CHAPTER 4 BASIC CONCEPTS OF THE PROJECT

4.1 Objectives of the Project

GOP's principal policy for the water sector is to restore environmentally sustainable irrigated agriculture which would increase per capita income and alleviate poverty. Complying with the GOP's policy, this Project is formulated with following objectives:

(1) To increase agricultural production through lining of Distributaries and Minors which would create new water resources;

(2) To develop participatory water management system for sustainable O&M of irrigation and drainage systems; and

(3) To realize equity of water distribution.

To achieve the above objectives and according to the S/W, the Project has been formulated broadly comprising of two components: (i) physical works including the lining of 540 km of Distributaries and Minors belonging to 12 Distributary systems with a command area of 241,111 ha and remodelling of relevant structures and (ii) formulation of farmers organizations under the GOP's institutional reform program. The Project would be implemented on a pilot basis.

4.2 Necessity of the Project

GOP's primary policy for agricultural development is to achieve a growth rate higher than the population growth rate. Since water is the most important input for agricultural production, continuous development of water resources is essential. As manifested in the Eighth Five Year Plan, GOP places higher priority on the small scale investment on existing infrastructures rather than the large scale dam and reservoir development as were implemented in the 1960s and 1970s. Measures will be taken such as the lining of watercourses and distributaries/minors, rehabilitation and remodelling of infrastructures, and improvement of water management in order to achieve the increase in water supply, enhancement of irrigation efficiency, protection of waterlogging and salinity, and sustainable expansion of agricultural production.

This project is also aimed to increase water supply for crop production, rationalize water management, and alleviate waterlogging and salinity through the lining of distributaries and minors. Since these objectives are identical to the above mentioned government strategies, this project exactly complies with GOP's policy.

The history of canal lining in the Indus Basin traces back to the last century. Trials were done to line many large main, branch and link canals, but not so successful. Lining of watercourses

has been implemented in On Farm Water Management Projects on a large scale. Lining of distributaries and minors has been implemented in the Irrigation System Rehabilitation Project, Command Water Management Program, Annual Development Programme of Government of the Punjab, and others.

Despite the long experience in canal lining, no authorized lining method nor economic evaluation method have been established yet. In this sense the canal lining is still in the experimental stage. GOPunjab expects to resolve the long pending problems through the current JICA Study as the Study is comprehensive covering a large survey area and various survey items. Also GOPunjab intends to tackle the problems throughout the various stages of project implementation by means of conducting bench-mark survey and ensuing monitoring. In this regards, the project is a pilot project.

GOP plans to execute a nation wide institutional reform regarding the O&M of irrigation and drainage system in the country. The Provincial Irrigation Department (PID) will be transformed to the Provincial Irrigation and Drainage Authorities (PIDAs) and Area Water Boards (AWBs). Both are autonomous bodies with independent revenue and expenditure. The O&M of distributaries and minors will be transferred from PID to Farmers Organizations (FOs). GOP expects that a workable model of FO would be evolved based on the results of pilot projects for adoption on a countrywide basis.

In line with GOP's basic strategy for the institutional reform, the Study Team formulated a pilot project plan for O&M of Distributaries and Minors including the plan for organizational structure, setting up, finance, transfer of facilities, and water management. For this purpose, the Study Team had a number of meetings with farmers and obtained farmers' opinion on the institutional reform.

4.3 Functions and Benefits of Canal Lining

Canal lining will have various functions such as the control of seepage, strengthening of levee, increased flow velocity, activated function of structures, environmental improvement, betterment of O&M, etc. Each function brings about a variety of benefits which are either quantifiable or unquantifiable. Among the benefits accrued from the Project, those quantifiable will be as follows: (i) increased crop production; (ii) cost saving of tubewells; and (iii) reduced O&M cost. In the assessment of economic viability of the Project only these three benefits will be taken into account. Other benefits including the equity of water distribution or improved water management will not be counted as economic benefit, because they are unquantifiable and it had better not count them for conservative evaluation. Impacts of success of the institutional reform would be unfathomable. But its direct benefits are unquantifiable, too.

A. Benefits from Seepage Control

(i) Evaluation of Seepage Rate

As mentioned in the Section 3.3.3, according to the seepage survey by IRI, it was found out that (i) there is no substantial difference in seepage rates between those measured by the inflow-outflow method (50 reaches) and those measured by the ponding method (10 reaches); (ii) 60 data distribute in the range from 1 to 13 cfs/msf; (iii) as shown in Figure 3.3.3-2, the frequency distribution curve has the maximum frequency in 1-2 cfs/msf and tends to descend towards 13 cfs/msf in straight line; and (iv) the mean seepage rate for earth channels is 6.32 cfs/msf and that of concrete lined channel is 1.47 cfs/msf.

