	126,034	86,720	16,999	56,362	39,363	4,371	15,856	11,485	10,824	36,289	25,465
E. Production Cost (NRs)																					
Paddy(N.I)		6,857	5,994	3,945	2,791	4,555	22,080			8,643			2,462			449			1,808		
Paddy(P.I)		7,325	6,353	4,046	2,748	4,733	22,502			8,742			2,407			420			1,794		
Paddy(F.I)		9,808	8,748	6,231	4,815	6,981		65,419			26,157			8,038			1,589			5,794	
Wheat(N.I)		5,753	5,496	4,273	3,439	4,715	5,431			2,325			782			162			547		
Wheat(P.I)		6,458	6,030	4,389	3,465	4,877	4,779			2,002			628			128			444		
Wheat(F.I)		9,190	8,653	6,755	5,686	7,320		30,253			10,721			3,290			512			2,298	
Maize(P.I)		5,364	4,677	3,045	2,126	3,531	499			192			55			11			39		
Pulses(N.I)		4,847	4,293	2,977	2,237	3,369	2,782			1,103			330			65			239		
Pulses(P.I)		5,204	4,570	3,064	2,217	3,512	677			265			77			13			56		
Oilseed(N.I)		4,309	3,778	2,516	1,806	2,892	1,754			688			199			36			145		
Oilseed(P.I)		4,623	4,012	2,560	1,743	2,992	772			301			82			14			63		
Oilseed(FI)		6,902	6,233	4,643	3,749	5,116		5,756			2,331			748			154			532	
Vegetables(PI)		13,469	12,115	8,898	7,088	9,856	2,492			1,006			320			64			227		
Vegetables(FI)		16,874	15,375	11,812	9,808	12,873		7,256			6,611			2,752			922			1,931	
Total							63,767	108,685	44,918	25,266	45,820	20,554	7,342	14,827	7,486	1,362	3,176	1,814	5,361	10,556	5,194

(To be Contenued)

Table E.3.6 Farm Budget under the Without and With Project Conditions (3/3)

Description	Net Return (NRs/ha)					Large Farmer			Medium Farmer			Small Farmer			Marginal Farmer			Average Farmer		
	Large	Medium	Small	Marginal	Average	Without Project	With Project	Increment	Without Project	With Project	Increment	Without Project	With Project	Increment	Without Project	With Project	Increment	Without Project	With Project	Increment
F. Net Return (NRs)																				
Paddy(N.I)	598	1,461	3,510	4,664	2,900	1,926			2,107			2,190			751			1,151		
Paddy(P.I)	4,225	5,197	7,504	8,802	6,817	12,979			7,151			4,465			1,347			2,584		
Paddy(F.I)	13,817	14,877	17,394	18,810	16,644		92,159			44,482			22,438			6,207			13,815	
Wheat(N.I)	127	384	1,607	2,441	1,165	120			162			294			115			135		
Wheat(P.I)	3,742	4,170	5,811	6,735	5,323	2,769			1,384			831			249			484		
Wheat(F.I)	8,810	9,347	11,245	12,314	10,680		29,003			11,581			5,476			1,108			3,354	
Maize(P.I)	4,956	5,643	7,275	8,194	6,789	461			231			131			41			75		
Pulses(N.I)	2,993	3,547	4,863	5,604	4,471	1,718			912			540			163			317		
Pulses(P.I)	4,036	4,670	6,176	7,023	5,728	525			271			154			42			92		
Oilseed(N.I)	3,166	3,697	4,959	5,669	4,583	1,289			673			392			113			229		
Oilseed(P.I)	6,915	7,526	8,978	9,795	8,545	1,155			564			287			78			179		
Oilseed(FI)	12,598	13,267	14,857	15,751	14,384		10,507			4,962			2,392			646			1,496	
Vegetables(PI)	5,781	7,135	10,352	12,163	9,394	1,069			592			373			109			216		
Vegetables(FI)	45,126	44,625	48,188	50,192	47,127		19,404			19,189			11,228			4,718			7,069	
Total						24,010	151,073	127,063	14,048	80,214	66,166	9,657	41,534	31,877	3,008	12,679	9,671	5,463	25,733	20,270

Note: N.I: Non-Irrigated, P.I: partially Irrigated, F.I: Fully Irrigated

FIGURES

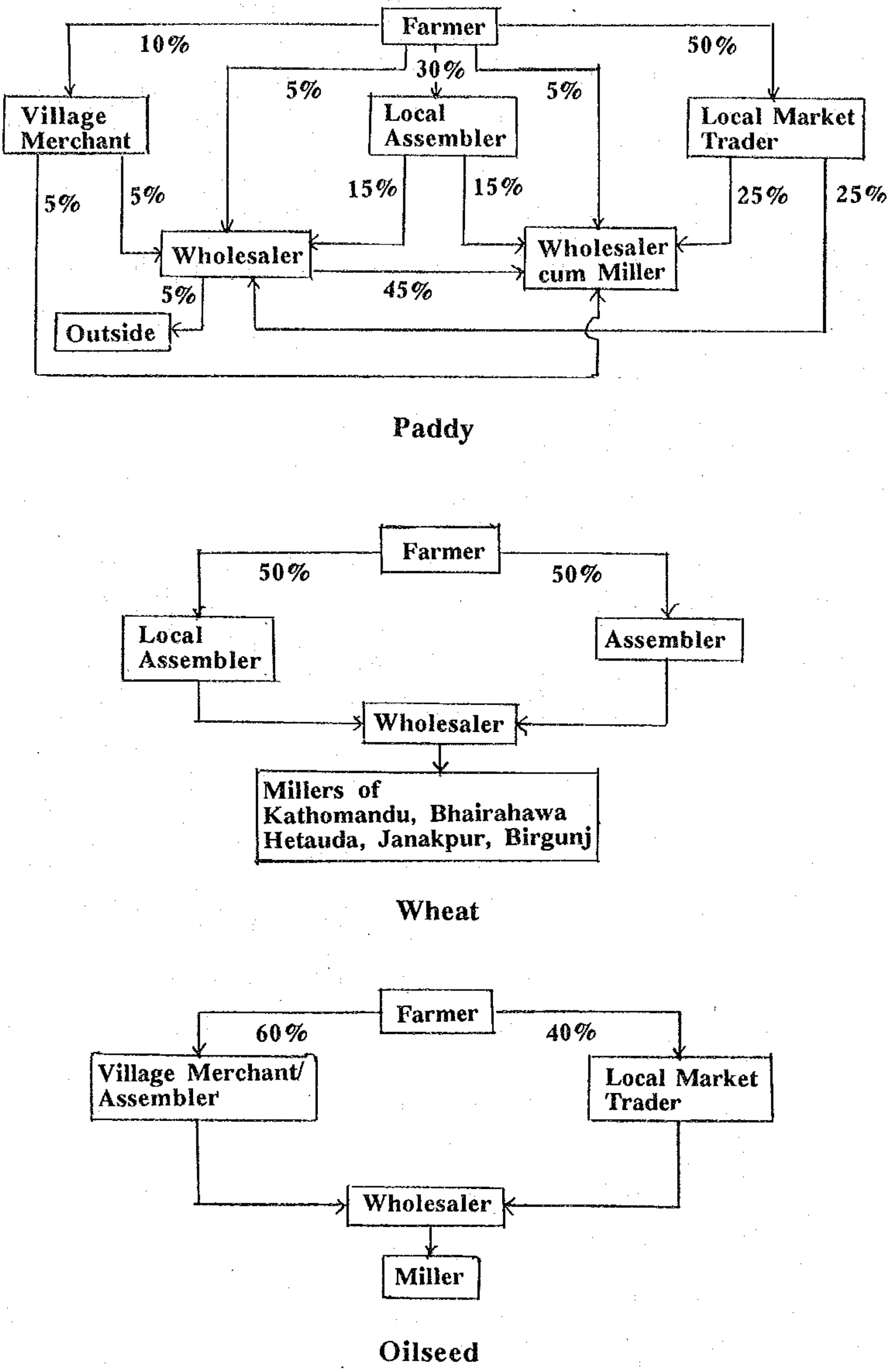

Fig. E.2.1 Market Channels of Major Crops

ANNEX - F

IRRIGATION AND DRAINAGE

ANNEX - F

IRRIGATION AND DRAINAGE

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ANNEX - F IRRIGATION AND DRAINAGE

F.1 PRESENT IRRIGATION AND DRAINAGE

F.1.1 Irrigation and Drainage System

The potential irrigation water sources in the study area have been identified as follows;

i) Gudrung river, Kondre river, Belwagurdwa river, Banganga river, and small streams such as the Ghorahi nala (natural drain),

ii) Springs situated in the north-west of the area, and

iii) Small/medium-size ponds scattered in the area.

Among these water sources, the Kondre river and Belwagurdwa river have not been utilized because of their extremely low river beds compared to the farm field level. Banganga river, flowing by the south end of the study area, has a low bed level and wide river course, which restrains the use of water except for some pumping systems. Consequently, the water sources being used at present are the Gudrung river, springs, Ghorahi drain and small/medium-size ponds.

The Gudrung river is being diverted at Ranikudwa point, situated north of Pattharkot, for the Ranikudwa Farmers' Irrigation System. The Ranikudwa Irrigation System commands an irrigation network of about 600 ha from Pattharkot down to Purena. However, the actual irrigation area varies from year to year due to flood damage to the intake facilities, leakage/seepage losses of the deteriorated canals and small discharge in the dry season. The actual irrigation area in the dry season remains about one-third of that in the rainy season.

Ghorahi drain water has also been used for irrigation at different reaches by farmers with earthen bunds. These irrigation systems comprise of a series of canal networks, but the actual irrigation area is extremely small compared to the size of the facilities. This is due to the varying intake discharge from season to season and temporary nature of the diversion works.

The Department of Agriculture constructed a weir, "Jasbariya dam" in 1986 on Ghorahi drain near the southern end of the project area. Although the design command area of the dam was 670 ha, the actual irrigation area remains less than half that figure even in the rainy season because of the deteriorated intake facilities and the diversion of water in the upstream reaches.

About sixty (60) ponds exist in the study area, most of which are small in size and have been abandoned due to sedimentation. Six (6) medium-size ponds with canals are presently used for irrigation. These ponds are mainly used for supplementary irrigation in the rainy season, while in the dry season their small storage capacities, except that of the Buddi pond, restrain the application of water for irrigation in the dry season.

Irrigation by pumping water from the Banganga river is practiced using small portable pumps for meeting the peak water requirements such as for land preparation, transplanting and heading stages for paddy, and plowing & heading stages for wheat. The pumping sites are not generally fixed.

Even if the rotation system was applied to tackle the problem of water scarcity in every system of the study area, extremely uneven distribution of irrigation water (more water in the head reaches and less in the tail reaches) would still prevails. The following table shows the present irrigation area commanded by the different irrigation systems in the study area.

<u>Present Irrigation Area</u>

(Unit : ha)

		Summer crop (paddy rice)	Winter crop (wheat)	Spring crop (vegetables, etc)
1.	Ranikudwa Farmers' Irrigation System			
	(including the Birpur springs)	590	270	25
2.	Pond irrigation system			
	Buddi pond			
	(including water fed from the Ghorahi drain)	140	110	0
	Badahara pond	25	0	0
	Dubiya pond	20	0	0
	Pratrappur pond	10	0	0
	Gelwar pond	5	0	0
	<u>Sub-total</u>	<u>200</u>	<u>110</u>	<u>0</u>
3.	Ghorahi drain irrigation system			
	(in different reaches)	60	20	0
4.	Jasbariya dam (Ghorahi drain)	300	0	0
5.	Banganga pumping irrigation system	150	120	15
	Total	1,300	520	40

The main drain in the study area is Ghorahi natural drain (small stream). Natural small drains running through the depressions are functioning as secondary drains. The irrigation canals for the Ranikudwa Farmers' Irrigation System are also partly used as drains, which is a common practice in the study area.

Since the water of the Ghorahi drain is dammed up by the farmers for irrigation at several locations, some paddy fields along a strip parallel to the drain, north of the East-West Highway, are subject to poor drainage. The drainage condition is also poor in the paddy fields close to the natural drains in the depressions.

F.1.2 Irrigation and Drainage Facilities

The existing irrigation systems as mentioned above, except two intakes, were constructed by the farmers . Since the structures were built without any technical background, they are technically primitive and thereby not functioning well.

An inundation type canal intake for diverting water to the headrace canal of the Ranikudwa Irrigation System, consists of a temporary weir made of boulders and gravels on the Gudrung river. No permanent structure exists in the headworks. Seepage/leakage loss along the 450 m headrace canal is serious as it was constructed using boulders and earth material without a lining. The main as well as the branch canals of the system are also unlined. However, some wet/dry masonry protection works have been provided in stretches that pass through densely populated areas such as Pattharkot. Major related structures for the irrigation system include concrete culverts for crossing the Gorsinge-Pattharkot road, wooden bridges and tree-trunk aqueducts to cross the drains. No cross or head regulators have been provided at the bifurcation and turnout points. Water is distributed in proportion to the difference between bed levels of the main and branch canals. No drop structure exists there, hence, the canals have formed regime condition.

The canals and related facilities of other existing irrigation systems are similar to those of the Ranikudwa System. The brick masonry intakes constructed at the Ghorahi drain have been damaged and deteriorated by floods and, hence are not functioning well.

The East-West Highway crosses over the Ghorahi drain by a concrete bridge, while other drains across the highway are provided with culverts. Earthen bunds of a temporary nature have been provided to divert water from the Ghorahi drain to the canals.

F.1.3 Water Management and O&M

The water management and O&M of the Ranikudwa Farmers' Irrigation System have been carried out by the Ranikudwa Water Users' Association (RWUA) voluntarily organized by the beneficiary farmers without receiving financial assistance from HMG/N and technical guidance from DOI. The RWUA is organized by twelve Water Users' Groups (WUGs) formed by twelve villages (mouja) where the irrigation canals run.

The daily water management and O&M of each WUG have been carried out by an employed canal watcher (Chaukidar) under the control of both the canal chief (Badaghar) and the secretary (Sachiv) elected by the member farmers. However, both the water management and O&M of the Ranikudwa intake facility and headrace canal and the water distribution to the command area by a rotation system have been conducted by WUG of Pattharkot village located in the northern tip of the command area. The canal chief of Pattharkot WUG is an ex-officio chief of Pattharkot village, cum chairman of Mahendrakot VDC.

The restoration or rehabilitation of the intake facility and headrace canal damaged by floods, etc. has been executed by the member farmers of each WUG temporarily called out by the chairman of Mahendrakot VDC. WUG and its member farmers who did not obey the chairman's call must pay compensation by cash or other means for such a violation. In general, the water management and O&M of the Ranikudwa Farmers' Irrigation System have been smoothly carried out by such WUA and its rules as described above.

The water management and O&M of the Buddi Pond Irrigation System have also been smoothly carried out by the Buddi Pond WUA organized mainly by the beneficiary farmers in Buddi village, of which the chief is the ex-officio canal chief, without receiving financial and technical assistance from HMG/N or DOI, the same as the case of the Ranikudwa WUA. The water management and O&M of other farmers' irrigation schemes have been practised by the farmers' WUAs or WUGs which are similar to the Ranikudwa or Buddi WUAs or WUGs.

F.2 ASSESSMENT OF RANIKDUWA FARMERS' IRRIGATION SYSTEM

F.2.1 Headworks

The existing headworks of the Ranikudwa Farmers' Irrigation System which commands about 600 ha of paddy fields extending from Pattharkot to Purena village, locating at Rani- kudwa point of the Grudung river, consist of a temporary weir made of boulders/gravels and an ungated open intake. However, these temporary structures which were constructed by beneficiary farmers without any technical background have often been flushed away by big floods every year, and accustomed to be re-constructed by the farmers themselves immediately after flushing.

A permanent or semi-permanent type headworks will therefore be required to assure the regular intake of the Gudrung discharge even in the flood season and the stable supply of irrigation water to the command area throughout a year.

F.2.2 Headrace Canal

A 450 m long headrace canal with a capacity of about 1.2 m3/sec, connecting the temporary intake and primary canal, has been constructed at toe of steep hills along the left bank of the Gudrung river . The headrace canal is made of boulders, gravels, and earth materials without a lining. Accordingly, seepage/leakage losses have been serious throughout the whole reach and small-scale rock-fall and surface erosion from steeper surface slope of the hills have often occured in the specific stretches.

Therefore, the existing headrace canal will have to be improved by constructing a concrete/masonry flume or concrete box culvert so that the canal is protected from seepage/leakage, surface erosion of hills and rock-fall from hills.

F.2.3 Primary and Secondary Canals

The irrigation canal network in the Ranikudwa command area is not necessarily rational, since primary, secondary and tertiary canals have gradually been constructed over the last 60 years by the beneficiary farmers themselves without a definite canal layout plan/designs and a technical guidance during construction stage.

The present primary canal is a 8.9 km long earth canal including 1.9 km of a natural stream. The flow capacity is 1.2 m^3/sec at the initial stretch connecting the headrace channel. The cross section of the canal changes from place to place owing to the erosion, scouring, sedimentation, leakage and so on except the stretches protected with wet boulder masonry and boulder pitching. The longest protection stretch is a 400 m long masonry lining in the densely populated Pattharkot village.

The secondary canals branched from the primary canal are six and about 12.2 km in total length. The diversion of irrigation water from the primary to secondary canals has been carried out by utilizing the elevation difference between the primary and secondary canal bottoms. The canal capacity varies from 1.2 m3/sec to 0.3 m3/sec. The cross sections of each canal change section by section due to the erosion, scouring, sedimentation and so on.

The major structures related to the primary and secondary canals are : 24 nos. of cross drainage culvert, 9 nos. of wooden bridge, 2 nos. of wooden aqueduct, 1 no. of submarged intake (at Koika point of Gudrung river), etc. These are temporary structures and mostly deteriorated except some of cross drainage culverts.

Therefore, the existing primary and secondary canals and related structures have to be improved in order to utilize the limited irrigation water efficiently, to minimize the conveyance and operation losses as well as to facilitate equitable distribution of the irrigation water in the whole command area.

F.2.4 Tertiary Canals

There are 50 tertiary canals of which total length is about 30.7 km. The canal capacity and command area range from 0.3 m3/sec to 0.05 m3/sec and from 30 ha to 5 ha, respectively. The canal capacity does not match with its command area, since all the canals was constructed by the beneficiary farmers without engineering background. Also, no related structure is provided for all the tertiary canal.

Therefore, the tertiary canals shall be rehabilitated or improved based on a definite layout plan and engineering design.

F.2.5 Water Management and Its Organization

A rotational irrigation has been practiced throughout a year to increase the irrigation area as much as possible and to stabilize the unit yield and production of the prevailing crops such as paddy in the rainy season and wheat, mustard and vegetables in the dry season by efficient use of the limited irrigation water taken from the Gudrung river as well as to mitigate crop damages by an unforeseen dry spell under the rainfed condition.

However, since the priority of the rotational irrigation has been placed on the upstream area, the rotation mode (rotation interval) in the middle and downstream areas has been so large that it ranges from 1: 5 to 1: 10 for the rainy season paddy and from 1: 15 to 1: 30 for the dry season crops. In general, the irrigation to wheat and mustard is made twice during the plowing and heading stages or once in either plowing or heading stage and that to mustard is given once in either plowing or heading stage. The irrigation to spring crops such as maize, vegetables, etc. in the dry season is limited to a northernmost part of the upstream area due to the limited river flow in the season.

The water management on the rotational irrigation as mentioned above has been carried out by a water users' association (WUA) based on water users' groups (WUGs) organized by each of twelve villages (*Mouja*) located in the Ranikudwa command area. Each WUG has an elected Canal Chief (*Badaghar*), a Secretary (*Sachiv*) and a Canal Watchman (*Chaukidar*) employed to control the water distribution to the secondary and tertiary canals and to maintain the canal conditions throughout day and night. The WUA has been managed by an elected Chairman, a Secretary and Canal Chiefs of WUGs. In general, the WUA including WUGs has well functioned by the system and organization mentioned above.

F.2.6 Operation and Maintenance(O & M)

The O & M of the Ranikudwa system has also well been carried out by the WUA and WUGs mentioned above. The restoration of the temporary weir and intake damaged by big floods and the headrace canal partly breached by seepage/leakage, rock-falls from steep hills, surface erosion of steeper left bank, etc. has been carried out from time to time by the manpower of the member farmers of the WUA timely called up by the Chairman.

The regular O & M of the primary, secondary and tertiary canals has been executed by the member farmers of the WUG(s) which is responsible to manage and supervise all or parts of such canals, but daily O & M of such canals has been carried out by the canal watchmen employed by the WUGs concerned.

In general, the O & M of the irrigation system has well been performed under the existing WUA and WUGs except the irregular cross sections of each canal left.

F.3 ESTIMATE OF IRRIGATION AND DRAINAGE WATER REQUIREMENT

F.3.1 Proposed Irrigation & Drainage Method and System

In the Terai plain, surface irrigation using small basign is prevalent. The Project has been proposed as a run-of-river system with irrigation ponds using gravity irrigation. Irrigation projects in the past had been designed to be controlled by gates provided at all the control structures, however, vraious constraints such as un-equitable water distribution, complicated canal operation have been pointed out through actual water management.

Recognizing these problems, the Government has decided to introduce the rotational irrigation system to recent on-going irrigation projects such as the Narayani, Sunsari Morang irrigation projects and so on. Following this government decision, the rotational irrigation system has been proposed for the Project.

The proposed irrigation system consists of water supply system and distribution system. The supply system further comprises headworks, headrace and primary & secondary feeder canals and the system convey water from the headworks to the irrigation ponds. The distribution system also further comprises main, secondary and tertiary irrigation canals.

As for the drainage, gravity drainage system has been proposed for the Project and existing natural streams are proposed to be incooperated as long as possible in the proposed system. The proposed drainage system comprises primary, secondary and tertiary drains.

F.3.2 Irrigation Field Tests

Irrigation field tests were carried out in order to determine the vertical intake rates in the study area and the variation of these rates according to soil types and landforms. The tests consited of :

- in-situ permeability tests in the rainy season (Aug. 11 to 19, 1992)
- cylinder infiltration tests in the dry season (Jan. 22 to Feb. 18, 1993)
- canal infiltration tests in the dry season (Feb. 20 to 24, 1993)

(The location map of these tests is shown in Fig. B.2.2 in Annex-B.)

F.3.2.1 In-situ Permeability Test

The permeability, K of the soil was measured by the auger-hole method using the well pump-in technique. In addition, permeability of the soil was estimated by D_{20} of particle size analysis (sieve test and hydrometer test). Table F.3.1 shows the results. The former method gives the K-values from the most permeable part of the auger-hole. On the other hand, the latter method shows K-values from the least permeable part of the hole. These values show horizontal values of permeability, K_H.

Generally, soils show large unisotropy : The horizontal values of permeability, K_H, are 2 to 100 times, on average 10 times, larger than the vertical values of permeability, Kv. Because the lowest value of vertical permeability is required for irrigation design, the permeabilities of the study area are estimated as follows, assuming $K_H/K_V=10$.

Location	Estimated Vertical Permeability Kv (cm/s)	
Pattharkot*	3.1×10^{-6}	(2.7 mm/d)
Pattharkot-1*	1.3×10^{-5}	(10.8 mm/d)
Birpur	1.3×10^{-6}	(1.1 mm/d)
Birpur-1	4.0×10^{-6}	(3.5 mm/d)
Bhelai	2.0×10^{-6}	(1.7 mm/d)
Murmy (0 ~ 0.3m)	2.6×10^{-6}	(2.2 mm/d)
Murmy (0.9 m±)	9.0×10^{-7}	(0.78 mm/d)

Note; * Avearge value of Kv in Pattharkot area may be between the above two.

The above values are consistent with the groundwater recharge rates, and deep percolation rates for paddy fields in Terai, a few mm/day. The value of Kv in Pattharkot is relatively high, because Pattharkot is located on a piedmont fan.

F.3.2.2 Cylinder Infiltration Test

Measurement of Basic Intake Rates

Cylinder infiltration tests were carried out in order to estimate the basic intake rates and the deep percolation rates by means of both single and double infiltmeters. The results are shown in Table F.3.2 and Fig.F.3.1 and are summarized in the following page :

Basic Intake Rates

Location	Topography Type*	Mean Basic Intake Rate $\bar{I}_B$ (mm/hr)
Pattharkot	piedmont fan	2.7
Birpur	piedmont fan	1.8
Tikker	high land	(3.4)**
Bhelai	alluvium	0.063
Chapela	old terrace	(3.5)**
Changhat	alluvium	0.056
Bhelai (South)	alluvium	(2.5)**
Murmy	alluvium	0.24
Ghanchaura	old terrace	2.9
Morma	alluvium	0.45
Purena	alluvium	0.45
Gorusinge	alluvium	0.18
Bakadaria	high land	1.5
Buddi	alluvium	1.5
Sitapur	alluvium	0.64
Chauri	high land	2.5

Topography Type	Mean Basic Intake Rate $\bar{I}_B$ (mm/hr)
piedmont fan	1.8 - 3
high land	1.5 - 2.5
old terrace	(2) - 3
alluvium	0.05 - 1.5

Note :

* Geologically, "alluvium" is the Holocene deposits. Others are the Pleistocene deposits.

** Because of the influence of surface cracks, higher values were obtained. The real values would not be higher than 3 mm/hr for high land and old terrace, 1.5 mm/hr for alluvium.

Due to the tests in the dry season higher values than would normally be found were obtained in some places, although pre-wetting was conducted and surface cracks were filled with impermeable soil to a few cm from the surface. In those places, cracks of about 20 cm depth were found. However, the values obtained in most places were consistent with the representative values listed below, as paddy field in the study area are mainly covered with silt, loam and clay. In addition, it became clear that all locations in the study area are suitable for growing rice.

Soil Texture	Representative $\bar{I}_B$ (mm/h)	Normal Range of $\bar{I}_B$ (mm/h)
Loam	10	1 - 20
Clay loam	8	2 - 15
Silty clay	2	0.3 - 5
Clay	0.5	< 0.1 - 8

Source : Booker Tropical Soil Manual (1991)

Basic Intake Rate $\bar{I}_B$ (mm/h)	Suitability for Paddy Irrigation
< 1	suitable
1 - 3	marginally suitable
3 - 7	unsuitable

Source : Booker Tropical Soil Manual (1991)

Estimate of Deep Percoration Losses from Basic Intake Rates

Deep percolation losses (DPL) in the rainy seasons were taken into consideration in the calculation of water requirements for paddy. Deep percolation losses have been estimated with taking the following two items into account :

i) The basic intake rate, $\bar{I}_B$, measured in the dry season, 1993, is proportional to the vertical permeability, K_V, estimated from the horizontal permeability, K_H, obtained in the rainy season, 1992.

ii) K_V is almost equal to DPL.

