4.7. Irrigation and Drainage Plan

4.7.1. Beneficial Area and Proposed Cropping Intensity

As mentioned in the paragraph on Land Use Plan, 6,600 ha (16,300 acres) of the beneficial area will be divided into four major areas with respective stress on growing items as vegetables, tree crops, cereal crops, and animal husbandry. And three alternative cropping plans are prepared for those four areas in taking into consideration the results of the farm survey on the optimum cultivation acreage with the three cropping patterns and selection of crops to be introduced. In details, the Case 1 has 166 percent of cropping intensity which is at maximum to reach, while the Case 3 has 142 percent of cropping intensity which is at minimum to show possibility of achievement in view of present agriculture and farmers' intention. The Case 2 has 154 percent of cropping intensity which is between the Case 1 and Case 3.

The irrigation water requirements were calculated for the aforesaid three alternative cases, respectively, and the results have revealed that the Case 3 with 142 percent of cropping intensity is best suited for the Project. For references, the Case 3 will have 168 percent of cropping ratio when including rainfed cropping.

Alternative Cropping Area

Priority Area in the Agricultural Promotion Area	Percent of Area	Percent of Area by Cropping Type					
		Case 1			Case 2		
		A	B	C	A	B	C
a. Percent of Area by Priority Area							
- Vegetable	100	85	5	10	60	2	38
- Orchard	100	40	55	5	20	40	40
- Grain and Livestock	100	50	5	45	25	2	73
b. Percent of Area in the Cultivable Commanded Area (6,600 = 100)							
- Vegetable	50	42	3	5	30	1	19
- Orchard	10	4	5	1	2	4	4
- Grain and Livestock	40	20	2	18	10	1	29
Total	100	66	10	24	42	6	52
c. Cropping Intensity (%)							
- by Cropping Type		200	100	100	200	100	100
- in the Project Area		132	10	24	84	6	52
- Total of Intensity			166%			142%	

4.7.2. Irrigation Water Requirement

1) Crop Water Requirement

a) Evapotranspiration

Potential evapotranspiration (ETo) was estimated as presented below by applying the Penman method using climatological data observed at Chaklala station.

Estimated Evapotranspiration (ETo)

(unit: mm)

Month	ETo	Month	ETo
Jan.	1.8	Jul.	6.7
Feb.	2.5	Aug.	5.7
Mar.	3.7	Sep.	5.0
Apr.	5.5	Oct.	3.8
May	7.4	Nov.	2.4
Jun.	8.4	Dec.	1.6
		Ave.	4.5

b) Crop Water Requirement

Crop water requirement (consumptive use of water, ET) is calculated by multiplying the ETo value by the crop coefficient (Kc) corresponding to growth stages of crops and monthly crop water requirement is tabulated as shown in the following table.

Monthly Crop Water Requirement

(unit: mm)

Month	Rabi Crop			Perennial	Kharif Crop	
	Wheat	Fodder	Vegetable	Orchard	Vegetable(I)	Vegetable(II)
Jan.	42	47	48	48	-	-
Feb.	70	77	37	68	2	-
Mar.	98	100	12	96	31	-
Apr.	61	60	-	141	111	-
May	5	0	-	189	141	-
Jun.	-	-	-	213	61	44
Jul.	-	-	-	171	-	108
Aug.	-	-	3	144	-	110
Sep.	-	5	25	129	-	69
Oct.	3	36	48	96	-	19
Nov.	17	36	53	60	-	-
Dec.	26	33	44	42	-	-
Total	322	394	270	1,397	345	350

Note: In cases of wheat and fodder crops, irrigation water is not applied for 10 days at the harvesting stage.

The crop coefficients are determined using basically the same igures as proposed in "Irrigation Requirement of Crop" by Irrigation and Power Department, Province of Punjab, although partial revision of the figures was made based on "FAO Technical Paper No.24". The following table shows the crop coefficients applied in the calculation of the crop water requirements.

Crop Coefficient (Kc)

Crop Growing Stage (%)	Rabi Crop			Perennial Orchard	Kharif Crop Vegetable
	Wheat	Fodder	Vegetable		
10	0.43	0.40	0.39	0.85	0.39
20	0.54	0.48	0.50	0.85	0.50
30	0.66	0.57	0.63	0.85	0.63
40	0.83	0.70	0.78	0.85	0.78
50	0.90	0.82	0.92	0.85	0.92
60	0.97	0.99	1.00	0.85	1.00
70	1.03	1.05	1.05	0.85	1.05
80	0.97	0.98	0.95	0.90	0.95
90	0.49	0.75	0.85	0.90	0.85
100	0.25	0.55	0.75	0.85	0.75

Data Source:

1. On-farm Water Management Field Manual, prepared by Ministry of Food, Agriculture and Cooperatives, Government of Pakistan.

2. Irrigation Requirement of Crop in the Punjab, prepared by Irrigation and Power Department, Province of Punjab.

3. FAO Technical Paper No.24.

2) Diversion Water Requirement

The diversion water requirements are calculated in taking into account the effective rainfall and the irrigation efficiency in addition to the crop water requirements. The criteria for the calculation of the effective rainfall and the irrigation efficiency in the study are presented hereunder.

a) Effective Rainfall

On the basis of the daily water balance analysis between rainfall and crop water requirements, effective rainfall for individual crops is calculated. In the calculation, TRAM (total readily available moisture) value of 35 mm is adopted as the depth of maximum effective rainfall. The estimated effective rainfalls are shown in the following table.

Effective Rainfalls for Individual Crops

(unit: mm)

Crops		Probability 1/2	1/5	1/10
Rabi Crop	- Wheat	231	189	149
	- Fodders	278	192	137
	- Vegetable	185	167	145
Perennial Crop	- Orchard	750	623	507
Kharif Crop	- Vegetable (I)	200	174	133
	- Vegetable (II)	347	303	287

b) Irrigation Efficiency

The irrigation efficiency was determined on the basis of the prevailing topography and proposed irrigation method as follows:

- Conveyance efficiency (Ec) 0.90
- Operation efficiency (Eb) 0.90
- Application efficiency (Ea) 0.75

Irrigation Efficiency (E) = 0.9 x 0.9 x 0.75 = 0.60

c) Diversion Water Requirement

Following the aforementioned procedures, 10-day diversion water requirements for individual crops for 35 year (1952 - 1986) are estimated as presented in Table 4-11. And the Table 4-11 shows the probable annual diversion water requirements per 1,000 ha by

respective return periods of 2, 5 and 10 years for the proposed cropping pattern and with cropping intensity of 142 percent for irrigation period.

Annual Diversion Water Requirements (DWR)

(unit: MCM)

Item	Probability 1/2	1/5	1/10
DWR for 1,000 ha	3.68	4.57	5.38
DWR for 6,600 ha	22.30	30.16	35.47

Monthly diversion water requirements in the return periods of 2 and 10 years are presented in Figure 4-8.

4.7.3. Irrigation Water Supply Plan

1) Proposed Irrigation Systems

The total irrigation area of 6,600 ha (16,300 acres) can be divided into two irrigation systems; the Upstream Area (3,790 ha) and the Downstream Area (2,810 ha) by irrigation water sources and topographic conditions. The Upstream Area extends in the hilly area and the Downstream Area is primarily in the flat land area. Furthermore, the both areas are subdivided into several portion by lateral irrigation systems. The proposed irrigation systems are shown in Figure 4-9.

2) Design Irrigation Requirement

The design irrigation requirements for 1,000 ha are 0.600 cu.m/sec (*13, 14 cusec/1,000 acres) equivalent to the maximum water

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Note: *13 ... As is observed in Table E-12, the maximum irrigation requirement is 0.616 cu.m/sec/1,000 ha, which will occur at the beginning of April for 10-days, but this maximum requirement will be coped with canal cross section with freeboard because of short period of time.

requirements. Accordingly, the design irrigation requirements for the commanded area of 6,600 ha (16,300 cusec) are 3.96 cu.m/sec (233 cusec).

3) Proposed Irrigation Method

a) Measurement of Intake Rate

The intake rates were measured by using cylinder infiltrometers at five sites in the Project Area in order to employ an adequate irrigation method.

The following table gives the basic intake rates at each site, which were calculated on the basis of the results of measurements.

Basic Intake Rate

Locations	Basic Intake Rate (mm/hr)	Remarks
1. Dhok Hayat (No. 1)	5.8	Dry conditions
2. Khanna Dak (No. 4)	23.7	- do -
3. Banigala (No. 5)	7.0	Wet conditions
4. Balagh (No. 7)	62.1	- do -
5. Shahpur (No.10)	39.6	Dry Conditions

The locations and results of intake rate measurement are shown in Figure E-2 to Figure E-7.

b) Proposed Irrigation Method

In considering that the basic intake rates obtained through measurement are found in a range from 5.8 mm/hr to 62.1 mm/hr (0.23 in/hr to 2.44 in/hr), and the Project Area is situated in Punjab Barani area, the furrow irrigation method is selected for the Project.

c) Water Depth and Interval of Irrigation

Such physical properties of soils as real and apparent specific gravity, porosity, field capacity, and wilting point were measured with samples collected at the sites where measurement of the intake rate were conducted. The results of the measurement are shown in Table E-21. On the basis of the results, available moisture in the soil layer within the effective root zones and the Total Readily Available Moisture (TRAM) in the effective root zones are calculated as shown in Table E-22 to Table E-26. TRAM values thus obtained are summarized as shown below.

TRAM Value of Each Location

Location		TRAM (mm)
No.1	Dhok Hayat	18.4
No.4	Khanna Dak	39.6
No.5	Banigala	42.4
No.7	Balagh	24.8
No.10	Shahpur	33.0
	Average	35.0

Since the average value of TRAM is 35 mm as shown in above table and the soil type observed at the location of No.10 (Shahpur) is distributed in about 80 percent of the total commanded area, the TRAM value of 35 mm is adopted for the study on the depth and interval of irrigation application in the Project.

The interval of irrigation application is obtained by dividing the TRAM by the maximum crop evapotranspiration as follows:

Interval of Irrigation Application

Crops		TRAM (mm)	Max. Evapo-Transpiration (mm/day)	Irrigation Interval (days)
Rabi Crop	- Wheat	35	3.6	9
	- Fodders	35	4.1	8
	- Vegetable	35	2.9	12
Perennial Crop	- Orchard	35	7.1	4
Kharif Crop	- Vegetable	35	7.8	4

As it is seen in the above table, the irrigation interval is different by crops. However, the proposed irrigation interval is planned by seven days considering the convenience of the farmers water management works in the fields.

4.7.4. Drainage Plan

1) Purpose of Drainage Plan

As there are no existing drainage canals in the Project Area, runoff of the surface soils is observed in the on-farm area during heavy rainfall. Accordingly, the basic objective of the drainage plan is to control soil erosion. In the plan, the on-farm drainage canals are to be constructed in the lower portion of the on-farm area. The typical layout of these drainage canals is presented in Drawing No.O-1001 and No.O-1002.

2) Drainage Modulus

a) Design Rainfall

For the analysis of design rainfall, the rainfall records at Chaklala station were used and the maximum daily rainfall with return period of 5 and 10 years is calculated as follows;

Probability 1/5	:	128.0 m
Probability 1/10	:	150.3 m

In the Project, the maximum daily rainfall of 128.0 mm (5.0 in) with return period of 5 years is adopted as the design rainfall to ensure the balance with other related facilities.

b) Design Drainage Modulus

The design drainage modulus was decided at 14.8 lit/sec/ha (0.211 cusec/acre) by applying the above mentioned probable rainfall with a return period of 5 years.

TABLE 4–11. DIVERSION WATER REQUIREMENT (CASE 3)

CROPPING PATTERN WHEAT =0.626 FODDERS =0.104 VEGET(R) =0.210 VEGET(K1)=0.210 VEGET(K2)=0.210
ORCHARD =0.060 MAIZE(K)=0.130 PULSES(K=0.130
CROPPING INTENSITY = 168.0% IRRIGATION EFFICIENCY = 60.0%

(UNIT...MCM/1000HA)

YEAR	(JAN)	(FEB)	(MAR)	(APR)	(MAY)	(JUN)	(JUL)	(AUG)	(SEP)	(OCT)	(NOV)	(DEC)	ANNUAL
1952	0.076	0.198	0.447	0.914	0.610	0.201	0.109	0.076	0.200	0.293	0.498	0.549	4.173
1953	0.004	0.367	1.233	0.720	0.535	0.555	0.177	0.085	0.165	0.176	0.498	0.452	4.967
1954	0.060	0.013	0.723	0.939	0.608	0.469	0.173	0.074	0.124	0.142	0.441	0.354	4.118
1955	0.686	0.808	0.815	0.673	0.497	0.501	0.201	0.122	0.048	0.256	0.498	0.269	5.375
1956	0.273	0.972	0.378	0.719	0.708	0.160	0.034	0.008	0.274	0.144	0.418	0.449	4.536
1957	0.024	0.224	0.509	0.103	0.401	0.285	0.416	0.086	0.195	0.056	0.042	0.018	2.359
1958	0.343	0.908	0.561	0.885	0.668	0.556	0.087	0.107	0.157	0.209	0.270	0.189	4.939
1959	0.039	0.032	0.835	0.526	0.416	0.403	0.162	0.077	0.006	0.127	0.077	0.090	2.791
1960	0.002	0.862	0.361	0.609	0.665	0.525	0.135	0.088	0.126	0.192	0.498	0.481	4.544
1961	0.116	0.299	1.062	0.301	0.625	0.374	0.139	0.072	0.006	0.106	0.065	0.136	3.302
1962	0.229	0.360	0.515	0.608	0.565	0.323	0.141	0.029	0.042	0.281	0.275	0.088	3.457
1963	0.518	1.050	0.379	0.422	0.441	0.467	0.215	0.012	0.024	0.256	0.051	0.080	3.917
1964	0.115	0.527	0.949	0.283	0.538	0.461	0.107	0.126	0.093	0.352	0.498	0.517	4.567
1965	0.354	0.098	0.501	0.033	0.307	0.371	0.259	0.127	0.262	0.316	0.113	0.223	2.966
1966	0.548	0.363	0.440	0.311	0.551	0.377	0.187	0.043	0.035	0.094	0.306	0.426	3.679
1967	0.395	0.504	0.540	0.573	0.514	0.504	0.100	0.010	0.142	0.088	0.193	0.025	3.588
1968	0.188	0.078	0.686	0.646	0.653	0.436	0.147	0.040	0.299	0.177	0.074	0.077	3.502
1969	0.597	0.134	0.764	0.754	0.499	0.475	0.209	0.075	0.093	0.096	0.125	0.376	4.196
1970	0.494	0.415	0.615	0.936	0.681	0.354	0.156	0.023	0.021	0.179	0.237	0.213	4.325
1971	0.554	0.758	0.997	0.623	0.524	0.085	0.251	0.064	0.098	0.267	0.191	0.412	4.823
1972	0.112	0.234	0.412	0.262	0.561	0.363	0.374	0.162	0.090	0.112	0.252	0.031	2.966
1973	0.270	0.653	0.723	0.584	0.569	0.250	0.065	0.033	0.034	0.115	0.482	0.279	4.055
1974	0.338	0.254	0.928	0.851	0.581	0.202	0.117	0.121	0.151	0.207	0.498	0.104	4.353
1975	0.694	0.178	0.423	0.897	0.470	0.378	0.101	0.068	0.056	0.363	0.333	0.505	4.467
1976	0.292	0.065	0.364	0.303	0.686	0.375	0.087	0.030	0.058	0.119	0.435	0.577	3.392
1977	0.238	0.750	1.449	0.270	0.482	0.234	0.028	0.041	0.169	0.101	0.119	0.225	4.105
1978	0.387	0.341	0.680	0.734	0.578	0.362	0.020	0.010	0.031	0.185	0.083	0.272	3.682
1979	0.028	0.567	0.462	0.504	0.534	0.350	0.297	0.032	0.142	0.140	0.173	0.103	3.331
1980	0.007	0.039	0.172	0.627	0.621	0.307	0.073	0.146	0.050	0.165	0.354	0.274	2.834
1981	0.078	0.203	0.187	0.404	0.437	0.375	0.072	0.012	0.075	0.201	0.405	0.577	3.025
1982	0.101	0.049	0.129	0.497	0.326	0.404	0.396	0.046	0.187	0.133	0.172	0.073	2.513
1983	0.486	0.293	0.437	0.186	0.551	0.255	0.084	0.078	0.030	0.028	0.339	0.577	3.342
1984	0.804	0.576	0.746	0.408	0.642	0.310	0.056	0.041	0.042	0.318	0.428	0.283	4.654
1985	0.014	0.674	0.997	0.859	0.521	0.533	0.095	0.050	0.170	0.086	0.212	0.112	4.322
1986	0.410	0.398	0.584	0.685	0.496	0.308	0.178	0.055	0.150	0.086	0.224	0.015	3.590
MEAN	0.282	0.407	0.629	0.561	0.545	0.368	0.156	0.065	0.110	0.176	0.282	0.269	3.850