In the past, discussion was concentrated in the measurement method of seepage rate and observation errors. In this Study, however, more attention was paid to the frequency distribution of seepage rates. The distribution curve is considered to represent the proper value of each canal reach which shows substantial variation even within the same canal system. In selecting priority projects, one of the selection criteria was canals of which observed seepage rate was higher than 5 cfs/msf. But if the observed seepage rate is used for the whole canal system, it may be an overvaluation. It would be reasonable to consider that the same frequency distribution curve applies even in the same canal system and the mean value is conservatively applicable for estimation of all canal systems in this Study. Hence, the saving volume by concrete lining is estimated by the following formula.

$$S = 6.32*Ap - 1.47*Ad$$

where S: saving volume (cusec)

Ap: wetted surface of existing earth canal (msf)

Ad: wetted surface of designed concrete canal (msf)

The total saving volume of 12 canal systems thus calculated is 10.7 % of the total authorized discharge, or 5.64 m3/sec, or 163 MCM/year.

(ii) Benefits in SGW and FGW Zones

The Study area was delineated into SGW and FGW zones based on the ground water salinity of 1,000 ppm. Priority was accorded to the canal system falling in SGW zone. Because the seepage water from canal to the fresh ground water aquifer has a chance to be re-used by means of tubewells; while that to the saline ground water aquifer becomes totally a loss in terms of water resources.

SGW zone

Benefits by canal lining in SGW zone is evaluated based on increased crop production. It is evident from the results of the farm household survey by the Study Team that if the water

supply is increased, farmers will give additional water to the same cultivated area at present rather than expand the cultivated area. The relationship between the additional water supply to crops under water stress and the increase in yield is referred to as the yield response factor which has been worked out by FAO and examined in SCARP project. Increase in crop production in this Project has been estimated by the yield response factor.

FGW zone

Presently 52 % of the Study area is irrigated by canal and tubewells, 28 % by only canal and 20 % by only tubewells. The source of tubewells is seepage water and riverbed water. Number of farmers' tubewells in the Study area is 80,400; one tubewell in 19 ha. Majority of farmers' tubewells are operating in FGW zones. In view of the density of tubewells and declining trend of water table in certain areas, the utilization of ground water seems approaching to the allowable limit. Since the ground water in FGW zones is fully utilized, benefits by the canal lining will be only the saved O&M costs and depreciation costs of tubewells .

iii) Control of Waterlogging and Salinity

Since ground water is less utilized by tubewells in SGW zones, waterlogging and salinity are likely enhanced. If seepage is controlled by canal lining, potential drainage excess can be reduced. This is another benefit in SGW zones. But this benefit is not counted in this Study because number of operating SCARP tubewells is very few in the Study area and alignment of new drainage system under NDP is not clear yet.

B. Strengthening of Canal Bank

There are many canal reaches where the width of canal is irregularly widened and the canal bank is lowered and damaged. These were caused by herd of buffaloes which bath in the canal or cross the canal, and the destruction of bank for illegal water use. The Project will regularise the canal shape and provide bathing ponds for buffaloes and bridges to cross the canal. The benefits are counted by the decrease in O&M costs.

C. Increased Design Velocity of Canal

Earth canal in Pakistan has been designed based on the non-scouring and non-silting concept, which produced the shallow and wide cross section of canal and gentle longitudinal slope with many drops. But the concept has been changed for this Project. If the design parameters of the earth canal is not changed and lining is applied for the same canal, many benefits of lining will be lost. The lining canal can be deeper, narrower and steeper, which will bring about such benefits as lower lining cost, lower seepage volume, and less silting compared to the lining of canal based on the earth canal concept.

D. Remodelling of Outlets

Outlet (Mogha) is the key structure of canal system for equitable water distribution. Normally gateless automatic proportional type of structures such as the open flume and adjustable proportional module are used. Many Moghas have undergone artificial interference or tampering and lost the original function as equitable distributor. According to PID's survey, out of 140 outlets 31 outlets were interfered. The Project will remodel most of the outlets so that the equity of water distribution is restored to the satisfaction of farmers. It is considered, however, even if water is distributed equitably to the tail-end farmers, the total production will not change because total volume of water is the same. Therefore, although the Project will greatly contribute to the equitable water distribution, its benefit will not be counted in the economic terms in this Study.

E. Environmental Effects

An initial environmental examination is undertaken in this Study on the natural and social environments as well as pollution. Critical issues are the equity of water distribution, institutional reform, farm income, waterlogging, salinity, and quality of drinking water. There will be not much adverse impacts by the Project that may require further environmental assessment. But certain mitigative actions and monitoring would be needed.

F. Betterment of O&M

Breach of canal bank and silting on the canal bed will be reduced by lining. Also O&M of canal system will become easy and cheap by remodelling of structures, particularly outlets. These benefits will be counted by the decreased O&M costs.