The relation between K_V and $\bar{I}_B$ was obtained at seven points (see Table F.3.2). Hence, the relationship between DPL and $\bar{I}_B$ is approximately expressed by :

$$DPL\ (mm/d) = 1.775\ \bar{I}_B\ (mm/hr) + 0.507$$

Using the equation, deep percoration losses in the study area have been estimated as follows :

Location	Topography Type	Estimated Deep Percoration Losses	DPL (mm/d)
Pattharkot	piedmont fan	5.3	(4.3 - 6.4)
Birpur	piedmont fan	3.7	(3.5 - 3.8)
Bhelai	alluvium	0.6	
Changhat	alluvium	0.7	
Murmy	alluvium	0.9	
Ghanchaura*	old terrace	5.7	
Morma	alluvium	1.3	
Purena	alluvium	1.3	
Gorusinge	alluvium	0.8	(0.8 - 0.9)
Bakadaria	high land	3.2	(2.4 - 4.2)
Buddi	alluvium	3.2	
Sitapur	alluvium	1.6	(1.4 - 1.9)
Chauri*	high land	4.9	

Note; * : DPL in high land and old terrace may be smaller than that of piedmont fan, when more sample will be taken.

Topography Type	Estimated representative DPL(mm/d) in the Study Area
piedmont fan (7%)	3.7- 5.3
high land (5%)	3.2 - 4.9
old terrace (20%)	(4.1) - 5.7
alluvium (68%)	0.6 - 1.6
	Maximum weighted mean DPL=2.84

Soil Texture	Representative DPL (mm/d) : Long Term Irrigated
Very fine sandy loam, silty loam, sandy clay loam	5
Silty clay loam, clay loam, silty clay, clay	2

Source : PSDP Manual

Month	Representative DPL for Terai Paddy Fields (mm/d)
Mar.	3.0
1st half of Apr.	3.25
2nd half of Apr. to May	3.5
1st half of Jun.	2.5
2nd half of Jun.	2.0
1st half of Jul.	1.5
2nd half of Jul. to Aug.	1.0
Sep. to 1st half of Oct.	2.5
2nd half of Oct. to Nov.	3.0

Source : PSDP Manual

From the tables above, the followings are pointed out :

a) The estimated representative DPL in the study area is approximately less than 6 mm/d, and it is related to the topography type.

b) The estimated DPL in the study area is consistent with the representative DPL for Terai paddy fields.

c) If the maximum values of DPL are used as a worst case, the maximum weighted mean DPL would be 3 mm/day.

F.3.2.3 Canal Infiltration Test

Canal infiltration tests were carried out at 7 locations in order to estimate the canal seepage losses (CSL). The observed rates are slightly high, since the tests were conducted in the dry season. The results are given in the following page :

Canal	Equipment	Date (1993)	Location (Upper) & Discharge Upstream Site (UPS)	(Lower l/s) Downstrea m Site (Distance from the UPS)	: leakage (l/s)	Canal Width (Upper) & Water Depth (Lower) : m	Wetted perimeter (m)	Canal seepage Losses (l/s/km/m of wetted perimeter)
a. Rajikudwa main canal	rectanguler weir	Feb. 20	50m downstream from the intake site 37.1	323.1 m 25.0	12.1	3.0 0.3	3.393	11.04
b. Pattharkot secondary canal	V notch	Feb. 21	west of Pattharkot village 25.5	276.2 m 24.3	1.2	0.66 0.24(0.08~0.36)	0.870	4.99
c. East Birpur springs canal	V notch	Feb. 22	Tikker village (29.7)	278 m 24.3	5.4	1.5 0.25	1.707	11.38
d. East Birpur springs canal	V notch	Feb. 22	southwest of Tikkar village 18.3	392.4 m 9.7	8.6	2.0 0.2	2.166	10.12
e. East Birpur springs canal	V notch	Feb. 23	south of Tikker village 16.6	306.2 m 14.9	1.7	1.0 0.3	1.393	3.99
f. Gholai drain	pershall flume	Feb. 24	downstream from the East-West Highway	75 m 2.9	1.1	0.3* 0.05*	0.400	(36.67) (extremely dry condition)

* excavated for the measurement.

In porous soils such as sandy and gravelly soils where CSL ≥ 5.2 *l/s/km/m*, the canal is required to be lined. The following table gives typical values of canal seepage losses in a normal canal.

Typical Seepage Loss

Types of Soils	Canal Seepage Losses l/s/km/m
Rock	< 0.5
Impervious clay loam	0.8 to 1.2
Medium clay loam	1.2 to 1.7
Clay loam or silty soil	1.7 to 2.7
Gravelly clay loam, sandy clay or gravel cemented with clay	2.7 to 3.5
Sandy loam	3.5 to 5.2
Sandy soil	5.2 to 6.4
Sandy soil with gravel	6.4 to 8.6
Pervious gravelly soil	8.6 to 10.4
Gravel with some earth	10.4 to 20.8

Source : Etcheverry, Irrigation Practice and Engineering.

F.3.3 Irrigation Water Requirement

F.3.3.1 General

The crops proposed to be grown in the area are paddy and upland crops such as wheat, mustard, vegetables, etc. Their irrigation requirements are separately estimated based on the proposed cropping pattern. The irrigation water requirement consists of crop consumptive use, ancillary water demands for respective crops and irrigation losses.

The irrigation water requirements for the crops were firstly estimated on 10-day basis, using climatic data at Bhairahawa agricultural center (station No.0707). The irrigation water requirement was estimated by the following procedure:

(1) Paddy

i) Estimate of crop consumptive use(ET_{crop}) from reference crop evapotranspiration (ET_0) calculated by climatic data and crop coefficients (Kc) varying from growing stages,
ii) Estimate of deep percolation loss (P),
iii) Estimateof effective rainfall (R_e),
iv) Estimate of other requirements such as nursery and land preparation (LP),
v) Estimate of net irrigation requirement (NR), and
$NR = ET_{crop} + P - R_e + LP$
vi) Estimate of diversion water requirement (GR) based on the overall irrigation efficiency (C_{ip})

(2) Upland Crops

i) Estimate of crop consumptive use (ET_{crop}),
ii) Estimateof effective rainfall (R_e),
iii) Estimate of net irrigation water requirement (NR), and
$NR = ET_{crop} - R_e$
iv) Estimate of diversion water requirement (GR) based on the overall irrigation efficiency (C_{iu}).

F.3.3.2 Reference Crop Evapotranspiration

Crop evapotranspiration is estimated as a product of reference crop evapotranspiration (ET_0) and crop coefficient (Kc), which varies with crop growth stage. Since no evapotranspiration data is available in and around the project area, the reference crop evapotranspiration has been estimated by Modified Penman method recommended in "Crop

Water Requirements, FAO Irrigation and Drainage Paper, vol.24,1977". This method is generally accepted in the world as one of the most accurate formulae.

The reference crop evapotranspiration calculated is given in the following table.

unit : mm

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
2.1	3.0	4.9	7.0	8.0	6.8	5.3	5.0	4.3	3.9	3.0	2.0	4.3

F.3.3.3 Crop Coefficient

The proposed cropping pattern consists of rainy season paddy and upland crops. The crop coefficient varies with kind of crop, time of planting or sowing and stage of crop development. The crop coefficients have been determined based on the FAO paper. Taking into consideration the crop coefficients adopted by other irrigation projects in the Terai plain, the crop coefficients given in Table F.3.3 were used for this study.

F.3.3.4 Crop Consumptive Use

Crop consumptive use (ET_{crop}) is calculated by multiplying the estimated evapo-transpiration (ET_0) by crop coefficient (Kc).

$$ET_{crop} = ET_0 \times Kc$$

F.3.3.5 Percolation Rate

Infiltration test in the study area was carried out during the study period. As described in Section F.3.2, the infiltration rate ranges from 0.3 mm/day to 5 mm/day and weighted average by area is 2.4 mm/day. Taking some allowance into consideration, deep percolation loss for the project area is set at 3.0 mm/day.

F.3.3.6 Land Preparation and Nursery Requirement

Land preparation period (30 days) includes nursery, ploughing and paddling period. According to the general farming practices conducted in the study area, the first half of the land preparation period is used for preparation of nursery and ploughing. Then, paddling is carried out with certain amount of water.

The total water requirement in the period has been estimated to be 220 mm in net (367 mm in gross) in which percolation loss of 3.0 mm/day and evaporation loss of 4.0 mm/day have been assumed. The proposed water requirement is considered reasonable comparing with those of other irrigation projects in Nepal.

F.3.3.7 Effective Rainfall

Effectiveness of rainfall on crops depends on rainfall characteristics, meteorological condition, land characteristics, soil characteristics, management practices, groundwater characteristics, etc. Empirical formulae and procedures of field measurement of effective rainfall are introduced in "Effective Rainfall", FAO Irrigation and Drainage Paper vol.25. Effective rainfall in the study area has been estimated referring to procedures widely used in the irrigation project in Nepal, taking the conditions of the project area into consideration.

Design rainfall for the estimate of water requirement is probable minimum rainfall of once in five years' return period. The effective rainfall is estimated to be 70 % of the rainfall in the farm field, referring to PDSP manual.

F.3.3.8 Irrigation Efficiency

The losses of irrigation water generally consist of conveyance loss in the irrigation canal and application loss at the field. The conveyance loss depends on the soil condition on canal route, embankment materials of canal, lining, technical and managerial facilities of water control in the canals and skillness level on water management. The application loss is primarily affected by method and control of operation, type of field soils, length of field canals, size of irrigation canal, etc.

(1) Conveyance Efficiency

As already mentioned, canal infiltration test was carried out during the study period. Since the test was carried out in dry condition of the irrigation canals, the results of seepage loss seemed to be much higher than the actual status (F.3.2 Irrigation Field Test).

Taking the soil texture, topographic condition, results of canal infiltration test into account, the conveyance efficiency is assumed to be 80 %.

(2) Application Efficiency

The field application efficiency in paddy field is considered comparatively small, but that for upland crop irrigation is significant since it includes percolation and other losses. Taking into account the soil characteristics, topography, climate, irrigation practices and results of field test, etc, the application efficiency is assumed to be 75 % for the paddy irrigation and 60 % for upland crop irrigation.

(3) Overall Irrigation Efficiency

Based on the above mentioned assumptions, an overall irrigation efficiency are estimated as follows:

For paddy irrigation	: 60 %
For upland crop irrigation	: 48 % Say 50 %

F.3.3.9 Diversion Water Requirement

Diversion water requirement has been estimated by dividing net irrigation water requirement by overall irrigation efficiency. Based on the diversion water requirement and requirement for feeding irrigation ponds, the design discharge of irrigation facilities such as canals and related structures have been determined. The calculated water requirements are given in Table F.3.4 for the respective crops (1978-92) and in Table F.3.5 for a reference year (1983). The peak requirement for the system has been decided to be 1.2 lit/sec/ha, taking some allowance for future crop variation into consideration.

F.3.4 Drainage Water Requirement

F.3.4.1 General

Drainage in relation to irrigation schemes falls into two main categories. They are internal drainage for runoff of excess water from the fields within the irrigation area and external drainage for runoff generated outside the irrigation area.

In Nepal the predominant crops are paddy in the rainy season and dry food crops in dry winter/spring season such as wheat, mustard and vegetables. Internal drainage system is required only to drain excess rainfall and irrigation water and no drainage of the root zone is necessary. External drainage system is required to drain runoff inflow entering into the project area from outside area.

F.3.4.2 Drainage Water Requirement

In Nepal a broad distinction must be drawn between the physical details of the bunded fields in the hill area and the Terai area. The Terai fields have generally larger area with typical bund height of 200 mm. The topography is flat so that runoff is relatively slow and may spread widely

The runoff from bunded fields, e.g. paddy field, is estimated from a simplified water balance. This approach has been used in Nepal at the Narayani and the Sunsari Morang Irrigation Projects. The water balance includes the following assumptions:

- Initial water level is 40 mm in paddy field;
- Maximum water level is 300 mm which may persist for maximum one day;
- Depths of 200 mm may persist for maximum 3 days;
- No rain follows the design rainfall for several days;
- Consumption due to evapotranspiration and deep percolation are replaced by

The balance can be expressed:

$$h = 40 + \frac{P}{3} - Q \cdot t \qquad t \leq 3\text{days}$$

or

$$h = 40 + P - Q \cdot t \qquad t > 3\text{days}$$

where,
- h : the depth of water in mm
- P : the design rainfall in mm
- t : the number of days that have elapsed since the rainfall began
- Q : the drainage runoff in mm/day

The 3 day rainfall is recommended for the design of field drains in the Terai. A 10 year return period is suggested as a guideline. With a given elevation and mean annual rainfall at the prospective site, the mean value of annual maximum 3-day consecutive rainfall can be obtained from Fig.F.3.2. To estimate the value with a 10 year return period, the mean maximum will be multiplied by a growth factor of 1.5.

The runoff (Q) will be chosen so that the depth of water (h) on the fields never exceeds 300 mm, and is greater than 200 mm for not more than 3 days. The optimum value of Q can be found graphically by plotting (h) against the number of days for various values of (Q), using the above equations (Fig.F.3.3). As the results given in Fig. F.3.3, the drainage water requirement in 10-year return period has been decided to be 6 l/sec/ha for design of drainage canals.

External drainage requirement will be used for design of drainage facilities such as cross drain dealing with runoff from the outside of the project area. In this study, 9 l/sec/ha has been taken for design of drainage canals for the external drainage, taking less storage capacity in the outside forest area into consideration.

As for the design of drainage structures such as cross drains, 1.5 times of the above-mentioned drainage requirements have been applied, referring to PDSP manual. The estimated drainage requirements are summarized below :

Drainage Water Requirement

Water Source	Drains	Structures
Internal Drainage	6.0 lit/sec/ha	9.0 lit/sec/ha
External Drainage	9.0 lit/sec/ha	13.5 lit/sec/ha

F.4 AVAILABLE WATER AND WATER BALANCE

F.4.1 Basic Conditions in Water Balance

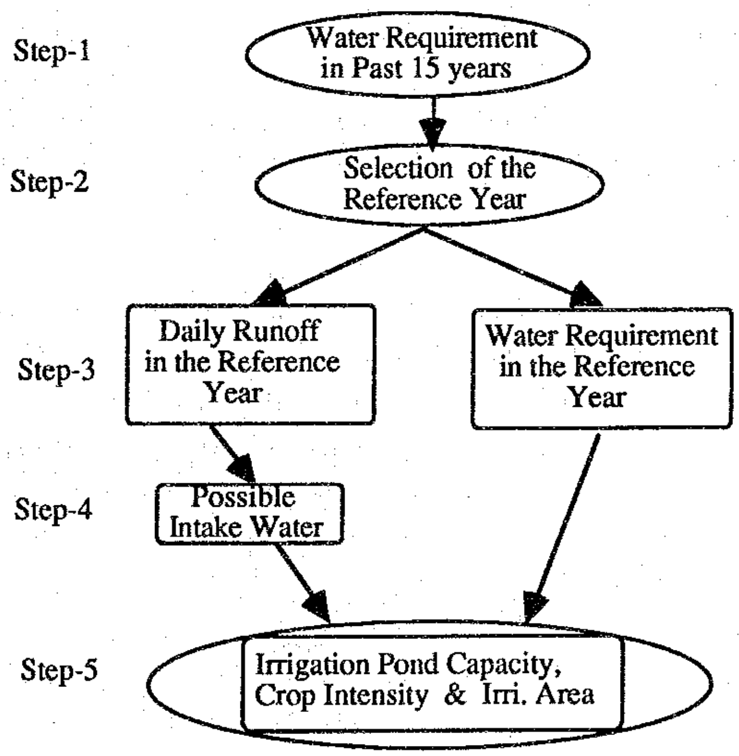
In order to decide the optimum size of the irrigation area, water balance calculations have been made under the following conditions :

i) 80 % dependability will be applied to the proposed irrigation system.

ii) The water balance calculation will be made on the daily basis in the reference year of the 80 % dependability for the irrigation planning.

iii) All the runoff will not be considered as possible intake water, since the runoff gives a sharp hydrograph due to steep and narrow mountainous watershed.

Under the above conditions, water balance calculations in various cases have been made in the following steps :



F.4.2 Reference Year in 80 % Dependability

The reference year has been decided on the basis of the required total irrigation depth of paddy from 1978 to 1992. The calculated total depths for paddy are given in Table F.3.4 and summarized below :

Required Irrigation Depth(mm)

Year	Depth	Year	Depth	Year	Depth
1978	282	1983	375	1988	231
1979	272	1984	392	1989	151
1980	202	1985	328	1990	338
1981	171	1986	128	1991	316
1982	395	1987	314	1992	379

From the above table, the reference year has been decided to be 1983 which return period corresponds to 5 years.

F.4.3 Available Water Resources for Gudrung Irrigation System

The available water sources to the Project consists of the natural runoff from its own basin of the Gudrun river and a spring. The natural runoff is intaken by the headworks and is stored in the proposed irrigation ponds through the headrace and feeder canals. The runoff gives a sharp hydrograph depending upon basin rainfall, since the river originates from steep and small mountainous watershed.

According to the hydrological study given in Annex-A, annual river runoff at the proposed intake site ranges from 51.4 million m^3 to 27.6 million m^3 and is 39.3 million m^3 on average and annual spring runoff is estimated to be 949 m^3. All the above water resources, however, is not always available for the Project, since all river runoff can not be intaken to the proposed system due to the run-of-river system. All runoff will be available for the system during low water period but will not be available during floods or high water periods when the runoff exceeds the intake capacity.

According to the actual discharge measurement during August 1992 - February 1993 (Annex-A), the monthly mean discharge ranges from 0.61 m3/sec to 0.11 m3/sec for the Gudrung river and the runoff raises immediately after rain starts. The estimated runoff concentration time is 45 minutes (0.754 hour). Therefore, all the runoff can be intaken when it does not rain but can not be intaken when it rains.

Rainfall duration and intensity recorded by the automatic raingauge have been analyzed and it was found that a rainfall of 30 mm was observed within a few hours. Several patterns of rainfall intensity were examined using the tank model for the Gudrung river.

In addition to the Gudrung river, unconfined ground water at Birpur is also available for irrigation in the Gudrung system. According to the field observation carried out during the study period, it was estimated that the unconfined ground water was available as follows:

Rainy season	48 lit/sec
Dry season	24 lit/sec
Spring season	8 lit/sec

In order to estimate possible intake water, the following assumptions have been set up at the proposed headworks site :

i) All runoff less than the intake capacity will be intaken when it dose not rain.

ii) In order to intake runoff effectively, maximum diversion water at the headworks is set at 2.4 lit/sec/ha which is two times of the peak irrigation water requirement.

iii) Some part of runoff is expected to be intaken, depending upon rainfall. The following percentage was assumed on the basis of rainfall and flood duration observed in the study.

a.	Daily Rainfall : R < 30 mm/day	20.0 % of Daily Runoff
b.	30 mm/day < R < 60 mm/day	25.0 % of "
c.	60 mm/day < R	37.5 % of "

The estimated total available water resources for the Project in the reference year (1983) is given in Table F.4.2 and Fig.F.4.1 and summarized as follows :

Available River & Spring Runoff (1,000 m^3)

Month	Total	Month	Total	Month	Total
Jan.	717	May	688	Sep.	5,874
Feb.	525	Jun.	607	Oct.	2,539
Mar.	482	Jul.	2,333	Nov.	591
Apr.	464	Aug.	4,387	Dec.	1,097

F.4.4 Water Balance for Ponds in Gudrung Irrigation System

In the water balance calculation, the following conditions have been set up :

i) Seepage loss of 3.0 mm/day is applied for stored water in ponds.

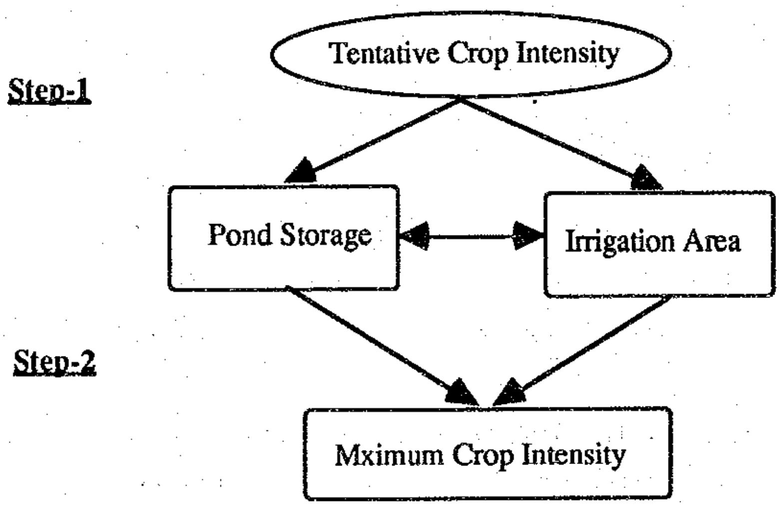
ii) Evaporation loss given in Annex-A is applied from water surface of ponds.

iii) 70 % of daily rainfall in the catchment is considered as effective rainfall in the calculation.

The water balance study has been conducted in the following procedure in order to decide an optimum combination of pond capacity, crop intensity and irrigation area :

Step-1 To *calculate a combination of Pond Capacity & Irrigation Area* under a constant crop intensity,

Step-2 To *adjust crop intensity* under the optimum combination of pond capacity & irrigation area.



In the Step-1 of the above procedure, the following results have been derived under a crop intensity of 155 % (Paddy 100%, Winter Crops 50 % & Spring Crops 5 %) :

Pond Capacity & Irrigation Area in Crop Intensity 155 %

Case	Total Pond Capacity	Max. Irrigation Area	Remarks
Case-A	3,080,000 m^3	2,000 ha	Max. Size of Ponds
Case-B	2,473,000 "	1,810 "	Medium Size "
Case-C	1,390,000 "	1,390 "	Small Size "
Case-D	391,000 "	630 "	Existing Size "
Case-E	0 "	340 "	Without Ponds

In the above cases, general conditions of respective ponds are given in Table F.4.1 and Case-A gives maximum storage of ponds which have been decided mainly from a topographic view point.

From the above table, it is understood that Case-A can serve the biggest irrigation area of 2,000 ha and only 340 ha can be irrigated without ponds. From a view-point of number of beneficiary farmers, Case-A (3.08 million m^3 & 2,000 ha) has been proposed for the Gudrung system.

On the basis of the proposed storage capacity and irrigation area (Case-A), the irrigation system has been delineated to cover 1,800 ha in net from view-points of topography, present paddy fields and so on. The delineated irrigation system is explained in Annex-G.

In the Step-2 of the above-mentioned procedure, an optimum crop intensity has been studied by the water balance study after fixing pond storage capacity of 3,080,000 m^3 and irrigation area of 1,800 ha. Calculation results of the water balance are summarized below :

Crop Intensity & Minimum Pond Storage

Case	Crop Intensity	Minimum Storage	Remarks
Case-1	155 %	542 x 1,000 m3	
Case-2	165 "	209 "	
Case-3	168 "	13 "	
Case-4	170 "	0 (-42) "	Insufficient Storage

From the above table, about 542 thousand m^3 will not be used effectively in case of the crop intensity of 155 %. On the other hand, the proposed pond capacity of 3,080 thousand m^3 is insufficient in case of the crop intensity of 170 %. And it is understood that the crop intensity of 168 % (Case-3) is the most optimum intensity for the irrigation area of 1,800 ha and the total pond capacity of 3,080,000 m^3 among the above 4 cases, since the pond storage can be utilized most effectively. The storage fluctuation in the reference year (Case-3) is shown in Fig. F.4.2 and its water balance calculation is given in Table F.4.2.

Through the above water balance study, general features of the proposed irrigation system have been determined as follows :

General Features of the Irrigation System

Item	Features
Irrigation Area	1,800 ha
- Irrigation by the River	209 ha
- Irrigation by the Ponds	1,591 ha
Total Pond Effective Storage	3,080,000 m^3
- Tikker	2,065,000 m3
- Badahara	120,000 m3
- Gorusinge	135,000 m3
- Dewari	490,000 m3
- Buddi	270,000 m3
Crop Intensity	168.3 % (3,030 ha)
- Paddy	100.0 % (1,800 ha)
- Winter Crops	62.8 % (1,130 ha)
- Spring Crops	5.5 % (100 ha)

F.4.5 Kondre Irrigation System

Water balance for the Kondre irrigation system has been studied on 10-day basis using the records of 1983. Irrigable area on the 10-day basis has been calculated using the unit water requirement and the estimated discharge at the original headworks site (500 m downstream point of the confluence of the Rajkudwa river and the Kondre river) as well as the revised site (Catchment area: 33 km^2). The water balance at the original and revised headworks site is summarized below:

Irrigable Area by Crops

Crops		Original Site	Revised Site
Paddy	:	210 ha	295 ha
Wheat	:	168 ha	231 ha
Mustard	:	56 ha	77 ha
Winter vegetables	:	56 ha	77 ha
Spring Vegetables	:	95 ha	135 ha
Total	:	585 ha	815 ha

Since the Kondre irrigation system does not include irrigation ponds due to topographic conditions, the irrigation area remains extremely small. Taking into consideration the work volume required for the irrigation system, the Kondre irrigation plan is hardly recommended as a promising scheme.

F.4.6 Independent Pond Irrigation System

Independent pond irrigation system consists of three new ponds and five existing ponds which can be used after rehabilitation. The general features of these ponds are summarized below:

Independent Ponds

	== New Ponds ==			======= Existing Ponds =======				
Parameter	Murmy	Gancha-ura 1	Gancha-ura 2	Purena	Dubiya	Pura-tapur	Gelwar	Chamar-gunya
Effective Capacity (x 000 m3)	413	138	46	71	87	33	26	36
Catchment area (ha)	57	39	11	40	40	9	54	119
Inundation area (ha)	28	10	4	8	9	4	4	6
Full Water Level (m)	130	122	121	120	123	120	119	113
Dead Water Level (m)	126	120	119	118	121	119	118	111

Water balance for the independent pond irrigation system has been studied using the records of 1983 in the same manner as the Gudrung irrigation system. Cropping intensity was fixed at 200 % for this calculation. The result of water balance simulation on daily basis is summarized as follows:

Irrigable Area by Crops

Crop		Irrigation area
Paddy rice	:	60 ha
Wheat	::	36 ha
Mustard	:	12 ha
Winter vegetables:		12 ha
Spring Vegetables:		0 ha
Total	:	120 ha

Since the irrigation area in the system is extremely small of 60 ha, it is not recommendable to be included in the proposed development plan of the project.