FIGURE 4-8. THE RELATION OF CONSUMPTIVE USE OF WATER AND DIVERSION WATER REQUIREMENT

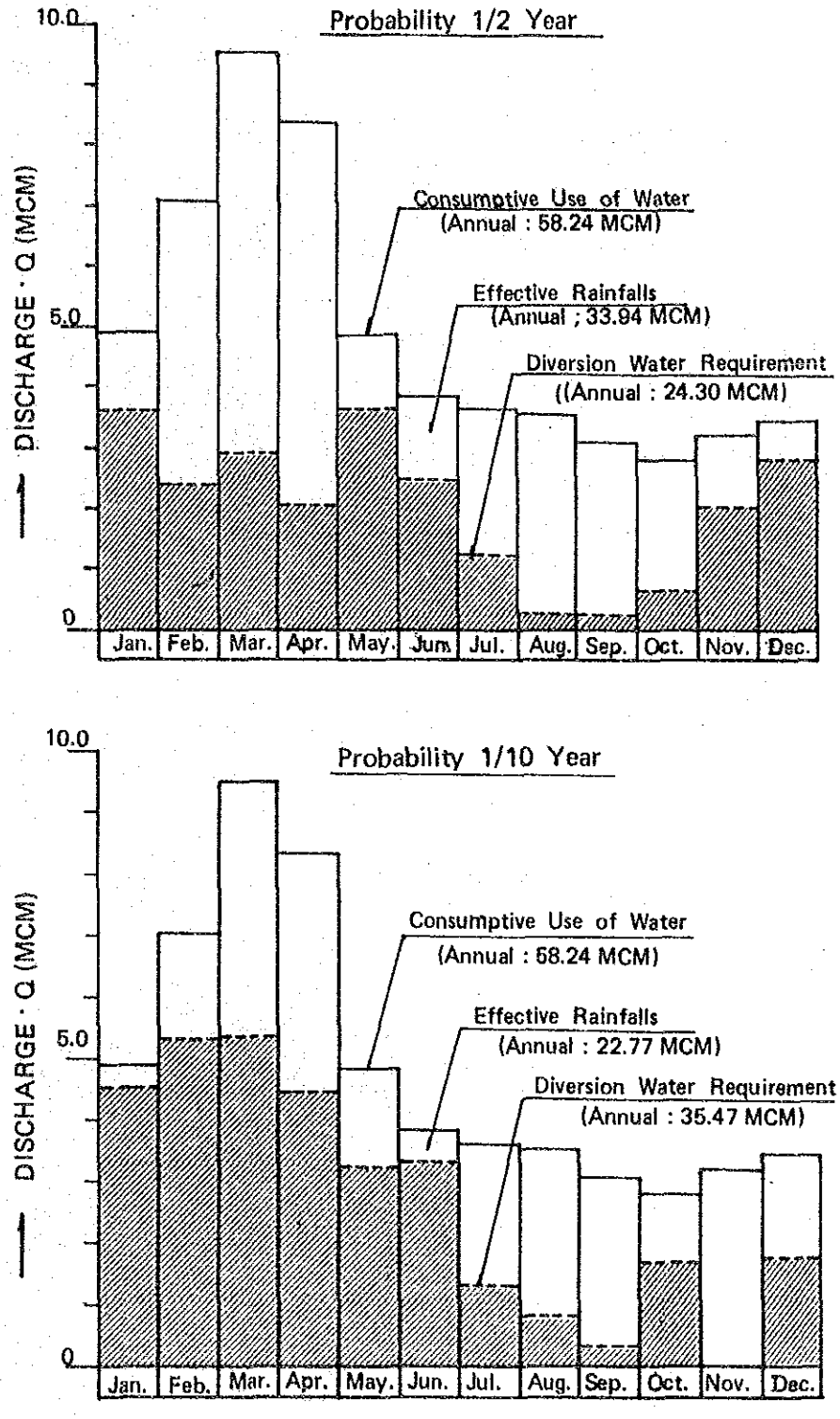
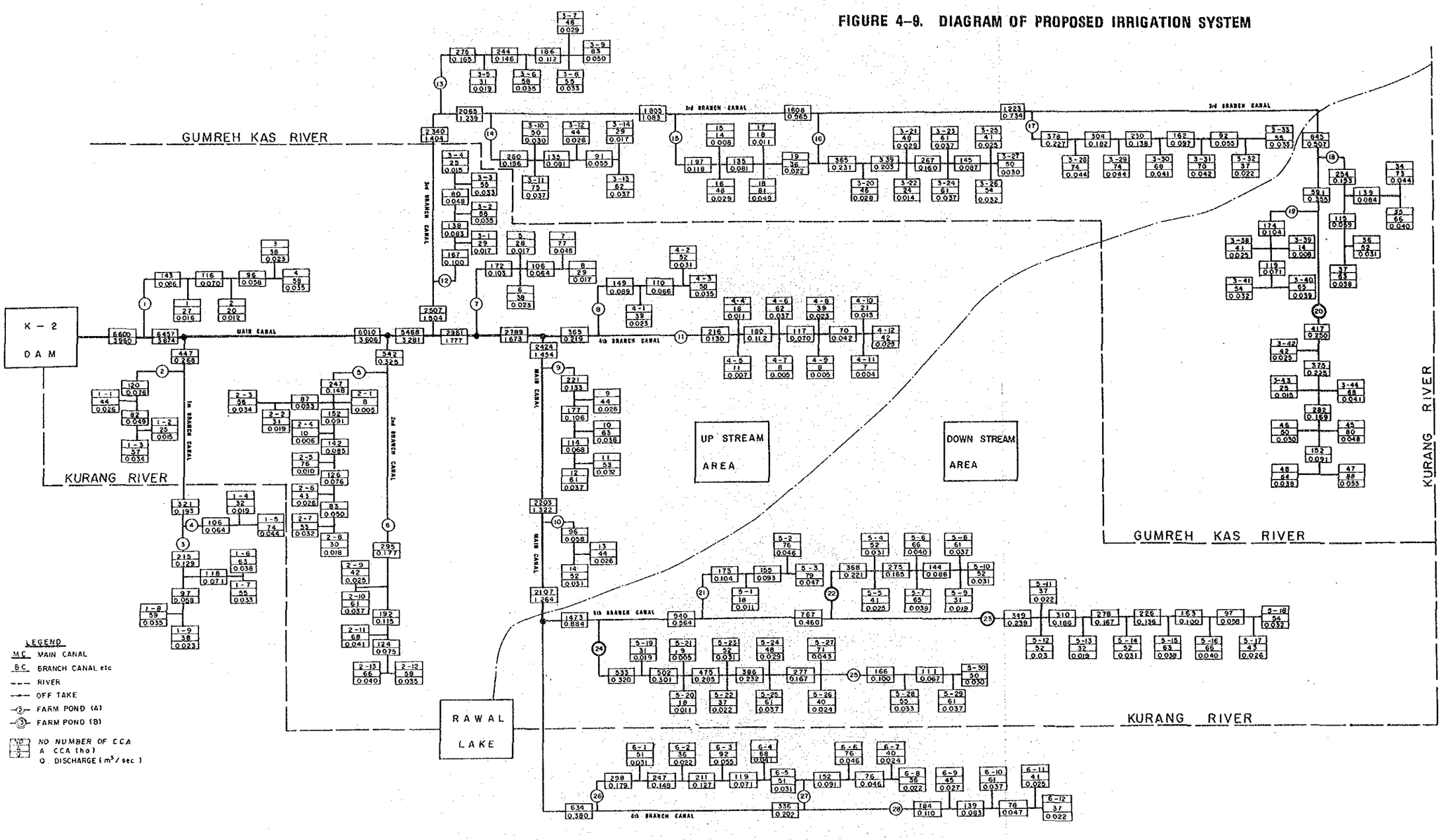


FIGURE 4-9. DIAGRAM OF PROPOSED IRRIGATION SYSTEM



4.8. Small-Scale Hydro-power Generation Plan

In the plan of K-2 Dam, two outlet works of an irrigation outlet and a river outlet are to be provided, and a small-scale hydro-power generation will be possible by using those facilities. However, the power generation plan by using the river outlet works is excluded from the study because it is assumed economically unfeasible by the following reasons;

- In ordinary years, releases of water through the river outlet works is available only for two months of July and August. And the rate of operation of the power plant will be very low.
- The annual released discharges fluctuate sharply in amount. It is assumed, therefore, that the turbine will be operated at low efficiency for a long term.

1) Power Generation Plan using Irrigation Outlet Works

a) Design Year

According to the results of the water balance study for 35 years, 1952-1986, the annual released discharge from the irrigation outlet works is 25.1 MCM (20 x 10^3 acre ft) on an average. These discharges in the following four years are almost the same as the average annual released discharge (see Figure H-1).

Year	Annual Released Discharge (MCM)
1963	25.9
1966	24.3
1978	24.3
1985	25.9

As the flow-duration curve of 1966 has the most similarity to the flow-duration curve of the mean values, the year of 1966 is selected as the design year for this generation plan.

b) Maximum Discharge

The maximum discharge is determined by 1.4 cu.m/sec (49.4 cusec) which corresponds to the 80-day stream flow on the flow-duration curve of 1966.

c) Intake Water Level

The average reservoir water level for 35 years is EL.645.7 m (2,128 ft) and is adopted as the intake water level.

d) Tailwater Level

The tailwater level is determined by EL.637.0 m (2,089 foot) which is the water level at the beginning point of the main irrigation canal.

e) Selection of Water Turbine

The S-Type tubular turbine, which is generally employed for small-scale hydro-power generation with low head, is selected as suitable water turbine for the plan (see Figure H-2).

f) Combined Efficiency

The combined efficiency (efficiency of turbine x efficiency of generator) of 75 percent will be used for estimation of the generated output.

g) Generated Output

The power output, P (KW) can be obtained by the following formula;

$$P = 9.8 \times Qmax \times He \times \eta = 9.8 \times 1.4 \times 8.7 \times 0.75$$
$$= 89.5 \fallingdotseq 90 \text{ KW}$$

Where,

Qmx: Maximum Discharge = 1.4 cu.m/sec
He : Effective Head = EL.645.7 - EL.637.0 = 8.7 m
η : Combined Efficiency = 75%

The layout of the necessary facilities for hydro-power generation is shown in Figure 4-10.

2) Annual Power Generation

The annual generation potential, which means the energy to be generated when the plant is continuously operated for 365 days, is computed to be 345,000 KWH for the year of 1966. The annual power generation is estimated at 330,000 KWH corresponding to 95 percent of the annual possible power generation by considering the interruption in the operation for maintenance of the plant (Refer to Table H-1).

Unit Cost of Power Generation

i) Construction Cost

Item	Quantity	Amount ('000 Rs)
- Water Turbine, Generator etc.	Lump Sum	7,000
- Civil Works	"	400
- Building Works	"	200
Total		7,600

ii) Annual Cost

Annual Cost = C x CRF + O/M
= C x i (1 + i)**n / ((1 + i)**n-1) + O/M
= 650,000 Rs.

Where,

C : Construction Cost
CRF : Capital Recovery Factor
i : Interest = 7%
n : Life Span = 30 years
O/M : O/M Cost = C x 0.5%

iii) Unit Cost of Power Generation

Unit Cost of Power Generation = Annual Cost / Annual Power Generation
= 650,000/330,000 = 1.97 Rs/KWH

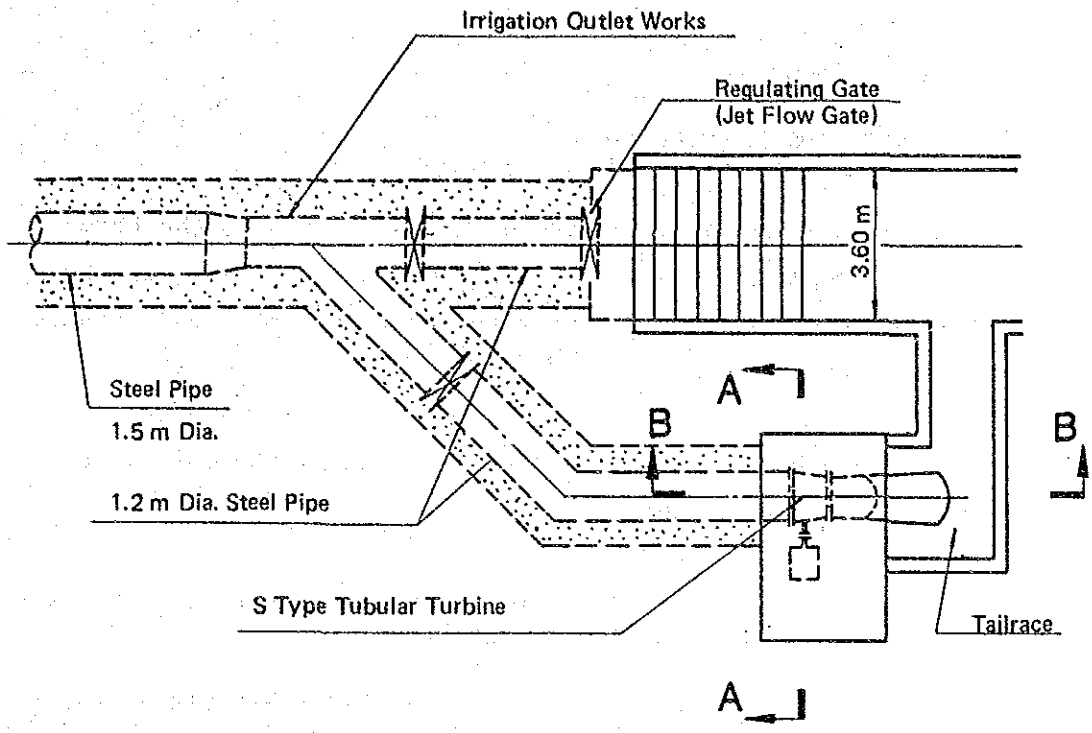
Propriety of the Power Generation Plan

According to the obtained data, prevailing electric rates on the monthly basis are as follows;

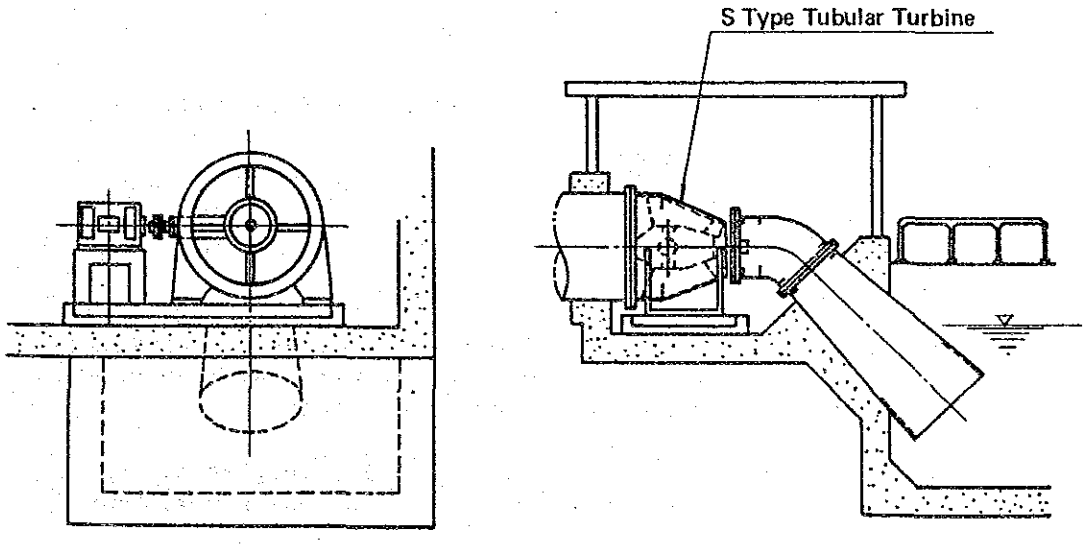
Present Electric Rates

Consumption (KWH)	Rates (Rs/KWH)
1 - 50	0.39
51 - 150	0.46
151 - 300	0.58
301 - 600	0.64
above 600	0.89

As it is observed in the above study, the unit cost of the power generated is higher than the present electric rates, so that the said small-scale hydro-power generation plan can not to be involved in the Project Plan due to being unfeasible.



PLAN



SECTION A-A

SECTION B-B

FIGURE 4–10. GENERAL PLAN OF SMALL–SCALE HYDRO–POWER GENERATION

4.9. Agricultural Production Plan

4.9.1. Crop Production Plan

1) Proposed Crop Cultivation

As mentioned in the paragraph of "Land Use Plan", the three types of farming will be developed in the area as farming centering around vegetable cropping, around tree-fruits cropping, and around cereals and fodder cropping.

The proposed crops have been selected taking the following factors into consideration;

i) Crops better suited to irrigated agriculture together with large demand and high profitability,

ii) Vegetables easily cultivable in farming techniques for the early development stage and crops to be changed into those requiring higher techniques with development advancing,

iii) Fruits for consumers close to the farms with thin skin and soft pericarp not to stand for long-distance transportation and grown easily in farming techniques, and

iv) Fodders not only for feeding milk cow but for retaining soil fertility,

In view of the above factors, the following crops will be introduced to the Project Area.

Cereals and Fodders

- Rabi Season : wheat, italian rye-grass, oats, weeping lovegrass, persian clover, egyptian clover, rape and mustard and turnip
- Kharif Season: maize, sorghum, soybean, mungbeans, groundnut, alfalfa, cow-pea, sun-flower

Garden Crops - Vegetable (*14)

- Rabi Season :	Root Vegetable	japanese radish, turnip, radish, carrot, garden beet
	Leaf Vegetable	cabbage, chinese cabbage, spinach, parsley, (lettuce, celery)
	Flower Vegetable	cauliflower, broccoly
	Pulse Crops	peas
- Kharif Season:	Root Vegetable	carrot, japanese radish, turnip, radish
	Leaf Vegetable	cabbage, spinach, parsley
	Flower Vegetable	cauliflower
	Fruit Vegetable	(tomato, egg-plant, sweet pepper, cucumber, water melon, melon, strawberry) bottle gourd, pumpkin, quinine sponge gourd, okra
	Pulse Crop	kidney beans, snap beans, common gram

Garden Crop - Fruit Trees -

Peach, loquat,	plum, apricot, nectarine, persimmon, cherry, lemon

For vegetable cropping, selection of the crops and the cropping pattern should be carefully made in consideration of suitability to the local conditions and market trend relative to other production areas.

Note: *14 ... Crops in parenthesis require high skilled technique for cultivation.

2) Proposed Cropping Pattern

The proposed cropping pattern was classified into four types, Type A, B and C in the cultivable commanded area and Type D in the waste land based on the land classification (see Figure 4-11).

Irrigated Area (6,600 ha)

Type A : (2,800 ha, 42%)	Land classification belongs to 1st class, and in 50 percent of the fields, vegetable is to be cropped for both seasons of Rabi and Kharif. And in the remaining fields, wheat for Rabi season is to be cropped following green fodder or fallow for the Kharif season. Pasturing during the Kharif season aims at soil fertility and then vegetable will be cropped for the next Rabi season. In order to increase the farmers' income and to make the best use of the Project Areas' advantage lying near the huge consumption area, vegetable harvesting at off-season should be emphasized in Kharif season.
Type B : (400 ha, 6%)	Land classification belongs to 2nd class. Perennial orchard is to be cropped mulching with grass farming. Variety of orchard should be selected based on the criteria of difficulty in storage and transportation.
Type C : (3,400 ha, 52%)	Land classification belongs to 3rd class. In the Rabi season, wheat and fodder are to be cropped in the proportion of 80 and 20 percent respectively with irrigation water supply. In the Kharif season, maize and pulses are to be cropped in the areas of 25 percent respectively without irrigation water supply.

Un-irrigated Area (3,900 ha)

Type D :	Land classification belongs to 4th class. In order to prevent soil erosion, grass farming in both seasons, Rabi and Kharif will be proposed. The grass would be harvested throughout the year.

3) Water Management for Crop Husbandry

Fundamentally, irrigation can be practised with information available only for the number of interval days and unit water requirements. For upland cropping with vegetables, however, irrigation shall be carried out very carefully in the following manner.

- Sowing Period : Irrigation is practised very frequently but with a relatively small amount of water till full germination (about 5.0 mm per day).

- Planting Period : For a planting period of vegetables, timely irrigation with a considerable amount of water is carried out to meet the field capacity (FC).

- Early Growing Period: After rooting, irrigation water should be reduced in its amount per day (vegetation period) so that the field soils can be maintained in less moistened condition for developing root zones and vegetation control (for curbing too thick vegetation).

- Middle Vegetation Period: (Flower Budding) Careful irrigation practice should be made to give sufficient water to the level of the field capacity and maintain the field moisture appropriately.

  Any withering will cause some physiological troubles with plants. (Blossomend-rot of tomato and green pepper, black rot of celery, etc.)

- Late Vegetation Period: (Ripening and Harvesting) Irrigation water supply should be reduced in its amount or stopped in supply so as to harden the cell tissues of the crops or increase the sweetness for upgrading of the crop quality.

As learnt from the above, the water management for successful vegetable growing requires to be highly flexible under delicate control of irrigation water amount, intervals, etc. so as to meet requirements of crops by their kinds and types and growing stages. And farm ponds should be provided in the related fields to be successful in such sophisticated water management. In future, when nursery pots, green houses and other farming facilities will be introduced for raising the irrigation efficiency with sprinklers, drippers, etc., the sufficient water sources should be provided as closely as possible to the fields.

4) Farming Practices and Farm Inputs

The Irrigated agriculture development for upland cropping in the Project Area will enable the small land holding farmers to have farm income increase together with increase in productivity. Successful realization of the Project, however, has several constraints to overcome as discussed in the previous paragraphs on the present agriculture.

The cropping methods and necessary amounts of input materials for the proposed crops are summarized as follows to show improvement points and countermeasures to be taken. The related details are given in Annex G.