CHAPTER 5 THE PROJECT

5.1 Selection of Priority Canals and Areas

5.1.1 General

The Study area is located in the province of Punjab in the Upper Indus plain. It is divided into doabs, or lands lying between the rivers, and consists of the Lower Jhelm System (LJC), the Lower Chenab System (LCC) and the Central Bari Doab System (CBDC).

Geographical area, gross command area (GCA) and culturable command area (CCA) of the Study area are 27,250 km, 24,450 km, and 21,160 km, respectively, and broken down as shown in the following table:

Irrigation System	Geographical Area (sq km)	Gross Command Area (sq km)	Culturable Command Area (sq km)
Lower Jhelum	7,190	1,630	6,140
Lower Chenab	16,160	14,970	12,360
CBDC	3,900	2,850	2,660
Total	27,250	24,450	21,160

The number and length of the distributaries and minors are (i) 261 and 1,981 km in LJC, (ii) 399 and 3,787 km in LCC, and 102 and 847 km in CBDC, totalling 717 and 6,615 km as sununalized in the following table:

Irrigation Systems	Distributaries		Minors		Total	
	Number	Length (km)	Number	Length (km)	Number	Length (km)
Lower Jhelum	87	1,320	129	661	216	1,981
Lower Chenab	178	2,681	221	1,106	399	3,787
Central Bari Doab	34	510	68	337	102	847
Total	299	4511	418	2,104	717	6,615

5.1.2 Criteria for Selection of Priority Canals

During the Interim Stage in Phase-I, selection of the priority canals was made in accordance with the following criteria (see Table 5.1.1-1 in detail):

(1) Degree of salt concentration of ground water and its level. Salt concentration is to be more than 1,000 ppm.

(2) Degree of seepage losses through distributaries and minors. Seepage rate should be more than 5 cfs/msf to be economically liable.

(3) Status of Water Users Association for watercourses. Condition of watercourses, lined or unlined is to be considered.

(4) A distributary with its minors is regarded as one system,. If the distributary is located in the saline area (more than 30% in length), its minors are deemed to be the same.

5.1.3 Field Work in Phase-I

The initial step for the selection of the priority canals was to classify the Study area into two, in accordance with the salinity of the ground water, so-called the saline area (more than 1,000 ppm) and the fresh area (less than 1,000 ppm) using the ground water salinity map prepared by WAPDA in 1971.

Secondly, the reference was made to the selection of the canals for the seepage tests in the list of the priority channels for lining which was prepared by PID based on: (1) degree of deterioration and (2) degree of salinity, since the number of seepage tests was limited to 60 locations only (50 by inflow-outflow method and 10 by ponding method).

Based on the above information, the following selection standards were prepared:

(1) To select distributaries located in the high saline areas, but not to concentrate locally,

(2) To select two points along the long distributaries for the comparison of seepage rates at upper and lower reaches,

(3) To select minors equivalent to approx. one-fourth (14 points) for the comparison with the distributaries,

(4) To select representative sections of concrete lining, brick lining and rock excavation (7 points) for the comparison with unlined sections, and

(5) To select canals at appropriate intervals (every 3 or 4 intervals) so as to estimate seepage rates of other channels without tests.

Careful arrangements were made in the selection of canals to be adopted for the seepage tests so as to enable to estimate seepage rate of any other canals, considering that there would be some discrepancies in the distribution of salinity between the two observations of WAPDA in 1971 and JICA in 1996. The name of the canals selected for the seepage test and results are shown in Table 3.3.3-1.

5.1.4 Selection During The Interim Stage

The selection criteria (1) and (2) of the preceding section of 5.1.2 were the ground water salinity map prepared by IRI as a subcontracted ground water quality survey, and the seepage rate measured by IRI also as a sublet seepage test. The criterion (3) consists of the information on the outlets and watercourses (a. Outlet register, including information on kind of outlet, size

and authorized discharge, and b. Watercourse list, including information on culturable command area, status of lining and WUA).

Number and length of distributaries including minors thus selected are 25 and 210 km in the LJC System, 39 and 471 km in the LCC System, and 2 and 51 km in the CBDC System. Therefore, the channels preliminary selected are 66 in number and 732 km in length.

In the LCC System, since the Asian Development Bank has already taken up the two distributary systems of Dijkot and Khewra for comprehensive development including canal lining in its Water Conservation Project, it was decided to delete these systems from the list made in the third selection. Therefore, the distributaries and minors provisionally selected are 51 in number, 553 km in length and 176,856 ha in area (CCA).

5.1.5 Field Work in Phase-II

It should be noted that the ground water quality map prepared for the Inception Stage was somewhat modified according to the subsequent additional investigation conducted by IRI. Minor rearrangement of the selected canals was made accordingly based on the modified contour-map within the range of the total length stated in the Inception Report, together with the Chief Engineers and/or Superintending Engineers of the respective zones.