F.5 PROPOSED WATER MANAGEMENT AND O&M

A part of the discharge of the Gudrung river taken at the headworks will first be used to irrigate 209 ha of paddy fields located at the most upstream of the Tikker pond which will be the first irrigation pond, and the rest will be supplied to the five irrigation ponds one by one in order from north to south. The remaining irrigation area of 1,591ha will be divided into four sub-irrigation areas, each of which will be commanded by an irrigation pond with a canal network.

The 209 ha of paddy fields and five irrigation ponds will be continuously fed by the primary and secondary feeder canals, but the remaining paddy fields of 1,591 ha will be intermittently irrigated by the four irrigation systems originating from the respective irrigation ponds.

Since present water management and O&M of the each existing systems: Ranikudwa, Badahara, Buddi, etc. have been carried out by a single water users' group, similar type of provision will be applied for the new system. That is, there will be no separate organization for water management and O&M under the proposed irrigation system.

Water Users' Group (WUG), the lowest unit of the Water Users' Association (WUA) will be organized in every tertiary block of about 30 ha command area. All farmers of the tertiary unit will be a member of the WUG concerned and all WUGs under the secondary canal concerned will form a secondary WUA. Similarly, an upstream WUA and five pond WUAs will be organized by the secondary WUA sconcerned, and a central level WUA (CLWUA) will be formed by the upstream WUA and five pond WUAs for the proposed irrigation system.

A chairperson and a secretary will be elected from each WUG to the secondary level Water Users' Association (SLWUA) and they will be members of the SLWUA. Similarly, the Chairperson and the Secretary elected from each SLWUA will be members of the pond WUA (PWUA) concerned or the primary canal upstream WUA (PUWUA), each of which has a Chairperson and two Secretaries elected from the members, and CLWUA of the entire irrigation system will be composed of a Chairperson and two Secretaries elected from each of the PUWUA and PWUAs and will have a Chairperson and two Secretaries elected from the members.

The Chairman and the Deputy Chairman of the VDC concerned will also be the ex-officio members of the CLWUA which will also have one Chairperson and two Secretaries elected from the members.

The CLWUA will be responsible for the overall water management and O&M of the proposed entire system including the five irrigation ponds, however, they will be especially responsible for the O&M of the headworks, headrace canal and primary and secondary feeder canals. Decisions regarding canal discharges, pond operation, rotation mode and rotation schedule will also come under the responsibility of CLWUA. The regulation of the WUA, including penalty clauses to violators will also be established by the CLWUA in support of the majority of the members.

The PUWUA or PWUA will take responsibility for the water management and O&M of the pond concerned and its main canal.

The SLWUA will be responsible for the water management and O&M of the secondary canals concerned and equitable distribution of water among the tertiary canals. Supervision to prevent irrigation water from stealing will also come under its responsibility.

The WUGs will be responsible for the water management and O&M of the tertiary, quaternary and field channels concerned. They will also be responsible for the equitable water distribution among quaternaries and prevention of water stealing

CLWUA will employ a required number of gatemen for O&M of the intake gate, spillway gate and sandflush gate in the headworks, cross regulator gates in the primary canal, turnout gates in secondary canals, and intake and offtake gates in irrigation ponds. The required cost including salary of employees and the repair and maintenance cost of gates and others will be collected from all the beneficiary farmers under the proposed system in proportion to their irrigated area.

Routine O&M of primary and secondary feeder canals, irrigation ponds, main, secondary and tertiary canals such as clearing weeds, desilting, maintaining pond levees and canal sections, etc will be timely carried out by labor contribution as decided by CLWUA, and PUWUA, PWUA, SLWUA and WUG concerned.

O&M of the drainage system will also have to be carried out by the water users' organizations concerned at respective levels in the irrigation system. That is, O&M of primary, secondary and tertiary drains will be carried out by CLWUA, and PUWUA, PWUA, SLWUA and WUG concerned.

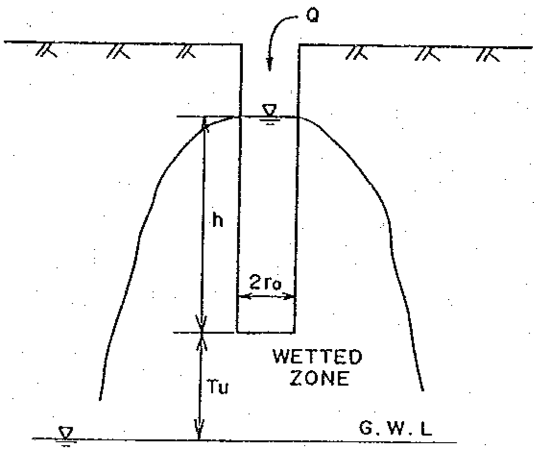
The organization chart of the proposed O&M, WUAs and WUGs is shown in Fig.F.5.1 and Fig. F.5.2.

TABLES

Table F.3.1 In-Situ Permeability Test in Rainy Season (August 11 - 19, 1992)

Location	Coefficient of Permeability K (cm/s): Well Pump-in Technique *	Estimation from D_{20} of Particle Size test**: Depth (m)	D_{20} (cm)	K (cm/s)
Pattharkot	2.72×10^{-3} (97.9 mm/h)	0.0 ~ 0.4	0.018	3.12×10^{-5} (1.12 mm/h)
Pattharkot - 1	7.70×10^{-4} (22.7 mm/h)	0.6 ~ 0.7	0.035	1.25×10^{-4} (4.50 mm/h)
Birpur	1.81×10^{-3} (65.2 mm/h)	0.4 ~ 1.0 (0.60 +)	0.011	1.30×10^{-5} (0.468 mm/h)
Birpur - 1	7.14×10^{-4} (25.7 mm/h)	0.7 - 1.0	0.020	4.00×10^{-5} (1.44 mm/h)
Bhelai	2.70×10^{-4} (9.72 mm/h)	0.2 ~ 0.6 (0.5 +)	0.014	2.03×10^{-5} (0.731 mm/h)
Mumy	7.36×10^{-4} (26.5 mm/h)	0.0 ~ 0.3	0.016	2.60×10^{-5} (0.936 mm/h)
		0.6 ~ 1.2 (0.9 +)	0.009	9.00×10^{-6} (0.324 mm/h)

(Note) * Average horizontal permeability from 0 m to 1 m
** Horizontal permeability of the depth where the particle size is the finest.
(The depth of test holes is 1 m.)



Schematic of Well Pump-in Technique

a) $Tu \geq 3h$: $K = \frac{Q}{2\pi h^2}[\ln\{\frac{h}{r_0} + \sqrt{1 + (\frac{h}{r_0})^2}\} - 1]$

b) $h \leq Tu < 3h$: $K = 3Q \cdot \ln(\frac{h}{r_0}) / \{\pi h(h + 2Tu)\}$

c) $Tu < h$: $K = Q \cdot \ln(\frac{h}{r_0}) / \{\pi Tu(2h - Tu)\}$

Relationships Between D_{20} and Permeability

D_{20} (mm)	K (cm/s)	Soil Type
0.005	3.00×10^{-6}	coarse clay
0.01	1.05×10^{-5}	fine silt
0.02	4.00×10^{-5}	coarse silt
0.03	8.50×10^{-5}	
0.04	1.75×10^{-4}	
0.05	2.80×10^{-4}	
0.06	4.60×10^{-4}	very fine sand
0.07	6.50×10^{-4}	
0.08	9.00×10^{-4}	
0.09	1.40×10^{-3}	
0.10	1.75×10^{-3}	
0.12	2.6×10^{-3}	fine sand
0.14	3.8×10^{-3}	
0.16	5.1×10^{-3}	
0.18	6.85×10^{-3}	
0.20	8.90×10^{-3}	
0.25	1.40×10^{-2}	
0.3	2.20×10^{-2}	medium sand
0.35	3.20×10^{-2}	
0.4	4.50×10^{-2}	
0.45	5.80×10^{-2}	
0.5	7.5×10^{-2}	
0.6	1.10×10^{-1}	coarse sand
0.7	1.60×10^{-1}	
0.8	2.15×10^{-1}	
0.9	2.8×10^{-1}	
1.0	3.60×10^{-1}	
2.0	1.80	fine gravel

(after Creager)

Table F.3.2 Cylinder Intake Rate in the Study Area

No.	Location		Topography Type*	Date (1993)	Measuring Time	Method**	Intake D(mm)	Intake Rate I (mm/hr)	Basic Intake Rate IB (mm/hr)	Surface Conditions	Average IB IB(mm/hr)
1	Pattharkot	1	PF	Feb. 9	12 : 37 ~ 2 hrs	Single Ring Method	$D=10.6\,t^{0.276}$	$I=175\,t^{-0.724}$	2.15	dry	
		2		"	12 : 43 ~ 2 hrs	"	$D=7.0\,t^{0.359}$	$I=151\,t^{-0.641}$	3.32	"	2.74
2	Birpur	1	PF	Feb. 9	15 : 27 ~ 2 hrs	"	$D=3.7\,t^{0.366}$	$I=81.3\,t^{-0.634}$	1.88	dry	
		2		"	15 : 32 ~ 2 hrs	"	$D=5.9\,t^{0.308}$	$I=109\,t^{-0.692}$	1.68	"	1.78
3	Tikker	1	HL	Feb.16	11 : 53 ~ 2 hrs	"	$D=6.8\,t^{0.363}$	$I=148\,t^{-0.637}$	3.35 ***	dry, cracked	
		2		"	11 : 57 ~ 2 hrs	"	$D=9.3\,t^{0.333}$	$I=186\,t^{-0.667}$	3.41 ***	"	(3.38 ***)
4	Bhelai	1	A	Feb.16	16 : 21 ~ 2 hrs	"	$D=3.2\,t^{0.439}$	$I=84.3\,t^{-0.561}$	3.22 ***	dry, cracked	
		2		"	"	"	$D=2.0\,t^{0.505}$	$I=60.6\,t^{-0.495}$	3.61 ***	"	0.0631
		3		Jan. 22	11 :35 ~ 4 hrs	Double Ring Method	$D=1.24\,t^{0.159}$	$I=11.8\,t^{-0.841}$	0.0631	wet	
5	Chapela		OT	Jan.24	11 : 15 ~ 4 hrs	"	$D=8.8\,t^{0.341}$	$I=179\,t^{-0.659}$	3.48 ***	dry, a little cracked	(3.48***)
6	Changhat		A	Jan.26	12 : 15 ~ 3 hrs	"	$D=2.63\,t^{0.101}$	$I=15.9\,t^{-0.899}$	0.0558	wet	0.0558
7	Bhelai (South)		A	Jan.31	11 : 50 ~ 3 hrs	"	$D=0.87\,t^{0.557}$	$I=29.1\,t^{-0.493}$	2.45 ***	dry	(2.45 ***)
8	Murmy	1	A	Feb.17	14 : 30 ~ 2 hrs	Single Ring Method	$D=1.3\,t^{0.530}$	$I=41.3\,t^{-0.470}$	2.91 ***	dry, cracked	
		2		"	"	"	$D=0.66\,t^{0.627}$	$I=24.8\,t^{-0.373}$	3.36 ***	dry, cracked	0.237
		3		Feb. 2	11 : 30 ~ 2.5 hrs	Double Ring Method	$D=0.40\,t^{0.382}$	$I=9.17\,t^{-0.618}$	0.237	wet	
9	Ghanchaura		OT	Jan.27	12 : 15 ~ 3 hrs	"	$D=4.65\,t^{0.389}$	$I=109\,t^{-0.611}$	2.94	dry	2.94
10	Morma		A	Jan.28	11 : 15 ~ 3 hrs	"	$D=4.21\,t^{0.218}$	$I=55.1\,t^{-0.782}$	0.449	dry	0.449
11	Purena		A	Jan.29	13 : 15 ~ 3 hrs	"	$D=0.96\,t^{0.357}$	$I=20.5\,t^{-0.643}$	0.446	dry	0.446
12	Gorusinge	1	HL	Feb.18	10 : 02 ~ 2 hrs	Single Ring Method	$D=1.7\,t^{0.232}$	$I=23.7\,t^{-0.768}$	0.213	dry	
		2		"	"	"	$D=1.79\,t^{0.191}$	$I=20.5\,t^{-0.809}$	0.138	"	0.178
13	Bakadaria	1	HL	Feb.18	13 : 45 ~ 2 hrs	"	$D=2.3\,t^{0.354}$	$I=48.9\,t^{-0.646}$	1.04	dry	
		2		"	"	"	$D=1.72\,t^{0.459}$	$I=47.8\,t^{-0.541}$	2.08	"	1.54
		3		Feb. 1	11 : 15 ~ 3 hrs	Double Ring Method	$D=3.50\,t^{0.349}$	$I=73.3\,t^{-0.651}$	1.51	"	
14	Buddi		A	Feb. 5	12 : 15 ~ 2.5 hrs	"	$D=1.19\,t^{0.462}$	$I=33.0\,t^{-0.538}$	1.47	dry	1.47
15	Sitapur	1	A	Feb.18	16 : 43 ~ 2 hrs	Single Ring Method	$D=3.9\,t^{0.278}$	$I=50.0\,t^{-0.722}$	0.624	dry	
		2		"	"	"	$D=4.61\,t^{0.260}$	$I=71.9\,t^{-0.740}$	0.79	"	0.637
		3		Feb. 5	11 : 45 ~ 2.5 hrs	Double Ring Method	$D=1.12\,t^{0.352}$	$I=84.2\,t^{-0.596}$	0.496	"	
16	Chauri		HL	Feb. 4	12 : 15 ~ 2.5 hrs	"	$D=3.39\,t^{0.414}$	$I=84.2\,t^{-0.596}$	2.53	dry	2.53

* Topography type : PF refers to piedmont fan, it geologically includes middle terrace and older fan deposits of the Pleistocene.HL refers to high land, the geology is the Pleistocene.
A refers to alluvium, the geology is the Holocene.
OT refers to old terrace, the geology is the Pleistocene. (older than high land)

** For the single ring method, water was filled in the circumference of the cylinder for some 10 cm wide.

*** Because of the influence of surface cracks, higher values were obtained.

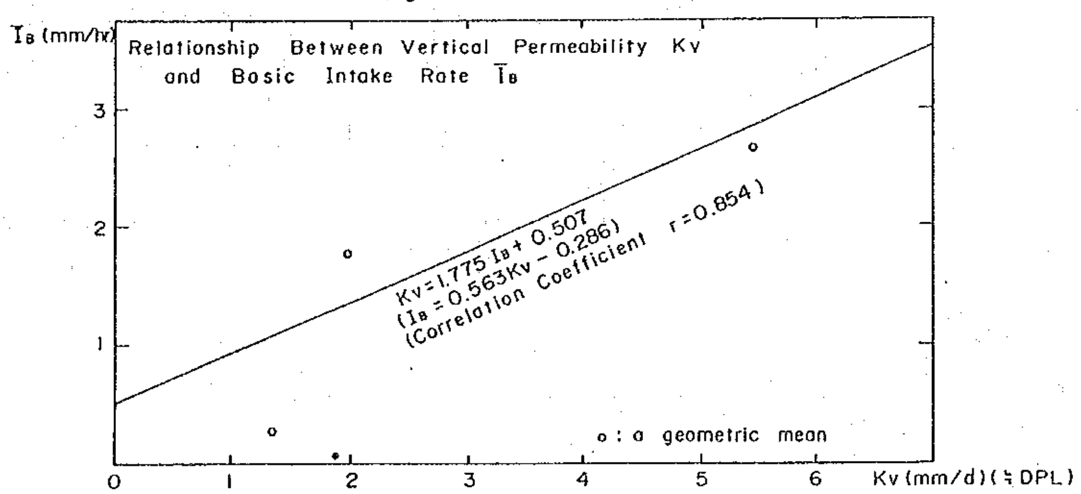


Table F.3.3 Applied Crop Coefficients

** Kc Value **

Crop	First Month			Second Month			Third Month			Fourth Month		
	1-10 day	11-20 day	21-30 day	1-10 day	11-20 day	21-30 day	1-10 day	11-20 day	21-30 day	1-10 day	11-20 day	21-30 day
Paddy	1.00	1.00	1.15	1.15	1.15	1.20	1.20	0.90	0.00	0.00	-	-
Wheat	0.57	0.71	0.90	1.08	1.13	1.16	1.14	1.08	0.91	0.45	0.00	0.00
Winter Vegetable	0.28	0.31	0.34	0.54	0.70	0.86	0.95	0.95	0.89	0.00	-	-
Mustard	0.40	0.43	0.46	0.82	0.91	1.00	1.00	0.86	0.00	-	-	-
Spring Vegetable	0.30	0.30	0.60	0.60	0.60	0.80	0.80	0.70	0.00	-	-	-

Table F.3.4 Summary of Cropwise Gross Irrigation Water Requirements

Year	Paddy		Wheat		Winter vegetables		Mustard		Spring vegetables	
	Total (mm)	Peak (l/sec/ha)	Total (mm)	Peak (l/sec/ha)	Total (mm)	Peak (l/sec/ha)	Total (mm)	Peak (l/sec/ha)	Total (mm)	Peak (l/sec/ha)
1978	282	1.147	363	0.559	205	0.440	223	0.486	534	1.420
1979	272	1.172	305	0.559	169	0.416	171	0.464	648	1.481
1980	202	0.855	426	0.559	274	0.558	266	0.486	446	1.134
1981	171	0.493	265	0.530	164	0.517	146	0.400	472	1.352
1982	395	1.491	348	0.559	223	0.517	209	0.486	544	1.481
1983	375	1.001	347	0.559	218	0.639	196	0.486	499	1.225
1984	392	1.055	355	0.559	213	0.639	194	0.464	624	1.382
1985	328	0.998	364	0.559	232	0.483	216	0.486	470	0.972
1986	128	0.330	313	0.559	209	0.462	206	0.486	500	1.106
1987	314	1.087	423	0.559	271	0.639	261	0.486	578	1.389
1988	231	0.863	397	0.559	252	0.639	235	0.486	520	1.331
1989	151	0.444	344	0.540	208	0.639	199	0.486	527	1.481
1990	338	1.065	366	0.559	219	0.547	227	0.486	397	0.972
1991	316	1.393	365	0.559	236	0.639	214	0.486	586	1.389
1992	379	1.145	363	0.559	237	0.464	226	0.486	619	1.229
80%	**375**	**1.147**	**366**	**0.559**	**237**	**0.639**	**227**	**0.486**	**586**	**1.420**
Maximum	395	1.491	426	0.559	274	0.639	266	0.486	648	1.481
Minimum	128	0.330	265	0.530	164	0.416	146	0.400	397	0.972
Average	285	0.969	356	0.556	222	0.549	213	0.477	531	1.290

Table F.3.5 Proposed Irrigation Water Requirement (1/2)

Irrigation efficiency (paddy) = 0.60
Irrigation efficiency (upland crops)= 0.50
Crop Intensity (paddy)= 100 %
Crop Intensity (wheat)= 38 %
Crop Intensity (winter veg.)= 12.5 %
Crop Intensity (mustard)= 12.5 %
Crop Intensity (spring veg.)= 5 %
Total Intensity= 168 %

Item	Unit	Jan. 1	Jan. 2	Jan. 3	Feb. 1	Feb. 2	Feb. 3	Mar. 1	Mar. 2	Mar. 3	Apr. 1	Apr. 2	Apr. 3	May 1	May 2	May 3	Jun. 1	Jun. 2	Jun. 3
(1) Rainfall in 1983	(mm)	0	0	25	0	0	3	0	0	0	0	25	0	16	67	27	11	26	44
(2) Effective rainfall in 1983	(mm)	0	0	18	0	0	2	0	0	0	0	18	0	11	47	19	8	18	31
(3) ET0	(mm)	21	21	23	30	30	24	49	49	54	70	70	70	80	80	88	68	68	68
(4) Percolation	(mm)																30	30	30
(5) Evaporation	(mm)																40	40	40
(6) Area factor (paddy)																		0.17	0.50
Area factor (wheat)		1.00	1.00	1.00	1.00	1.00	1.00	0.50											
Area factor (winter vegetables)		1.00	1.00	1.00	1.00	1.00	0.50												
Area factor (mustard)		1.00	1.00	1.00	1.00	0.75	0.25												
Area factor (spring vegetables)								0.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50		
Nursery and Land preparation stage																			
(7) Nursery and Land preparation	(mm)																50	170	
	(mm)																	50	170
	(mm)																		50
	(mm)																		
Growth stage																			
(8) Kc (paddy)																			1.00
Kc (wheat)		1.14	1.08	0.91	0.45	0.00	0.00												
		1.16	1.14	1.08	0.91	0.45	0.00	0.00											
Kc (winter vegetables)		0.86	0.95	0.95	0.89	0.00													
		0.70	0.86	0.95	0.95	0.89	0.00												
Kc (mustard)		1.00	1.00	0.86	0.00														
		0.91	1.00	1.00	0.86	0.00													
Kc (spring vegetables)								0.30	0.30	0.60	0.60	0.60	0.80	0.80	0.70	0.00			
									0.30	0.30	0.60	0.60	0.60	0.80	0.80	0.70	0.00		
(9) Consumptive use (paddy)	(mm)																		68
	(mm)																		
	(mm)																		
	(mm)																		
Consumptive use (wheat)	(mm)	24	23	21	14	0	0												
	(mm)	24	24	25	27	14	0	0											
Consumptive use (winter veg.)	(mm)	18	20	22	27	0													
	(mm)	15	18	22	29	27	0												
Consumptive use (mustard)	(mm)	21	21	20	0														
	(mm)	19	21	23	26	0													
Consumptive use (spring veg.)	(mm)							15	15	32	42	42	56	64	56	0			
	(mm)								15	16	42	42	42	64	64	62	0		
(10) Percolation	(mm)																		30
	(mm)																		
	(mm)																		
	(mm)																		
(11) Subtotal	(mm)																		98
	(mm)																		
	(mm)																		
	(mm)																		

Item	Unit	Jul. 1	Jul. 2	Jul. 3	Aug. 1	Aug. 2	Aug. 3	Sep. 1	Sep. 2	Sep. 3	Oct. 1	Oct. 2	Oct. 3	Nov. 1	Nov. 2	Nov. 3	Dec. 1	Dec. 2	Dec. 3	Total
(1) Rainfall in 1983	(mm)	123	82	260	348	82	179	371	231	77	215	40	0	0	0	0	0	0	78	2328
(2) Effective rainfall in 1983	(mm)	86	57	182	243	57	125	260	162	54	151	28	0	0	0	0	0	0	54	1630
(3) ET0	(mm)	53	53	58	50	50	55	43	43	43	39	39	43	30	30	30	20	20	22	1684
(4) Percolation	(mm)	30	30	33	30	30	33	30	30	30	30	30	33							
(5) Evaporation	(mm)	40	40	44	40	40	44	40	40	40	40	40	44							
(6) Area factor (paddy)		0.83	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.83	0.50	0.17							
Area factor (wheat)														0.50	1.00	1.00	1.00	1.00	1.00	
Area factor (winter vegetables)															0.50	1.00	1.00	1.00	1.00	
Area factor (mustard)															0.25	0.50	1.00	1.00	1.00	
Area factor (spring vegetables)																				
Nursery and Land preparation stage																				
(7) Nursery and Land preparation	(mm)																			220
	(mm)																			
	(mm)	170																		
	(mm)	50	170																	
Growth stage																				
(8) Kc (paddy)		1.00	1.15	1.15	1.15	1.20	1.20	0.90	0.00	0.00										
		1.00	1.00	1.15	1.15	1.15	1.20	1.20	0.90	0.00	0.00									
			1.00	1.00	1.15	1.15	1.15	1.20	1.20	0.90	0.00	0.00								
				1.00	1.00	1.15	1.15	1.15	1.20	1.20	0.90	0.00	0.00							
Kc (wheat)														0.57	0.71	0.90	1.08	1.13	1.16	
															0.57	0.71	0.90	1.08	1.13	
Kc (winter vegetables)															0.28	0.31	0.34	0.54	0.70	
																0.28	0.31	0.34	0.54	
Kc (mustard)															0.40	0.43	0.46	0.82	0.91	
																0.40	0.43	0.46	0.82	
Kc (spring vegetables)																				
(9) Consumptive use (paddy)	(mm)	53	61	67	58	60	66	39	0	0										
	(mm)	53	53	67	58	58	66	52	39	0	0									
	(mm)		53	58	58	58	63	52	52	39	0	0								
	(mm)			58	50	58	63	49	52	52	35	0	0							
Consumptive use (wheat)	(mm)													17	21	27	22	23	26	
	(mm)														17	21	18	22	25	
Consumptive use (winter veg.)	(mm)														8	9	7	11	15	
	(mm)															8	6	7	12	
Consumptive use (mustard)	(mm)														12	13	9	16	20	
	(mm)															12	9	9	18	
Consumptive use (spring veg.)	(mm)																			
	(mm)																			
(10) Percolation	(mm)	30	30	33	30	30	33	30	0	0										
	(mm)	30	30	33	30	30	33	30	30	0	0									
	(mm)		30	33	30	30	33	30	30	30	0	0								
	(mm)			33	30	30	33	30	30	30	30	0	0							
(11) Subtotal	(mm)	83	91	100	88	90	99	69	0	0										687
	(mm)	83	83	100	86	86	99	82	69	0	0									
	(mm)		83	91	88	88	96	82	82	69	0	0								
	(mm)			91	80	88	96	79	82	82	65	0	0							

Table F.3.5 Proposed Irrigation Water Requirement (2/2)