Wheat

New high yielding varieties should be introduced together with deep plowing for expansion of plant root zones. The adequate planting density should be ensured by keeping stripe seeding with 15 cm intervals. Fertilization should be practised with nitrogen by 1/2, potash by 1/2 and phosphate by all respectively for the necessary amount, as basal fertilizer, while with nitrogen by 1/2 and potash by 1/2 as ear manure for the production increase.

Vegetables

New high yielding varieties should be introduced and cultivated with high ridges keeping the soil moisture contents in the most suitable range. The direct seeding applied currently should be changed at proper time to stripe seeding or hill seeding to keep the suitable planting density by thinning.

Successful upland crop raising requires to grow healthy seedlings in nursery beds and to transplant them in fields by proper planting density. The plants should be grown by such proper farming works as intertillage, weeding, disbudding, training, trimming, etc. As basal fertilizers, barnyard manure should be given at the rate of 10 - 25 tons/ha (4.0 - 10.1 tons/acre), and the amount of each element of chemical fertilizers to be applied is estimated by deducting the natural supplies of the elements from the necessary amount of the elements, and then dividing the results obtained by the respective absorption rates.

As the study results, phosphate should be applied totally as basal fertilizer and the remaining 1/2 as top dressing.

Agri-chemicals particularly herbicides, should be minimized in quantity of dosing, and contrarily, such ecological control should be positively practised as rotational cropping, application of organic matters, and other field management of manuring, appropriate field practices, introduction of resistant crop varieties, adopting stocks of superior varieties, etc.

Tree Crops

Superior scions should be put on disease resistant stocks and planted with about 330 trees per hectare, and then, thinning works should be practised in accordance with their growth stages to become a suitable in planting density.

Organic matters and chemical fertilizers should be applied in deep plowing at different places once a year, and such fertilization should be practised at different places every year. As an example, about 100 kg/ha (40.5 kg/acres) of nitrogen, 60 kg/ha (24.3 kg/acres) of phosphate, and 40 - 50 kg/ha (16.2 - 20.2 kg/acres) of potash are recommended as proper amount of dosing for peach trees with 15 years of age.

Insect/pest control should be carried out mainly by bagging and paper trapping, and chemical application should be minimized both in dosing frequency and amount. Timely and careful field works are required for pruning, pollination, cluster thinning, fruit thinning, bagging, etc. In ill-drained areas, drainage facilities are essential with underground drainage.

Fodder Crops

There are two kinds of fodder crops, one for silage and the other for pasture grass, and either of the two are grown in superior varieties.

Silage crops should be grown in stripe seeding and be kept in suitable planting density by thinning.

Pasture grass should be sown by even spraying to have plants growing evenly.

Fertilization of these crops should be made before seeding for the whole objective fields with nitrogen of 100 kg/ha (40.5 kg/acre) and phosphate of 100 kg/ha.

For ratooning, nitrogen and phosphate should be dosed by about 50 kg/ha (20.2 kg/acre) each as top dressing immediately after the harvest.

When the harvest of these crops decreased below 70 to 60 percent of the best harvest in the ordinary cultivation, plowing should be practised to effectively turn the field soils.

Mechanization of Field Works

- The field works of plowing, soil crushing, land levelling, ridging, chemicals spraying, etc. should be practised by farming machines such as tractors, speed sprayers, etc.

- The field works of seeding, planting, fertilization, intertillage, weeding, harvesting, transporting, etc. should be carried out by man power and draft animals for the time being; however, power-tiller type tractors should be introduced in future for labour saving.

- Mechanization will be difficult in other works such as thinning, disbudding, training, trimming, pruning, etc.

The farm mechanization for the Project should be introduced only partially to supplement the draft animals.

5) Estimated Agricultural Production

The data and information on the irrigation effects are not available by PARC. Unavoidably, therefore, the production increase by irrigation only is assumed to be in a range from 120 percent to 130 percent. The other favorable factors like introduction of new varieties, fertilization, deep plowing, uplevelling of farming techniques, etc. shall be taken into consideration in the stating manner to estimate the agricultural production expected 10-15 years after the project completion. And the results of the estimation can be shown as increase by 3.5 - 5.0 ton/ha for wheat, 65 - 85 ton/ha for fodder crops, 12 - 25 tons/ha for vegetables in Rabi, and 20 ton/ha for vegetables, 16 - 20 ton/ha for tree-crops in Kharif. Even when maize and fodder crops are cultivated in rainfed land, the production of the former will become 20 - 25 tons/ha and that of the latter 50 - 60 ton/ha by improved soil fertility and advanced farming techniques.

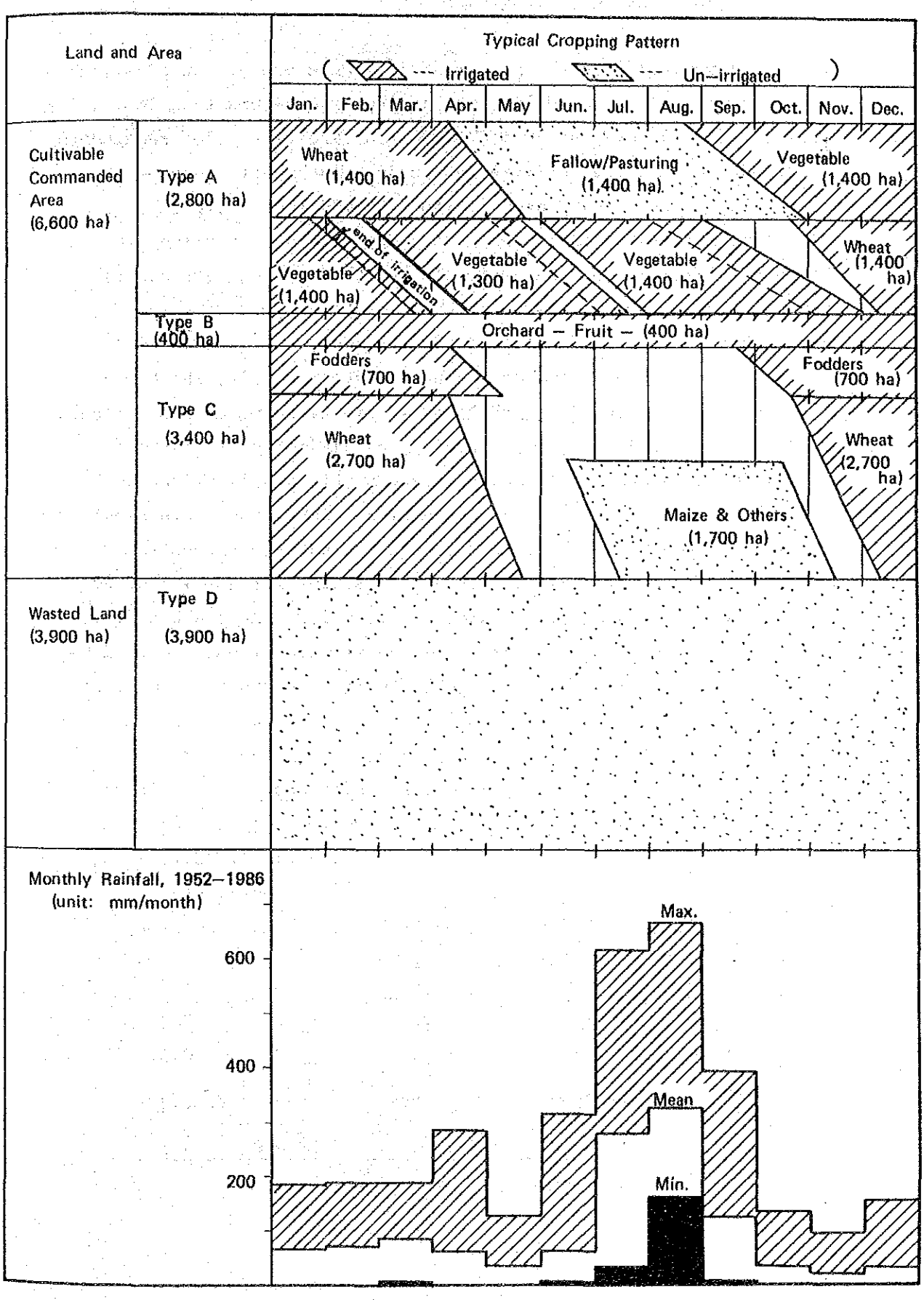
The following table shows the crop production with the Project.

TABLE 4–12. CROP PRODUCTION WITH PROJECT

Crops	Cropped Area ha	Cropped Area (acre)	Average Yield tons/ha	Average Yield (tons/acre)	Production tons
1. Rabi Crops					
- Wheat	4,100	(10,130)	5.0	(2.0)	20,500
- Fodder	700	(1,730)	85.0	(34.4)	59,500
- Vegetable					
° Leaf Vegetable (Cabbage)	500	(1,240)	25.0	(10.1)	12,500
° Route Vegetable (J. Radish)	500	(1,240)	20.0	(8.1)	10,000
° Pulse Crop (Peas)	400	(990)	12.0	(4.9)	4,800
2. Kharif Crops					
- Vegetable					
° Fruit Vegetable (Tomato)	1,300	(3,210)	20.0	(8.1)	26,000
° Fruit Vegetable (Cucumber)	1,000	(2,470)	15.0	(8.1)	20,000
° Flower vegetable (Cauliflower)	400	(990)	20.0	(8.1)	8,000
- Fruit (Peach)	400	(990)	20.0	(8.1)	8,000
- Maize 1/	850	(2,100)	2.5	(1.0)	2,130
- Fodders 1/	850	(2,100)	60.0	(24.3)	51,000
Total	11,000	(27,180)	(Cropping intensity = 167%) 2/		
Total of Irrigated Crops	9,300	(22,980)	(Cropping intensity = 141%)		

Note: 1/ Un-irrigated crops
2/ Average cropping intensity for 35 years, 1952 - 1986.

FIGURE 4-11. PROPOSED CROPPING PATTERN



4.9.2. Animal Husbandry Program

Implementation of the Project will enable production of silage fodder to be raised to 60,000 tons in Rabi and 51,000 tons in Kharif. Furthermore, straw of 15,000 tons and vegetables remainders of 20,000 tons will be utilized as feeds. Such better use of these materials is expected to produce about 23,000 tons of Total Digestive Nutrients (TDN) and about 3,000 tons of Digestive Crude Protein (DCP). And on the basis of the TDN value converted, the number of head of milk cow to be bred can be estimated at 13,700 head, which is 1.8 times as large as the adult cattle bred at present. The proposed number of the domestic animals, which are estimated by the ratio of each kind of animals being bred at present will be 5,200 head of milk cow, and 4,500 head of water buffalo. The fodder crop production increase and stable supply of feeds throughout the year will enable milk production to be increased by 4.0 kg per head for milk cow and 6.0 kg for buffalo. When taking the birth rate of milking animals by 74 percent for cattle and 80 percent for buffalo, milking cattle will be 3,900 head and buffalo 3,600 head, respectively. The total annual milk production will be about 11,300 tons, which will be able to meet the increasing milk demand in Islamabad and Rawalpindi.

Planned Production of Fodder Crops

(unit: 1,000 ton)

Cropping Season	Production		Nutrients	
	Fresh	Dry Matter	TDN	DCP
- Rabi Crop	59.5	13.2	8.5	1.3
- Kharif Crop	51.0	11.0	7.3	1.0
Sub-total	110.5	24.2	15.8	2.3
Wheat Strow	15.0 1/	13.4	5.9	0.5
Vegetable Remainder	20.0	2.0	1.3	0.3
Total	145.0	39.6	23.0	3.1

Note: 1/ Airdry matter

Livestock	Planned Feeding Number (head)	Production of Milk: Milking Cow (head)	Milk Yield (kg)	Annual Milk Production (ton)
Cattle	5,200	3,900	4	4,758
Buffalo	4,500	3,600	6	6,588
Goat	6,000	-	-	-
Sheep	4,800	-	-	-

Note: Number of milk production days per year: 305 days, two times of milking per day.

4.9.3. Proposed Farming

Successful irrigated upland farming will ensure i) increase and stabilization of agricultural productivity, ii) labour saving of farming practices, iii) upgrading of quality of farm products, etc. In other respects, such rational farming will allow intensive farm management realized, land use rationalized, marketing system established and will come to require comprehensive measure to form production areas or blocks for specific crops.

Such modernized irrigated farming must enable local farmers to replay the main role and as many farmers as possible to participate in the irrigated upland farming. For success in the Project, therefore, it is quite essential that the local farmers have their own action programs to appropriately respond to the irrigated upland farming to be realized in the very near future.

Consequently, the following three types of farming pattern are worked out for selecting best-suited crops to the farm land in considering those conditions of soils, topography, meteorology, etc.

i) Vegetables + Cereals + Fodders + Dairy
ii) Three-crops + Cereals + Fodders + Dairy
iii) Cereals + Fodders + Vegetables + Dairy

Selection of the farming pattern out of the above three types shall be made on the village basis through consultative discussion on the following matters.

i) The farming pattern with vegetable

- The farming pattern with vegetable as a core will be suitable to the areas which are flat gently sloped, well-permeable, highly retentionable with water, and convenient in farming/water management. The land to meet the above requirements can be found in the Downstream Area of the Rawal Dam, where many farmers experience the irrigated vegetable growing with well water.

- Since, however, irrigated upland farming commonly compels the land to remarkably reduce its fertility, complex farming with dairy farming is quite inevitable to fertilize the soils by barnyard/green manure produced by domestic animals or by animal waste by liberation of animals in the fallow land.

- On the other hand, single item mass cropping will often result in trouble from consecutive cropping, and therefore, it is quite essential to introduce a following rotational cropping pattern as proposed for avoiding the trouble.

  Vegetable - Vegetable - Wheat - Fallow - Vegetable

ii) The farming pattern with tree-crops

- This pattern as a core is suitable to the areas gently sloped to the south with forest land extending their northern backside to prevent cold wind in the winter season.

- The tree-crops husbandry will be available even in the areas not blessed with the aforesaid natural conditions, only if the wind brokers can be provided for the crops. A collective farming, however, is necessary for bringing up the production areas or blocks for specific crops. And crop selection shall be made in taking advantage of the suburban farming areas. As an example, such fruits crops are preferable as loquat, figs, peach, plum which have soft skins and pericarp only to stand for short distance transportation.

- It is recommended, furthermore, that some vegetables or fodder crops should be cultivated under fruit-trees so that the former plays a vital role as cash crops and the latter will encourage dairy farming, since tree-crops husbandry takes a considerably long-time to bare fruits for marketing.

- In other respect, thick plantation will be required for raising the yield in the early stage of tree-crop farming and trimming should be made as the trees grow up so as to keep fair space for fruits growing.

ii) The farming pattern of dairy farming with cereals and fodder

- The pattern as core is best suited to the hilly areas where many cattle have been fed at present. The irrigated farming shall be carried out for production increase of cereals and fodders. On the other hand, the waste land with gally erosion is found around the hilly land, and such waste land shall be utilized as fodder harvesting areas with cropping Rabi and Kharif fodders in mixture. This will enable to increase in number of breeding cattle. Although cattle breeding has been made in liberation or in tight with trees in the field at present, the confinement in the houses or rope-tight to the ratch shall be carried out so as to collect animal wastes which can be used for vegetable cultivation as barnyard manure in close contact with vegetable growers. In other words, the dairy farmers give animal wastes to the vegetable growers and the vegetable growers give small pieces or residues of vegetables to the dairy farmers as feeds for animals.

- The farming plan is worked out as above aiming at development of the local agriculture through fair distribution of limited water resources in effective and efficient manner.

- Under the conditions, the successful achievement of the Project will require plotting/arrangement of upland fields, construction of farm roads, enlargement of farm plots for collective works, providing village roads, etc. for comprehensive development, or construction of new villages or new rural communities. Therefore, the aforesaid farming plan plays a vitally important role as part of the total development plan of the new villages.

- And in every part the production and the marketing shall be organized for smooth activities. In particular, development from rainfed agriculture to irrigated agriculture must be made step by step. And in the early development stage, the extension organization and the experimental station will function as important organization for extension of irrigation techniques, selection of crops/cropping patterns and farming management technology. The demonstration farms will also play an important role for successful extension.

Future farming pattern with the introduction of vegetable farming in the project will be forecasted in the following progress;

Subject of Farm Management by Development Step

1st Step	-	to introduce technology of irrigation (1st
(1st- 5th year)	-	to diversify open field vegetable varieties
	-	to raise land productivity
2nd Step	-	to improve cropping techniques
(6th - 10th year)	-	to lessen open field vegetable varieties
	-	to raise labor productivity
3rd Step	-	to firmly establish farming techniques
(11th - 15th year)	-	to grow less crops in number in rotation
	-	to raise capital productivity

4.10. Agricultural Supporting Services

4.10.1. Agricultural Extension Services

1) General

The agricultural extension services in the Islamabad Capital Territory have been currently rendered by Technical Transfer Unit (TTU) of NARC. In the Capital Territory, rainfed farming has been practised in most of the farm land, and accomplishment of the proposed target in the agricultural production depends only upon a successful improvement of the extension service organization.

Further to this, the study of application of irrigation farming technology to the Project Area and the extension of the aforesaid study result to the local farmers will have a clue to success in reaching the target agricultural production.

2) Study on Application of Irrigation Farming Technologies and Training of Farmers

The Extension Center for Irrigated Agriculture should be firmly established in TTU for successful extension of the irrigation farming technology in the Project Area and uplevelling of the extension service program is quite essential for the purpose.

The study, application, and training of the irrigation farming technology shall be carried out in the system with a core of the Extension Center as shown below (see Figure 4-2).

a) Training of Agricultural Technology from the Fundamental Matters

About 1,600 sq.m will be necessary for the building spaces. The training shall be given to the local farmers and their successors with the existing facilities of the training center.

b) Application Study of Irrigation Farming Technology

The application study shall be made by eight experts belonging to the Extension Center.

The fields covered by the above experts are;

Vegetables	Staff	2
Tree-crops		1
Cereals		1
Fodder Crops & Live Stock Breeding		1
Soils & Fertilizers		1
Irrigation and Drainage Engineering		1
Farm Management		1
Total		8

Major subjects to be studied.

- Selection of crops well-suited to irrigation farming
- Irrigation standards
- Fertilization standards by crops
- Cultivation guide lines by crops
- Rotational cropping Pattern
- Farm management

c) Systematization of Application Studies by Extension Center

The cooperative studies by the experts of the Extension Center and the respective staffs of TTU shall permit the results to be readily applicable to farming in the farmers' own fields.

d) Training of Applicable Technology to Farmers' Fields

The experts of the Extension Center, with their study results, shall give lectures and training to extension workers, farmers and their successors both at the lecture rooms and on the experimental farms of the Extension Center.

e) Demonstration of the Results of Application Studies

The experts and extension workers shall give guidances and training to the farmers on the model farms for uplevelling the farming techniques of the local farmers so that the traditional Barani irrigated agriculture (rainfed/extensive agriculture) can be successfully changed into the irrigated agriculture (modernized/intensive agriculture).

The model farms shall be provided near five Division Offices and it is desirable to select the location of the model farms with the irrigation water sources available and several farmers having enthusiasm for improvement of their farming and playing an important role as local leaders.