The canal systems thus finally selected are listed below. The number, length (excluding the length of lined section) and area are, respectively, four canal systems, 182 km and 78,286 ha in the LJC System, seven canal systems, 291 km and 120,558 ha in the LCC System, and two canal systems, 67 km and 42,267 ha in the CBDC Systems, totalling 12 canal systems, 540 km and 241,111 ha (see Table 5.1.5-1 and Fig. 5.1.5-1).

System/ Distributary	Culturable Command Area (CCA.) (ha)	Length of Distributaries and Minors (km)	Proposed Lining Length (km)
1. Lower Jhelum			
Pindi	2,285	6.86	6.86
Hujjan	25,236	80.13	78.18
Kirana	50,765	138.08	96.49
Sub-total	78,286	225.07	181.53
2. Lower Chenab			
Sarangwala	6,627	25.04	24.74
Nasrana	34,677	81.42	75.77
Gojra	7,540	17.77	15.52
Mungi	19,161	41.29	37.31
Janiwala/Hamza	6,513	18.58	18.51
Pirmahal	18,242	82.13	82.13
Killianwala	27,798	57.17	36.98
Sub-total	120,558	323.40	291.03
3. Central Bari Doab			
Thamman	25,877	64.54	33.87
China	16,390	33.27	33.08
Sub-total	42,267	97.81	66.95
Grand Total	241,111	646.28	539.51

5.1.6 Summary of the Current Study

In selecting distributaries and minors for lining, firstly, saline areas were delineated based on the sublet ground water quality investigation. The second selection was based on the seepage rates of the canals, of which survey was also sub-contracted. The third selection criterion was the accomplishment of FO and lining of watercourses. As discussed in the preceding paragraphs 5.1.4 and 5.1.5, twelve distributaries and 33 minors were finally selected. It should be noted however that further investigations is necessary for the canals which have not been chosen in this Study, since the number of the seepage survey was limited to 60 (39 for the distributaries) and accomplishment of FO and lining of watercourses are progressing. In this regard, classification of all the distributaries and minors are made in accordance with the location in terms of salinity, accomplishment of seepage tests, test results and other conditions, as shown in the following table (see Table 5.1.6-1 in detail):

Classification of fresh/salinity areas, status of seepage test	IJC		LCC		CBDC		Total	
	No. of canal	Length (km)	No. of canal	Length (km)	No. of canal	Length (km)	No. of canal	Length (km)
A. Entire canal	216	1,981	399	3,787	102	847	717	6,615
B. Canals in fresh areas	89	852	186	1,779	36	250	311	2,882
C. Canals in saline areas	127	1,129	213	2,008	66	547	406	3,734
1. Seepage tests completed	43	421	60	678	15	188	118	1,288
(1) Selected in this stage	20	201	24	324	9	132	53	656
(2) To be selected in the next	13	129	1	19	6	57	20	205
(3) Other projects, ADB	0	0	17	153	0	0	17	153
(4) Little lining effect	10	91	18	183	0	0	28	247
2. Seepage tests to be done	84	707	153	1,330	51	409	288	2,446

5.2 Irrigation Development and Canal Lining Plan

5.2.1 General

The basic concept of the Project is envisaged, (1) to carry out the basic design of the lining and the related structures for saving and equitable distribution of water by evaluating the present conditions of the distributaries and minors and measuring their seepage rates, (2) to propose lining method to control ground water table and salt hazard by evaluating the present ground water quality and table as well as soil salinity, and (3) to prepare the most appropriate irrigation practices, water management system, and operation and maintenance method in line with the basic concept of institutional reforms and farmers organization. Agricultural development concept is to be established in accordance with these concepts of structural and institutional development plans. Assessment of environmental examination on the issues on the implementation of the Project is to be performed and monitoring procedure be established.

5.2.2 Irrigation and Water Management Plan

(1) Irrigation Management Plan

In order to make sustainable agriculture possible in the Study Area where not only water deficit but also salinity and water logging are becoming serious, comprehensive water management from distributary up to field level will be more important. In the Study Area, since late 1970s, Pilot On-farm Water Management Projects have been implemented in order to increase agricultural productivity with watercourses improvement, precision land levelling and improved agronomic practices.

Irrigation method widely used in the Study area is furrow irrigation method for wheat, vegetable etc. and basin method for paddy, sugarcane, fodder, orchard crop, etc.. Traditional rotational irrigation called "Warabandi" is widely applied. Although irrigation efficiency has

improved as a result of lined watercourses and precision land levelling, more efficient method such as sprinkler and trickle irrigation are not applied in the Study Area. As is mentioned in 5.3, it is not practical to change drastically the on-going irrigation practice and cropping pattern, future water management to be conducted by Farmers' Organization such as water saving through canal lining should be in line with the one which has been conducted in On Farm Water Management Projects. Consequently, complete change in irrigation method is not to be introduced. Implementation of water management in accordance with NDP and OFWM Projects taking into consideration of leaching and land improvement, future irrigation management practice will be more effective.