		Jan.			Feb.			Mar.			Apr.			May			Jun.			Jul.			Aug.			Sep.			Oct.			Nov.			Dec.			Total
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
(12) Unit water requirement (paddy)	(mm)																50	170	98	83	91	100	88	90	99	69	0	0										907
	(mm)																	50	170	83	83	100	88	88	99	62	69	0	0									
	(mm)																		50	170	83	91	88	88	96	82	82	69	0	0								
	(mm)																			50	170	91	80	88	96	79	82	82	65	0	0							
Unit water requirement (wheat)	(mm)	24	23	21	14	0	0																									17	21	27	22	23	26	217
	(mm)	24	24	25	27	14	0	0																									17	21	18	22	25	
Unit water requirement (winter veg)	(mm)	18	20	22	27	0																											8	9	7	11	15	140
	(mm)	15	18	22	29	27	0																											8	6	7	12	
Unit water requirement (mustard)	(mm)	21	21	20	0																												12	13	9	16	20	135
	(mm)	19	21	23	26	0																												12	9	9	18	
Unit water requirement (spring veg)	(mm)							15	15	32	42	42	56	64	56	0																						334
	(mm)								15	16	42	42	42	64	64	62	0																					
(13) Net irrigation requirement (paddy)	(mm)																42	152	67	0	34	0	0	33	0	0	0	0										225
	(mm)																	32	139	0	26	0	0	30	0	0	0	0	0									
	(mm)																		19	84	26	0	0	30	0	0	0	15	0	0								
	(mm)																			0	113	0	0	30	0	0	0	28	0	0	0							
Net irrigation requirement (wheat)	(mm)	24	23	3	14	0	0																									17	21	27	22	23	0	174
	(mm)	24	24	7	27	14	0	0																									17	21	18	22	0	
Net irrigation requirement (winter veg.)	(mm)	18	20	4	27	0																											8	9	7	11	0	109
	(mm)	15	18	4	29	27	0																											8	6	7	0	
Net irrigation requirement (mustard)	(mm)	21	21	2	0																												12	13	9	16	0	98
	(mm)	19	21	5	26	0																												12	9	9	0	
Net irrigation requirement (spring veg.)	(mm)							15	15	32	42	25	56	53	9	0																						249
	(mm)								15	16	42	25	42	53	17	43	0																					
(14) Gross irrigation requirement (paddy)	(mm)																71	253	112	0	56	0	0	54	0	0	0	0										375
	(mm)																	53	232	0	43	0	0	50	0	0	0	0	0									
	(mm)																		32	140	43	0	0	50	0	0	0	25	0	0								
	(mm)																			0	188	0	0	50	0	0	0	47	0	0	0							
Gross irrigation requirement (wheat)	(mm)	48	45	7	27	0	0																									34	43	54	43	45	0	347
	(mm)	49	48	14	55	27	0	0																									34	43	36	43	0	
Gross irrigation requirement (winter veg.)	(mm)	36	40	8	53	0																											17	19	14	22	0	218
	(mm)	29	36	8	57	53	0																											17	12	14	0	
Gross irrigation requirement (mustard)	(mm)	42	42	4	0																												24	26	18	33	0	196
	(mm)	38	42	11	52	0																												24	17	18	0	
Gross irrigation requirement (spring veg.)	(mm)							29	29	65	84	49	112	106	19	0																						499
	(mm)								29	32	84	49	84	106	35	85	0																					
(15) Gross unit irrigation requirement (paddy)	(l/s/ha)																0.010	0.496	1.001	0.449	0.957	0.000	0.000	0.594	0.000	0.000	0.000	0.208	0.000	0.000	0.000							1.001
Gross unit irrigation requirement (wheat.)	(l/s/ha)	0.559	0.540	0.111	0.472	0.156	0.000	0.000																								0.198	0.444	0.559	0.458	0.512	0.000	0.559
Gross unit irrigation requirement (winter veg.)	(l/s/ha)	0.379	0.440	0.089	0.639	0.309	0.000																										0.097	0.205	0.150	0.204	0.000	0.639
Gross unit irrigation requirement (mustard)	(l/s/ha)	0.464	0.486	0.079	0.299	0.000																											0.069	0.144	0.206	0.296	0.000	0.486
Gross unit irrigation requirement (spring veg.)	(l/s/ha)							0.170	0.340	0.510	0.972	0.567	1.134	1.225	0.310	0.449	0.000																					1.225
Diversion requirement	(l/s/ha)	0.317	0.320	0.063	0.296	0.098	0.000	0.009	0.019	0.028	0.054	0.032	0.063	0.068	0.017	0.025	0.010	0.496	1.001	0.449	0.957	0.000	0.000	0.594	0.000	0.000	0.000	0.208	0.000	0.000	0.000	0.075	0.189	0.255	0.218	0.256	0.000	1.001

Table F.4.1 General Conditions of Irrigation Ponds
in Case Study

Items	Unit	Name of Irrigation Ponds					
		Tikker	Badahara	Gorusinge	Dewari	Buddi	Total
A. Maximum Size of Ponds							
Effective Capacity	(TCM)	2,065	120	135	270	490	3,080
Reservoir Area	(ha)	51.5	13.9	6.4	27.3	51.0	150.1
Catchment Area	(ha)	80.0	42.6	33.3	49.1	114.6	319.6
Full Water Level	(m)	141.6	118.0	118.1	114.5	114.5	-
B. Medium Size of Ponds							
Effective Capacity	(TCM)	1,347	143	97	297	589	2,473
Reservoir Area	(ha)	41.0	13.9	10.7	23.0	39.9	128.5
Catchment Area	(ha)	80.0	42.6	33.3	49.1	114.6	319.6
Full Water Level	(m)	140.0	118.0	117.0	114.0	114.0	-
C. Small Size of Ponds							
Effective Capacity	(TCM)	791	143	97	110	249	1,390
Reservoir Area	(ha)	30.0	13.9	10.7	14.4	28.1	97.1
Catchment Area	(ha)	80.0	42.6	33.3	49.1	114.6	319.6
Full Water Level	(m)	138.5	118.0	117.0	113.0	113.0	-
D. Existing Ponds							
Effective Capacity	(TCM)	-	84	54	73	180	391
Reservoir Area	(ha)	-	9.0	8.0	9.0	20.0	46.0
Catchment Area	(ha)	-	42.6	33.3	49.1	114.6	239.6
Full Water Level	(m)	-	117.5	116.2	112.5	112.5	-

Table F.4.2 Pond-Storage Simulation in Standard Year 1983 (1/10)

" Maximum Size of Ponds "

Crop Intensity =	168.3%		
Pond Irri. Area:	1,591 ha	Catchment Area =	320 ha
Storage =	3,080,000 m3	Reservoir Area =	159 ha (FWL)
Max. Intake=	4.40 m3/sec	Upstream Irr. Area =	209 ha

Month	Day	Inflow & Upstream Demand River: Q (m3/sec)	Q.Expected (m3/sec)	Spring (lit/sec)	Upstream (lit/sec)	Ponds Inflow (lit/sec)	Unit D. W. Requirement (lit/sec/ha)	Diversion W. Requirement (lit/sec)	Rainfall (mm/day)	Evaporation (mm/day)	Percolation (mm/day)	Pond Storage (m3)	In or Outflow (m3)	Rain, EV & P (m3)	Deficit/ Surplus	Spill-out (m3)
Jan.	1	0.196	0.196	24	66	154	0.317	504	0.0	2.67	3.00	2,939,619	-30,292	-6,291	-36,583	0
	2	0.196	0.196	24	66	154	0.317	504	0.0	2.67	3.00	2,903,036	-30,292	-6,291	-36,583	0
	3	0.196	0.196	24	66	154	0.317	504	0.0	2.67	3.00	2,866,454	-30,292	-6,291	-36,583	0
	4	0.195	0.195	24	66	153	0.317	504	0.0	2.67	3.00	2,829,871	-30,378	-6,291	-36,669	0
	5	0.195	0.195	24	66	153	0.317	504	0.0	2.67	3.00	2,793,202	-30,378	-6,291	-36,669	0
	6	0.195	0.195	24	66	153	0.317	504	0.0	2.67	3.00	2,756,533	-30,378	-6,291	-36,669	0
	7	0.195	0.195	24	66	153	0.317	504	0.0	2.67	3.00	2,719,864	-30,378	-6,291	-36,669	0
	8	0.194	0.194	24	66	152	0.317	504	0.0	2.67	3.00	2,683,194	-30,465	-6,291	-36,756	0
	9	0.194	0.194	24	66	152	0.317	504	0.0	2.67	3.00	2,646,439	-30,465	-6,291	-36,756	0
	10	0.194	0.194	24	66	152	0.317	504	0.0	2.67	3.00	2,609,683	-30,465	-6,291	-36,756	0
Jan.	11	0.193	0.193	24	67	150	0.320	509	0.0	2.67	3.00	2,572,928	-31,018	-6,291	-37,308	0
	12	0.193	0.193	24	67	150	0.320	509	0.0	2.67	3.00	2,535,619	-31,018	-6,291	-37,308	0
	13	0.193	0.193	24	67	150	0.320	509	0.0	2.67	3.00	2,498,311	-31,018	-6,291	-37,308	0
	14	0.192	0.192	24	67	149	0.320	509	0.0	2.67	3.00	2,461,003	-31,104	-6,291	-37,395	0
	15	0.192	0.192	24	67	149	0.320	509	0.0	2.67	3.00	2,423,608	-31,104	-6,291	-37,395	0
	16	0.192	0.192	24	67	149	0.320	509	0.0	2.67	3.00	2,386,213	-31,104	-6,291	-37,395	0
	17	0.192	0.192	24	67	149	0.320	509	0.0	2.67	3.00	2,348,818	-31,104	-6,291	-37,395	0
	18	0.191	0.191	24	67	148	0.320	509	0.0	2.67	3.00	2,311,423	-31,190	-6,291	-37,481	0
	19	0.191	0.191	24	67	148	0.320	509	0.0	2.67	3.00	2,273,942	-31,190	-6,291	-37,481	0
	20	0.191	0.191	24	67	148	0.320	509	0.0	2.67	3.00	2,236,461	-31,190	-6,291	-37,481	0
Jan.	21	0.190	0.190	24	13	201	0.063	100	0.0	2.67	3.00	2,198,979	8,692	-6,291	2,401	0
	22	0.190	0.190	24	13	201	0.063	100	0.0	2.67	3.00	2,201,380	8,692	-6,291	2,401	0
	23	0.190	0.190	24	13	201	0.063	100	0.0	2.67	3.00	2,203,781	8,692	-6,291	2,401	0
	24	0.189	0.189	24	13	200	0.063	100	0.0	2.67	3.00	2,206,182	8,605	-6,291	2,315	0
	25	0.189	0.189	24	13	200	0.063	100	0.0	2.67	3.00	2,208,497	8,605	-6,291	2,315	0
	26	0.189	0.189	24	13	200	0.063	100	0.0	2.67	3.00	2,210,811	8,605	-6,291	2,315	0
	27	0.461	0.243	24	13	254	0.063	100	6.5	2.67	3.00	2,213,126	13,306	8,251	21,557	0
	28	1.243	0.750	24	13	761	0.063	100	18.8	2.67	3.00	2,234,682	57,076	35,768	92,844	0
	29	0.766	0.766	24	13	777	0.063	100	0.0	2.67	3.00	2,327,527	58,458	-6,291	52,167	0
	30	0.479	0.479	24	13	490	0.063	100	0.0	2.67	3.00	2,379,694	33,661	-6,291	27,371	0
	31	0.308	0.308	24	13	319	0.063	100	0.0	2.67	3.00	2,407,065	18,887	-6,291	12,596	0

Table F.4.2 Pond-Storage Simulation in Standard Year 1983 (2/10)

Month	Day	Inflow & Upstream Demand: River: Q (m3/sec)	Q.Expected (m3/sec)	Spring (lit/sec)	Upstream (lit/sec)	Ponds Inflow (lit/sec)	Unit D. W. Requirement (lit/sec/ha)	Diversion W. Requirement (lit/sec)	Rainfall (mm/day)	Evaporation (mm/day)	Percolation (mm/day)	Pond Storage (m3)	In or Outflow (m3)	Rain, EV & P (m3)	Deficit/ Surplus	Spill-out (m3)
Feb.	1	0.188	0.188	24	62	150	0.296	471	0.0	3.68	3.00	2,419,661	-27,717	-7,411	-35,129	0
	2	0.188	0.188	24	62	150	0.296	471	0.0	3.68	3.00	2,384,532	-27,717	-7,411	-35,129	0
	3	0.188	0.188	24	62	150	0.296	471	0.0	3.68	3.00	2,349,404	-27,717	-7,411	-35,129	0
	4	0.188	0.188	24	62	150	0.296	471	0.0	3.68	3.00	2,314,275	-27,717	-7,411	-35,129	0
	5	0.188	0.188	24	62	150	0.296	471	0.0	3.68	3.00	2,279,147	-27,717	-7,411	-35,129	0
	6	0.188	0.188	24	62	150	0.296	471	0.0	3.68	3.00	2,244,018	-27,717	-7,411	-35,129	0
	7	0.188	0.188	24	62	150	0.296	471	0.0	3.68	3.00	2,208,889	-27,717	-7,411	-35,129	0
	8	0.187	0.187	24	62	149	0.296	471	0.0	3.68	3.00	2,173,761	-27,804	-7,411	-35,215	0
	9	0.187	0.187	24	62	149	0.296	471	0.0	3.68	3.00	2,138,546	-27,804	-7,411	-35,215	0
	10	0.187	0.187	24	62	149	0.296	471	0.0	3.68	3.00	2,103,331	-27,804	-7,411	-35,215	0
Feb.	11	0.186	0.186	24	20	190	0.098	156	0.0	3.68	3.00	2,068,116	2,903	-7,411	-4,508	0
	12	0.186	0.186	24	20	190	0.098	156	0.0	3.68	3.00	2,063,608	2,903	-7,411	-4,508	0
	13	0.186	0.186	24	20	190	0.098	156	0.0	3.68	3.00	2,059,099	2,903	-7,411	-4,508	0
	14	0.185	0.185	24	20	189	0.098	156	0.0	3.68	3.00	2,054,591	2,817	-7,411	-4,595	0
	15	0.185	0.185	24	20	189	0.098	156	0.0	3.68	3.00	2,049,996	2,817	-7,411	-4,595	0
	16	0.185	0.185	24	20	189	0.098	156	0.0	3.68	3.00	2,045,401	2,817	-7,411	-4,595	0
	17	0.184	0.184	24	20	188	0.098	156	0.0	3.68	3.00	2,040,806	2,730	-7,411	-4,681	0
	18	0.184	0.184	24	20	188	0.098	156	0.0	3.68	3.00	2,036,125	2,730	-7,411	-4,681	0
	19	0.183	0.183	24	20	187	0.098	156	0.0	3.68	3.00	2,031,444	2,644	-7,411	-4,768	0
	20	0.183	0.183	24	20	187	0.098	156	0.0	3.68	3.00	2,026,676	2,644	-7,411	-4,768	0
Feb.	21	0.183	0.183	24	0	207	0.000	0	0.0	3.68	3.00	2,021,909	17,885	-7,411	10,473	0
	22	0.182	0.182	24	0	206	0.000	0	0.0	3.68	3.00	2,032,382	17,798	-7,411	10,387	0
	23	0.182	0.182	24	0	206	0.000	0	0.0	3.68	3.00	2,042,769	17,798	-7,411	10,387	0
	24	0.182	0.182	24	0	206	0.000	0	0.0	3.68	3.00	2,053,156	17,798	-7,411	10,387	0
	25	0.257	0.195	24	0	219	0.000	0	3.0	3.68	3.00	2,063,543	18,956	-700	18,256	0
	26	0.181	0.181	24	0	205	0.000	0	0.0	3.68	3.00	2,081,799	17,712	-7,411	10,301	0
	27	0.181	0.181	24	0	205	0.000	0	0.0	3.68	3.00	2,092,100	17,712	-7,411	10,301	0
	28	0.180	0.180	24	0	204	0.000	0	0.0	3.68	3.00	2,102,400	17,626	-7,411	10,214	0
	29	0.180	0.180	24	0	204	0.000	0	0.0	3.68	3.00	2,112,614	17,626	-7,411	10,214	0
Mar.	1	0.180	0.180	8	2	186	0.009	14	0.0	5.62	3.00	2,122,828	14,844	-9,564	5,280	0
	2	0.179	0.179	8	2	185	0.009	14	0.0	5.62	3.00	2,128,108	14,757	-9,564	5,193	0
	3	0.179	0.179	8	2	185	0.009	14	0.0	5.62	3.00	2,133,301	14,757	-9,564	5,193	0
	4	0.178	0.178	8	2	184	0.009	14	0.0	5.62	3.00	2,138,494	14,671	-9,564	5,107	0
	5	0.178	0.178	8	2	184	0.009	14	0.0	5.62	3.00	2,143,601	14,671	-9,564	5,107	0
	6	0.177	0.177	8	2	183	0.009	14	0.0	5.62	3.00	2,148,708	14,584	-9,564	5,020	0
	7	0.176	0.176	8	2	182	0.009	14	0.0	5.62	3.00	2,153,729	14,498	-9,564	4,934	0
	8	0.176	0.176	8	2	182	0.009	14	0.0	5.62	3.00	2,158,663	14,498	-9,564	4,934	0
	9	0.175	0.175	8	2	181	0.009	14	0.0	5.62	3.00	2,163,597	14,412	-9,564	4,848	0
	10	0.175	0.175	8	2	181	0.009	14	0.0	5.62	3.00	2,168,444	14,412	-9,564	4,848	0

Table F.4.2 Pond-Storage Simulation in Standard Year 1983 (3/10)

Month	Day	Inflow & Upstream Demand River: Q (m3/sec)	Q.Expected (m3/sec)	Spring (lit/sec)	Upstream (lit/sec)	Ponds Inflow (lit/sec)	Unit D. W. Requirement (lit/sec/ha)	Diversion W. Requirement (lit/sec)	Rainfall (mm/day)	Evaporation (mm/day)	Percolation (mm/day)	Pond Storage (m3)	In or Outflow (m3)	Rain, EV & P (m3)	Deficit/ Surplus	Spill-out (m3)
Mar.	11	0.174	0.174	8	4	178	0.019	30	0.0	5.62	3.00	2,173,292	12,770	-9,564	3,206	0
	12	0.174	0.174	8	4	178	0.019	30	0.0	5.62	3.00	2,176,498	12,770	-9,564	3,206	0
	13	0.173	0.173	8	4	177	0.019	30	0.0	5.62	3.00	2,179,704	12,684	-9,564	3,120	0
	14	0.173	0.173	8	4	177	0.019	30	0.0	5.62	3.00	2,182,824	12,684	-9,564	3,120	0
	15	0.172	0.172	8	4	176	0.019	30	0.0	5.62	3.00	2,185,943	12,597	-9,564	3,033	0
	16	0.172	0.172	8	4	176	0.019	30	0.0	5.62	3.00	2,188,976	12,597	-9,564	3,033	0
	17	0.171	0.171	8	4	175	0.019	30	0.0	5.62	3.00	2,192,010	12,511	-9,564	2,947	0
	18	0.171	0.171	8	4	175	0.019	30	0.0	5.62	3.00	2,194,956	12,511	-9,564	2,947	0
	19	0.170	0.170	8	4	174	0.019	30	0.0	5.62	3.00	2,197,903	12,424	-9,564	2,860	0
	20	0.170	0.170	8	4	174	0.019	30	0.0	5.62	3.00	2,200,764	12,424	-9,564	2,860	0
Mar.	21	0.169	0.169	8	6	171	0.028	45	0.0	5.62	3.00	2,203,624	10,938	-9,564	1,374	0
	22	0.169	0.169	8	6	171	0.028	45	0.0	5.62	3.00	2,204,999	10,938	-9,564	1,374	0
	23	0.168	0.168	8	6	170	0.028	45	0.0	5.62	3.00	2,206,373	10,852	-9,564	1,288	0
	24	0.168	0.168	8	6	170	0.028	45	0.0	5.62	3.00	2,207,661	10,852	-9,564	1,288	0
	25	0.167	0.167	8	6	169	0.028	45	0.0	5.62	3.00	2,208,949	10,765	-9,564	1,202	0
	26	0.167	0.167	8	6	169	0.028	45	0.0	5.62	3.00	2,210,150	10,765	-9,564	1,202	0
	27	0.166	0.166	8	6	168	0.028	45	0.0	5.62	3.00	2,211,352	10,679	-9,564	1,115	0
	28	0.165	0.165	8	6	167	0.028	45	0.0	5.62	3.00	2,212,467	10,593	-9,564	1,029	0
	29	0.165	0.165	8	6	167	0.028	45	0.0	5.62	3.00	2,213,496	10,593	-9,564	1,029	0
	30	0.164	0.164	8	6	166	0.028	45	0.0	5.62	3.00	2,214,525	10,506	-9,564	942	0
	31	0.164	0.164	8	6	166	0.028	45	0.0	5.62	3.00	2,215,467	10,506	-9,564	942	0
		0.147														
Apr.	1	0.163	0.163	8	11	160	0.054	86	0.0	8.09	3.00	2,216,409	6,376	-12,304	-5,928	0
	2	0.163	0.163	8	11	160	0.054	86	0.0	8.09	3.00	2,210,481	6,376	-12,304	-5,928	0
	3	0.162	0.162	8	11	159	0.054	86	0.0	8.09	3.00	2,204,553	6,290	-12,304	-6,014	0
	4	0.161	0.161	8	11	158	0.054	86	0.0	8.09	3.00	2,198,539	6,204	-12,304	-6,101	0
	5	0.160	0.160	8	11	157	0.054	86	0.0	8.09	3.00	2,192,438	6,117	-12,304	-6,187	0
	6	0.160	0.160	8	11	157	0.054	86	0.0	8.09	3.00	2,186,251	6,117	-12,304	-6,187	0
	7	0.159	0.159	8	11	156	0.054	86	0.0	8.09	3.00	2,180,063	6,031	-12,304	-6,274	0
	8	0.158	0.158	8	11	155	0.054	86	0.0	8.09	3.00	2,173,790	5,944	-12,304	-6,360	0
	9	0.158	0.158	8	11	155	0.054	86	0.0	8.09	3.00	2,167,430	5,944	-12,304	-6,360	0
	10	0.157	0.157	8	11	154	0.054	86	0.0	8.09	3.00	2,161,070	5,858	-12,304	-6,446	0
Apr.	11	0.156	0.149	8	7	150	0.032	51	1.3	8.09	3.00	2,154,623	8,571	-12,304	-3,733	0
	12	0.156	0.156	8	7	157	0.032	51	0.0	8.09	3.00	2,150,890	9,193	-4,474	4,719	0
	13	0.156	0.149	8	7	150	0.032	51	3.5	8.09	3.00	2,155,609	8,571	-12,304	-3,733	0
	14	0.155	0.155	8	7	156	0.032	51	0.0	8.09	3.00	2,151,875	9,107	-12,304	-3,198	0
	15	0.154	0.154	8	7	155	0.032	51	0.0	8.09	3.00	2,148,677	9,020	-12,304	-3,284	0
	16	0.154	0.154	8	7	155	0.032	51	0.0	8.09	3.00	2,145,393	9,020	-12,304	-3,284	0
	17	0.153	0.153	8	7	154	0.032	51	0.0	8.09	3.00	2,142,109	8,934	-12,304	-3,371	0
	18	0.152	0.152	8	7	153	0.032	51	0.0	8.09	3.00	2,138,738	8,847	32,887	41,734	0
	19	0.993	0.316	8	7	318	0.032	51	20.2	8.09	3.00	2,180,473	23,034	-12,304	10,730	0
	20	0.480	0.480	8	7	481	0.032	51	0.0	8.09	3.00	2,191,203	37,187	-12,304	24,882	0

Table F.4.2 Pond-Storage Simulation in Standard Year 1983 (4/10)

Month	Day	Inflow & Upstream Demand River: Q (m3/sec)	Q.Expected (m3/sec)	Spring (lit/sec)	Upstream (lit/sec)	Ponds Inflow (lit/sec)	Unit D. W. Requirement (lit/sec/ha)	Diversion W. Requirement (lit/sec)	Rainfall (mm/day)	Evaporation (mm/day)	Percolation (mm/day)	Pond Storage (m3)	In or Outflow (m3)	Rain, EV & P (m3)	Deficit/ Surplus	Spill-out (m3)
Apr.	21	0.173	0.173	8	13	168	0.063	100	0.0	8.09	3.00	2,216,085	5,841	-12,304	-6,464	0
	22	0.152	0.152	8	13	147	0.063	100	0.0	8.09	3.00	2,209,621	4,026	-12,304	-8,278	0
	23	0.152	0.152	8	13	147	0.063	100	0.0	8.09	3.00	2,201,343	4,026	-12,304	-8,278	0
	24	0.151	0.151	8	13	146	0.063	100	0.0	8.09	3.00	2,193,065	3,940	-12,304	-8,365	0
	25	0.150	0.150	8	13	145	0.063	100	0.0	8.09	3.00	2,184,700	3,853	-12,304	-8,451	0
	26	0.150	0.150	8	13	145	0.063	100	0.0	8.09	3.00	2,176,250	3,853	-12,304	-8,451	0
	27	0.149	0.149	8	13	144	0.063	100	0.0	8.09	3.00	2,167,799	3,767	-12,304	-8,537	0
	28	0.148	0.148	8	13	143	0.063	100	0.0	8.09	3.00	2,159,261	3,681	-12,304	-8,624	0
	29	0.148	0.148	8	13	143	0.063	100	0.0	8.09	3.00	2,150,638	3,681	-12,304	-8,624	0
	30	0.147	0.147	8	13	142	0.063	100	0.0	8.09	3.00	2,142,014	3,594	-12,304	-8,710	0
May	1	0.146	0.140	8	14	133	0.068	108	1.1	8.78	3.00	2,133,304	2,177	-3,674	-1,496	0
	2	0.156	0.142	8	14	135	0.068	108	4.2	8.78	3.00	2,131,807	2,350	2,590	4,941	0
	3	0.303	0.200	8	14	194	0.068	108	7.0	8.78	3.00	2,136,748	7,396	-5,240	2,156	0
	4	0.215	0.153	8	14	147	0.068	108	3.5	8.78	3.00	2,138,904	3,370	-13,070	-9,700	0
	5	0.145	0.145	8	14	139	0.068	108	0.0	8.78	3.00	2,129,204	2,644	-13,070	-10,426	0
	6	0.144	0.144	8	14	138	0.068	108	0.0	8.78	3.00	2,118,778	2,557	-13,070	-10,512	0
	7	0.144	0.144	8	14	138	0.068	108	0.0	8.78	3.00	2,108,265	2,557	-13,070	-10,512	0
	8	0.143	0.143	8	14	137	0.068	108	0.0	8.78	3.00	2,097,753	2,471	-13,070	-10,599	0
	9	0.142	0.142	8	14	136	0.068	108	0.0	8.78	3.00	2,087,154	2,385	-13,070	-10,685	0
	10	0.141	0.141	8	14	135	0.068	108	0.0	8.78	3.00	2,076,469	2,298	-13,070	-10,772	0
May	11	0.141	0.141	8	4	145	0.017	27	0.0	8.78	3.00	2,065,697	10,230	41,741	51,971	0
	12	1.173	0.440	8	4	444	0.017	27	24.5	8.78	3.00	2,117,668	36,063	-13,070	22,993	0
	13	0.558	0.558	8	4	562	0.017	27	0.0	8.78	3.00	2,140,662	46,259	-13,070	33,189	0
	14	0.190	0.190	8	4	194	0.017	27	0.0	8.78	3.00	2,173,850	14,463	-13,070	1,393	0
	15	0.140	0.140	8	4	144	0.017	27	0.0	8.78	3.00	2,175,244	10,143	18,475	28,618	0
	16	0.649	0.240	8	4	245	0.017	27	14.1	8.78	3.00	2,203,862	18,801	49,572	68,372	0
	17	1.654	0.950	8	4	954	0.017	27	28.0	8.78	3.00	2,272,234	80,127	-13,070	67,057	0
	18	0.847	0.847	8	4	851	0.017	27	0.0	8.78	3.00	2,339,291	71,228	-13,070	58,158	0
	19	0.363	0.363	8	4	367	0.017	27	0.0	8.78	3.00	2,397,450	29,411	-13,070	16,341	0
	20	0.140	0.140	8	4	144	0.017	27	0.0	8.78	3.00	2,413,790	10,143	-13,070	-2,927	0
May	21	0.140	0.140	8	5	143	0.025	40	0.0	8.78	3.00	2,410,864	8,899	36,148	45,048	0
	22	1.047	0.350	8	5	353	0.025	40	22.0	8.78	3.00	2,455,911	27,043	-1,884	25,159	0
	23	0.735	0.450	8	5	453	0.025	40	5.0	8.78	3.00	2,481,071	35,683	-13,070	22,613	0
	24	0.296	0.296	8	5	299	0.025	40	0.0	8.78	3.00	2,503,684	22,378	-13,070	9,308	0
	25	0.141	0.141	8	5	144	0.025	40	0.0	8.78	3.00	2,512,992	8,986	-13,070	-4,084	0
	26	0.141	0.141	8	5	144	0.025	40	0.0	8.78	3.00	2,508,907	8,986	-13,070	-4,084	0
	27	0.141	0.141	8	5	144	0.025	40	0.0	8.78	3.00	2,504,823	8,986	-13,070	-4,084	0
	28	0.140	0.140	8	5	143	0.025	40	0.0	8.78	3.00	2,500,739	8,899	-13,070	-4,171	0
	29	0.140	0.140	8	5	143	0.025	40	0.0	8.78	3.00	2,496,568	8,899	-13,070	-4,171	0
	30	0.139	0.139	8	5	142	0.025	40	0.0	8.78	3.00	2,492,397	8,813	-13,070	-4,257	0
	31	0.138	0.138	8	5	141	0.025	40	0.0	8.78	3.00	2,488,140	8,726	-13,070	-4,344	0