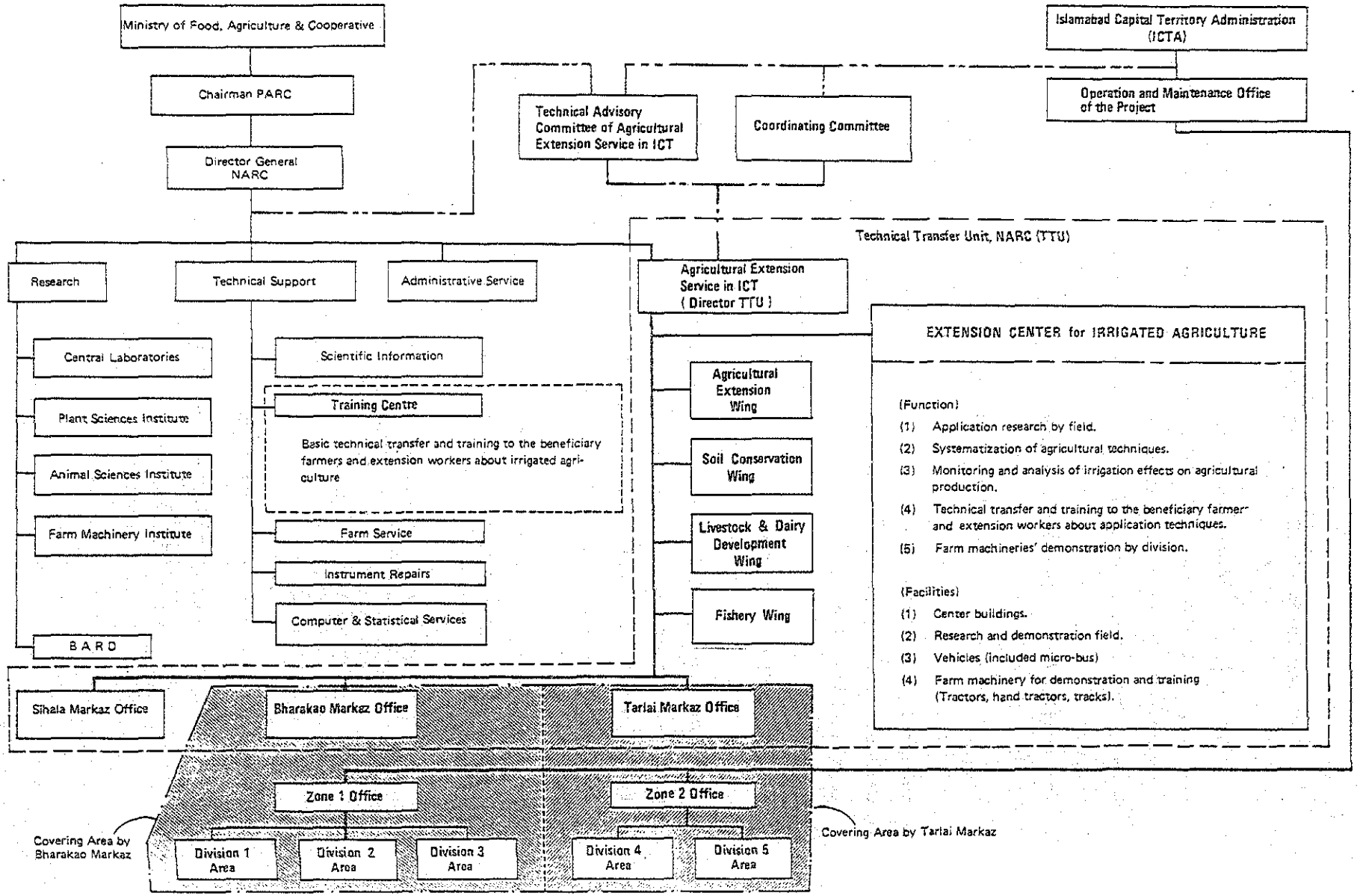
3) Extension Activities

For raising agricultural productivity and realizing the proposed target yields through irrigation, various applied techniques firmly established by the Extension Center for Irrigated Agriculture shall be diffused to the local farmers.

Such being the case, the extension services should be rendered in placing emphasis on the following matters.

- Each one of the staff specializing in such fields at least should be deployed in the extension office, as vegetables, tree-crops, other crops, livestock breeding, soils, fertilizer, farm management, and pest control, so that the appropriate and organic guidance can be given to develop the local farmers.
- Adequate guidances should be given on
  i) field irrigation techniques (irrigation and drainage),

FIGURE 4–12. PROPOSED ORGANIZATION CHART OF AGRICULTURAL EXTENSION SERVICES IN THE PROJECT AREA



ii) irrigation standards by crops (water management, water amount per one irrigation, interval periods),

iii) specific features of superior varieties by crops (varieties highly suitable to irrigated farming),

iv) irrigated farming methods by crops (planting pattern, seeding method, seedling method, training method, crop protection method, and cropping pattern),

v) fertilization method (soils analysis and timing and amount of fertilizer dosing),

vi) livestock breeding and protection methods (feeding amount, artificial insemination, diagnosis and cure of diseases),

vii) farm management (farm management checking, booking for farm management, statistical study on the market, marketing, and organization of marketing activities),

- The local farmers should be developed through practices with knowledge and techniques obtained by lectures and seminars held in the respective beneficial villages, and recommendations and advices available by training and guidance given by Extension Center.

4.10.2. Establishment of Water Users' Association

1) Purpose and Business of Water Users' Association (WUA)

Purpose : Securing fair distribution of irrigation water to the member farmers fields.

Business:
- Total and adjustment for the request of irrigation area
- Plan of water distribution
- Operation and maintenance of irrigation facilities
- Collecting irrigation fee

Organization:
Management director 1
Secretary general 1
Permanent staffs 5
(staffs for general affairs, operation and maintenance, farm management, water distribution and etc.)

2) Establishment Order of Water Users' Association

i) Obtaining of beneficiaries consent about implementation of the irrigation project.

ii) Preparation of members' list

iii) Establishment of water users' association

iv) Election of managing director and employment of permanent staffs

v) Lay down association rules

vi) Section of Water Management Group (WMG) and Farmers Group (FG) and draw up a irrigation register.

With reference to the existing Water Users' Association in Pakistan, it is necessary to investigate and arrange the details about the rules and the operation method of the WUA.

3) Supporting for the Establishment of Water Users' Association

Successful execution of irrigation projects essentially requires to establish a Water Users' Association with beneficiary farmers for securing fair distribution of irrigation water to their fields. In principle, Farmers' Group will be a fundamental unit for organization, and Water Management Group will be organized on the water diversion basis so that the farmers can be organized by Divisions as a whole.

The association unified on the Division basis should be organized into the Federation of the Water Users' Associations, which shall carry out the operation and maintenance (O & M) of the major facilities. Associations should try to make better and effective use of irrigation water in the Area together with the Operation and Maintenance Office. ICTA, with LGRD as core, shall prepare the following matter prior to implementation of the Project so as to encourage the associations to be activated in their works.

- to confirm the numbers of beneficial villages, total households and farmers,

- to study and prepare the program for organizing the associations,

- to prepare the acts, regulations and rules for the association activities under the administration of ICTA,

- to study the extent of O & M charges to be borne by beneficiary farmers,

- to have thorough public relations with beneficiary farmers on the works realized by Project, impacts and necessity of the Project,

- to bring up the educational staff of ICTA for giving training and guidance in organizing the associations, and

- to study possibility to organize the associations with function of agricultural cooperatives.

4.11. Processing/Marketing of Farm Products and Agricultural Cooperative

1) Meanings for Individual Farmers to Intend for Establishment of Agri-Cooperatives

Commonly, a lot many of producers grow many variety of crops, while a limited number of middlemen or retailors deal the farm products with the farmers. In such dealing of farm products and input materials, the farmers are apt to take much disadvantage in various matters to the merchants. Fundamentally, a trade is practised by one seller to one buyer. The farm products, however, have been dealt with many farmers to a few merchants (middlemen/retailors), and the imbalance in numbers of buyers and sellers has resulted in uneven distribution of their income.

On the other hand, when the sales of the products and procurement of input materials are not made by individual farmers but by collective farmers like cooperative organization, the products are traded at reasonable prices with the balanced power of the sellers and the buyers. Therefore, individual farmers should be organized into cooperative organizations in this point.

2) Water Users' Association with Function of Agricultural Cooperative

From the viewpoint of marketing of farm products' procurement of input materials and early/solid organization of farmers' association, the Agri-Cooperative functions should play an important role in the establishment of the water Users' Association in the project.

It will be quite impossible, however, to establish and operate successfully the Agri-Cooperatives unless the local farmers have

full recognition on demerits of sale/procurement without such organization and can raise farmers' conscious for full cooperative works. The local rainfed cropping farmers would require ample time to thoroughly understand individually the impact of the Project, which means that it will take considerably long time for the said farmers to recognize a variety of their sale/procurement problems as their common and serious problems.

Consequently, it is deemed appropriate that, with irrigation water supply, the collective works shall be promoted with marketing of vegetables and fruits farming by cooperative use of machines/facilities such as trucks, collecting yards, etc. as well as procurement of input materials (see Figure 4-13). The successful cooperatives shall be developed by collecting yards of farm products/milk provided for smooth marketing of the local farm products in the future.

FIGURE 4-13. THE STAGE DEVELOPMENT OF WATER USERS' ASSOCIATION

Operation Title	Operation during Construction Stage	Operation during Water Supply Stage	Additional Operation in the Future
1. Organization	—Obtaining Beneficiaries Consent about Implementation of the Irrigation Project (by ICTA) —Preparation of Members' List —Establishment Water Users' Association —Election of Managing Director and Employment of Permanent Staffs —Lay Down Association Rules		—Employment of Permanent Staffs
2. Operation of Joint Use Equipment and Machinery	—Section of WMG(1/) and FG(2/) and Draw up Irrigation Register —Witness the On-farm Development Works —Operation Trial for Irrigation —Joint Use of Tractors, Hand Tractors and Pickup (Tractors, Hand Tractors and Rickup are included in the Project Cost as Agricultural Supporting Facilities)	—Operation and Maintenance of Irrigation Facilities —Joint Use of Tractors, Hand Tractors and Pickup —Collection & Shipping House for Vegetables and Furuits by Village (temporary)	—Wheat Mill —Contract Farming —Nursing Seedling Plants —Collecting & Shipping House for Vegetables and Furits(permanent) 3/ —Sorting Plants for Crops —Storage for Crops —Cold Storage for Crops —Collecting & Shipping house for Livestock Products 3/ —Collecting & Shipping house for Milk —Cold Storage for Livestock Products —Milk Processing Plants —Service Station for Farm Machinery —Gas Station
3. Education/Extension Operation			—Foster for Cooperative Groups of Agricultural Production (in cooperation with Extension Center & Extension Offices) —Training Successors —Survey and Analysis about Agricultural Production Cost —Official Report (Information about Crop Prices and etc.) 3/
4. Sales Operation		—Mediation for Joint Shippingof Vegetables & Furuits (by Using WUAs' Pikup)	—Joint Sales for Vegetables & Fruits —Joint Sales fot Livestock Products —Joint Sales for Dairy Products
5. Procurement Operation		—Mediation for Procurement Fertilizers —Mediation for Procurement Pesticides —Mediation for Procurement Seeds —Mediation for Procurement Farm Machineries	—Joint Procurement for Fertilizers —Joint Procurement for Pesticides —Joint Procurement for Seeds —Joint Procurement for Feeds —Joint Procurement for Farm Machineries —Joint Procurement for Pesonal Necessaries
6. Credit Operation			—Obtain Loans for Procurement of Joint Use Equipment & Machinery —Loans for Farm Management —Saving

Note: 1/ ····· Water Management Group
2/ ····· Farmers Group
3/ ····· Priority operation in the Future

4.12. On-Farm Development Plan

4.12.1. Concept of On-Farm Development

The terminal farm size commanded by one outlet is determined through the careful study on the field investigation on topography, present land use conditions, depending upon an available topographic map of 1:21,100 in scale. Basic concept for the study is as follows;

- Average size of the terminal filed to be covered by the outlet is 40 to 50 ha (99 to 124 acres) on average.
- Boundary of the terminal farm area will be fundamentally based on division of village and administration.

Total number of on-farm areas is counted to be 136 areas, 81 areas in Upstream Area and 55 areas in Downstream Area as shown below;

Average Area of Terminal On-Farm Area

Item	Unit	Upstream Area	Downstream Area	Total
No. of On-Farm Area	Nos.	81	55	136
Total Irrigation Area	ha	3,790	2,810	6,600
Average Size of On-Farm Area	ha	46.8	51.1	48.5

4.12.2. Irrigation, Drainage and Farm Road Plan in On-Farm Area

1) Irrigation and Drainage Facilities

Water courses, which are the on-farm irrigation canals, will be provided in order to supply water through Nucca to each farm plot. The designed unit water requirements (qi) of the water courses is 1.08 lit/sec/ha(*15), and accordingly design discharge of water courses can be calculated by the following equation;

Note: *15 ... qi = 0.6 lit/sec/ha x 0.9 x 24/12 = 1.08 lit/sec/ha

$$Q = qi \times A$$

where ; qi: Designed unit water requirement, 1.08 lit/sec/ha

A: Irrigation area (ha)

On the other hand, the farm drains as terminal drainage canals will be provided at the lower side of the on-farm area to drain surplus surface water as well as to protect the farm land from soil erosion by heavy rainfall. The designed unit drainage modulus (qd) is determined to be 14.8 lit/sec/ha(*16), which corresponds to the amount of rainfall with return period of 5-years.

2) Farm Roads

Farm roads with the total width of 4.05 m (13.3 ft) (effective width of 3.05 m) will be provided in the on-farm areas, to meet the requirements for transportation of inputs materials and agricultural products and also to carry out operation and maintenance of the irrigation and drainage facilities.

Note: *16 ... $qd = 128\ mm \times 10^{-3} \times 1.0ha \times 10^{4}/86,400 = 14.8$ lit/sec/ha

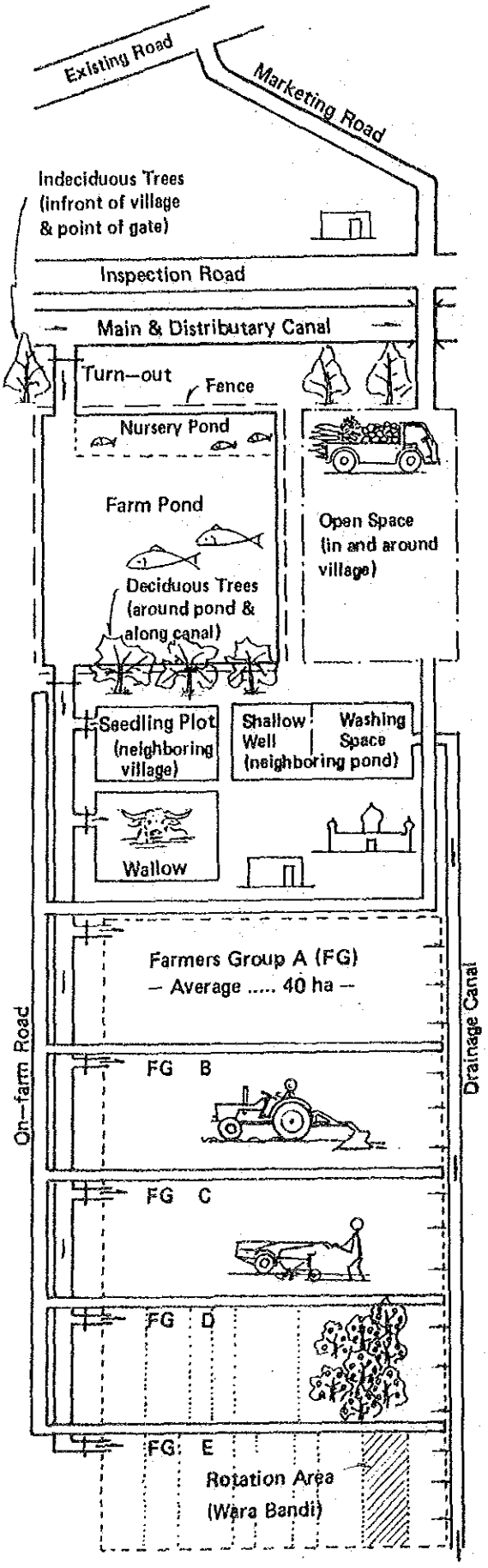
4.13. Village Development Plan

In the study area, the disparity in income and life environment level between urban areas and rural ares has become one of the serious social problems. This is caused by the difference in geographical conditions between the two and also among villages and even among households in a village. For the well balanced development of the area, it is necessary to improve the base of agricultural production and villagers' life environment.

Figure 4-13 shows a model of the water-based village development plan. Within the scope of the Project, it is intended that as many farmers as possible can have an opportunity for leading more pleasant life secured by irrigated agriculture by implementing or improving the related facilities and marketing roads which are the most fundamental agricultural production bases.

The production level of crops in the farmland is expected to rise sharply as a result of construction of irrigation facilities, organization of farmers as to water management, and technical support to farmers on irrigated agriculture and on agricultural management. Improvement of the marketing road networks will enable the farm products to be delivered in fresh and favorable condition to the consumer area as well as the increase of cash income of the farmers. The new improved marketing road network will function also as a connecting road network. It will benefit not only the farmers but also the whole residents of the Project Area, improving the social and economical environment.

FIGURE 4–14. MODEL OF THE WATER BASED VILLAGE DEVELOPMENT PLAN



FARM POND

- Keeping water with night storage for timely irrigation to crops especially vegetables.
- Growing and harvesting fish.

SHALLOW WELLS & WASHING SPACE

- Supplying drinking and domestic water for all villagers.
- Supplying washing water for vegetable.

SEEDLING PLOT

- Supplying vegetable seedlings for on time transplanting

ANIMAL WALLO

- Bathing space for buffalos and other large animals.

MULTIPURPOSE OPEN SPACE

- Collection and shipment farm products in cooperation.
- Assembly and communication space.
- Sport and game space.

TRUCKS (Owned by WMG)

- Transportation of farm inputs and products and construction materials for improvement of on-farm works, and communication between town and village.

TRACTORS OR POWER TILLERS (Owned by WMG)

- Cultivation of farm land in keeping proposed cropping pattern on time and effective water use.

OFFICE OF WATER MANAGEMENT GROUP

- Operation and maintenance of the irrigation and drainage canals covering by the territory of water management group.
- Requesting the fund for procurement and operation of agricultural service equipment to banks through the Federation of Water Users' Association.
- Negotiation with dealers to lower the price of farming equipment and input materials as well as to keep the reasonable price of products.

CHAPTER V. PROJECT FACILITIES

CHAPTER V. PROJECT FACILITIES

5.1. Dam and Reservoir Plan

5.1.1. General

The proposed K-2 damsite is located at the northeast corner of Islamabad Capital Territory and about 15 km (9.3 mil) upstream of the existing Rawal dam along the Kurang River. The village nearest to the damsite is Dohala. The K-2 Dam, which has a live storage of 18.5 MCM (15,000 acre ft), will be classified into a category of storage dam, and the purpose of the storage is to irrigate the culturable commanded area of 6,600 ha (16,300 acres). When shortage of water occurs in Rawal Dam in a drought year and K-2 reservoir has enough storage, the water stored in the K-2 reservoir will be released into the Kurang River at the rates dictated by water needs for domestic water supply.