(2) Water Management Plan

As is explained in 3.3.7, since Indus Basin Irrigation System was designed for cropping intensity of 75% during British Regime Period, available irrigation water does not meet crop water requirement under the present cropping intensity of 130% despite the fact that supplemental ground water irrigation is extensively applied. Under the circumstances, it is quite significant and effective that irrigation efficiency shall be improved through counter measures such as canal lining, however, without new additional water resources to be developed in the future, there will be no complete solution for the water scarcity.

Usually, water management system targets performing optimum use of irrigation water with respect to timing and quantity controlling surplus and deficit of water through gate operation, however, due to constant insufficiency of water it, is quite difficult to apply the concept to the irrigation system in the Project Area without complete reduction of irrigation area and change of cropping pattern. Consequently, it is the best tactics to maintain and operate the present water distribution system on Distributary and Minor canals with additional tube well irrigation under solid and practical operation and maintenance work to keep design condition of canals and their related structures.

Typical Stuffing and Items to be conducted for Water Management Plan by each Farmers' Organization are as follows:-

1) Operation and Maintenance Team consists of:-
   - A Technical Supervisor (sub-engineers/overseer) responsible for day to day operations;
   - One Canal Patrol who covers 8-10 km length of the Project Distributary for routine Operation and Maintenance;
   - A Gauge Reader responsible for distributary regulation and Two Regulation Baildars.

2) Operation and Maintenance Items are as follow:-

Water Acquisition

To acquire water and monitor the authorized discharge for the Project Distributary or the average discharge for the last ten years, whichever is greater.

Monitoring Water Distribution

- Measure gauges by a Gauge Reader at heads of Distributary and Minors daily and co-sign the Gauge Book for the Distributary with the roving gauge reader of the PID,
- Preparation of H-discharge curves by a Technical Supervisor,
- Check of dimensions and setting of all outlets in relation to sanctioned parameters by a Technical Supervisor,
- Check of supplies at heads of off-taking minors and adjust according to the supply by a Technical Supervisor,
- Check for any leakage, overflow and unauthorized withdrawal on the way by Canal Patrol,

Routine Maintenance of Distributary

- Daily Patrol for both banks of Project Distributary and Minors by Canal Patrol,
- Removal of floating debris by Canal Patrol,
- Clear Bridges, falls and regulators of the obstruction, bushes, etc. by Canal Patrol and Regulation Baildars,
- Repair rain cuts and clear weed growth and bushes by Canal Patrol,
- Check for leaks from banks and repair rodent holes by Canal Patrol,
- Check for overflow of banks and make up for free board by Canal Patrol,
- Maintenance of service road along the Project Distributary by Canal Patrol,
- Lubricate gates and gearings of the regulator by Regulation Baildar.

Special Maintenance of Distributary

Special Maintenance of Distributary is required when,

- there is deviation in water level by more than +/- 3cm,
- free board is reduced to less than 15cm,
- a canal is silted, raising the water level, resulting in over-drawal by outlets at head,
- there is vast deviation between existing and designed parameters of canal prism/section,
- the road along the Distributary deteriorates.

The FO's objective under special maintenance is to restore and maintain the designed parameters of the Project Distributary. The administrative responsibility will rest with

the Member Technical, and technical responsibility with the Technical Supervisor. The work will be carried out:

- If its magnitude is not much, by pooling all the Canal Patrols, working under the supervision of the Technical Supervisor.
- Otherwise, through contract labour after going through the procedure of tendering.

Data collection for private tubewells

Finally, necessity of data collection of ground water irrigation should be emphasized although private tubewells may not be under direct control of Farmers' Organization, since ground water irrigation plays an important role in the Study Area. Following data should be collected and analyzed for water management practice.

- Nos, location, abstraction rate, utilization ratio, operation hour, irrigation area and water quality ,
- Plot to plot irrigation diagram including additional tubewells irrigation for each Project Distributary,

5.2.3 Design Discharge

The authorized discharge in the Study area is based on the so-called Irrigation Branch Method which was derived from the experience gained by the Department during the last hundred years.

The Full Supply Factor which should be derived from the statistical records for other projects in operation, is the duty, i.e. the area successfully irrigated during a base period, per cusecs of mean supply at channel head, was determined without considering crop water requirements, since the canal system in the Study area was designed with the objective of extensive irrigation to bring more areas under irrigation in order to settle more people.

After determining the full supply factor, the intensity of Irrigation, which is the percentage of the culturable area irrigated annually, was determined to be 75% in the area. By studying different factors such as the type of soil, cultivation, habits of the people, marketability, climate, etc. the quantity of area to be irrigated in Kharif as well as Rabi was fixed. The ratio of area to be irrigated in Kharif and Rabi is known as Kharif-Rabi Ratio, which was originally determined to be 35% -40% per annum.