Table F.4.2 Pond-Storage Simulation in Standard Year 1983 (5/10)

Month	Day	Inflow & Upstream Demand: River: Q (m3/sec)	Q.Expected (m3/sec)	Spring (lit/sec)	Upstream (lit/sec)	Ponds Inflow (lit/sec)	Unit D. W. Requirement (lit/sec/ha)	Diversion W. Requirement (lit/sec)	Rainfall (mm/day)	Evaporation (mm/day)	Percolation (mm/day)	Pond Storage (m3)	In or Outflow (m3)	Rain, EV & P (m3)	Deficit/ Surplus	Spill-out (m3)
Jun.	1	0.137	0.137	48	2	183	0.010	16	0.0	7.61	3.00	2,483,797	14,429	-11,772	2,657	0
	2	0.137	0.137	48	2	183	0.010	16	0.0	7.61	3.00	2,486,454	14,429	-9,535	4,894	0
	3	0.136	0.130	48	2	176	0.010	16	1.0	7.61	3.00	2,491,348	13,789	-11,772	2,018	0
	4	0.136	0.136	48	2	182	0.010	16	0.0	7.61	3.00	2,493,366	14,342	-11,772	2,571	0
	5	0.135	0.135	48	2	181	0.010	16	0.0	7.61	3.00	2,495,936	14,256	-11,772	2,484	0
	6	0.134	0.134	48	2	180	0.010	16	0.0	7.61	3.00	2,498,420	14,170	-11,772	2,398	0
	7	0.134	0.134	48	2	180	0.010	16	0.0	7.61	3.00	2,500,818	14,170	-7,297	6,872	0
	8	0.133	0.129	48	2	175	0.010	16	2.0	7.61	3.00	2,507,690	13,738	6,126	19,863	0
	9	0.364	0.175	48	2	221	0.010	16	8.0	7.61	3.00	2,527,554	17,729	-11,772	5,957	0
	10	0.133	0.133	48	2	179	0.010	16	0.0	7.61	3.00	2,533,511	14,083	-11,772	2,311	0
Jun.	11	1.175	0.450	48	104	394	0.496	789	24.1	7.61	3.00	2,535,823	-34,111	-11,772	-45,883	0
	12	0.587	0.587	48	104	531	0.496	789	0.0	7.61	3.00	2,489,940	-22,274	-11,772	-34,046	0
	13	0.234	0.234	48	104	178	0.496	789	0.0	7.61	3.00	2,455,895	-52,773	-11,772	-64,545	0
	14	0.133	0.133	48	104	77	0.496	789	0.0	7.61	3.00	2,391,350	-61,500	-7,074	-68,573	0
	15	0.133	0.129	48	104	73	0.496	789	2.1	7.61	3.00	2,322,776	-61,845	-11,772	-73,617	0
	16	0.132	0.132	48	104	76	0.496	789	0.0	7.61	3.00	2,249,160	-61,586	-11,772	-73,358	0
	17	0.132	0.132	48	104	76	0.496	789	0.0	7.61	3.00	2,175,802	-61,586	-11,772	-73,358	0
	18	0.131	0.131	48	104	75	0.496	789	0.0	7.61	3.00	2,102,444	-61,672	-11,772	-73,444	0
	19	0.131	0.131	48	120	59	0.496	789	0.0	7.61	3.00	2,029,000	-63,084	-11,772	-74,856	0
	20	0.130	0.130	48	120	58	0.496	789	0.0	7.61	3.00	1,954,144	-63,170	-11,772	-74,942	0
Jun.	21	0.129	0.129	48	209	0	1.001	1,593	0.0	7.61	3.00	1,879,202	-137,600	5,007	-132,593	0
	22	0.336	0.170	48	209	8	1.001	1,593	7.5	7.61	3.00	1,746,610	-136,875	9,034	-127,841	0
	23	0.550	0.415	48	309	154	1.001	1,593	9.3	7.61	3.00	1,618,769	-124,294	-7,521	-131,815	0
	24	0.306	0.215	48	258	5	1.001	1,593	1.9	7.61	3.00	1,486,954	-137,168	-11,772	-148,940	0
	25	0.129	0.129	48	209	0	1.001	1,593	0.0	7.61	3.00	1,338,014	-137,600	-6,179	-143,779	0
	26	0.129	0.128	48	209	0	1.001	1,593	2.5	7.61	3.00	1,194,235	-137,600	-1,704	-139,304	0
	27	0.184	0.139	48	209	0	1.001	1,593	4.5	7.61	3.00	1,054,931	-137,600	-4,836	-142,436	0
	28	0.147	0.132	48	209	0	1.001	1,593	3.1	7.61	3.00	912,495	-137,600	-11,772	-149,372	0
	29	0.128	0.128	48	209	0	1.001	1,593	0.0	7.61	3.00	763,123	-137,600	21,786	-115,814	0
	30	0.712	0.450	48	209	289	1.001	1,593	15.0	7.61	3.00	647,309	-112,648	-11,772	-124,420	0
		0.130														
Jul.	1	0.720	0.650	48	94	604	0.449	714	7.5	6.25	3.00	522,889	-9,521	32,468	22,946	0
	2	1.309	1.120	48	114	1,054	0.449	714	19.1	6.25	3.00	545,836	29,345	12,109	41,454	0
	3	1.204	1.050	48	114	984	0.449	714	10.0	6.25	3.00	587,290	23,297	116,139	139,436	0
	4	3.483	2.250	48	134	2,164	0.449	714	56.5	6.25	3.00	726,726	125,249	34,257	159,506	0
	5	3.007	2.015	48	114	1,949	0.449	714	19.9	6.25	3.00	886,232	106,673	-10,263	96,410	0
	6	1.720	1.720	48	94	1,674	0.449	714	0.0	6.25	3.00	982,642	82,927	-10,263	72,664	0
	7	0.948	0.948	48	94	902	0.449	714	0.0	6.25	3.00	1,055,306	16,226	-10,263	5,963	0
	8	0.485	0.485	48	94	439	0.449	714	0.0	6.25	3.00	1,061,269	-23,777	12,333	-11,444	0
	9	0.715	0.247	48	94	201	0.449	714	10.1	6.25	3.00	1,049,825	-44,340	-10,263	-54,603	0
	10	0.346	0.346	48	94	300	0.449	714	0.0	6.25	3.00	995,221	-35,787	-10,263	-46,050	0

Table F.4.2 Pond-Storage Simulation in Standard Year 1983 (6/10)

Month	Day	Inflow & Upstream Demand: River: Q (m3/sec)	Q.Expected (m3/sec)	Spring (lit/sec)	Upstream (lit/sec)	Ponds Inflow (lit/sec)	Unit D. W. Requirement (lit/sec/ha)	Diversion W. Requirement (lit/sec)	Rainfall (mm/day)	Evaporation (mm/day)	Percolation (mm/day)	Pond Storage (m3)	In or Outflow (m3)	Rain, EV & P (m3)	Deficit/ Surplus	Spill-out (m3)
Jul.	11	0.130	0.130	48	200	0	0.957	1,523	0.0	6.25	3.00	949,172	-131,552	-10,263	-141,814	0
	12	0.131	0.131	48	200	0	0.957	1,523	0.0	6.25	3.00	807,357	-131,552	-10,263	-141,814	0
	13	0.131	0.131	48	200	0	0.957	1,523	0.0	6.25	3.00	665,543	-131,552	-10,263	-141,814	0
	14	0.131	0.131	48	200	0	0.957	1,523	0.0	6.25	3.00	523,728	-131,552	-6,907	-138,459	0
	15	0.132	0.132	48	200	0	0.957	1,523	1.5	6.25	3.00	385,270	-131,552	107,638	-23,914	0
	16	2.649	1.150	48	200	998	0.957	1,523	52.7	6.25	3.00	361,356	-45,325	-10,263	-55,588	0
	17	1.507	1.507	48	200	1,355	0.957	1,523	0.0	6.25	3.00	305,768	-14,481	-10,263	-24,744	0
	18	0.822	0.822	48	200	670	0.957	1,523	0.0	6.25	3.00	281,024	-73,665	46,562	-27,103	0
	19	1.689	0.442	48	200	290	0.957	1,523	25.4	6.25	3.00	253,921	-106,514	-5,788	-112,302	0
	20	1.032	0.310	48	200	158	0.957	1,523	2.0	6.25	3.00	141,619	-117,867	-10,263	-128,130	0
Jul.	21	0.809	0.266	48	0	314	0.000	0	5.4	6.25	3.00	13,489	27,112	-9,815	17,297	0
	22	0.413	0.187	48	0	235	0.000	0	0.2	6.25	3.00	30,786	20,269	182,584	202,853	0
	23	5.523	2.152	48	0	2,200	0.000	0	86.2	6.25	3.00	233,639	190,112	42,311	232,424	0
	24	3.961	0.896	48	0	944	0.000	0	23.5	6.25	3.00	466,063	81,579	47,681	129,259	0
	25	3.924	0.889	48	0	937	0.000	0	25.9	6.25	3.00	595,323	80,940	87,055	167,995	0
	26	5.126	1.379	48	0	1,427	0.000	0	43.5	6.25	3.00	763,317	123,293	26,651	149,944	0
	27	4.604	1.025	48	0	1,073	0.000	0	16.5	6.25	3.00	913,261	92,690	-9,815	82,874	0
	28	2.952	0.694	48	0	742	0.000	0	0.2	6.25	3.00	996,136	64,143	17,031	81,174	0
	29	2.816	0.667	48	0	715	0.000	0	12.2	6.25	3.00	1,077,310	61,793	-2,433	59,361	0
	30	2.273	0.559	48	0	607	0.000	0	3.5	6.25	3.00	1,136,671	52,410	85,937	138,347	0
	31	3.963	1.088	48	0	1,136	0.000	0	43.0	6.25	3.00	1,275,018	98,172	-10,263	87,909	0
		0.384														
Aug.	1	25.828	4.400	48	0	4,448	0.000	0	149.0	6.05	3.00	1,362,927	380,160	-10,041	370,119	0
	2	6.619	4.400	48	0	4,448	0.000	0	0.0	6.05	3.00	1,733,046	380,160	248,356	628,516	0
	3	22.406	4.400	48	0	4,448	0.000	0	115.5	6.05	3.00	2,361,561	380,160	93,765	473,925	0
	4	14.027	3.795	48	0	3,843	0.000	0	46.4	6.05	3.00	2,835,486	332,014	2,264	334,277	89,764
	5	6.924	1.692	48	0	1,740	0.000	0	5.5	6.05	3.00	3,080,000	150,336	19,938	170,274	170,274
	6	5.469	1.401	48	0	1,449	0.000	0	13.4	6.05	3.00	3,080,000	125,194	-10,041	115,153	115,153
	7	3.467	3.467	48	0	3,515	0.000	0	0.0	6.05	3.00	3,080,000	303,696	-10,041	293,655	293,655
	8	2.728	2.728	48	0	2,776	0.000	0	0.0	6.05	3.00	3,080,000	239,846	12,778	252,625	252,625
	9	2.727	0.853	48	0	901	0.000	0	10.2	6.05	3.00	3,080,000	77,812	6,738	84,550	84,550
	10	2.522	0.812	48	0	860	0.000	0	7.5	6.05	3.00	3,080,000	74,269	-10,041	64,228	64,228
Aug.	11	4.888	1.510	48	124	1,434	0.594	945	56.6	6.05	3.00	3,080,000	42,232	1,145	43,377	43,377
	12	3.697	1.047	48	124	970	0.594	945	5.0	6.05	3.00	3,080,000	2,195	-10,041	-7,846	0
	13	2.689	2.689	48	124	2,613	0.594	945	0.0	6.05	3.00	3,072,154	144,098	-10,041	134,057	126,211
	14	2.027	2.027	48	124	1,951	0.594	945	0.0	6.05	3.00	3,080,000	86,901	4,725	91,626	91,626
	15	1.906	0.688	48	124	612	0.594	945	6.6	6.05	3.00	3,080,000	-28,754	-10,041	-38,795	0
	16	1.438	1.438	48	124	1,362	0.594	945	0.0	6.05	3.00	3,041,205	36,012	-10,041	25,971	0
	17	1.102	1.102	48	124	1,026	0.594	945	0.0	6.05	3.00	3,067,176	6,981	20,609	27,590	14,765
	18	1.534	0.614	48	124	538	0.594	945	13.7	6.05	3.00	3,080,000	-35,182	-10,041	-45,223	0
	19	1.054	1.054	48	124	978	0.594	945	0.0	6.05	3.00	3,034,777	2,834	-10,041	-7,207	0
	20	0.714	0.714	48	124	638	0.594	945	0.0	6.05	3.00	3,027,570	-26,542	-10,041	-36,583	0

Table F.4.2 Pond-Storage Simulation in Standard Year 1983 (7/10)

Month	Day	Inflow & Upstream Demand: River: Q (m3/sec)	Q.Expected (m3/sec)	Spring (lit/sec)	Upstream (lit/sec)	Ponds Inflow (lit/sec)	Unit D. W. Requirement (lit/sec/ha)	Diversion W. Requirement (lit/sec)	Rainfall (mm/day)	Evaporation (mm/day)	Percolation (mm/day)	Pond Storage (m3)	In or Outflow (m3)	Rain, EV & P (m3)	Deficit/ Surplus	Spill-out (m3)
Aug.	21	1.042	0.516	48	0	564	0.000	0	11.2	6.05	3.00	2,990,987	48,695	66,471	115,166	26,153
	22	2.417	0.892	48	0	940	0.000	0	34.2	6.05	3.00	3,080,000	81,238	-1,316	79,922	79,922
	23	1.719	0.651	48	0	699	0.000	0	3.9	6.05	3.00	3,080,000	60,394	16,358	76,752	76,752
	24	1.703	0.648	48	0	696	0.000	0	11.8	6.05	3.00	3,080,000	60,117	17,253	77,370	77,370
	25	1.720	0.651	48	0	699	0.000	0	12.2	6.05	3.00	3,080,000	60,411	921	61,332	61,332
	26	1.358	0.579	48	0	627	0.000	0	4.9	6.05	3.00	3,080,000	54,156	2,264	56,419	56,419
	27	1.161	0.539	48	0	587	0.000	0	5.5	6.05	3.00	3,080,000	50,751	921	51,673	51,673
	28	0.996	0.506	48	0	554	0.000	0	4.9	6.05	3.00	3,080,000	47,900	-10,041	37,859	37,859
	29	0.624	0.624	48	0	672	0.000	0	0.0	6.05	3.00	3,080,000	58,061	-10,041	48,020	48,020
	30	0.384	0.384	48	0	432	0.000	0	0.0	6.05	3.00	3,080,000	37,325	191,307	228,632	228,632
	31	5.876	2.444	48	0	2,492	0.000	0	90.0	6.05	3.00	3,080,000	215,266	-10,041	205,225	205,225
Sep.	1	2.948	2.948	48	0	2,996	0.000	0	0.0	5.29	3.00	3,080,000	258,854	229,959	488,813	488,813
	2	14.951	4.400	48	0	4,448	0.000	0	106.9	5.29	3.00	3,080,000	380,160	25,031	405,191	405,191
	3	5.338	1.717	48	0	1,765	0.000	0	15.3	5.29	3.00	3,080,000	152,513	-9,198	143,316	143,316
	4	3.498	3.498	48	0	3,546	0.000	0	0.0	5.29	3.00	3,080,000	306,374	221,234	527,608	527,608
	5	15.614	4.400	48	0	4,448	0.000	0	103.0	5.29	3.00	3,080,000	380,160	11,608	391,768	391,768
	6	6.187	1.887	48	0	1,935	0.000	0	9.3	5.29	3.00	3,080,000	167,184	19,886	187,070	187,070
	7	4.984	1.646	48	0	1,694	0.000	0	13.0	5.29	3.00	3,080,000	146,396	-4,052	142,344	142,344
	8	3.306	1.311	48	0	1,359	0.000	0	2.3	5.29	3.00	3,080,000	117,400	33,309	150,709	150,709
	9	3.530	1.356	48	0	1,404	0.000	0	19.0	5.29	3.00	3,080,000	121,271	219,444	340,715	340,715
	10	14.778	4.400	48	0	4,448	0.000	0	102.2	5.29	3.00	3,080,000	380,160	-9,198	370,962	370,962
Sep.	11	32.099	4.400	48	0	4,448	0.000	0	145.0	5.29	3.00	3,080,000	380,160	-4,052	376,108	376,108
	12	8.639	2.377	48	0	2,425	0.000	0	2.3	5.29	3.00	3,080,000	209,555	-9,198	200,357	200,357
	13	5.766	4.400	48	0	4,448	0.000	0	0.0	5.29	3.00	3,080,000	380,160	-2,934	377,226	377,226
	14	3.840	1.418	48	0	1,466	0.000	0	2.8	5.29	3.00	3,080,000	126,628	-9,198	117,430	117,430
	15	2.862	2.862	48	0	2,910	0.000	0	0.0	5.29	3.00	3,080,000	251,424	-9,198	242,226	242,226
	16	2.329	2.329	48	0	2,377	0.000	0	0.0	5.29	3.00	3,080,000	205,373	44,495	249,868	249,868
	17	3.165	1.283	48	0	1,331	0.000	0	24.0	5.29	3.00	3,080,000	114,964	44,048	159,011	159,011
	18	3.629	1.375	48	0	1,423	0.000	0	23.8	5.29	3.00	3,080,000	122,982	51,207	174,188	174,188
	19	4.064	1.462	48	0	1,510	0.000	0	27.0	5.29	3.00	3,080,000	130,499	5,120	135,619	135,619
	20	3.265	1.303	48	0	1,351	0.000	0	6.4	5.29	3.00	3,080,000	116,692	-9,198	107,494	107,494
Sep.	21	4.498	1.734	48	43	1,738	0.208	331	40.0	5.29	3.00	3,080,000	121,573	70,223	191,796	191,796
	22	5.053	1.872	48	43	1,877	0.208	331	35.5	5.29	3.00	3,080,000	133,561	-6,961	126,601	126,601
	23	3.647	1.379	48	43	1,384	0.208	331	1.0	5.29	3.00	3,080,000	90,945	-9,198	81,747	81,747
	24	2.718	2.718	48	43	2,723	0.208	331	0.0	5.29	3.00	3,080,000	206,634	-9,198	197,436	197,436
	25	2.106	2.106	48	43	2,111	0.208	331	0.0	5.29	3.00	3,080,000	153,757	-9,198	144,560	144,560
	26	1.674	1.674	48	43	1,679	0.208	331	0.0	5.29	3.00	3,080,000	116,433	-9,198	107,235	107,235
	27	1.344	1.344	48	43	1,349	0.208	331	0.0	5.29	3.00	3,080,000	87,921	-9,198	78,723	78,723
	28	1.166	1.166	48	43	1,171	0.208	331	0.0	5.29	3.00	3,080,000	72,541	-9,198	63,344	63,344
	29	0.991	0.991	48	43	996	0.208	331	0.0	5.29	3.00	3,080,000	57,421	-9,198	48,224	48,224
	30	0.812	0.812	48	43	817	0.208	331	0.0	5.29	3.00	3,080,000	41,956	-9,198	32,758	32,758

Table F.4.2 Pond-Storage Simulation in Standard Year 1983 (8/10)

Month	Day	Inflow & Upstream Demand River: Q (m3/sec)	Q.Expected (m3/sec)	Spring (lit/sec)	Upstream (lit/sec)	Ponds Inflow (lit/sec)	Unit D. W. Requirement (lit/sec/ha)	Diversion W. Requirement (lit/sec)	Rainfall (mm/day)	Evaporation (mm/day)	Percolation (mm/day)	Pond Storage (m3)	In or Outflow (m3)	Rain, EV & P (m3)	Deficit/ Surplus	Spill-out (m3)
Oct.	1	0.658	0.290	48	0	338	0.000	0	2.1	4.88	3.00	3,080,000	29,203	49,201	78,404	78,404
	2	1.758	0.510	48	0	558	0.000	0	25.9	4.88	3.00	3,080,000	48,211	-8,743	39,468	39,468
	3	1.097	1.097	48	0	1,145	0.000	0	0.0	4.88	3.00	3,080,000	98,928	-8,743	90,185	90,185
	4	0.674	0.674	48	0	722	0.000	0	0.0	4.88	3.00	3,080,000	62,381	-8,743	53,638	53,638
	5	0.392	0.392	48	0	440	0.000	0	0.0	4.88	3.00	3,080,000	38,016	-8,743	29,273	29,273
	6	0.247	0.247	48	0	295	0.000	0	0.0	4.88	3.00	3,080,000	25,488	-8,743	16,745	16,745
	7	0.198	0.198	48	0	246	0.000	0	0.0	4.88	3.00	3,080,000	21,254	214,753	236,008	236,008
	8	7.574	2.964	48	0	3,012	0.000	0	99.9	4.88	3.00	3,080,000	260,237	159,047	419,284	419,284
	9	12.745	4.400	48	0	4,448	0.000	0	75.0	4.86	3.00	3,080,000	380,160	18,327	398,487	398,487
	10	4.106	0.980	48	0	1,028	0.000	0	12.1	4.88	3.00	3,080,000	88,785	-8,743	80,042	80,042
Oct.	11	5.045	1.410	48	0	1,458	0.000	0	34.0	4.88	3.00	3,080,000	125,950	4,680	130,630	130,630
	12	3.768	0.912	48	0	960	0.000	0	6.0	4.88	3.00	3,080,000	82,944	-8,743	74,201	74,201
	13	2.598	2.598	48	0	2,646	0.000	0	0.0	4.88	3.00	3,080,000	228,614	-8,743	219,872	219,872
	14	2.004	2.004	48	0	2,052	0.000	0	0.0	4.88	3.00	3,080,000	177,293	-8,743	168,550	168,550
	15	1.601	1.601	48	0	1,649	0.000	0	0.0	4.88	3.00	3,080,000	142,474	-8,743	133,731	133,731
	16	1.303	1.303	48	0	1,351	0.000	0	0.0	4.88	3.00	3,080,000	116,726	-8,743	107,984	107,984
	17	1.106	1.106	48	0	1,154	0.000	0	0.0	4.88	3.00	3,080,000	99,706	-8,743	90,963	90,963
	18	0.970	0.970	48	0	1,018	0.000	0	0.0	4.88	3.00	3,080,000	87,955	-8,743	79,212	79,212
	19	0.820	0.820	48	0	868	0.000	0	0.0	4.88	3.00	3,080,000	74,995	-8,743	66,252	66,252
	20	0.666	0.666	48	0	714	0.000	0	0.0	4.88	3.00	3,080,000	61,690	-8,743	52,947	52,947
Oct.	21	0.515	0.515	48	0	563	0.000	0	0.0	4.88	3.00	3,080,000	48,643	-8,743	39,900	39,900
	22	0.371	0.371	48	0	419	0.000	0	0.0	4.88	3.00	3,030,000	36,202	-8,743	27,459	27,459
	23	0.216	0.216	48	0	264	0.000	0	0.0	4.88	3.00	3,080,000	22,810	-8,743	14,067	14,067
	24	0.208	0.208	48	0	256	0.000	0	0.0	4.88	3.00	3,080,000	22,118	-8,743	13,376	13,376
	25	0.208	0.208	48	0	256	0.000	0	0.0	4.88	3.00	3,080,000	22,118	-8,743	13,376	13,376
	26	0.208	0.208	48	0	256	0.000	0	0.0	4.88	3.00	3,080,000	22,118	-8,743	13,376	13,376
	27	0.208	0.208	48	0	256	0.000	0	0.0	4.88	3.00	3,080,000	22,118	-8,743	13,376	13,376
	28	0.208	0.208	48	0	256	0.000	0	0.0	4.88	3.00	3,080,000	22,118	-8,743	13,376	13,376
	29	0.209	0.209	48	0	257	0.000	0	0.0	4.88	3.00	3,080,000	22,205	-8,743	13,462	13,462
	30	0.209	0.209	48	0	257	0.000	0	0.0	4.88	3.00	3,080,000	22,205	-8,743	13,462	13,462
	31	0.209	0.209	48	0	257	0.000	0	0.0	4.88	3.00	3,080,000	22,205	-8,743	13,462	13,462
Nov.	1	0.209	0.209	24	16	217	0.075	119	0.0	3.81	3.00	3,080,000	8,467	-7,556	912	912
	2	0.208	0.208	24	16	216	0.075	119	0.0	3.81	3.00	3,080,000	8,381	-7,556	825	825
	3	0.208	0.208	24	16	216	0.075	119	0.0	3.81	3.00	3,080,000	8,381	-7,556	825	825
	4	0.208	0.208	24	16	216	0.075	119	0.0	3.81	3.00	3,080,000	8,381	-7,556	825	825
	5	0.208	0.208	24	16	216	0.075	119	0.0	3.81	3.00	3,080,000	8,381	-7,556	825	825
	6	0.208	0.208	24	16	216	0.075	119	0.0	3.81	3.00	3,080,000	8,381	-7,556	825	825
	7	0.207	0.207	24	16	215	0.075	119	0.0	3.81	3.00	3,080,000	8,294	-7,556	739	739
	8	0.207	0.207	24	16	215	0.075	119	0.0	3.81	3.00	3,080,000	8,294	-7,556	739	739
	9	0.207	0.207	24	16	215	0.075	119	0.0	3.81	3.00	3,080,000	8,294	-7,556	739	739
	10	0.206	0.206	24	16	214	0.075	119	0.0	3.81	3.00	3,080,000	8,206	-7,556	652	652