Rawal Dam has a live storage of 53 MCM (43,000 acre ft) and its water use plan is as follows:

Water Use Plan of Rawal Dam

Item	Annual Water Demand	Maximum Monthly Water Demand (June)
Domestic Water	51.0 MCM 1/	5.3 MCM
Irrigation Water	(5.2 ") 2/	(0.5 ") 2/
Total	51.0 MCM	5.3 MCM = 176,700 cu.m/day = 2.04 cu.m/s (72 cusec)

Note: 1/ ... Including the volume of water diverted from Kurang River with diversion works located upstream from Rawal Dam.

2/ ... In case that K-2 Dam is constructed for irrigation, the irrigation water will be supplied from K-2 reservoir.

The general description of the K-2 and Rawal damsites are given hereunder on the catchment area, average annual rainfall and runoff discharge, respectively.

Catchment Area, Average Annual Rainfall and Average Annual Runoff of Kurang River

Item	K-2 Damsite	Rawal Damsite
Catchment Area	137.0 sq.km (52.0 sq.mi)	275.1 sq.km (106.2 sq.mi)
Average Annual Rainfall	1,556 mm (61.3 in)	1,411 mm (55.6 in)
Average Annual Runoff	62.1 MCM (50,340 acre-ft)	103.0 MCM (83,500 acre-ft)

5.1.2. Design Data

1) Basic Data for Design of Dam

The basic data required for planning of the dam and reservoir were collected in the Feasibility Study stage and are shown as follows;

Topographic Maps

- Topographical Map, 1/ Scale 1:50,000
- " , 1/ " 3 inches a mile
- " , Reservoir Area 2/ " 1:5,000
- " , Damsite 2/ " 1:1,000
- Profile on Axis of Main Dam 2/ " 1:500

1/ Obtained from Survey of Pakistan
2/ Surveyed during the period of Phase I Field Work

Aerial Photograph

Aerial photographs of a scale of 1/40,000 and 1/10,000 around the damsite and reservoir area were obtained from Survey of Pakistan.

Geological Maps

The following geological maps are obtained from Geological Survey of Pakistan.

- Geological Map of Pakistan, Scale 1 : 2,000,000
- Geological map of Islamabad, Scale 1 : 50,000
- Seismic Risk Map of Northern Pakistan, Scale 1 : 1,000,000

Foundation Exploration

Core drillings at the damsite were commenced early October 1987, by using a drilling rig provided by JICA. The investigated quantities of the core drilling and rock tests were made as follows;

- Core Drilling
  - Left Abutment ..... Depth 40 m (131 ft)
  - River Bed ..... " 51.3 m (168 ft)
  - Right Abutment ..... " 40 m (131 ft)
  - Right Abutment Saddle .. " 30 m (98 ft)
- Field Permeability Test 30 Nos.
- Rock Tests
  - Specific Gravity/Absorption Test 12 Nos.
  - Unconfined Compression Test 12 Nos.

Construction Materials Investigation

For the embankment materials investigation for fill dams, five test pits were excavated at the places as shown in Figure 5-5. Three samples for impervious material and two samples for random materials were obtained from the test pits and the following laboratory tests were made according to ASTM.

Physical Tests:

- Specific Gravity ..... ASTM D854 5 Nos.
- Moisture Content ..... ASTM D2216 5 Nos.
- Gradation ..... ASTM D422 5 Nos.
- Liquid Limit ..... ASTM D423 5 Nos.
- Plastic Limit ..... ASTM D424 5 Nos.

Mechanical Tests:

-	Compaction Test	ASTM D698	5 Nos.
-	Compaction Test	ASTM D1557	2 Nos.
-	Permeability Test	ASTM D2434	5 Nos.

Salient Features of Existing Dams

Salient features of Rawal Dam and Simly Dam existing in the Islamabad Capital Territory are shown in Table 5-1.

Compensation of Reservoir Area

The reservoir area of K-2 Dam at the maximum water level of EL.649.8 (2,131.9 ft) is about 300 ha (740 acres), and the reservoir site costs for the following items will be required (see Figure H-5).

- Land Acquisition

Cultivated Area	:	130 ha (320 acres)
Uncultivated Area	:	170 ha (420 acres)

- Relocations of Existing Facilities

Residence	:	125 Nos.
Satra Mile - Angori Road	:	4.2 km 1/
Power Transmission Line (135 KV)	:	1.2 km 1/
" (11 KV)	:	7.0 km 1/,2/

- Population : about 780

1/ ... Length to be newly constructed
2/ ... Based on rough estimation of WAPDA (Islamabad)

3) Sedimentation in the Reservoir

Sedimentation in the K-2 reservoir was estimated on the basis of the sediment in Rawal Dam which was measured by Irrigation Research Institute of Punjab Government.

Observed Sediment in Rawal Dam

Year	Passed Years after Completion of Dam (Years)	Accumulated Sediment (MCM)	Average Specific Annual Sediment (cu.m/sq.km/year)
1962	0	0	0
1966	4	7.71	7,010
1972	10	8.57	3,120
1984	22	11.04	1,820

The above table shows that an average specific annual sediment in the Rawal Dam has a decreasing tendency every year. The sedimentation in the K-2 reservoir will be estimated by the following equation.

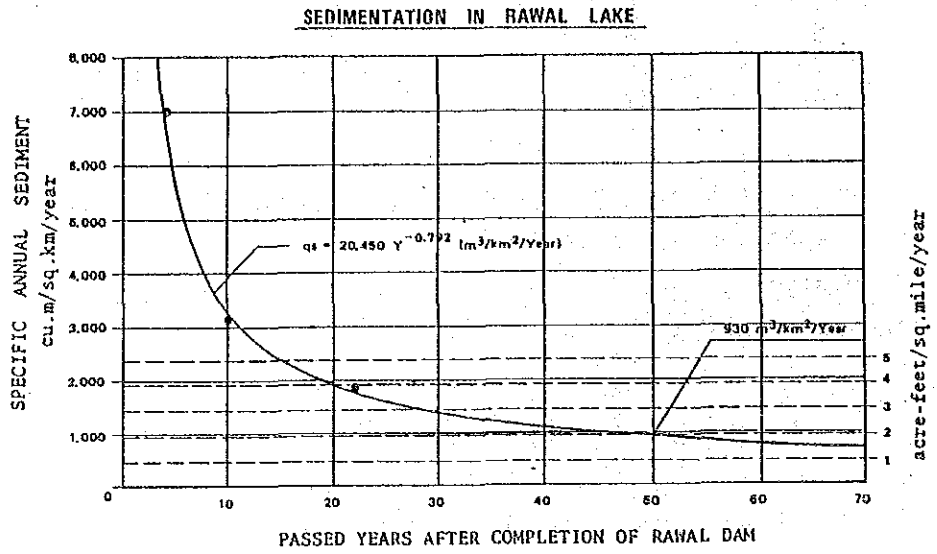
Design Sediment (cu.m)
= Specific Annual Sediment (cu.m/sq.km/year)
x Catchment Area (sq.km) x Design Period of Sediment (50 years)

The average specific annual sediment in 1984, the latest year of observation, was 1,820 cu.m/sq.km/year (3.82 acre ft) and the value of specific annual sediment in case of the design period of 50 years will be less than this value. Relation between the past year (Y) after completion of the dam and the average specific annual sediment (qs) will be expressed in the form of exponential function as shown in the following figure, and thus, the specific annual sediment in case of the design period for 50 years is estimated to be 930 cu.m/sq.km/year (1.95 acre ft/sq.mile/year). However, this value should be understood as the lowest value because of insufficiency of the observed data. Accordingly, the specific annual sediment of 1,500 cu.m/sq.km/year (3.15 acre ft/sq.mile/year) is adopted.

Design Sediment:

Qs = 1,500 cu.m/sq.km/year x 137 sq.km x 50 years
= 10.3 MCM (8,350 acre ft)

The lowest invert of the irrigation outlet is decided at EL.637 m (2,089.9 ft), so that K-2 Dam has the dead storage of 10.9 MCM (8,840 acre-ft).



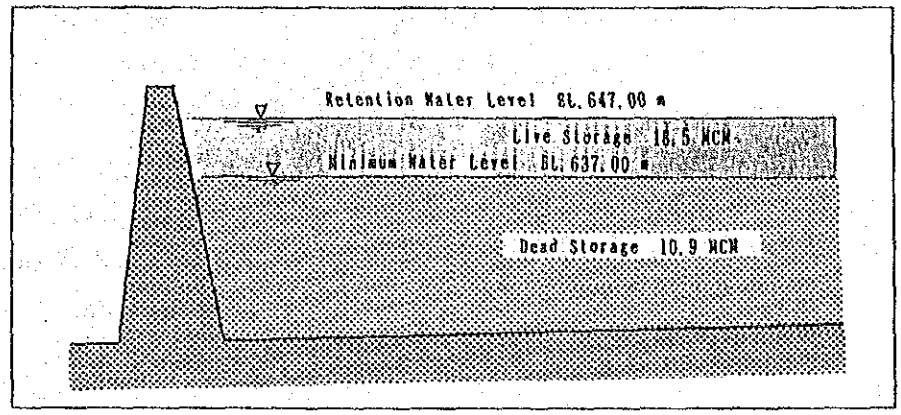
4) Reservoir Size and Functional Purpose of the Dam

Reservoir Size Limitation

The facilities of Ministry of Defence and Chattar Garden face the Murree road in the Chattar village located north of the K-2 Dam, and the relocation of the Murree road in that area seems difficult. In such conditions, it was decided that the water level should be less than EL.650 m (2,132.5 ft) because the existing facilities should remain unremoved at maximum. The spillway design head was expected to be about three meters, and then the possible highest retention water level was decided at EL.647 m (2,122.7 ft).

Reservoir Size

In considering the practical and physical limit of the K-2 reservoir, the reservoir size was decided by the paragraph of 4.2 entitled "Optimum Scale of Project" is as follows;



Functional Purpose of K-2 Dam

As shown in Figure 5-2, K-2 reservoir is formed by a main dam to be constructed across the Kurang River and a saddle dam on saddle of left bank. In this dam plan, the following two outlet works, irrigation outlet works and river outlet works, are necessary.

- Irrigation Outlet Works

  The irrigation outlet works will be provided under the saddle dam and stored water will be released to the irrigation main canal by gravity flow. The maximum irrigation outlet capacity is 3.96 cu.m/sec (140 cusec).

- River Outlet Works

  When shortage of water is occurred in the Rawal Dam in a drought year, water stored in the K-2 reservoir will be released at such rates as dictated by downstream needs. Maximum monthly water demand of the Rawal Dam, which will be occurred in June, is 5.8 MCM corresponding to 176,700 cu.m/day and 2.04 cu.m/sec, so that the maximum river outlet capacity is decided to be 2.04 cu.m/sec (72 cusec).

In addition, it is necessary to provide those facilities of the spillway with design capacity of 1,840 cu.m/sec (66,100 cusec) and the diversion tunnel with the design capacity of 690 cu.m/sec (24,800 cusec) for diverting floods during the construction period.

5.1.3. Topography and Damsite Geology

1) Topography

The left and right abutments of the main damsite present quite a different topography each other. The left abutment is composed of alternated sandstone and mudstone, and shows the ridge and trough topography because of the differentiated erosion and the high angle inclination of strata.

The right abutment shows table-shaped hill having one or two terrace halfway up the hill. The width of the river bed is 40 to 50 m (131 to 164 ft).

The reservoir area is located at and around the confluence of right and left tributaries of the Kurang River.

The narrow terrace lies on the both banks of the river flowing into the reservoir area. In the reservoir area, the broad flat land is sat on the left bank, so that it will be possible to obtain economical storage capacity although the saddle dam is required. However, this broad flat land is used as farmland at present and the farmland of about 130 ha (320 acres) will be submerged by construction of the dam.

2) Damsite Geology

The base rock of damsite and reservoir area is hard sandstone and relatively soft mudstone of Murree formation with minor part of intercalated pseudo-conglomerate and laminated sandstone.

As the results of unconfined compression tests of rock cores, the compression strengths of sandstone and mudstone are as follows;

Sandstone : 50 - 1,100 kgf/cm^2
Mudstone : 20 - 80 kgf/cm^2

Lugeon values of the mudstone zone except the portion near the ground surface are generally less than three and indicate that those zones have a relatively high watertightness, but the sandstone zone, especially the boundary with the mudstone, has a relatively high permeability. As shown in Figure 5-4, the overburden is composed of terrace deposits, residuals and river deposits.

Left abutment consists of the alternated sandstone and mudstone which include the muddy sandstone, and both of them have the thickness of 5 to 12 m (16 to 39 ft).

The value of schmidt hammer backlash of the hard sandstone demonstrates to be 50 to 55. On the other hand, the mudstone indicates the value of 20 - 30 at the point of fresh exposure, but the weathered part and cracky part have the value under 10.

In the right abutment, top of the hill is overburdened by upper terrace deposit and middle or lower terrace deposit covers the bed rock at the place where is 5 - 35 m (16 - 115 ft) high from river bed. The slope surfaces are overburdened by relatively thick talues deposit. The upper terrace deposit of about 5 m (16 ft) thick is composed of relatively well-sorted pebble and cemented partially by limy matrix. On the other hand, the middle-lower terrace deposit of 8 - 10 m (26 - 33 ft) thick in maximum is composed of silty soil as matrix and gravels ranging from granule to boulder.

The direction of bed rock at the left bank side and the downstream area from dam axis is almost uniform having the N40° - 60°E of strike and 70° - 90°NW of dip, although they have many gently folded curve. But at the upstream part of right bank side from dam axis, the direction of bedrock changes to N60°E - NW of strike and 50° - 70°S of dip. Moreover the upper direction of formation judged from the cross-lamination, is NE at the downstream area from the dam axis and is S-SW at the upstream area.

Two sheared zones of 40 - 50 cm (1.3 - 1.6 ft) wide run in the direction of NE-SW at the right side of river bed on the dam axis. Furthermore, relatively large scale of sheared zone runs behind the table-shaped hill of right abutment. Furthermore, the faults are assumed to exist along ravine on the right bank and the river bed of the Kurang River.

5.1.4. Construction Material

Embankment Materials

The rocks and soils around the damsite are composed of Residuals, Loess, Terrace deposit, sandstone, and mudstone of Murree formation. There are no materials suitable for filter zone of embankment dams and concrete aggregate around the damsite, so that those materials are planned to be provided by the Contractor. Suitable materials as rock material are sandstone strata and boulder contained in the terrace deposits, but it will be difficult to obtain the sandstone economically because the base rock of the damsite and its surrounding area is composed of the alternated sandstone and mudstone.

Residuals and/or Loess are planned as impervious material of embankment dams, and terrace deposit as random material. Then the test pit and auger boring were excavated at the borrow area shown in Figure 5-5. And soil test was carried out using the sample obtained from the test pits.

Impervious Materials

Residuals and Loess exist sufficiently around villages of Sakrila, Dohara and Malatha. These are the fine soil of a silty nature as shown in grading curve as shown in Figure 5-6, and classified into CL on unified soil classification.

They have sufficient imperviousness and relatively high maximum dry density (1.77 - 1.86 t/cu.m), but they are materials being easily developed by cracks, when they are dried, because they are of silty nature and of low plasticity.

As the height of the dam is relatively high (50 - 60 m), they are recommended to mix with terrace deposit with high gravel percentage for the following improvement of their properties.

- To make the possibility of development of cracks low by improving their gradation.
- To increase the shear strength and to improve the deformation characteristics by increasing their gravel percentage.

Random Materials

Terrace deposit which is in limits of adequate gradation as semipervious material is suitable for random material. This material being classified into GM has gravel of 64 percent and fine material of 11 percent, and its maximum dry density is 2.05 t/cu.m.

Although terrace deposit is distributed widely along the Kurang River, necessary quantity for dam embankment will be obtained from excavations for spillway and dam.

5.1.5. Selection of Damsite and Type

1) Selection of Damsite

The left and right tributaries of the Kurang River, which have almost the same catchment areas in the acreage, join at the place of about 700 m (2,300 ft) upstream of the proposed K-2 damsite.

In the case that the K-2 reservoir with live storage of about 20 MCM (16,210 acre ft) is planned, the K-2 damsite should be selected at the site downstream of the confluence to ensure sufficient runoff for the successful reservoir plan.

The suitable site of the K-2 Dam having the gross storage capacity of 29.4 MCM (23,830 acre ft) can be found only in the area shown in Figure 5-2 judging from topographic conditions of the area downstream of the confluence. The saddle dam of about 750 m (2,460 ft) length in the village of Sakrila located on the left bank of the Kurang River will be required.

2) Selection of Dam Type

The valley at the K-2 damsite is wide with the width-to-height ratio by 9 at EL.650 m (2,132.5 ft). Based on the cross section of embankment dam and concrete gravity dam as shown in Figure H-7, the volume of the both embankment dam and gravity dam and construction costs are tentatively estimated as shown below;

Embankment Dam: 1,900,000 cu.m x 190 Rs/cu.m = 360 million Rs.
Gravity Dam : 300,000 cu.m x 1,200 Rs/cu.m = 360 million Rs.

In the case that the dam foundation is composed of sound rock, there is little difference for the construction costs between the embankment and concrete gravity dams.

The foundation of the dam is composed of alternated sandstone and mudstone, and the both have the thickness of 5 - 12 m (16 - 39 ft). Sandstone is hard and mudstone is comparatively soft. Although the bearing capacity and shear strength of the foundation will be enough for embankment dams of 50 - 60 m (164 - 197 ft) high, the foundation will not be suitable for the construction of concrete gravity dams with the same height in the following reasons;

- Assuming that shear strength of a rock corresponds to 1/6 of the compressive strength, that of the mudstone will be 3 - 13 kgf/cm^2. On the other hand, concrete gravity dam of 50 - 60 m (164 - 197 ft) high will require the foundation with shear strength of 10 - 15 kgf/cm^2 to obtain the shear-friction factor of safety of 4, so that it may be impossible for the mudstone to ensure the required sliding stability.

- The dam is to be constructed on the foundation comprised of alternated sandstone and mudstone. Mudstone has high deformation characteristics, so that large tensile stresses will be developed in the dambody due to excessive deformation of the dam and foundation in case of the construction of concrete gravity dam.

As mentioned above, the concrete gravity dam does not take economical advantage to the embankment dam, and the foundation of the dam will not be suitable for the construction of concrete gravity dam. And the embankment dam is adopted for the Project.

5.1.6. Preliminary Design

1) Dam

The K-2 Dam is planned as a zone type earth dam in taking into consideration the properties of materials available from the borrow areas around the damsite and spillway. Because the foundation of the dam consists of alternated sandstone and mudstone with much different deformation characteristics, moderately sloping impervious core, which gives an even bottom pressure distribution below the fill downstream of the core, is adopted. Stability of the upstream section of the dam will be influenced directly by the fluctuation of the reservoir water level, so that the portion of the upstream section being higher than the minimum water level of the reservoir is designed as pervious zone to minimize such influence.

The upstream slope is protected against wave action by riprap and also the downstream slope against erosion from wind and rainfall runoff by riprap.

The base rock of the K-2 Dam has in general a relatively high watertightness, but the sandstone zone, especially the boundary with the mudstone, has a relatively high permeability. To prevent storage water from leakage through the portions with high permeability and piping, curtain grouting works are planned under the core zone, and blanket grouting works is planned additionally for the river bed to receive high water pressure.

Preliminary design of the dam is shown in attached Drawing No. D-1003.

2) Spillway

Spillway Capacity

The spillway capacity is 1,840 cu.m/sec (66,100 cusec) as decided in paragraph 3.2.3 on "Hydrology".