After taking all the above factors into consideration, the number of cusecs required at the outlet to irrigate one thousand acres of area fit for irrigation, known as Water Allowance, was fixed to be 2.84 cusecs/1,000 acres.

The authorized discharge of each outlet has been updated from time to time in the Outlet Register of the respective branch offices on the basis of area to be supplied with irrigation water inclusive of the other allowances such as gardens or paddocks which are entitled to an extra supply. The latest authorized discharge at each outlet which was provided by the respective branch offices was adopted as the basis of the design discharge for preliminary design as will be discussed in the subsequent paragraphs.

A series of discussions was made between the Chief Engineers/Superintending Engineers/Executive Engineers of the respective Irrigation Zones and the JICA Study Team for the determination of the design discharge.

It is a common practice to adopt Consumptive Use Method to estimate irrigation water requirement. The study made in the Inception Report indicates that the water requirement thus estimated is as high as four times of the actual surface water supply during the peak demand period with increase of crop intensity almost to 150% under the pressure of growing population in the recent years.

According to the request of PID, adjustment of design discharge was made based on the above water requirement on the original condition that the crop intensity is 75% consisting of 35% in Kharif and 40% in Rabi. As a result, it is understood that the design discharge in the peak month is also as high as two times of the present surface water supply.

As discussed in the preceding paragraphs, design discharge estimated rationally based on the consumptive use cannot be justified in view of the limited amount of total water resources for Punjab. It is also noted that there is no master plan for the increase of application of water despite the fact that the area is suffering from shortage of water. Nonetheless it is proposed that the design discharge be increased by 10% of present authorized discharge at outlet considering the future development of water resources including utilization of flood water in the Kharif season and more rational water management of the existing reservoirs in the near future.

The procedure for the calculation of the proposed design discharge for the priority canals for lining is as follows:

(1) The last updated authorized discharge at each outlet and CCA stated in the Outlet Register in the respective branch offices has been adopted as the basic figure.

(2) The authorized discharge stated above has been increased by 10% and accumulated from the tail to the head of the distributaries and the minors.

(3) The channel discharge has been designed by adding the standard absorption loss (Qab) stated in the guidelines* for unlined channels;

$$Qab = 0.0133 \times L \times Q^{0.5625},$$

where L: length of section (1,000 feet) and Q: discharge of the section in cusec.

It is understood that after lining of the channel, saved water will be the advantage of the beneficiaries in terms of quality and equity.

* Source: Design Guidelines for Irrigation Channels, Design Directorate Publication No.3.

5.2.4 Design Criteria

(1) Lining Method and Pre-qualification

Lining Method

Book review were done for the projects and programs conducted in Pakistan including canal lining works as component and for workshops, researches and studies concerned. Material applied for each methods are listed below.

No.	Materiel	Detailed Spec.	Thick-ness*1	Category Applicable (1)	(2)	(3)	(4)	(5)
A1	Earth	Bentonite Lining (5% mix)	50-200mm			*	*	
A2		Soil Cement (5-15% mix)	50-200mm	*			*	
A3		Compacted Clay	50-100mm				*	
A4		Stone Lining (Masonry)	50-150mm	*			*	
B1	Asphalt	Pre-mixed Asphalt Concrete	20-50mm	*				
B2		Asphalt(Prefabricated or hot)	20mm	*		*		
C1	Tile	Brick Tile Lining	50-75mm	*				
C2		Ceramic Tile Lining	10-15mm					
D1	Concrete	Flume/Pipe	-					*
D2		Cement Concrete Lining	50-100mm	*				
D3		Mortar (Shot-crete) Lining	50-100mm	*				
D4		Precast Slab/Block	-	*				
D5		Reinforced Concrete Lining	75-150mm	*				
E1	Textile	Grouted Fabric Mat	25-75mm		*	*		
E2		Geo-textile	10-50mm		*	*		
F1	Rubber	Vulcanized Rubber (EPDM)	0.5-2.5mm		*	*		
F2		Non-vulcanized (isobutylene)	0.5-2.5mm		*	*		
G1	Resin	Polyvinyl(PV, PVC) Sheet	0.1-0.2mm		*	*		
G2		Polyethylene(CPE,HDPE,HDA or Hypalon) Sheet	0.1-0.2mm		*	*		
G3		EVA(Vinyl Acetate) or FPA	0.1-0.2mm		*	*		
H1	Sealants	Natural or artificial sealant	-					*
H2	Mix	Combination of above	-	-	-	-	-	-

Category (1) Hard Surface(2)Exposed Membrane (3)Buried Membrane (4)Earth Lining(5) Other

EPDM: Ethylene Propylene Diene Monomer, CPE: Chlorinated Polyethylene
HDPE: High Density Polyethylene, HDA: High Density Polyethylene Alloy
Hypalon: Chlorosulfonated Polyethylene, FPA: Flexible Polyplopylene Alloy

Lining methods developed and applied so far are divided into Five (5) major categories[1] such as 1) hard surface linings, 2) exposed membrane linings, 3) buried (covered) membrane linings, 4) earth linings and 5) several ideas to prevent canal seepage such as soil sealant, concrete flumes or pipes and rubber or plastic tubes, which are not actually defined as lining but may also be nominated for canal improvement method. As material for membrane-using lining, synthetic rubber, polyethylene, polyvinyl and polypropylene have been used since 2 to 3 decades.