Table F.4.2 Pond-Storage Simulation in Standard Year 1983 (9/10)

Month	Day	Inflow & Upstream Demand: River: Q (m3/sec)	Q.Expected (m3/sec)	Spring (lit/sec)	Upstream (lit/sec)	Ponds Inflow (lit/sec)	Unit D. W. Requirement (lit/sec/ha)	Diversion W. Requirement (lit/sec)	Rainfall (mm/day)	Evaporation (mm/day)	Percolation (mm/day)	Pond Storage (m3)	In or Outflow (m3)	Rain, EV & P (m3)	Deficit/ Surplus	Spill-out (m3)
Nov.	11	0.206	0.206	24	40	190	0.189	301	0.0	3.81	3.00	3,080,000	-9,521	-7,556	-17,077	0
	12	0.205	0.205	24	40	189	0.189	301	0.0	3.81	3.00	3,062,923	-9,608	-7,556	-17,163	0
	13	0.205	0.205	24	40	189	0.189	301	0.0	3.81	3.00	3,045,760	-9,608	-7,556	-17,163	0
	14	0.205	0.205	24	40	189	0.189	301	0.0	3.81	3.00	3,028,596	-9,608	-7,556	-17,163	0
	15	0.204	0.204	24	40	188	0.189	301	0.0	3.81	3.00	3,011,433	-9,694	-7,556	-17,250	0
	16	0.204	0.204	24	40	188	0.189	301	0.0	3.81	3.00	2,994,183	-9,694	-7,556	-17,250	0
	17	0.204	0.204	24	40	188	0.189	301	0.0	3.81	3.00	2,976,933	-9,694	-7,556	-17,250	0
	18	0.203	0.203	24	40	187	0.189	301	0.0	3.81	3.00	2,959,684	-9,780	-7,556	-17,336	0
	19	0.203	0.203	24	40	187	0.189	301	0.0	3.81	3.00	2,942,347	-9,780	-7,556	-17,336	0
	20	0.202	0.202	24	40	186	0.189	301	0.0	3.81	3.00	2,925,011	-9,867	-7,556	-17,423	0
Nov.	21	0.202	0.202	24	53	173	0.255	406	0.0	3.81	3.00	2,907,589	-20,131	-7,556	-27,687	0
	22	0.202	0.202	24	53	173	0.255	406	0.0	3.81	3.00	2,879,902	-20,131	-7,556	-27,687	0
	23	0.201	0.201	24	53	172	0.255	406	0.0	3.81	3.00	2,852,215	-20,218	-7,556	-27,773	0
	24	0.201	0.201	24	53	172	0.255	406	0.0	3.81	3.00	2,824,442	-20,218	-7,556	-27,773	0
	25	0.201	0.201	24	53	172	0.255	406	0.0	3.81	3.00	2,796,668	-20,218	-7,556	-27,773	0
	26	0.200	0.200	24	53	171	0.255	406	0.0	3.81	3.00	2,768,895	-20,304	-7,556	-27,860	0
	27	0.200	0.200	24	53	171	0.255	406	0.0	3.81	3.00	2,741,035	-20,304	-7,556	-27,860	0
	28	0.199	0.199	24	53	170	0.255	406	0.0	3.81	3.00	2,713,176	-20,390	-7,556	-27,946	0
	29	0.199	0.199	24	53	170	0.255	406	0.0	3.81	3.00	2,685,229	-20,390	-7,556	-27,946	0
	30	0.199	0.199	24	53	170	0.255	406	0.0	3.81	3.00	2,657,283	-20,390	-7,556	-27,946	0
		0.192														
Dec.	1	0.198	0.198	24	46	176	0.218	347	0.0	2.72	3.00	2,629,337	-14,723	-6,346	-21,069	0
	2	0.198	0.198	24	46	176	0.218	347	0.0	2.72	3.00	2,608,268	-14,723	-6,346	-21,069	0
	3	0.198	0.198	24	46	176	0.218	347	0.0	2.72	3.00	2,587,200	-14,723	-6,346	-21,069	0
	4	0.198	0.198	24	46	176	0.218	347	0.0	2.72	3.00	2,566,131	-14,723	-6,346	-21,069	0
	5	0.197	0.197	24	46	175	0.218	347	0.0	2.72	3.00	2,545,062	-14,809	-6,346	-21,155	0
	6	0.197	0.197	24	46	175	0.218	347	0.0	2.72	3.00	2,523,906	-14,809	-6,346	-21,155	0
	7	0.197	0.197	24	46	175	0.218	347	0.0	2.72	3.00	2,502,751	-14,809	-6,346	-21,155	0
	8	0.196	0.196	24	46	174	0.218	347	0.0	2.72	3.00	2,481,596	-14,895	-6,346	-21,242	0
	9	0.196	0.196	24	46	174	0.218	347	0.0	2.72	3.00	2,460,354	-14,895	-6,346	-21,242	0
	10	0.196	0.196	24	46	174	0.218	347	0.0	2.72	3.00	2,439,112	-14,895	-6,346	-21,242	0
Dec.	11	0.196	0.196	24	54	166	0.256	407	0.0	2.72	3.00	2,417,871	-20,805	-6,346	-27,151	0
	12	0.195	0.195	24	54	165	0.256	407	0.0	2.72	3.00	2,390,719	-20,892	-6,346	-27,238	0
	13	0.195	0.195	24	54	165	0.256	407	0.0	2.72	3.00	2,363,481	-20,892	-6,346	-27,238	0
	14	0.195	0.195	24	54	165	0.256	407	0.0	2.72	3.00	2,336,244	-20,892	-6,346	-27,238	0
	15	0.194	0.194	24	54	164	0.256	407	0.0	2.72	3.00	2,309,006	-20,978	-6,346	-27,324	0
	16	0.194	0.194	24	54	164	0.256	407	0.0	2.72	3.00	2,281,681	-20,978	-6,346	-27,324	0
	17	0.194	0.194	24	54	164	0.256	407	0.0	2.72	3.00	2,254,357	-20,978	-6,346	-27,324	0
	18	0.194	0.194	24	54	164	0.256	407	0.0	2.72	3.00	2,227,033	-20,978	-6,346	-27,324	0
	19	0.193	0.193	24	54	163	0.256	407	0.0	2.72	3.00	2,199,709	-21,064	-6,346	-27,411	0
	20	0.193	0.193	24	54	163	0.256	407	0.0	2.72	3.00	2,172,298	-21,064	-6,346	-27,411	0

Table F.4.2 Pond-Storage Simulation in Standard Year 1983 (10/10)

Month	Day	Inflow & Upstream Demand River: Q (m3/sec)	Q.Expected (m3/sec)	Spring (lit/sec)	Upstream (lit/sec)	Ponds Inflow (lit/sec)	Unit D. W. Requirement (lit/sec/ha)	Diversion W. Requirement (lit/sec)	Rainfall (mm/day)	Evaporation (mm/day)	Percolation (mm/day)	Pond Storage (m3)	In or Outflow (m3)	Rain, EV & P (m3)	Deficit/ Surplus	Spill-out (m3)
Dec.	21	0.193	0.193	24	0	217	0.000	0	0.0	2.72	3.00	2,144,887	18,749	-6,346	12,402	0
	22	0.192	0.192	24	0	216	0.000	0	0.0	2.72	3.00	2,157,290	18,662	-6,346	12,316	0
	23	0.192	0.192	24	0	216	0.000	0	0.0	2.72	3.00	2,169,606	18,662	-6,346	12,316	0
	24	0.192	0.192	24	0	216	0.000	0	0.0	2.72	3.00	2,181,922	18,662	25,646	44,308	0
	25	0.861	0.326	24	0	350	0.000	0	14.3	2.72	3.00	2,226,230	30,223	135,716	165,939	0
	26	3.740	1.523	24	0	1,547	0.000	0	63.5	2.72	3.00	2,392,168	133,618	-6,346	127,271	0
	27	2.270	2.270	24	0	2,294	0.000	0	0.0	2.72	3.00	2,519,440	198,202	-6,346	191,855	0
	28	1.389	1.389	24	0	1,413	0.000	0	0.0	2.72	3.00	2,711,295	122,083	-6,346	115,737	0
	29	0.860	0.860	24	0	884	0.000	0	0.0	2.72	3.00	2,827,032	76,378	-6,346	70,031	0
	30	0.542	0.542	24	0	566	0.000	0	0.0	2.72	3.00	2,897,063	48,902	-6,346	42,556	0
	31	0.352	0.352	24	0	376	0.000	0	0.0	2.72	3.00	2,939,619	32,486	-6,346	26,140	0

FIGURES

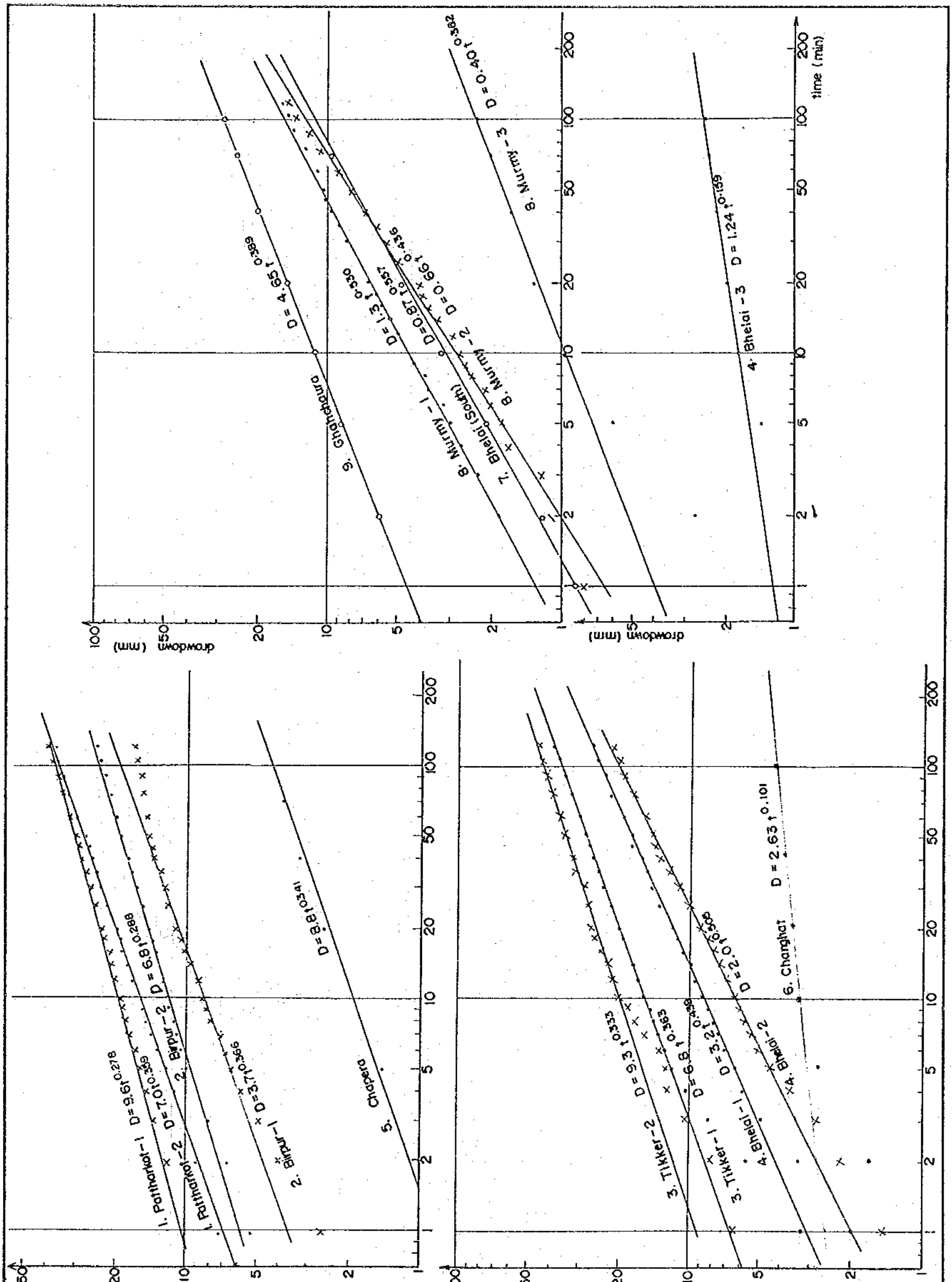


Fig.F.3.1 (a) Results of Cylinder Intake Rate Test

HIS MAJESTY'S GOVERNMENT OF NEPAL
FEASIBILITY STUDY ON THE RAJKUDWA IRRIGATION PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

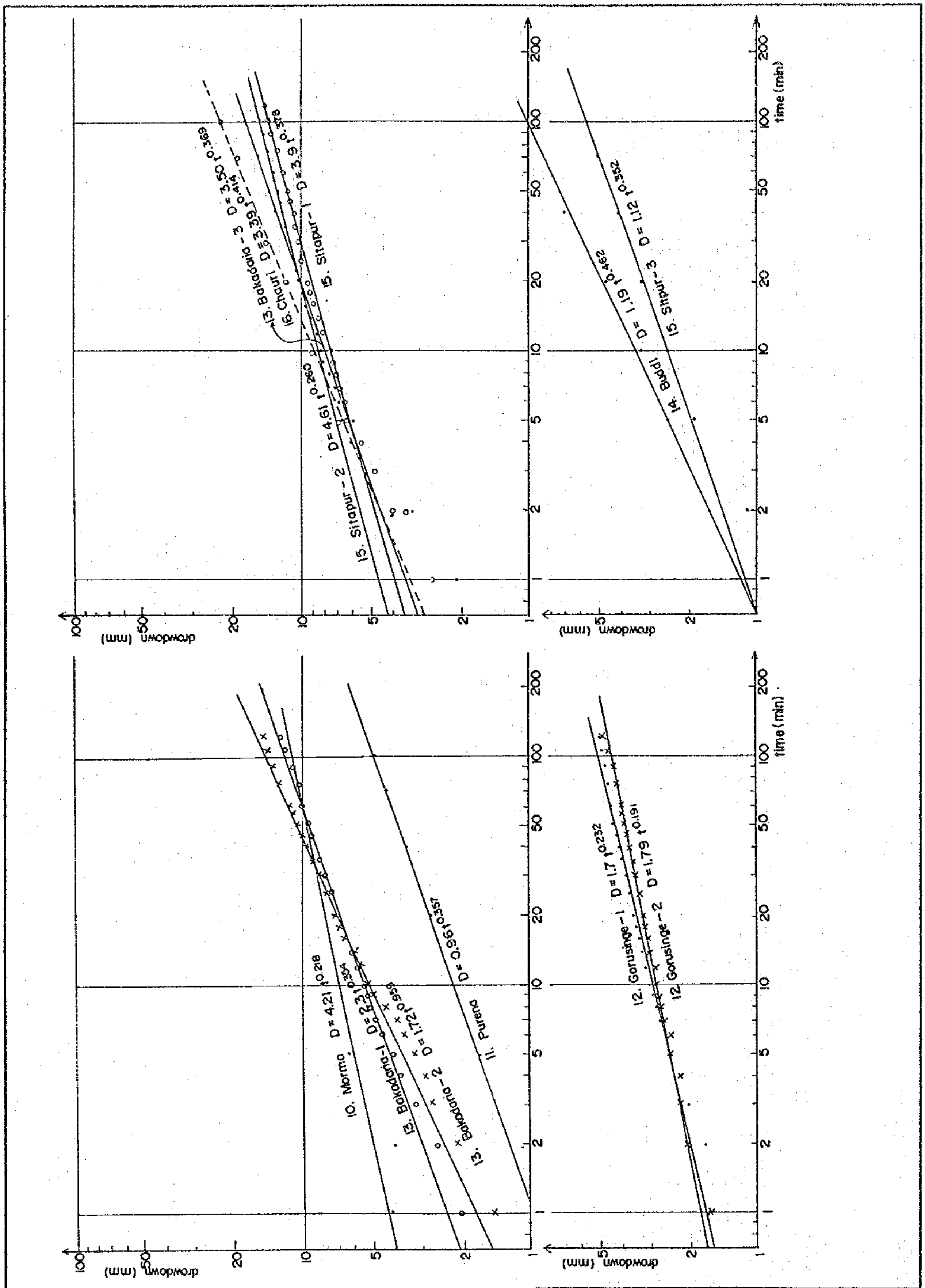


Fig.F.3.1 (b) Results of Cylinder Intake Rate Test

HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY ON THE RAJKUDWA IRRIGATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

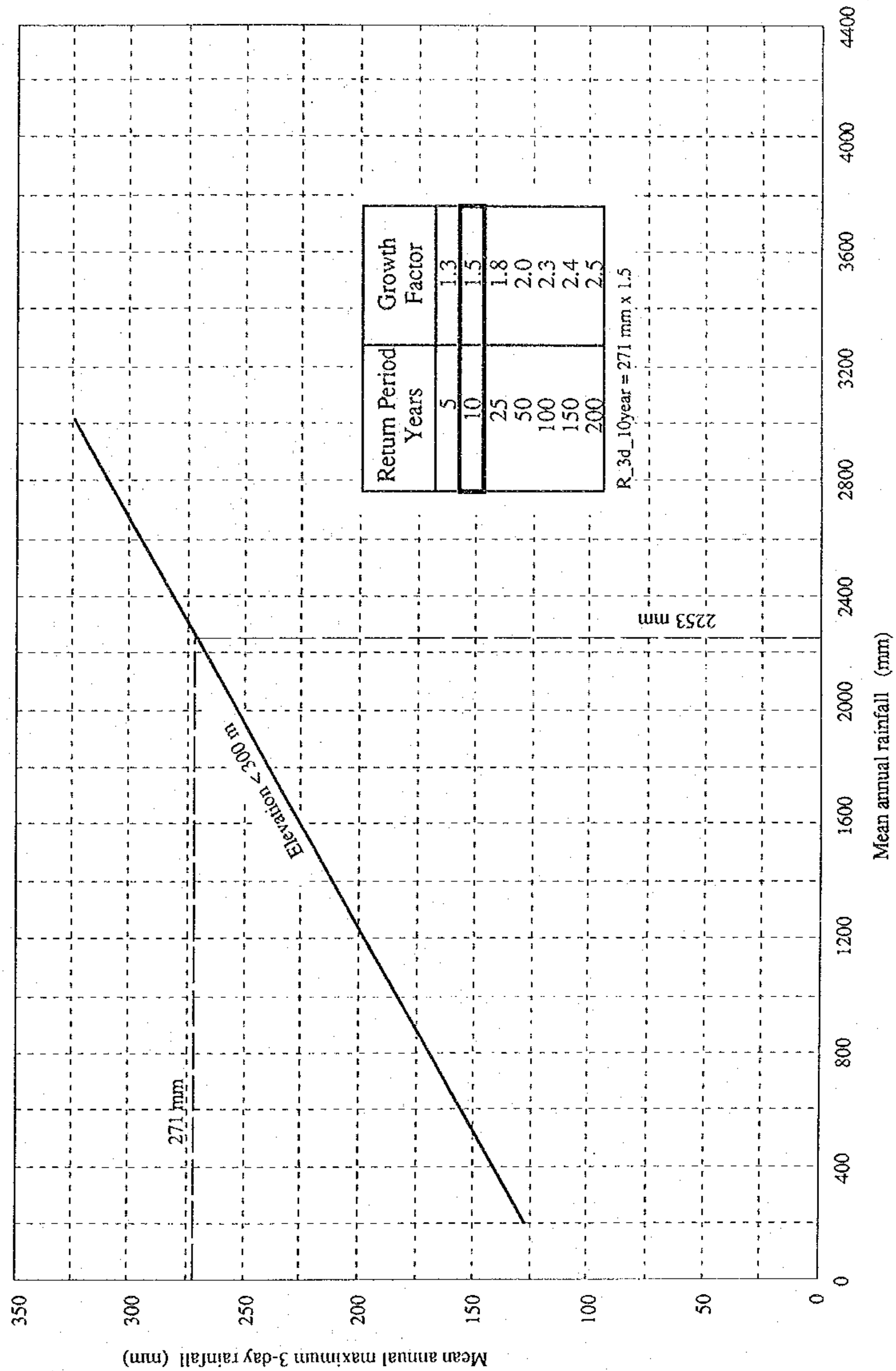


Fig. F.3.2 Maximum 3 day Rainfall of 1 in 10 years

HIS MAJESTY'S GOVERNMENT OF NEPAL

FEASIBILITY STUDY ON THE RAJKUDWA IRRIGATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

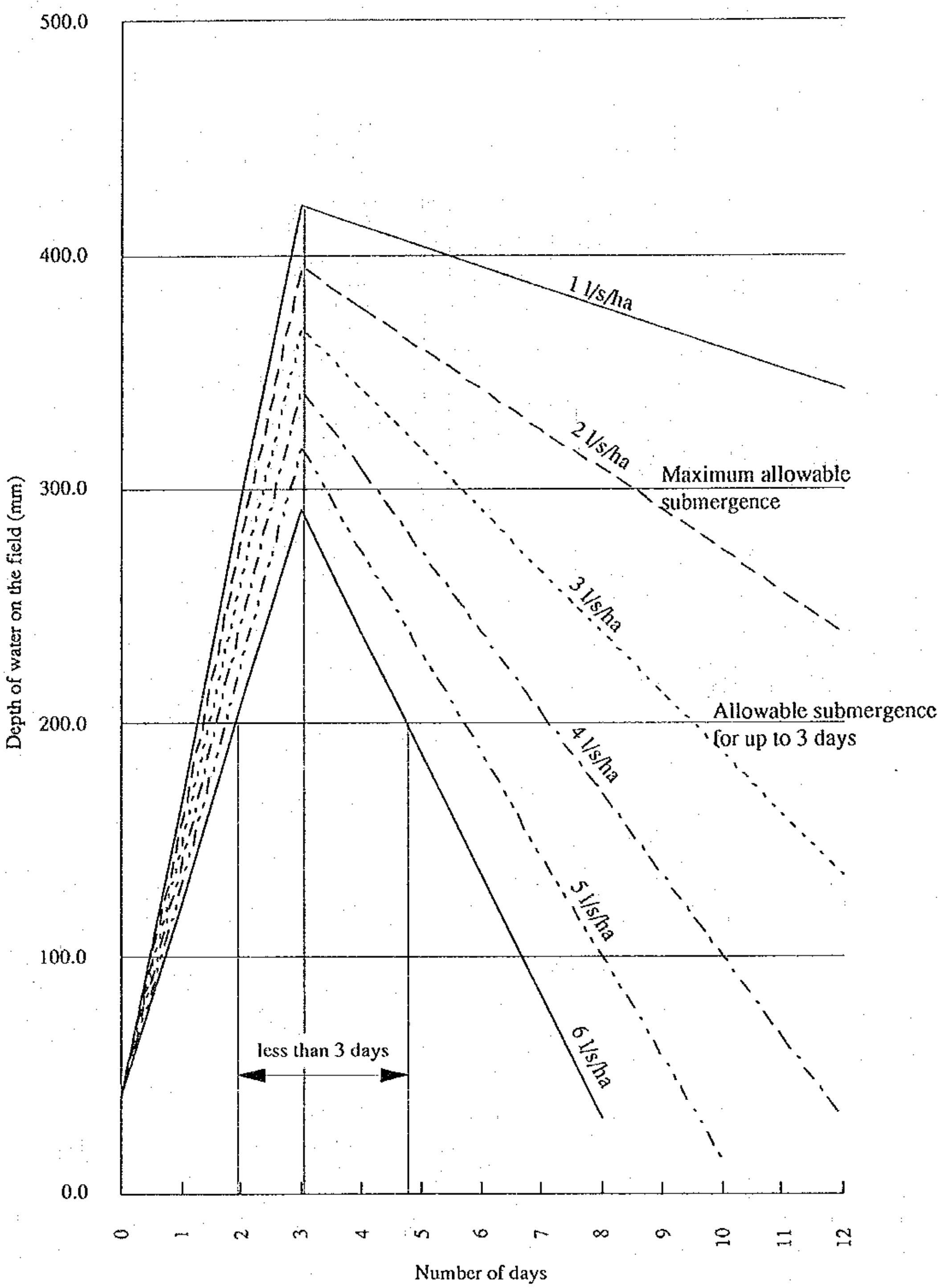


Fig. F.3.3 Submergence of Bunded Fields

HIS MAJESTY'S GOVERNMENT OF NEPAL
FEASIBILITY STUDY ON THE RAJKUDWA IRRIGATION PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.F.4.1 Runoff and Intake Discharge at the Gudrung Headworks (1/3)