Spillway Type

The left abutment of the ridge and trough topography are not suitable for the construction of the spillway, but there is no topographic limitation on the right bank of the Kurang River. Accordingly, the spillway route is selected on the right bank. As the K-2 Dam is a storage dam for irrigation, the ungated spillway is selected in the following reasons with advantages.

- Operation is done automatically and without trouble.
- Less maintenance cost is required because of its ability to function without gate operations.
- Construction is less complicated.

The maximum water level of K-2 reservoir should be lower than EL.650 m (2,132.5 ft) due to the topographic conditions. As the retention water level was decided to be EL.647 m (2,122.7 ft), the design head of the spillway should be less than three meters. Judging from the topographic conditions on the right bank for the spillway construction, a chute spillway with longer crest than a side channel spillway is adopted.

Spillway Crest Length

The spillway crest length required to release safely the design flood of 1,840 cu.m/sec is given by the following formula:

$$B = Qd/Cd \times Hd^{3/2}$$
$$= 1,840/2.1 \times 2.8^{3/2} = 187 \text{ m} \leq 189.4 \text{ m} \quad \text{(Design Length)}$$

where;

Qd = Spillway Capacity (cu.m/sec)

Cd = Coefficient of Discharge

Hd = Design Head (m)

Energy Dissipator

The hydraulic jump basin of USBR type II, which is 72 m (236 ft) long, is adopted as an energy dissipator.

The preliminary design of the spillway is shown in Drawing No. D-1004.

3) Outlet Works

In the dam plan, two outlet works, irrigation outlet works and river outlet works, are necessary.

- Irrigation Outlet Works

  The irrigation outlet works serve to release water stored in the K-2 reservoir at such rate which will be dictated by needs of the culturable commanded area into the irrigation main canal, and the maximum irrigation outlet capacity is decided at 3.96 cu.m/sec (140 cusec). This outlet works will be provided under the saddle dam by open excavation and its structure will be concrete encased 1.5 m (4.9 ft) diameter steel pipe conduit.

  An emergency gate will be provided with the upstream portion of the conduit for inspection and to repairs. At the downstream end of the conduit, a jet flow gate will be provided to regulate the discharge. A stilling basin will be provided at the downstream end of the outlet works for absorbing the energy of the flow.

  The preliminary design of the irrigation outlet works is shown in Drawing No. D-1005.

- River Outlet Works

  The river outlet works serve to release water stored in the K-2 reservoir at such rates which will be dictated by the downstream needs into the Kurang River, and the maximum river outlet capacity is 2.04 cu.m/sec (72 cusec). The outlet works is planned to be provided in the right abutment of the main dam, so that safety of the river outlet ensures directly safety of the dam. The outlet works are planned to be as a tunnel conduit with steel liner pipe of 1.0 m (3.3 ft) diameter for higher safety than cut-and-cover conduit. By the same reason as the case of the irrigation outlet works, an emergency gate and a flow gate will be provided; the former at the upstream end and the latter at the downstream end of the conduit, respectively. The flow through the regulating gate is to be discharged into a hydraulic jump-type basin to absorb the energy of the flow and then it will be released into the stilling basin of the spillway through pipe in two rows.

  The preliminary design of the river outlet works is shown in Drawing No. D-1006.

4) Diversion during Construction

The diversion flood during construction period is estimated at 690 cu.m/sec (24,800 cusec). The width of the river at the damsite

is only 40 to 50 m (131 to 164 ft), and a provision of temporary diversion channel through the embankment is not possible. Accordingly, a circular diversion tunnel with 9.0 m diameter (29.5 ft) is planned to be provided in the right abutment of the main dam.

Preliminary design of the diversion tunnel is shown in Drawing No. D-1007.

TABLE 5-1. SALIENT FEATURES OF EXISTING DAMS

Items		Rawal Dam	Simly Dam
River		Kurang	Soan
Catchment Area (sq.km)		275.1	152.8
" (sq.miles)		106	59
Reservoir			
Maximum Water Level	(ft)	1,761	2,320
Retention Water Level	(ft)	1,752	2,295
Minimum Water Level	(ft)	1,708	2,233
Gross Storage Capacity	(MCM)	58.6	35.5
"	(acre-ft)	47,500	28,750
Live Storage	(MCM)	53.0	24.7
"	(acre-ft)	43,000	20,000
Dead Storage	(MCM)	5.6	18.5
"	(Acre-ft)	4,500	15,000
Main Dam			
Type of Dam		Gravity[1/]	Rockfill
Top of Dam	(ft)	1,763.5	2,330
Dam Height	(ft)	133.5	263
Length of Dam	(ft)	700	1,010
Top Width	(ft)	14	30
U/S Slope of Dam		1:0.04	1:3.00-2.25
D/S Slope of Dam		1:0.675	1:1.75-1.5
Design Acceleration Force		0.1	0.19
Freeboad above Maximum WL (ft)		2.5	10
Spillway[2/]			
Type		Gate-Controlled	Uncontrolled
Capacity	(m^3/s)	2,320	1,280
"	(cusec)	82,000	45,000
Crest Elevation	(ft)	1,742	2,300
Design Head	(ft)	19	20
Length of Crest	(ft)	240	110
Max. Probable Flood	(m^3/s)	3,400	2,570
"	(cusec)	120,000	90,689
Construction			
Commenced		1,959	1,972
Completed		1,962	1,982

1/: Rawal Dam has a saddle dam of rolled earth embankment.
2/: Simly Dam has a fuse plug spillway of 400 feet long and 12 feet high.

TABLE 5-2. SALIENT FEATURES OF K-2 DAM

Location		North-East Corner of ICT	
River		Kurang River	
Catchment Area		137.0 sq.km :	52.9 sq.mi
Reservoir			
Maximum Water Level		649.8 m :	2,131.9 ft
Retention Water Level		647.0 m :	2,122.7 ft
Minimum Water Level		637.0 m :	2,089.9 ft
Gross Storage Capacity		29.4 MCM :	23,830 acre-ft
Live Storage Capacity		18.5 MCM :	15,000 acre-ft
Dead Storage Capacity		10.9 MCM :	8,840 acre-ft
Dam		Main Dam	Saddle Dam
Type of Earth Dam		Zoned	Modified Homogeneous
Top of Dam	(m)	652.8	652.8
Dam Height	(m)	53.0	12.0
Length of Dam	(m)	490.0	750.0
Top Width	(m)	9.0	9.0
U/S Slope of Dam		1:3.0	1:3.0
D/S Slope of Dam		1:2.5	1:2.5
Volume of Dam (m^3)		1,870,000	190,000
Spillway			
Type		Uncontrolled (Ungated)	
Capacity		1,840 m^3/s :	66,100 cusec
Crest Elevation		647.0 m :	2,122.7 ft
Design Head		2.8 m :	9.2 ft
Length of Crest		189.4 m :	621.4 ft
Diversion Tunnel			
Diversion Flood		690 m^3/s :	24,800 cusec
Diameter		9.0 m :	29.5 ft
Length		435.0 m :	1,430.0 ft
Outlet Works		Irrigation Outlet	River Outlet
Functional Purpose		Irrigation	Supplemental water supply to Rawal Lake
Design Capacity (m^3/s)		3.96	2.04
Type of Structure		Concrete Encased Pressure Pipe Conduit	Tunnel with Steel Liner Pipe
Diameter (m)		1.50 - 1.20	1.00 - 0.80

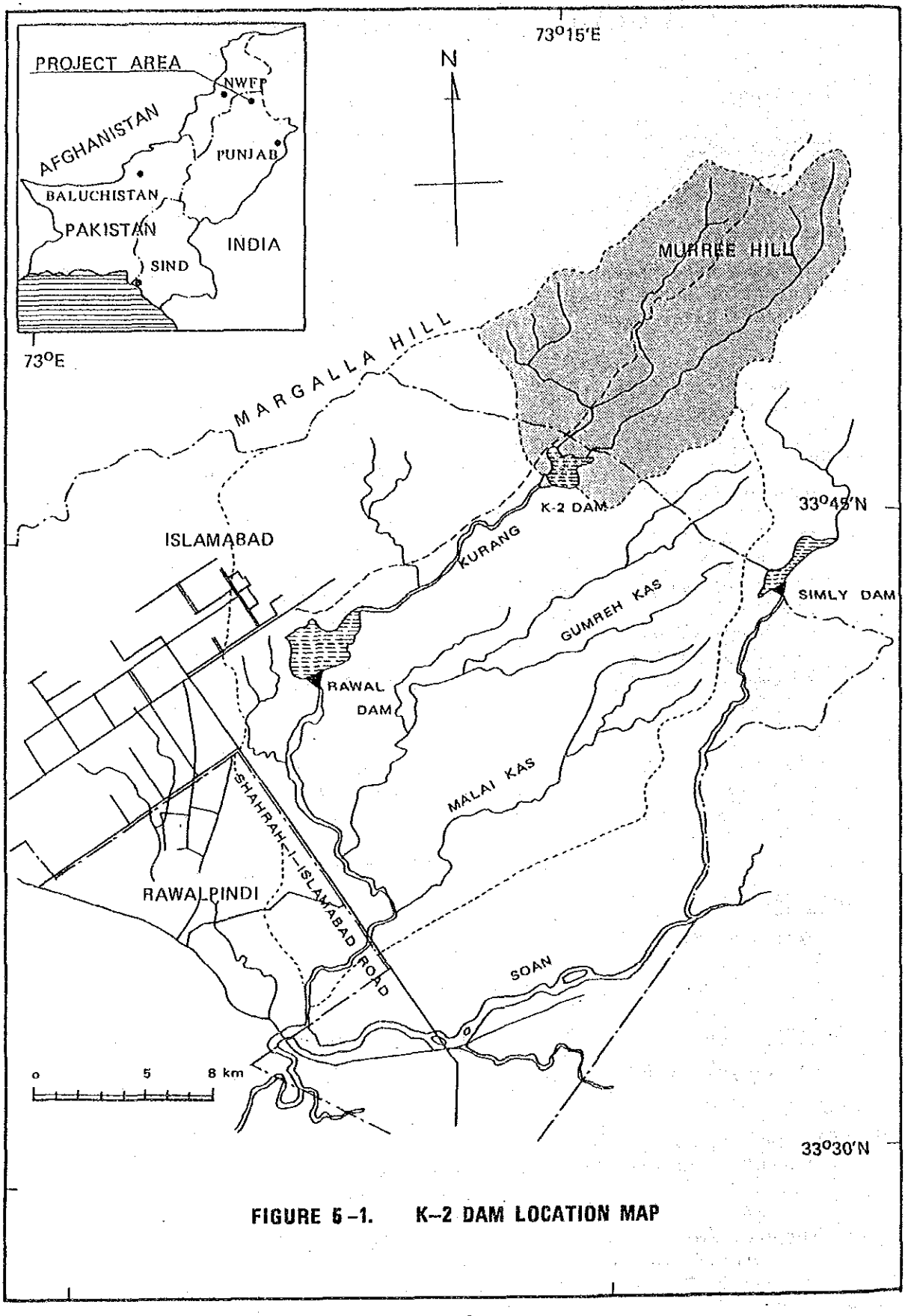


FIGURE 5-1. K-2 DAM LOCATION MAP

FIGURE 5–2. K–2 DAM GENERAL PLAN

FIGURE 5-3. SURFACE GEOLOGY OF DAMSITE

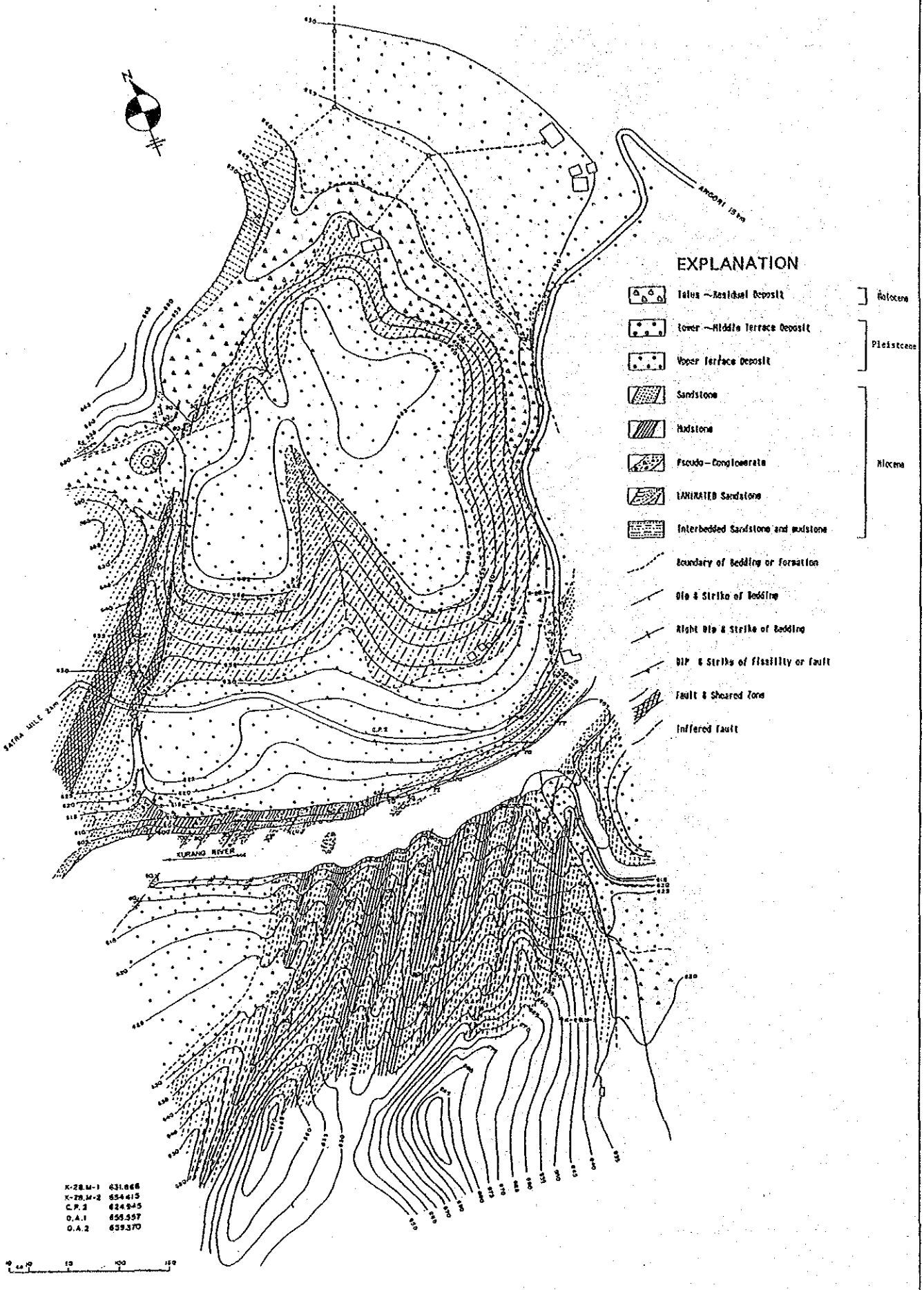
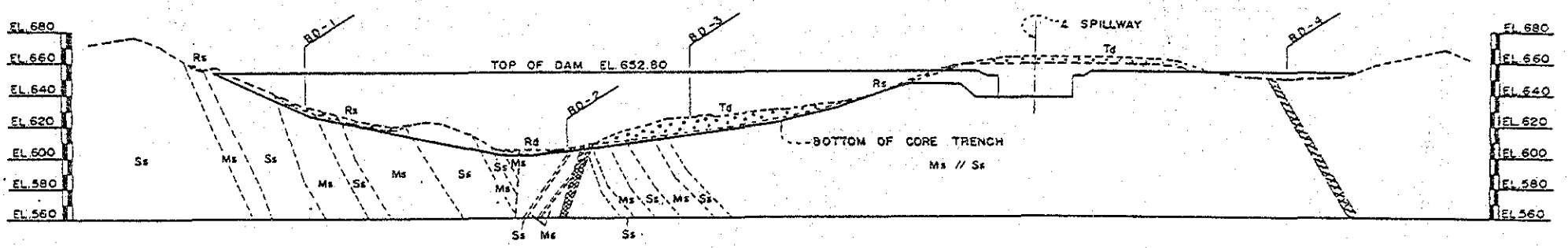


FIGURE 5–4. GEOLOGIC SECTION ALONG THE CENTERLINE OF MAIN DAM



SCALE

50 0 50 100m

LEGEND

Rd	River deposit	Holocene
Rs	Residuals	Holocene
Td	middle–Lower Terrace deposit	Pleistcene
Td	Upper Terrace deposit	Pleistcene
Ss	Sandstone	Miocene
Ms	Mudstone	Miocene
Ms/Ss	Mudstone–Sandstone–Alternation	Miocene