Among canal lining method tabulated above, 1) Improved brick lining, 2) Concrete lining and 3) Protected thick membrane lining are pre-qualified consequently according to arguments below and characteristic of each materials. Each types of lining are described in Figure 5.2.4-1

[1] Category definitions of canal lining method varies by references. The category quoted hereto are from Irrigation Canal Lining by FAO.

- Some site representatives appealed preference improvement of operation and maintenance activities to canal lining to save precious foreign currency since lined canals have been deteriorated so quickly. Major opinion among site representatives were that improvement of operation and maintenance solely could not give remedies to all constraints and that high cost performance lining should be considered.

- Maximum usage of local material and method of lining is claimed among engineers by reason that such conventional lining methods and material are well known to all contractors, engineers and labors. Brick remains as candidate for consideration because of its experiences, low cost and easiness of partial repair but improvement of its durability and hydraulic performance is requested. Stone masonry carries same week points and is expensive and not enough volume could be supplied.

- Any membrane under exposed condition is rejected considering damages by cattle/machinery passage as well as intentional hazard by people. Thin membranes are also rejected even under buried condition since penetration resistance against rodent and weed are low. Thick and durable membranes remain candidates for further study.

- Earth material such as compacted earth, clay, soil cement carry relatively high roughness coefficient and are supposed to give lower velocity than the other material, which cause more siltation. Earth material are hence rejected as lining material and even as covering materiel over membranes for the project.

- Asphalt material is reported difficult to keep even quality and life span is very short. Sealant material including bitumem have not been checked their performance yet in research. Both asphalt as well as any sealant material are rejected. Reinforcement concrete are very expensive and tending not to be applied to irrigation canals all over the world and hence rejected.

Unit construction cost and major repair cost for 10 years are estimated roughly for cost-benefit comparison study below for average canal assumed (30 cusec). Total cost for concrete and brick lining are close each other but periodical major repair would be required for brick lining to keep long-term water tightness and hence repair cost is higher and much conditional. Accordingly, concrete and brick lining could be economically viable. Application of membrane as a whole is denied but partial application for the particular area are to be left as alternative method considering its high water tightness and durability against alkali/salt. In accordance with all study results of literature review, field inspection, technical discussions, pre-

qualification study and rough cost-benefit evaluation above, concrete lining is basically proposed for the project.

Lining Method	Const. Cost (relative cost to concrete)	Repair Cost (% of initial const. cost)	Long-term water-Tightness	Availability of Const. Material
A: Concrete Lining	1.0	3-5	○	○
B: Brick Lining	0.8	8-12	Δ	◎
C: Membrane Lining	2.0	1-3	◎	Δ

(2) Design Criteria

Investigation and Basic Study

(1) Soil mechanics survey was conducted on 10 points within the study area and its results show dominance of sandy silt in LCC area and more clayey silt in the other areas. Permeability are relatively low in all area. Inside friction angles and cohesion show that earth material acquired near by canals are suitable for embankment and that canal inside slope could be designed as sharp as 1: 1.

(2) Water tightness of concrete is a important property as lining material. Methods to increase the water tightness are 1) application of admixtures AE or so, 2) improvement of water cement ration and size of aggregate and 3) careful construction supervision. According to evaluation of the methods above, approaches recommended to be applied to the project are 1) application of AE admixture to decrease entrapped air and water cement ratio, 2) application of rich mixed concrete (1:2:4) to decrease permeability of concrete, 3) application of steel slip form and rather small aggregate size to reduce required volume of water and 4) execution of careful supervision on even and less air content concrete as well as careful curling to avoid surface crack.

(3) Cost comparison of concrete lining sections by different B/D ratio were done using present canal prism situation and design B/D ration according to relevant discharges. Results of the comparison state that 1) work volumes for concrete and mortar as well as lining surface preparation increase relatively to B/D ration and hence narrowest section shows the smallest cost, 2) earthwork volumes show fluctuation and more corresponding to current canal prism than B/D ratio, and therefore 3) since unit price of concrete work is quite higher than that of earthwork, the comparison is concluded that the narrowest section come to be the most economical section in general. On the other hand side, canal depth of the narrowest section (B/D = 0.8) comes very deep. It is accordingly decided that the narrowest section will be applied to the project in

general with a depth regulation of about 1.5 m (5 feet) considering easiness of construction work and safeties of habitats and households.