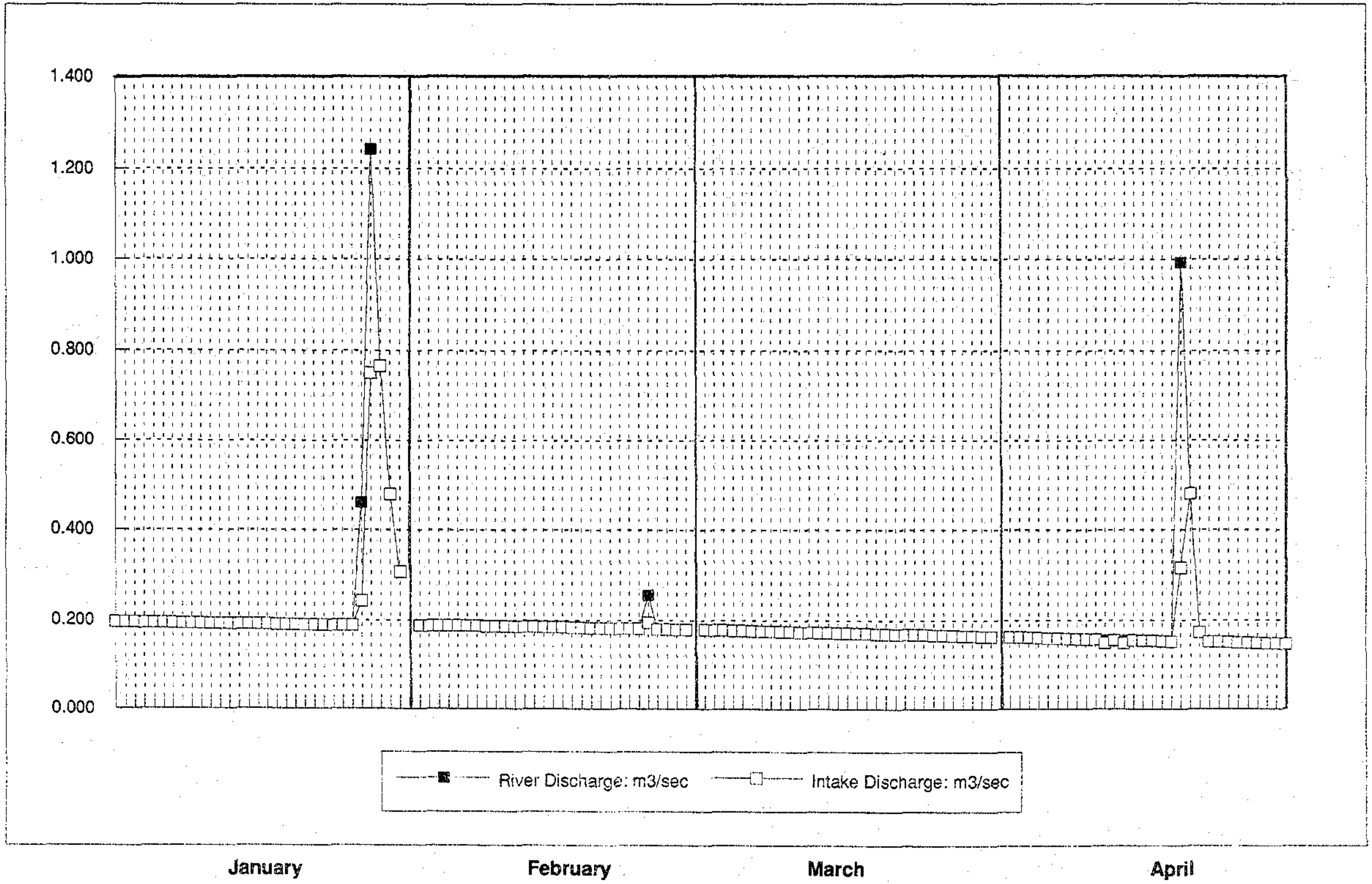


Fig.F.4.1 Runoff and Intake Discharge at the Gudrung Headworks (2/3)

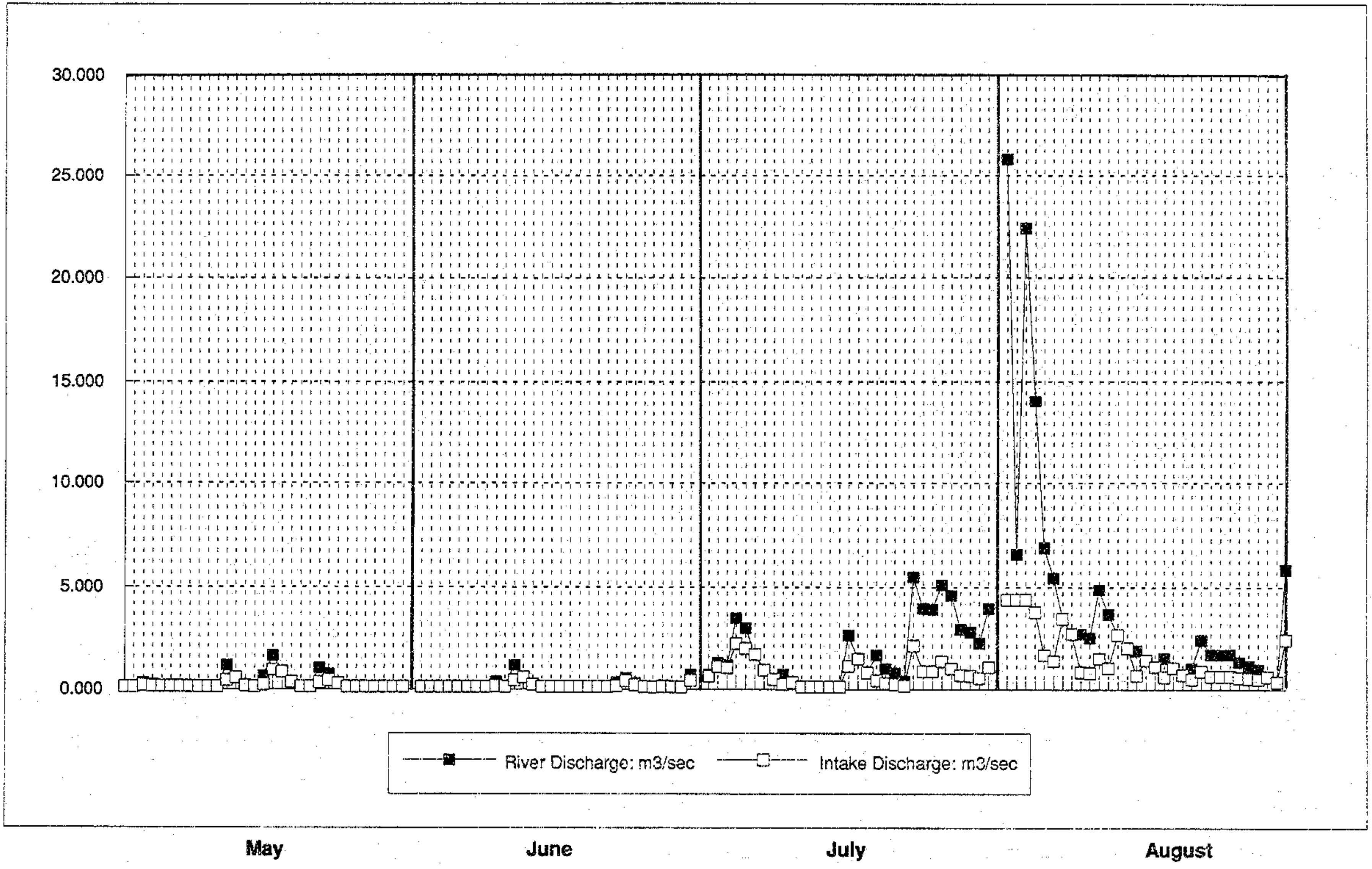


Fig.F.4.1 Runoff and Intake Discharge at the Gudrung Headworks (3/3)

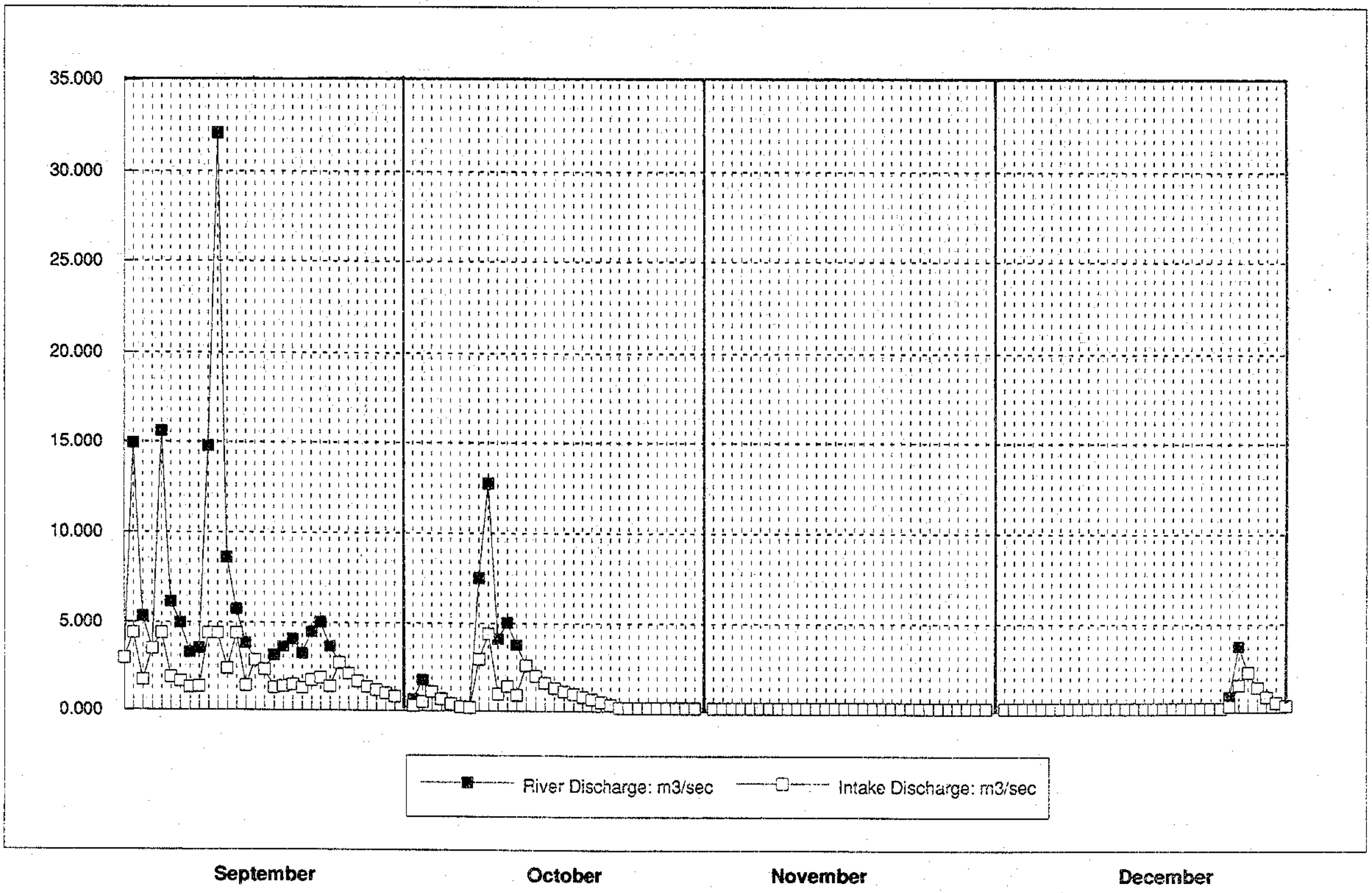


Fig. F.4.2 Pond Storage Fluctuation & Spill-out Water (1/3)

1983

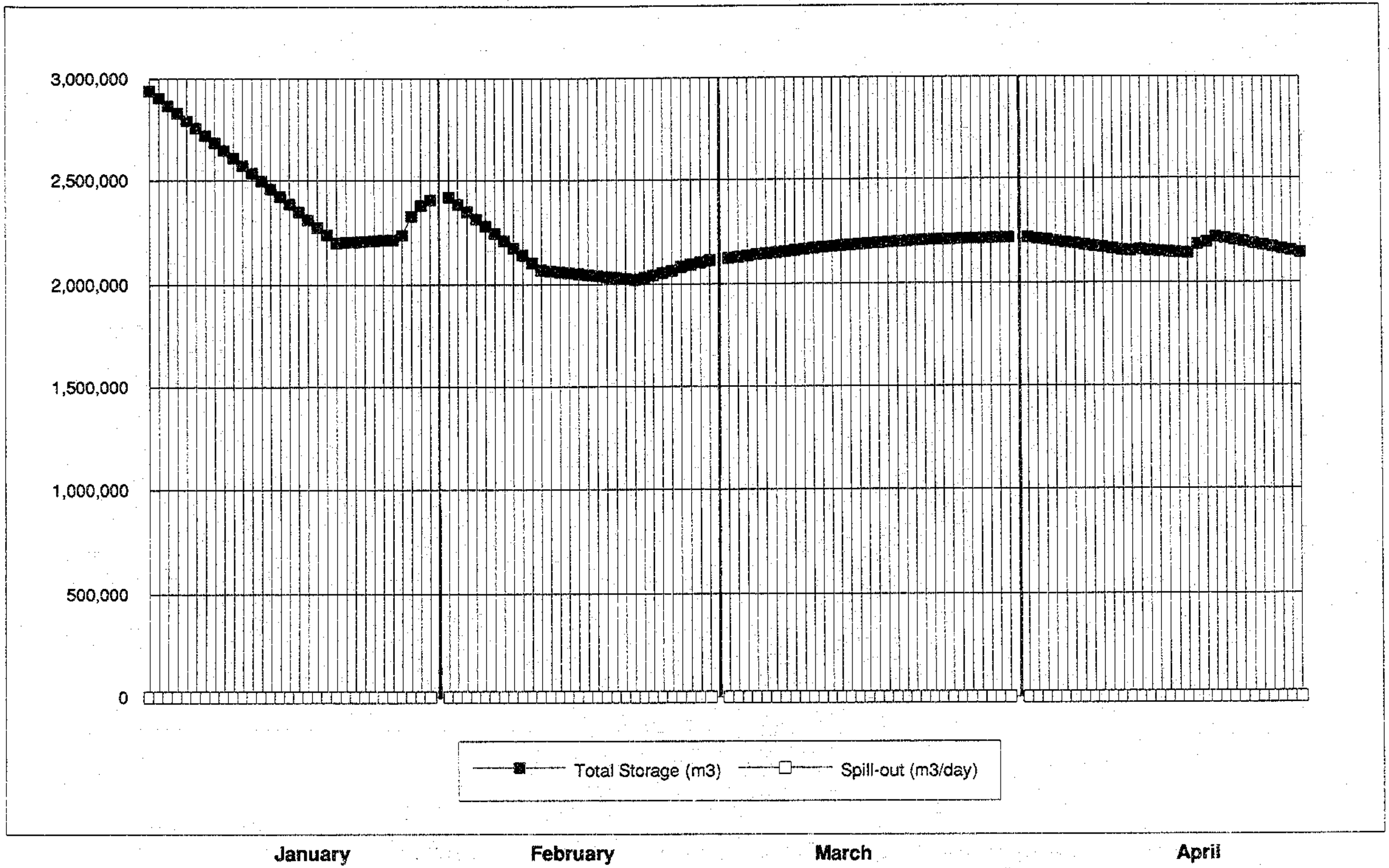


Fig. F.4.2 Pond Storage Fluctuation & Spill-out Water (2/3)

1983

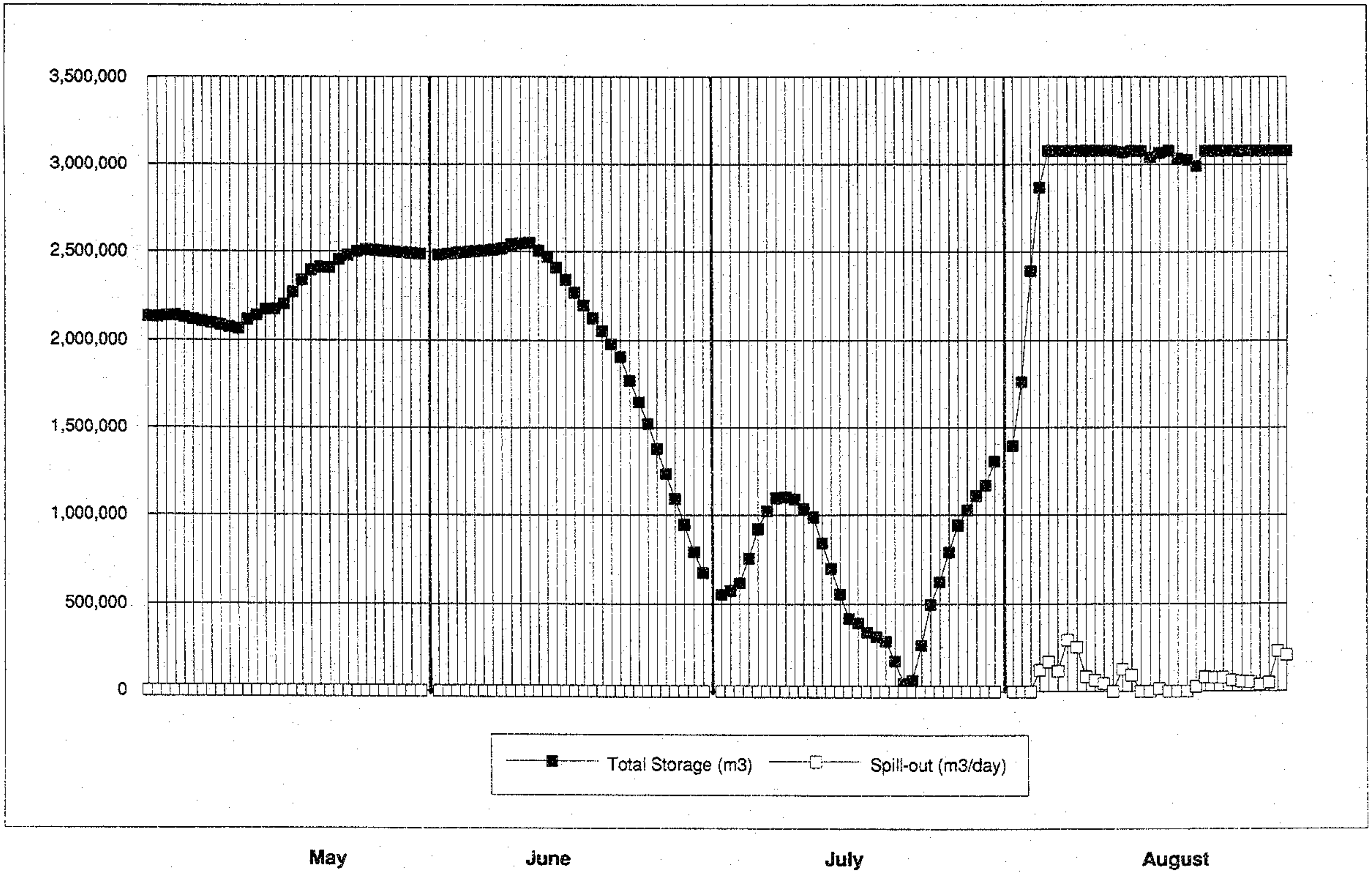
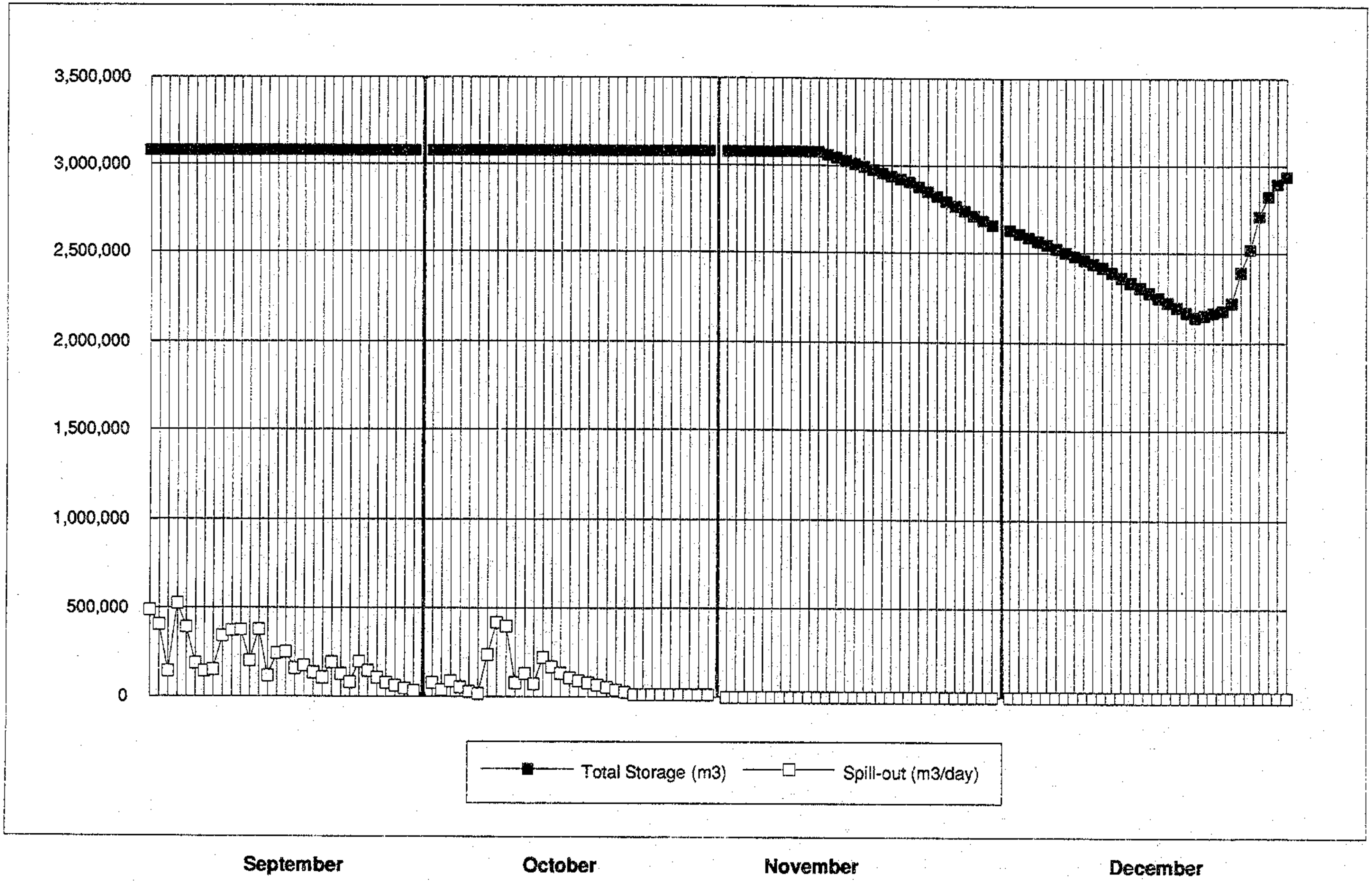
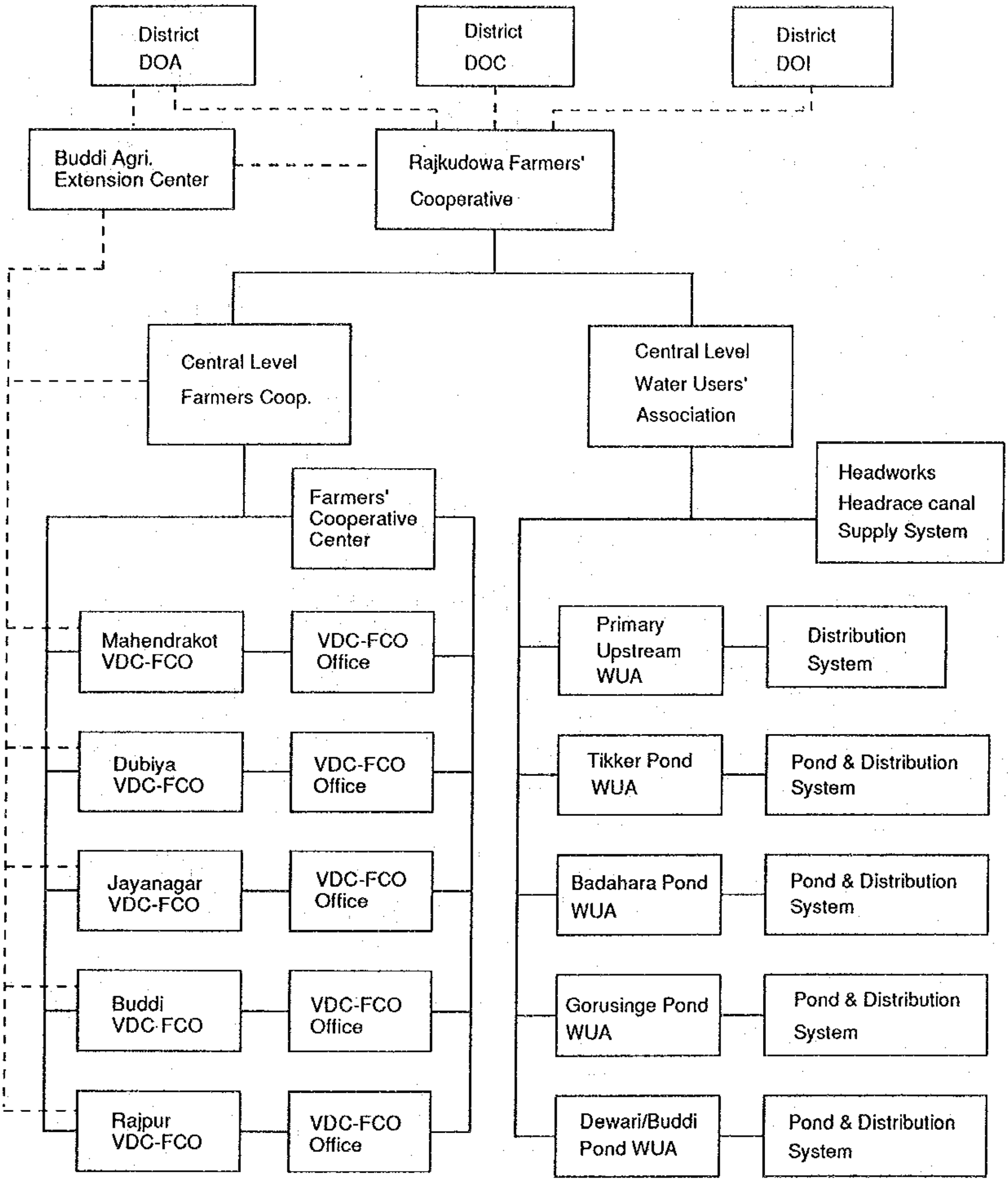


Fig. F.4.2 Pond Storage Fluctuation & Spill-out Water (3/3)

1983

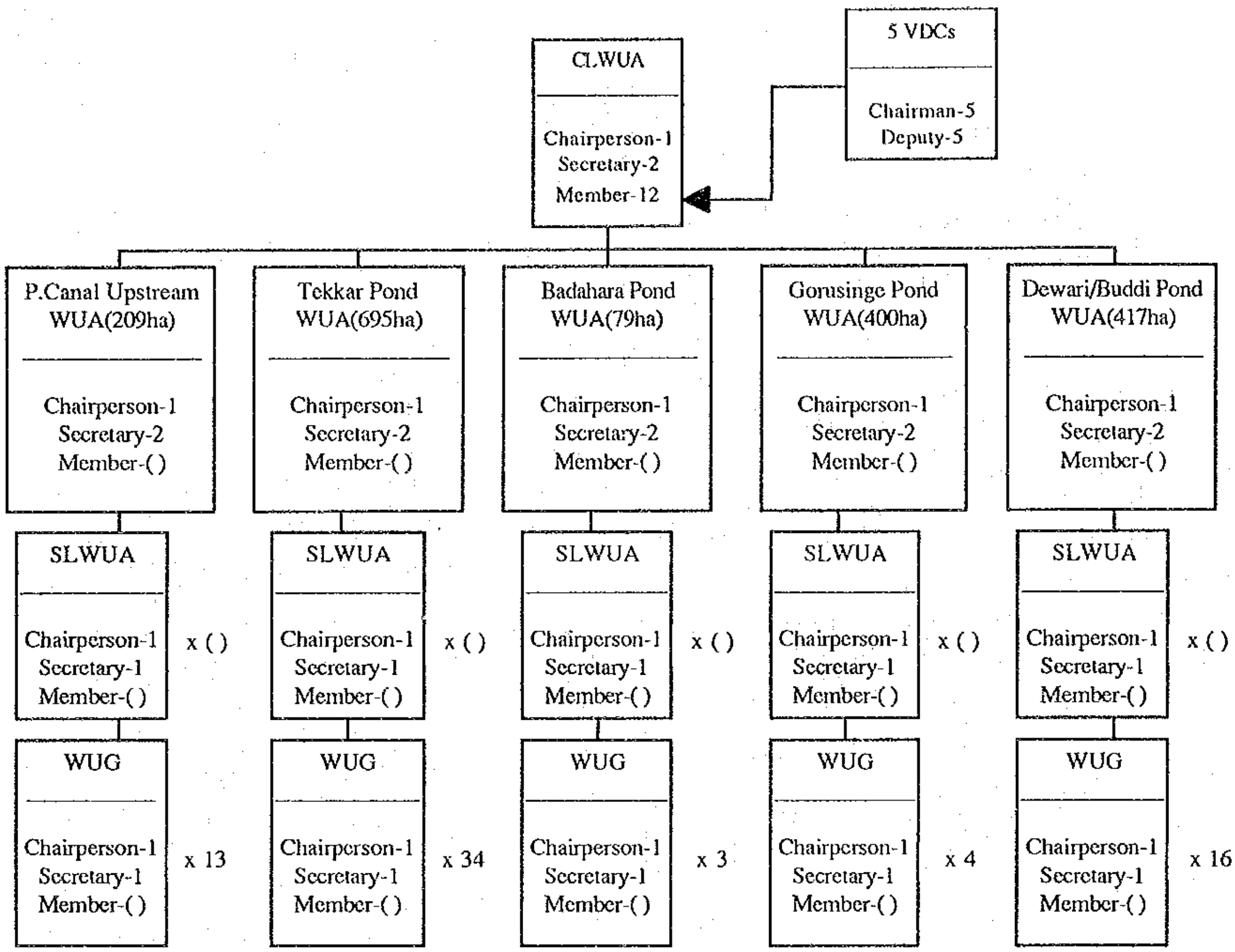




Note:

Organization of lower level WUAs and WUGs is shown in Fig. F.5.2.