Fault and Sheared Zone

Inferred fault

Boundary Of layer

FIGURE 5–5. LOCATION OF EXPLORATIONS FOR DAMSITE & BORROW AREA

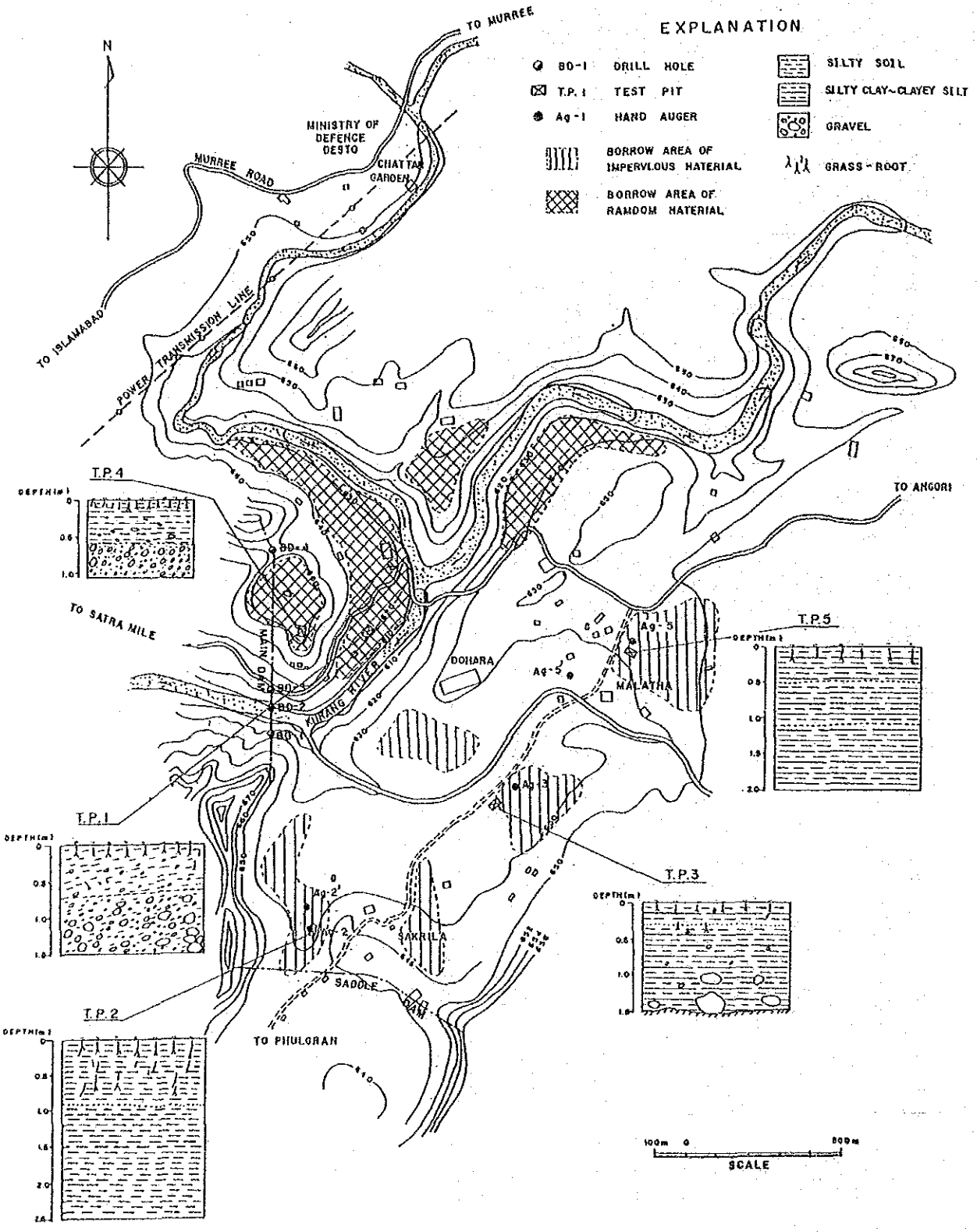
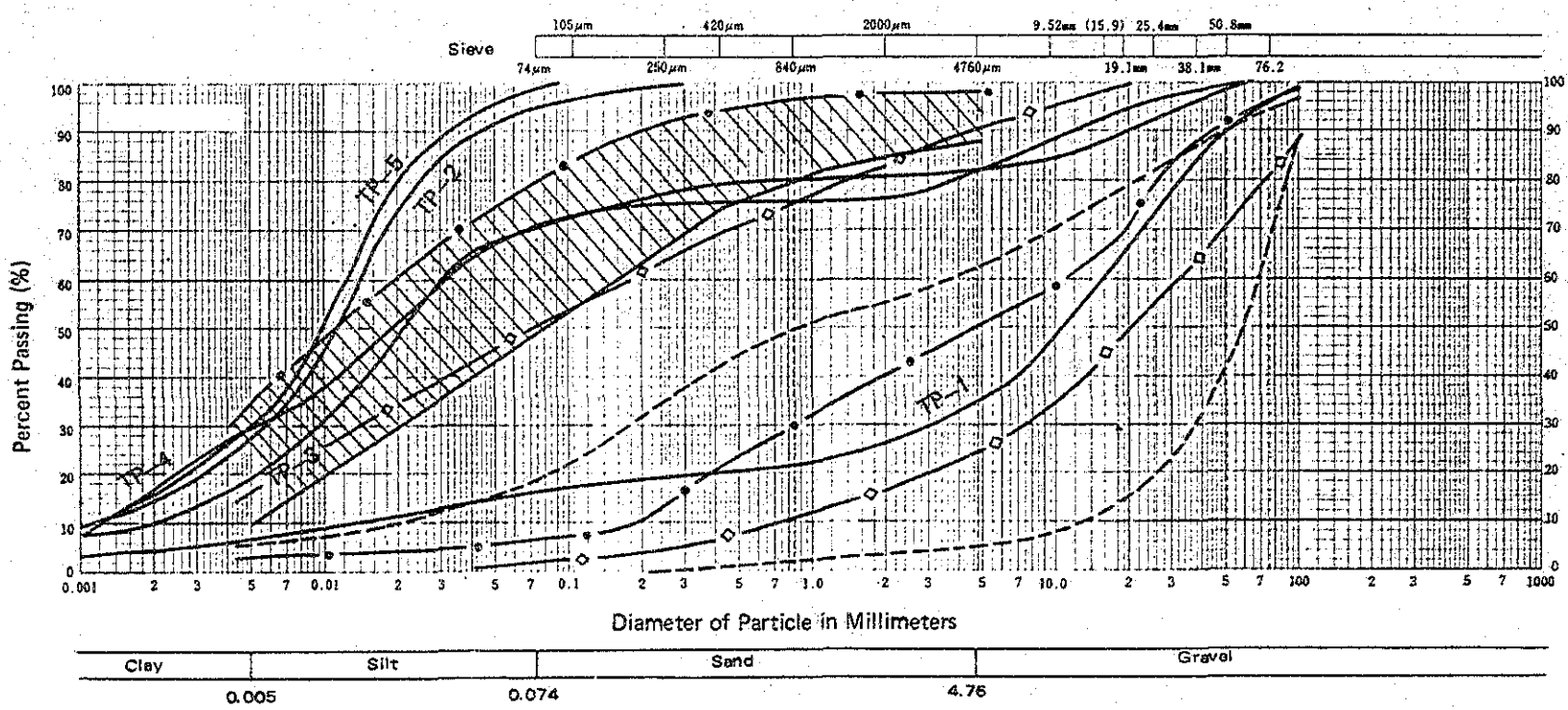


FIGURE 5–6. SOIL GRADATION



Size Limits in which Cracking may Occur

Size Limits for Reasonably Well–Graded, Impervious Material

Size Limits for Reasonably Well–Graded, Semi–Pervious Material

Size Limits for Reasonably Well–Graded, Pervious Material

5.2. Irrigation System Plan

5.2.1. Irrigation Canal Networks

1) General

The main water resource for irrigation in the Project is the water flow of the Kurang River running through the area upstream of the existing Rawal Dam and the river water will be utilized as irrigation water for the culturable commanded area of 6,600 ha (6,300 acres) by providing K-2 Dam and the irrigation canal networks as shown in Figure 5-7.

On the other hand, the supplemental water resources are the base and return flow discharges of the Kurang River and Gumreh Kas River which flow through the area at the downstream of the Rawal Dam. The discharge is estimated at about 1.0 cu.m/sec (35 cusec) in total and can irrigate about 800 ha (1,977 acres) of the upland area, provided that 50 percent of the discharge is available for irrigation. In this case, however, the diversion dams and pump stations proposed in the Master Plan will be required due to the constraint of topographic conditions.

The irrigation water required for the upland area along the Kurang River and the Gumreh Kas River could be supplied sufficiently from stored water in the K-2 reservoir without using the base and return flow discharges of those rivers, and the irrigation plan with the diversion dams and pump stations is eliminated due to costly maintenance, accordingly.

2) Topography and Geology

The Project Area is divided into two areas, the Upstream Area and Downstream Area of the Rawal Dam by the topographic conditions.

The Upstream Area is composed of hill ranges running from NE to SW and relatively undulated land. The topography along the rive is characterized by the dendritic drainage pattern and many abrupt cliffs, which are created due to erosion by surface runoff from heavy rainfall in short time flowing on the ground of low infiltration capacity with geologically vertical structure of Loess soil. Hard sandstone bed with nearly vertical inclination makes many small but long and narrow residual rock hills called "horseback" in the area.

On the other hand, the Downstream Area consists of alluvial flat lands as a whole. The area has also gully topography in some parts, but its relief is small.

The geology along the proposed canal alignment is semi-consolidated deposit of Loess, Residuals or River deposit. At the representative area on the proposed canal alignment, seven test pits were excavated. The logs of the test drilling are shown in Annex C.

3) Proposed Alignment of Main and Branch Canals

The proposed alignment of the irrigation canal is decided on the results of the study by using topographic maps with a scale of 1/21,100 and the field survey. The total length of the proposed irrigation canals is about 130 km (81 mi). The route survey was carried out for the main, 1st branch, and a part of 6th branch irrigation canals for their total extension of about 35 km (22 mi). The original ground surface of the remaining portions shown in the attached Drawings can be estimated from the topographic maps of 1/21,100.

In the Upstream Area, the Kurang River, the main course of the Gumreh Kas River and its right side tributary run roughly in parallel in the distance of 10 to 15 km (6 to 9 mi) in the direction of NE-SW. Consequently, the area can be divided into five sub-areas as presented below, and the irrigation canals are planned at the elevated location of each sub-area:

Canals in the Upstream Area

Sub-Area			Name of Canal
- Kurang River	:	Right Bank Area	Branch Canal No.1
- -do-	:	Left Bank Area	Branch Canal No.2
- Gumreh Kas Right Tributary	:	Right Bank Area	Main Canal
- -do-	:	Left Bank Area	Branch Canal No.4
- Gumreh Kas	:	Left Bank Area	Branch Canal No.3

On the other hand, Downstream Area of the Rawal Dam can be divided into the following three areas by topography and proposed irrigation canal networks for the Upstream Area;

Canals in the Downstream Area

Sub-Area	Name of Canal
- Right Bank Area of Kurang River	Branch Canal No.6
- Left Bank Area of Kurang River & Right Bank Area of Gumreh Kas	Main Canal and Branch Canal No.5
- Left Bank Area of Gumreh Kas	Branch Canal No.3

In addition to the above listed main and branch canals, distributaries and minor canals will be provided to convey irrigation water to the turnouts commanding the unit irrigation areas of approximately 50 ha each. The proposed canal alignment is shown in Figure 5-7 and the attached Drawing No. C-1001.

The irrigation water for the upland area at the foot of the Margalla hill in Bharakao will be supplied through a planned pump station at the downstream end of 1st branch canal.

In order to introduce the irrigated agriculture in the upland area with crops of vegetables, tree fruits, cereals, and fodders, the water conveyance system should be designed to meet the following design criteria;

- to supply the irrigation water within 12 hours in the daytime,

- to provide the farm ponds for easy water management,

In determining the best available water conveyance system to fulfill the requests mentioned above, the two plans as shown in Figure 5-8 are studied.

Distribution Plan I:

The farm pond is planned with a storage capacity to meet 50 percent or more than 50 percent of the maximum daily irrigation water required for the upland irrigation of its commanded area. And the irrigation canals of the main and branches provided in the upstream area of the farm pond can convey the required daily irrigation water throughout the day. The unit design discharge of these canals will be 0.6 lit/sec/ha.

Distribution Plan II:

The farm pond is planned with a storage capacity to meet the maximum daily irrigation water requirements of about 3/24 for the upland irrigation of its area commanded. This storage capacity will be the minimum for the farming in the upland areas. Therefore, the irrigation canals should convey the required daily irrigation water within 12 hours in the daytime. The unit design discharge of the irrigation canals will be 2 x 0.6 lit/sec/ha. A regulating reservoir is planned with the capacity of about 150,000 cu.m to meet 50 percent of the maximum daily irrigation water for the upland areas in the downstream of the regulating reservoir. And it will be provided on the route of main canal in the village of Athal. The main canal running through the upstream area of the regulating reservoir can convey the water throughout the day and the unit design discharge will be 0.6 lit/sec/ha accordingly.

Rough cost estimation of those two plans was made and the results are as follows;

Rough Cost Estimation of Canal Works

(unit: '000 Rs.)

Plan	Canal	Farm Pond	Reservoir	Total
Distribution Plan I	143,100	5,900	-	149,000
Distribution Plan II	165,700	3,300	2,200	171,200

In the project, the Distribution Plan I is adopted because it is less in construction cost and easier in management of the water distribution than those of the Distribution Plan II.

5.2.2. Preliminary Design of Canals and Related Structures

1) Water Conveyance System

In general, canal types can be classified into two by open flow type and closed flow type. The open flow type is adopted in the Project because of economic advantages and wide adaptation in Pakistan.

Accordingly, the proposed canal system of the project is composed of canals including open canals, siphons, culverts, aqueduct and drops and related structures such as turnouts, wasteways and farm ponds.

Open Canal

An average topographic gradient of the Upstream Area is as steep as in a range from 1/100 to 1/300, while the Downstream Area is relatively gentle in a range from 1/500 to 1/1,000. In the steep slope areas, the canal gradient should be designed with the drop works to maintain an adequate flow velocity in open canals.

Unlined canals, although lower in construction cost than lined canals, will cause much seepage loss than the lined canals, and suffer from erosion with the canal surface. Furthermore, the operation and maintenance cost of the unlined canals is higher than lined canals due to additions of the weed control in the canal. In the project, the minor canals are planned to be the unlined canals because of their small scale, while the major canals of the main, branch and distributary canals are planned with lined canals.

In selecting the lining type of the canals, the precast reinforced concrete flumes are not taken into consideration, because Pakistan has not produced those flumes yet nor provided the industrial standards in the line. However, it is supposed that the concrete factories in and around Islamabad Capital Territory have an ability to product them if the detailed drawings and specifications are provided. Since the precast reinforced concrete flumes have the advantages in enabling the quality control easy and construction less complicated, the possibility of their use should be studied carefully in the detailed design stage.

Comparison of four types of canal lining was made as shown in Table 5-3 and the following type of canal lining were adopted.

Type of Canal Lining

Canal	Type of Canal Lining
Main Canal	Reinforced concrete flume
Branch Canal	Concrete flume is adopted principally, but reinforced concrete flume will be adopted for the sections where gentle longitudinal gradient is designed due to the constraint of topographic conditions and then relatively large cross section is required.
Distributary Canal	Concrete flume

Along the canals except the portions adjoining to the existing roads, the roads with effective width of 3.05 m (10 ft) are planned to be constructed for water management and the operation and maintenance of the canal facilities, and for the transportation of farm products and farm machinery.

The preliminary design of the open canal is shown in the attached Drawing No. C-1001 to C-1005.

Siphon

At the portions where the canals cross rivers, a siphons will be provided. The reinforced concrete pipes made in Pakistan are to be used in principle. The preliminary design of the Kurang River siphon is shown in the attached Drawing No. C-1006.

Culvert

In principle, culverts are provided at portions where the side flow from hill into canals is to be observed and where collapse of canal embankment is foreseen, and at the sections crossing over main roads.

The culverts are designed as box shaped reinforced concrete structures and their width is the same as that of adjoining canals.

The preliminary design of culvert is shown in the attached Drawing No. C-1005.

Aqueduct

An aqueduct is provided at the section where 6th branch canal crosses over the existing irrigation canal branching off from the Rawal Dam. Structure of the aqueduct is reinforced concrete flume, and its canal width and longitudinal gradient are planned to be the same as these of the adjoining canal.

The preliminary design of aqueduct is shown in the attached Drawing No. C-1005.

Drop

In the portions with steep topographic gradient, drops are provided to maintain an adequate flow velocity in the open canals. Two types of the drops are designed to meet the height of the drop.

Type of Drops

Type	Height of Drop
A	1.0 m
B	2.0 m

Preliminary design of drop is shown in attached Drawing No. C-1007.

2) Related Structure

Turnout

Water supply from minor canals to unit irrigation areas of approximately 50 ha each is planned with concrete pipes through canal banks. At the diversion points of the canals except minor canal, double orifice turnouts will be installed for regulating irrigation water.

The preliminary design of turnout is shown in the attached Drawing No. C-1008 and C-1009.

Wasteway

The wasteways are provided to dispose excess water in the canals and to empty the canals for inspecting and repairing the

canal. Four wasteways, one in the main canal, two in 3rd branch canal and one in 6th branch canal, are designed for the water conveyance systems.

The preliminary design of wasteway is shown in the attached Drawing No. C-1010.

Farm Pond

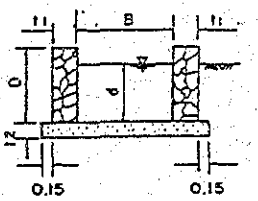
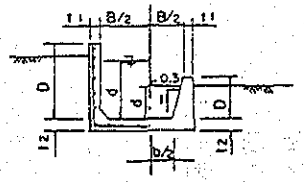
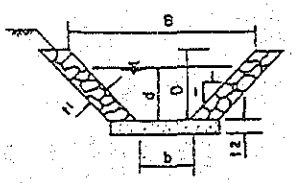
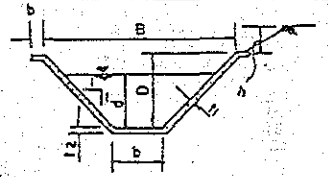
The farm ponds are planned to be provided at the beginning points of distributaries and minor canals to ensure effective water use and to enable water management easy. Two types of farm ponds are designed to fit for scale of the irrigation area in the downstream of the farm pond.

Type of Farm Pond

Type	Irrigation Area (ha)	Storage Capacity (cu.m)	No. of Farm Pond
A	200 - 300	5,600	24
B	300 - 400	8,400	4

The preliminary design of the farm ponds is shown in the attached Drawing No. C-1009.

TABLE 5–3. COMPARATIVE TABLE OF CANAL LININGS

ITEM \ TYPE		VERTICAL WALL TYPE				SLOPED WALL TYPE			
		STONE MASONRY		CONCRETE		STONE MASONRY		CONCRETE	
SECTION									
DIMENSION	Q (m³/S)	3.30	0.50	3.30	0.50	3.30	0.50	3.30	0.50
	I	1/1000	1/330	1/1000	1/330	1/1000	1/330	1/1000	1/330
	B, b (m)	2.00 —	0.80 —	2.00 —	1.12 0.70	4.10 1.10	1.90 0.60	4.10 1.10	1.90 0.60
	D (m)	1.60	0.70	1.60	0.70	1.50	0.65	1.50	0.65
	d (m)	1.20	0.45	1.20	0.42	1.10	0.37	1.06	0.37
	t1 (m)	0.50	0.50	0.15	0.15 ~ 0.36	0.50	0.50	0.15	0.10
	t2 (m)	0.30	0.30	0.20	0.25	0.30	0.30	0.15	0.10
	h (m)	—	—	—	—	0.50	0.50	0.60	0.40
	n	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
REINFORCING BAR	MAIN	—	—	D15 @ 250	—	—	—	—	—
	DISTRIBUTION	—	—	D13 @ 300	—	—	—	—	—
SUITABILITY TO NATURAL CONDITIONS	CROSS SECTION STEEP SLOPE	2	2	1	1	3	2	3	2
	AREA WITH SHINGLES	2	2	1	1	4	3	4	4
	HIGH GROUND WATER AREA	1	1	1	1	3	2	4	4
	RIGHT OF WAY	2	2	1	1	4	4	3	3
	UNDULATED AREA	2	2	1	1	3	3	4	4
EASINESS OF CONSTRUCTION	EARTH WORK	1	1	1	1	3	2	3	2
	STRUCTURE	2	2	1	1	3	3	4	1
	QUALITY CONTROL	3	3	1	1	3	3	2	2
DURABILITY OF STRUCTURE	HIGH VELOCITY	2	2	1	1	2	2	4	3
	FLUCTUATION OF WATER LEVEL	1	1	1	1	1	1	2	1
	LIFE SPAN (YEAR)	25 ~ 35 (30)		40 ~ 70 (50)		25 ~ 35 (30)		20 ~ 30 (25)	
	" " (ORDER)	2	2	1	1	2	2	3	3
COST (Rs/m)	CONSTRUCTION COST	3,030	1,750	2,700	1,480	3,480	2,030	2,220	1,170
	ORDER	3	3	2	2	4	4	1	1
	AMORTIZATION COST	244	141	196	107	280	164	190	100
	ORDER	3	3	2	2	4	4	1	1
OVERALL RATING		3	3	1	1	4	4	2	2

— For construction cost, see Table H–4 of Annex H.

— Amortization cost = construction cost x $i(1+i)^n / [(1+i)^n - 1]$ i = interest 7%, n = life span

TABLE 5-4. SALIENT FEATURES OF CANALS AND RELATED STRUCTURES

LENGTH OF CANAL

Canal	Design Discharge (cu.m)	Length (m)
- Main Canal	4.0 - 1.5	17,710
- Branch Canal		
1st Branch Canal	0.3	3,590
2nd Branch Canal	0.5 - 0.3	4,900
3rd Branch Canal	1.5 - 0.5	17,900
4th Branch Canal	0.3 - 0.5	1,900
5th Branch Canal	1.0 - 0.3	6,000
6th Branch Canal	0.5 - 0.15	7,900
Sub-Total	1.5 - 0.15	42,190
- Distributary Canal		4,830
- Minor Canal		65,320
Total		130,050

NUMBER OF CANAL STRUCTURES

Canal Structure	Main Canal	Branch Canal	Total
Siphon	10	13	23
Cut & cover Conduit	2	15	17
Aqueduct	-	1	1
Drop	43	63	106
Off Take	5	1	6
Turnout	4	24	28
Wasteway	1	3	4
Farm Pond	-	28	28

FIGURE 5 – 7 IRRIGATION CANAL SYSTEM — GENERAL PLAN

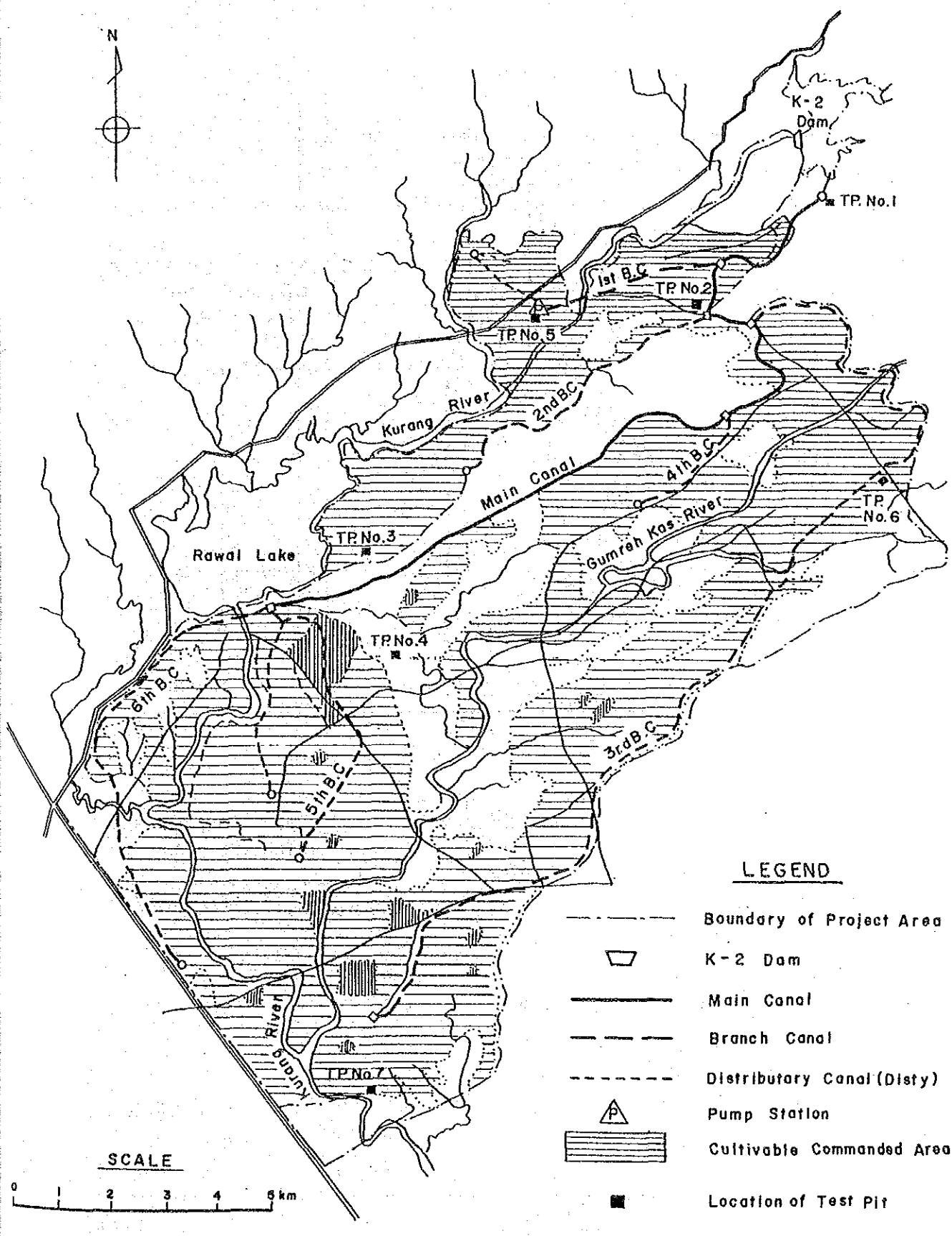
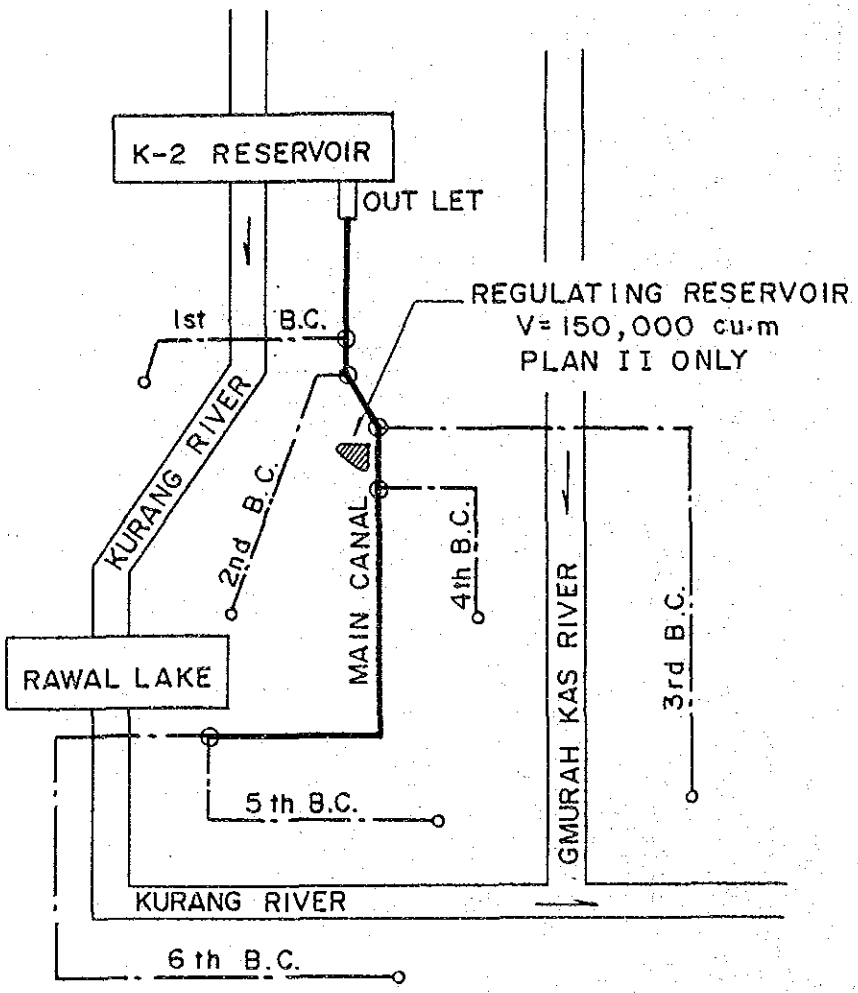


FIGURE 5-8 SCHEMATIC ILLUSTRATION OF IRRIGATION CANAL SYSTEM



	OUTLINE OF CANALS	MAXIMUM DESIGN DISCHARGE DISTRIBUTION PLAN	
	LENGTH	I	II
MAIN CANAL	17.7 km	4.0 Cu.m/s	4.2 Cu.m/s
1st BRANCH CANAL	3.6 "	0.3 "	0.5 "
2nd BRANCH CANAL	4.9 "	0.5 "	0.8 "
3rd BRANCH CANAL	17.9 "	1.5 "	3.0 "
4th BRANCH CANAL	1.9 "	0.3 "	0.5 "
5th BRANCH CANAL	6.0 "	1.0 "	2.0 "
6th BRANCH CANAL	7.9 "	0.5 "	0.8 "
DISTRIBUTARY CANAL	4.8 "	0.5 "	0.5 "
MINOR CANAL	65.3 "	0.5 "	0.5 "
TOTAL	130.0		

5.3. On-Farm Development Plan

5.3.1. Concept for Designing Typical On-Farm Facilities

Since the cultivable commanded area in the project Area can be divided into two areas, Upstream and Downstream Areas by topographic conditions, one sample area has been selected for designing typical on-farm facilities in each area.

In the project, the following two sample areas were selected from the result of study by the topographic map of 3 inches a mile and the field survey (see Figure I-1).

Sample Area - 1 (Upstream Area)	;	About 40 ha, Adjacent area to Simly road in the village of Pind Begwal of UC Tumair situated at north-eastern part of the Project Area.
Sample Area - 2 (Downstream Area)	;	About 45 ha, Area near the cross point of National Park road and Gumreh Kas River in the village of Chata Bakhtawar of UC Tarlai situated at southern part of the Project Area.

Basic principle for designing on-farm facilities is as follows;

- to provide water course on the higher place in the farm land.
- to provide drainage canal along the lower side of farm land to prevent erosion to be caused by rainfall and runoff.
- to provide farm road at a distance of less than 100 m (328 ft) from a longest farm.
- not to carried out land consolidation and leveling works.

5.3.2. Design of Typical On-Farm Facilities

The design of the typical on-farm facilities is made at the selected two sample areas by using topographic map with 1/1,000 in scale, which has been prepared by Study Team, and following on-farm facilities were planned;

Major On-Farm Facilities

- Water Course (Katcha): Terminal irrigation canal to convey water from turnout to each farm,
- Drainage Canal : Terminal drainage canal to drain surplus rainfall water to prevent soil erosion in the farm,
- Farm Road : Farm roads to serve for farm management and operation and maintenance of on-farm facilities.

Appurtenant Structure

- Water Course
  - ° Drop structure : Drop structure to alleviate the slope of ditches,
  - ° Cross culvert : Road crossing structure of ditches,
  - ° Nucca : Terminal water distribution facilities to supply water to farm lots,
  - ° On-farm turnout : Intake facilities in rotation area
- Drainage Canal
  - ° Cross culvert : Road crossing structure of ditches
  - ° Water way works : Drainage facilities to waste water from the drainage canal to present valley or river.

The design of the typical on-farm facilities in two sample areas is shown in Drawing No. 0-1001 to No.0-1003, and Table 5-5 shows the quantities of designed on-farm facilities.

TABLE 5-5. ON-FARM FACILITIES IN TWO SAMPLE AREAS

Item	Unit	Sample Area-1	Sample Area-2
1. Location		Pind Begwal	Chata Bakhtawar
2. Area			
Gross Area	ha	40.3[1/]	45.2
Cultivable Commanded Area	ha	25.6[1/]	37.5
3. Major On-Farm Facilities.			
Water Course (Katcha)	m	5,200 (203)[2/]	5,090 (136)[2/]
Drainage Canal	m	2,610 (102)	1,910 (51)
Farm Road	m	2,230 (87)	2,850 (76)
4. Appurtenant Structure			
Water Course			
Drop Structure	Nos.	42	10
Cross Culvert	Nos.	12	8
Nucca (TYPE I)	Nos.	203	138
Nucca (TYPE II)	Nos.	29	12
On-Farm Turnout(TYPE I)[2/]	Nos.	29	17
On-Farm Turnout(TYPE II)[2/]	Nos.	2	0
Drainage Canal			
Cross Culvert	Nos.	3	3
Water Way Works	Nos.	7	2

Note: 1/ : Details are given in Table I-1.
2/ : Density of on-farm facilities (m/ha).
3/ : Turnout is of earth structure and a part of water course.

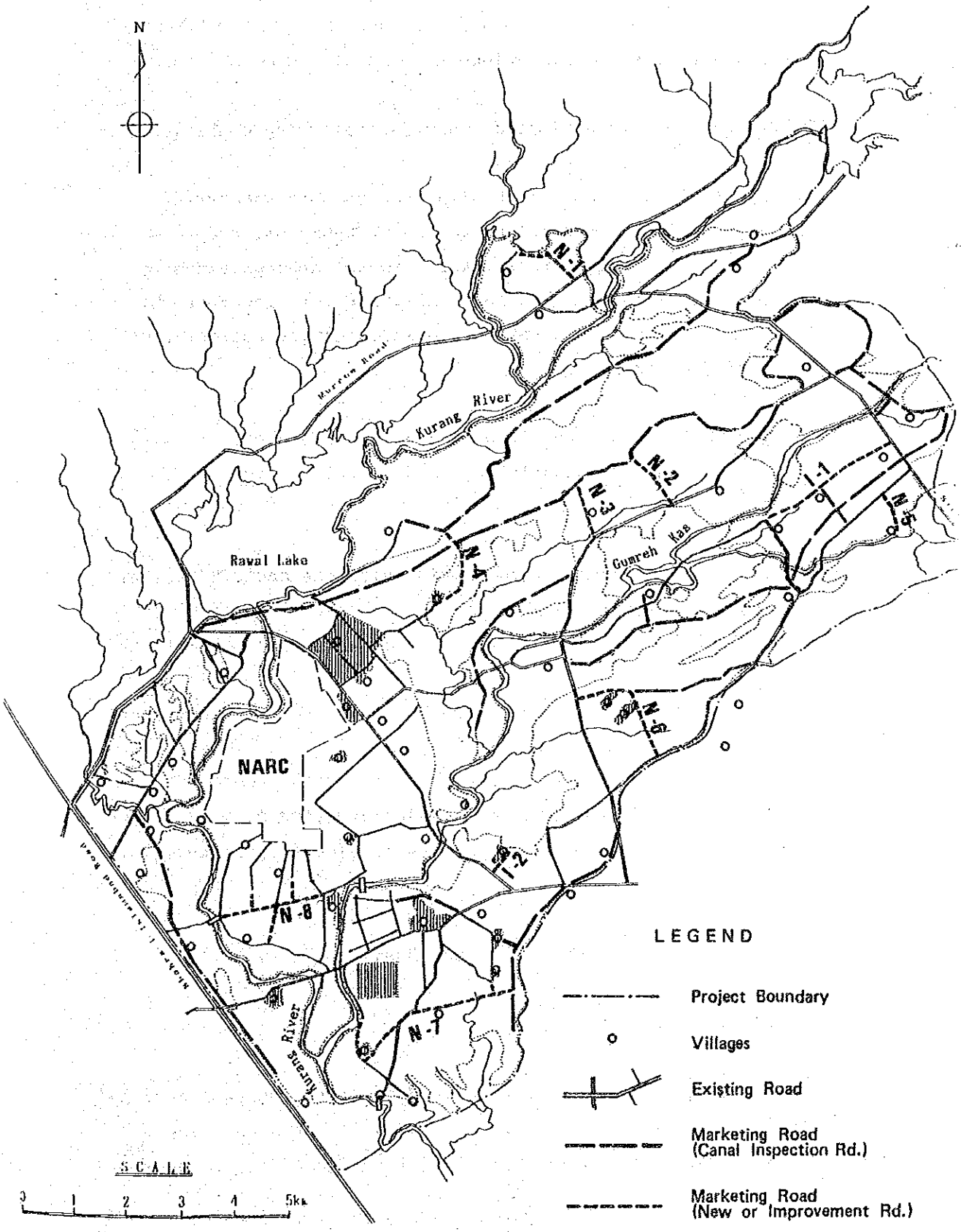
Type I ..... T- shaped turnout
Type II ..... Cross shaped turnout

5.4. Road Plan

In addition to the inspection roads along the irrigation canals, 18.6 km (11.6 mi) long marketing roads will be constructed including 13.8 km (8.0 mi) for new construction and 4.8 km (3.0 mi) for improvement. These marketing roads will serve for transporting farming inputs and products as well as successful communication among villages.

The marketing roads shall be of gravel pavement with total width of 6.10 m (effective width of 3.05 m). And the related route map is illustrated in Figure 5-9, and the preliminary design is shown in the attached Drawing No. R-1001.

FIGURE 5-9. PLAN OF MARKETING ROAD NETWORK



5.5. Cost Estimation

5.5.1. Condition of Cost Estimation

The project cost is estimated under the following conditions.

i) The civil works are to be implemented on the contract basis. The construction machinery, equipment and materials required for construction will be provided by the Contractors. Therefore, only depreciation costs of machinery and equipment are included in the estimated construction cost.

ii) The project cost consists of construction cost, associated cost, contingency and cost for price escalation.

iii) The exchange rate between Pakistani Rupee and U.S. Dollar is fixed as follows.
US$1.00 = Rp.17.3

iv) The Physical contingency related to the construction and associated costs is set at 10 percent.

v) The price escalation rate is predicted at 2.0 percent for foreign currency and 8.0 percent for local currency.

5.5.2. Construction Cost and Associated Cost

1) Construction Cost

The basic rate of labor, material and construction equipment is estimated in considering the prevailing rates in Pakistan. The detailed basic rates are shown in Table J-1 to Table J-6 of Annex J.

The construction cost is estimated based on the unit cost for individual working items. The summary is shown in Table 5-6 and the breakdown is shown in Table J-7 to Table J-11 of Annex J.

2) Associated Cost

The associated cost is composed of six items such as on-farm development cost, cost for agricultural supporting facilities, land acquisition/compensation cost, O/M equipment cost, project administration and consulting service cost. The breakdown of each item is shown in Table J-12 to Table J-17.

5.5.3. Project Cost

1) Project Cost

The project cost is estimated at about 1,330 million Rupees as shown in Table 5-6, and 667 million Rupees is foreign currency while 663 million Rupees is local currency.

2) Annual Disbursement Schedule

The annual disbursement schedule of the project cost is based on the project implementation schedule, and the summary is presented as follows:

Annual Disbursement Schedule

(unit: million Rs.)

Year	Foreign Currency	Local Currency	Total
1989	6.1	0	6.1
1990	2.7	0	2.7
1991	12.9	146.4	159.3
1992	179.0	118.4	297.4
1993	174.8	148.3	323.1
1994	201.1	161.5	362.6
1995	90.9	88.3	179.2
Total	667.5	662.9	1,330.4

Note: Details are given in Table J-18.

TABLE 5-6. PROJECT COST

(unit: '000 Rupee)

	Item	F/C	L/C	Total
1.	Civil Works			
	1.1. Pre-Engineering Works	7,300	0.0	7,300
	1.2. Dam Works	277,200	128,700	405,900
	1.3. Canal Works	82,700	66,300	149,000
	1.4. Road Works	5,400	2,500	7,900
	1.5. Project Facilities	1,400	4,300	5,700
	Sub-Total	374,000 (65%)	201,800 (35%)	575,800
2.	On-Farm Development	27,100	25,100	52,200
3.	Agricultural Supporting Facilities	16,700	3,300	20,000
4.	Land Acquisition and Compensation	3,400	110,500	113,900
5.	O & M Equipment	12,300	500	12,800
6.	Project Administration	4,200	5,300	9,500
7.	Consulting Services	60,000	23,800	83,800
8.	Total (1 - 7)	497,700	370,300	868,000
9.	Contingency (10%)	49,800	37,000	86,800
10.	Total (8 + 9)	547,500	407,300	954,800
11.	Price Escalation	120,000	255,600	375,600
	Grand Total (10 + 11)	667,500	662,900	1,330,400