Fig. F.5.1 Proposed O&M Organization



<u>Oblidgation and Responsibility of Each WUA and WUG</u>

1,The CLWUA will be responsible for the overall water management and O&M of the entire system including five irrigation ponds, but they will be espscially responsible for the O&M of headworks, headrace canal, and primary and secondary feeder canals. Decisions regarding canal discharges, pond operation, rotation mode and rotation shedule also come under the responsibility of CLWUA. The regulation of the proposed WUA, including penalty clauses to violators will be established by the CLWUA.

2, The PUWUA or PWUA takes responsibility in the water management and O&M of the concerned pond and its main canal.

3,The SLWUA is responsible for the water management and O&M of the concerned secondary canal and equitable distribution of water among the tertiary canals. Supervision to prevent stealing of irrigation water also comes under its responsibility.

4,The WUG is responsible for the water management and O&M of the concerned tertiary, quarternary and field channels. It is also responsible for the equitable water distribution among quarternaries and prevention from stealing of water.

5,The CLWUA will employ required number of gatemen for the O&M of intake gate, spillway gate and sandflush gate in the headworks, cross regulator gates at primary canal, the turnout gates at secondary canals and offtake gates at irrigation ponds.The required cost including salary of the employees and the repair and maintenance cost of gates and others will be collected from all the beneficiary farmers under the proposed system in propotion to their irrigated area.

6, Routine O&M of primary and secondary feeder canals, irrigation ponds, main secondary and tertiary canals such as clearing weeds , desilting , maintaining pond levees and canal sections, etc. will be timely carried out by labor contribution as decided by the CLWUA, the concerned PUWUA, PWUA, SLWUA and WUG, respectively.

7,O&M of drainage system will also have to be carried out by the concerned water users' organization at respective level as in the irrigation system. That is, O&M of primary, secondary and tertiary drains will be carried out by the CLWUA, the concerned PUWUA, PWUA, SLWUA and WUG.

Fig.F.5.2 Proposed Organization of Water Users' Association

ANNEX - G

PLANNING, DESIGN AND COST ESTIMATE OF CIVIL WORKS

ANNEX - G

PLANNING, DESIGN AND COST ESTIMATE OF CIVIL WORKS.

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CHAPTER G1 PRELIMINARY DESIGN OF IRRIGATION AND DRAINAGE FACILITIES

G.1.1 Planning and Design Concept

In the course of the Study, basic planning/design concepts have been formulated for preliminary design of the proposed project facilities. The formulated concepts are summarized as follows :

i) Design of the project facilities will be made, in principal, on the basis of "Design Manuals for Irrigation Projects in Nepal" prepared under Planning and Design Strengthening Project, 1990.

ii) Irrigation canals will be designed at the peak water requirement, 1.2 lit/sec/ha of 80 % dependability, but headrace and upstream stretch of the primary canal up to the Tikkar Pond will be designed by applying 2 times of the peak water requirement, 2.4 lit/sec/ha to cope with limited flood peak term.

iii) Drainage canals will be designed at the requirements of 6.0 lit/sec/ha for paddy field area and 9.0 lit/sec/ha for non-paddy field area which had been estimated from the rainfall of 1/10-year return period.

iv) Drainage structures will be designed at 1.5 times of the above drainage requirements which are 9.0 lit/sec/ha for paddy field area and 13.5 lit/sec/ha for non-paddy field area .

v) In order to mitigate farmers' burden in land acquisition, existing canal routes will be incorporated as long as possible.

vi) Intake weir will be a torrent intake type from view-points of river morphology at the proposed site. Among the torrent intakes, Tyrolean type is suitable due to boulders flowing down during floods.

vii) Sediment trap will be attached at the intake and the end of the headrace, and a closed conduit will be applied to the headrace in order to reduce damages by rolling stones from surface erosion of steep hillside slope.

viii) Existing four ponds close to the proposed primary feeder canal will be incorporated into the proposed system by heightening and extending existing levees.

xi) Irrigation canals will be a trapezoidal earth canal and their design velocity will be less than 0.6 m/sec in principal. Concrete flume or canal lining, however, will be applied in steep stretches to protect the canals from scouring/erosion as well as in densely populated area such as Patthorkot to reduce farmers' burden in land acquisition.

x) Drainage canals will be a trapezoidal earth canals and their design velocity will be, in principal, less than 1.0 m/sec in due consideration of frequency of use (1/10-year flood).

xi) On-off operation will be conducted in secondary and tertiary canals so that check gates will not be provided on the canals.

xii) Canal structure will be of concrete type, taking less maintenance cost and longer useful life into consideration.

xiii) The service roads will not be attached to the proposed irrigation canals, since sufficient farm roads are networked in the Project area. Major village roads and farm roads, however, will be improved by gravel metalling.

xiv) Adjustable Proportional Module(APM) turnout will be designed at the heads of respective tertiary canals.

G.1.2 Proposed Gudrung System

G.1.2.1 Headworks

The proposed site is located at a gorge and the top of the fun formed by the Gudrung river. The proposed Gudrung headworks will a torrent intake type consisting of a Tyrolean type diversion weir, a sand excluder and intake gates in order to avoid damages caused by large rolling boulders during floods. The diversion weir will be a concrete structure with iron bar screen on the crest portion and water will be taken into the headrace through spaces between bars on the screen. A sand excluder with a sand flash gate will be provided between the diversion weir and the headrace. Right bank abutment of the weir will be protected by wet masonry covering and left bank abutment by concrete retaining wall.

A flood of 500 m3/sec has been applied to the design flood at the proposed site which probability is 1/50-year flood. The water intake capacity of the weir will be 4.4 m3/sec and excess water over the intake capacity will be spilt out from a spillway attached to the sand trap.

Detailed features of the diversion weir are given in Annex-I and summarized as follows:

Gudrung Headworks

Description		Features
Design Flood (50-year return period)		500 m^3/sec
Design Flood Water Level (Upstream)		EL 202.0 m
Design Flood Water Level (Downstream)		EL 200.5 m
Water Intake Capacity		4.4 m^3/sec
Diversion Weir :	Length	40.0 m
"	Height (Crest - River bed)	1.5 m
"	Crest EL	EL 199.0 m
"	Bar-screen, Width	30.0 m
"	" , Bar Length	1.9 m
Intake Gates :	Steel Slide Gate 1.7 m x 1.7 m	2 sets
"	Gate Sill EL	197.1 m

G.1.2.2 Headrace

The proposed headrace will start from the outlet of the intake gates attached to the sand excluder and its total length is 450 m. The headrace consists of a closed concrete conduit and a sand excluder. The closed conduit has single box section and its length is 420 m. Manholes will be installed on the conduit with an interval of 50 m for unexpected desilting works. The sand excluder will be provided at the end of the headrace for sediment exclusion in the headrace and a spillway & a wasteway will be attached to the sand excluder. Design discharge of the headrace is 4.4 m3/sec.

General features of the proposed headrace are given in Table G.1.1 and are summarized in the following table :

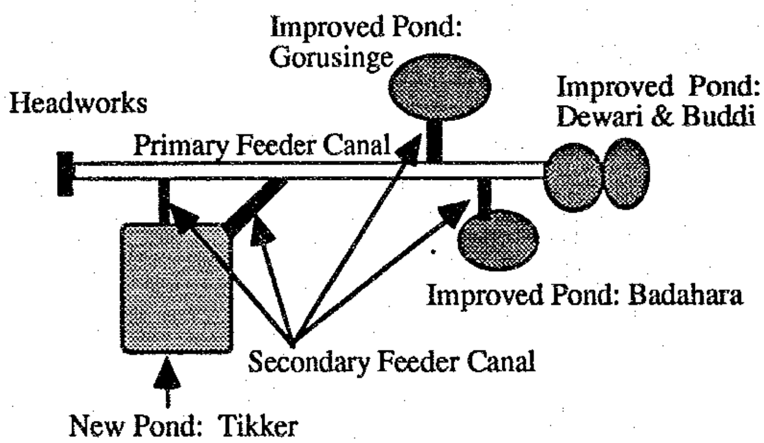
Headrace

Description	Features
Design Discharge	4.4 m^3/sec
Design Velocity	1.6 m/sec
Design Water Depth	1.1 m
Conduit Size : Width	2.50 m
" : Height	1.50 m

G.1.2.3 Supply System

Supply system consists of Primary Feeder Canal and Secondary Feeder Canals. Primary feeder canal, in principal, is a canal to supply intaken water to respective irrigation ponds through secondary feeder canals. Secondary feeder canals convey water from primary feeder canal to the irrigation ponds. The proposed supply system is illustrated below and the general features are summarized below, and the details are given in Table G.1.1, Fig.G.1.1 and Fig.G.1.4.

Proposed Supply System



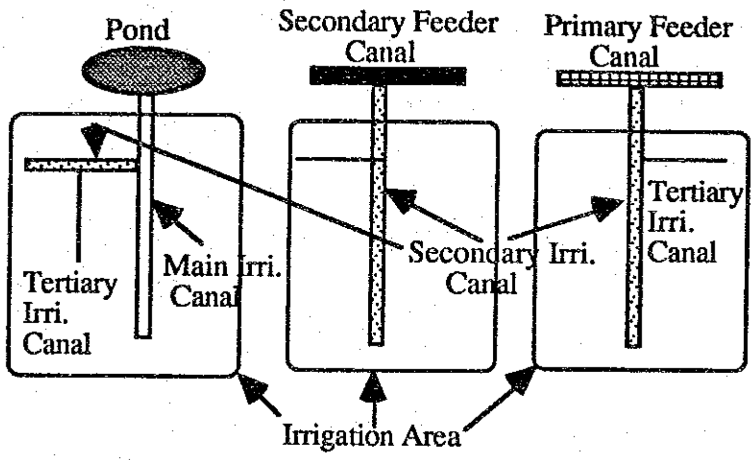
Supply System

Description		Features
Primary Feeder Canal: Upstream	Type	Concrete Flume Canal
	Length	5.3 km
	Max. Design Discharge	4.4 m^3/sec
: Downstream	Type	Trapezoidal Earth Canal
	Length	10.2 km
	Max. Design Discharge	1.7 m^3/sec
Secondary Feeder Canal	Type	Concrete Flume or Trapezoidal Earth Canal
	Number	4 nos
	Total Length	5.3 km
	Design Discharge	1.9 - 0.1 m^3/sec

G.1.2.4 Irrigation System

Irrigation system consists of main irrigation canals, secondary irrigation canals and tertiary irrigation canals. Main irrigation canal starts from a irrigation pond, and secondary irrigation canals start from the main irrigation canal, the primary feeder canal or the secondary feeder canal. Tertiary canals start from secondary canals. Typical irrigation systems are illustrated as follows :

Proposed Irrigation System



In the project area three types of irrigation distribution systems have been proposed as given above. The general features of the irrigation system are given in Table G.1.1, Fig G.1.1 & Fig.G.1.4 and summarized below :

Irrigation System

Description		Features
Main Irrigation Canal	Type	Trapezoidal Earth Canal
	Number	3 nos
	Total Length	4.5 km
	Design Discharge	0.5 - 0.1 m^3/sec
Secondary Irrigation Canal	Type	Trapezoidal Earth Canal
	Number	25 nos
	Total Length	26.8 km
	Design Discharge	0.23 - 0.02 m^3/sec
Tertiary Irrigation Canal	Type	Trapezoidal Earth Canal
	Number	64 nos
	Total Length	57.0 km
	Design Discharge	0.05 - 0.02 m^3/sec

G.1.2.5 Irrigation Structure in Supply & Irrigation Systems

Various canal related structures will be required in the proposed systems. General features of the major related structures are given in Table G.1.2 and summarized below :

Turnout: Three types of turnouts will be applied for the Project which are bifurcation, gated turnout and Adjustable Proportional Module (APM) turnout. The bifurcation will be constructed at diversion point between the primary feeder canal and the secondary feeder canal to Gorusinge Pond. Gated turnout will be provided at the head of respective secondary irrigation canals and secondary feeder canals to the Tikker or Badahara Pond, and APM turnouts will be installed at the head of respective tertiary irrigation canals.

Cross Regulator: Cross regulators will be provided just downstream of respective gated turnouts on the feeder or main irrigation canal in order to keep designed water levels for diversion.

Culvert: Culverts will be provided where farm or village roads cross canals. Two types of culverts will be applied which are a pipe culvert and a box culvert. Pipe culvert will be provided on tertiary canals and box culvert will be on larger canals.

Drop Structure: Drop structure will be provided where ground slope is steep. In addition to the drop structure, a stilling basin will be provided at a transition point between supercrtitical & subcritical flow in canal in order to dissipate flow energy.

Cross Drain: Cross drain will be provided where an irrigation canal crosses a natural drain/stream or a drainage canal. Concrete box type will be applied in principal.

Aqueduct: Aqueduct will be provided where an irrigation canal crosses a natural drain/stream.

Terminal Structure: Terminal structure will be provided at the end of respective secondary irrigation canals to drain excess water to drains.

In addition to the above major structures, washing steps, foot bridges, side spillways, sand excluders, drainage out-falls and so on will be provided in the proposed system and inside-surface of the curved earth canal will be protected by wet masonry. All of these structures will be made up of concrete and/or wet masonry.

G.1.2.6 Irrigation Pond

In order to utilize runoff of the Gudrung river effectively throughout the year, irrigation ponds will be provided in the proposed system. Existing four ponds close to the primary feeder canal will be incorporated into the proposed system after their improvements such as heightening and extending of the existing levees. One new pond will be provided at Tikker. Detailed features are given in Annex-I and are summarized below :

Irrigation Ponds

Name of Pond	Description	Features
Tikker Pond:	Total Storage	2,095,000 m^3
	Effective Storage	2,065,000 m^3
	High Water Level	141.6 m
	Low Water Level	134.3 m
	Bank Height	9.7 m
	Bank Length	2,200 m
Gorusinge Pond	Total Storage	185,000 m^3
	Effective Storage	135,000 m^3
	High Water Level	118.1 m
	Low Water Level	116.3 m
	Bank Height	3.8 m
	Bank Length	700 m
Badahara Pond	Total Storage	140,000 m^3
	Effective Storage	120,000 m^3
	High Water Level	118.0 m
	Low Water Level	116.3 m
	Bank Height	3.7 m
	Bank Length	1,100 m
Dewari Pond	Total Storage	440,000 m^3
	Effective Storage	270,000 m^3
	High Water Level	114.5 m
	Low Water Level	113.3 m
	Bank Height	4.9 m
	Bank Length	1,200 m
Buddi Pond	Total Storage	840,000 m^3
	Effective Storage	490,000 m^3
	High Water Level	114.5 m
	Low Water Level	113.3 m
	Bank Height	4.9 m
	Bank Length	1,600 m

G.1.2.7 Drainage System

Existing natural drainage systems will be incorporated into the proposed drainage system. Existing natural stream, Ghorai Nala will be used as Primary Drain and existing small drains will be used as secondary drains after their expansion. The proposed drainage system is given in Fig. G.1.2 and its discharge diagram is shown in Fig. G.1.5. Tertiary drains in most cases, however, will be constructed newly in the proposed drainage system. Bridges and culverts as drainage structures will be provided in the proposed system where drains will cross village or farm roads. The general features of the proposed drainage system are summarized below :

Drainage System

Description		Features
Primary Drain	Type	Trapezoidal Earth Canal
	Number	1 no
	Total Length	18.6 km
	Design Discharge	30.6 - 2.5 m^3/sec
Secondary Drain	Type	Trapezoidal Earth Canal
	Number	20 nos
	Total Length	24.2 km
	Design Discharge	4.3 - 0.2 m^3/sec
Tertiary Drains	Type	Trapezoidal Earth Canal
	Number	48 nos
	Total Length	26.4 km
	Design Discharge	0.20 - 0.06 m^3/sec

G.1.2.8 Village and Farm Roads

Major road network in and around the project area consists of the East-West Highway, Gorusinge-Sandekarka Zonal Road, village-to-village roads and farm roads. In the proposed project works, village-to-village roads and farm roads which are close to the proposed irrigation canals will be improved and any new road will not be constructed. The proposed road improvement is shown in Fig.G.1.3.

The proposed roads will have 3.5 m in total width and 2.5 m in effective width with 15-cm gravel metalling. Total length of the road improvement will be 49.5 km.

G.1.2.9 Work Quantity of the Project Works

Work quantities of the project works have been calculated on the basis of the above-mentioned preliminary designs of the project facilities. The calculated work quantities are given in Table G.1.3 and summarized as follows :

Work Quantities of the Major Items

Major Item		Quantity
Earthworks:	Excavation	741,500 m^3
	Embankment	493,000 m^3
	Stripping	99 ha
	Land Clearing	86 ha
	Gravel Metalling	18,600 m^3
Structure Works:	Concrete	15,500 m^3
	Wet Masonry	7,700 m^3
	Reinforcement Bar	535 ton
	Gabion	1,600 m^3
	Gates	65 sets

G.2 IMPLEMENTATION PROGRAM

G.2.1 Implementation Schedule

G.2.1.1 Basic Consideration

The project works comprise the following five major components :

1) Construction of the Headworks and Headrace,
2) Construction of the Irrigation System consisting of the Supply System and the Irrigation System,
3) Construction or Improvement of Irrigation Ponds,
4) Construction or Improvement of Drainage Systems, and
5) Construction of Agricultural Support Facilities.

These works will be independently executed but simultaneously implemented each other. The implementation program for the Project, accordingly, has been worked out on the basis of the following basic considerations :

i) The construction works of the headworks including headrace will be commenced firstly and be completed within around one dry season.

ii) A mechanized construction method would be introduced in order to minimize the construction period for the headworks.

iii) The construction of the irrigation system will be conducted simultaneously during the construction of the headworks in order to obtain project benefits as early as possible.

iv) To extend employment opportunities to the local people, small or simple works will be carried out by manual labour forces with locally available equipment and tools.

v) The construction works will be undertaken on a contract basis through the international competitive bidding (ICB).

vi) Experienced expatriate consultants will be engaged for the detailed design and the construction supervision.

G.2.1.2 Implementation Schedule

The implementation period will be about 3 years out of which the detailed design is scheduled to be completed within seven months and the construction works will be made within about two years. The proposed implementation schedule is given in Fig. G.2.1.

The survey and detailed design works will be implemented as a first step in the project implementation. During the design period, topo-survey and geological/soil investigation will first be carried out, and preparation of tender documents & design drawings for major project works will be prepared. Tertiary layouts with typical sections for tertiary irrigation canals/drains will be also made in the design period. Immediately after the preparation of the documents & drawings, tendering and land acquisition will be commenced.

The construction works will be concentrated on the dry season, and most works will be completed during two dry seasons. During mid rainy season, any construction work is not proposed in the implementation schedule. The construction of the project office will be initiated among the proposed works. Among the irrigation & drainage works, the construction of the headworks will be set out earlier than other construction works.

At the initial stage of the detailed design, existing Chanauda Branch Office of Butwal Tubewell Office will be improved for use of the Project office. During the construction stage, a new project office will be constructed in the Project area.

G.2.2 Organization and Management

Organization for Project Implementation

The executing agency of the Project will be Department of Irrigation (DOI) of the Ministry of Water Resources, since DOI has long experience and enough capability for project organization and management. Under the department, Rajkudwa Irrigation Project Office will be established and a project manager will be appointed for the project implementation. Proposed organization chart of the Project is shown in Fig. G.2.2.

In the project office, five sections will be established which are Survey & Design Section, Construction Section, Farmers' Organization Section, Administration Section and Finance Section. A section chief will be appointed in each section.

For the smooth project implementation, DOI and the Project Manger are required to coordinate related institutions to the Project, especially Department of Agriculture (DOA) of Ministry of Agriculture, Department of Forest of Ministry of Forest & Soil Conservation and these Kapilvastu District offices.

Prior to the detailed design works, it is proposed to establish a temporary project office in the branch office of Butwal Tubewell Office in Chanauda village for smooth project implementation.

Organization for Operation and Maintenance

After the completion of the construction works, the project facilities will be transferred to and operated & maintained by the beneficiary farmers' organizations in the Project area.

The irrigation & drainage facilities will be handed over to Water Users' Association and will be operated and maintained by the association under guidance of the district office of Department of Irrigation. The agricultural support facilities will be transferred to agriculture cooperative and will be operated and maintained by the cooperative under guidance of the district office of Department of Agriculture.

G.3 COST ESTIMATE

G.3.1 Basic Conditions and Assumption for Cost Estimate

The Project cost comprises direct construction cost, administration cost, engineering service cost and physical & price contingencies. Following basic conditions and assumption are made for the estimate of the project cost :

1) The unit prices for the cost estimate are based on the March-1993 current prices.

2) The exchange rate used in the cost estimate is as follows :
   US$ 1.00 = NRs. 50.0

3) Construction works will be executed on full contract basis through international competitive bidding. The construction machinery and equipment required for construction will be provided by the contractor themselves. Accordingly, depreciation cost of machinery and equipment is considered in the estimate of construction unit rates.

4) Taxes on the construction machinery and equipment to be brought into Nepal by the contractor are excluded from the cost estimate.

5) The construction cost comprises foreign and local currency portions. Local currency portion is estimated on the basis of the March-1993 prices collected from other on-going projects around the project area. Foreign currency portion is estimated based on the CIF prices at Birganj.

6) The physical contingency is estimated at 20 % of the direct construction cost in foreign and local currency portion.

7) The price contingency is calculated on the basis of the following escalation rates for foreign and local currency portion.

Foreign Currency Portion:	3.9 % per annum
Local Currency Portion:	12.0 % per annum

G.3.2 Currency of Cost Estimate

The construction cost is separately estimated at local currency portion and foreign currency portion in accordance with the origin of materials. The local currency portion and the foreign currency portion basically include the following costs:

Local currency portion

- Labour cost
- Cost of local materials
- Inland transportation cost
- Project administration expenses during construction period
- Contractors' general expenses
- Engineering services

Foreign currency portion

- Cost of all imported equipment and spare parts
- Cost of imported materials and foreign portion of local materials
- Contractors' general expenses
- Engineering services

G.3.3 Material and Labour Costs

The construction materials and labour costs are determined on the basis of the March-1993 prices in the price survey and the collected data of the on-going similar projects, especially Sunsari Morang Irrigation Project, in the country, which have been adjusted to the rates of the march-1993.

The price list of basic construction materials and labour cost used in the estimate is given in Table G.3.1 and the unit rates developed for the major construction works including the foreign and local currency portions are given in Table G.3.2.

G.3.4 Project Cost

G.3.4.1 Direct Construction Cost

The construction works to be undertaken by the contractors include construction of irrigation/drainage facilities and farmers' cooperative offices. The construction cost of respective project works are estimated on the basis of the work quantities estimated from preliminary design and unit prices. The summary of direct construction cost is given in Table G.3.3, its breakdown in Table G.3.4 and the cost is summarized as follows :

Direct Construction Cost

Description	Cost (NRs. thousand)
I. *Irrigation & Drainage Facilities*	
Headworks	34,817
Headrace	18,853
Supply System	103,396
Irrigation System	53,396
Drainage System	70,900
Irrigation Ponds	72,124
Village cum Service Roads	35,273
Project Office	1,570
II. *Farmers' Cooperative Offices*	
Farmers' Cooperative Center	3,584
VDC Farmers' Cooperative Offices	10,657
Total Direct Construction Cost	404,570

G.3.4.2 Administration Cost

Administration expenses consist of

i) Pesonnel cost for the detailed design and construction supervision,
ii) Direct management cost,
iii) Vehicle running cost,
iv) Other related administration cost for the project implementation
v) Agriculture Extension Services
vi) Compensation cost for crops and houses.

The estimated administration cost is NRs. 10,093 thousands in total and its breakdown is given in Table G.3.5.

G.3.4.3 Engineering Service Cost

Engineering service cost consists of traveling expenses, survey & investigation, detailed design, construction supervision and overseas training of the project staffs. The estimated total men-months required are 179 M/M including foreign and local experts and the estimated cost is NRs. 79,950 thousands in total. The breakdown of engineering service cost is as shown in Table G.3.6.

G.3.4.4 Annual Disbursement Schedule

The annual disbursement schedule is worked out according to the implementation schedule as shown below. The breakdown is as shown in Table G.3.7.