Canal Lining Design Criteria

The canal lining criteria was developed considering 1) Proportional distribution of water and silt, 2) Employment of hydraulically ideal section (narrowest section) and a regulation by maximum depth allowed, 3) Maximum removal of drops if possible and proper design of canal slope to acquire minimum allowable velocity of about 0.5 m/sec even at the tail of canals, 4) Setting of proper freeboard and 5) Employment of trapezoidal section with proper side slope. Proportional distribution of water and silt are discussed later in the structure planning. Principal elements of the criteria are summarized below. Connection between side slopes to bottom of channel is proposed to be done with circular line in accordance with the recommendation by PID design directorate.

Hydraulic Design	:	by Manning's Formula
Side Slope	:	1: 1 (1: 1.25, water depth is more than 4 feet (1.22 m)
Freeboard	:	1 foot and 0.3 m (0.5 feet (0.15m), water depth is less than 2 feet (0.61m)) for lining portion and 0.5 feet (0.15m) for earth portion
B/D Ratio	:	0.8 - 4.5 as shown in Figure 5.2.4-2 and minimum width of canal bed is set at 1.5 feet (0.46m)
Allowable Velocity:		4 feet (1.22 m/sec) Max., 1.5 feet (0.46m/sec) Min.
Lining	:	3 inch (7.5 cm) concrete on 1 inch (2.5 cm) mortar

Further details for the criteria are stated as follows. The designing discharge range is approximately from 4 cusec(0.12m3/s) to 500 cusec(11m3/s) and proposed B/D ration are from 0.8 to 4.5 respectively as shown in Figure 5.2.4-2. Minimum bottom width is set at 1.5 feet (0.46m) to keep workability. Velocity is proposed to be kept higher than 2 ft/s(0.61 m/s), design standard velocity, throughout but minimum allowable velocity of 1.5 ft/s(0.46 m/s) is also given for the case where the relevant gradient could not allow the standard velocity inevitably. Maximum velocity is allowed up to 4 ft/s (1.22 m/s) considering allowable velocity of 3 inch lining and safety of children and baby cattle.

Maximum depth is proposed to be no deeper than 5 feet (1.52 m) considering up-lift pressure at the canal bottom and sides during small discharge/empty periods and easiness of construction. Standard depth range for design are from 4 to 2 feet and minimum depth is no shallower than 1.5 feet (0.46m) according to a standard depth of 1 foot over crest at tail cluster. Freeboard within lining is proposed as 1 foot (0.3 m) where water depth is deeper than 2 feet (0.61 m) and as 0.5 feet (0.15 m) where water depth is equal to or shallower than 2 feet (0.61 m). In accordance with USBR criteria 0.5 feet (0.15 m) earthen freeboard is also proposed throughout for all the channels.

The Manning's formula is to be employed for hydraulic design. Designed full supply level at each outlet is to be set not lower than the last design full supply level to ensure the better condition. Section is to be changed at the points of outlets where discharge changes more than 10% of the head discharge or at drops only. No design modification will be given for the existing lined portion. Proper transition or some countermeasures will be given in case that hydraulic regime in the new-lined section is extremely different from that in the existing lined portion. As practical lining material, concrete lining of 3 inch thick over 1inch mortar plaster on the smoothen/trimmed surface in trapezoidal section are proposed. Smoothening at slope toe corner is proposed to avoid silt precipitation. Roughness coefficient is assumed to be 0.016.

(3) Structure Planning

Proposed structure planning are shown in Table 5.2.4-1.

- Each distributary canal system is proposed to be transferred to the relevant farmer's organization and discharge measurement and control is necessary at outlet from main and branch canals. For the purpose, installatin of diversion gates are proposed to the distributaries lacking them such as Mungi, Janiwala, Pirmahal, Killianwala, Thamman and China and automatic discharge reader and recorder are also proposed to be installed to all distributaries. Meter Flume is to be removed at construction.

- The ideally required function of an outlet, is that proportional distribution of water and silt shall be achieved at all levels in the distributary. Adjustable Proportional Module (APM) Outlet which has been used in most of cases at present has been observed to have weak silt extraction function and open flume Outlet is exposed and vulnerable. Adjustable Orifice Semi-Module (AOSM) is thus proposed in general for the project since AOSM, used for Command Water Management Project, showed good performance for proportional distribution of both water and silt. All outlets are to be renewed along with the construction of lining. Pipe cum AOSM with an outlet chamber is proposed generally. Operational heads are to be retained for the purpose of proportional operation of AOSM. In cases where operation head of outlet (water head between parent channel and watercourse) is not enough for proper function of AOSM particularly at tail. Open flume type is proposed and Pipe Outlet is adopted in the case where the other types are inapplicable.

Type of Outlet	Lower Jhelum	Lower Chenab	CBDC	Project Total
AOSM	225	487	125	837
Open Flume Type	75	62	16	153
Pipe Outlet	10	19		48
Total	310	568	160	1,038

Comparative study result on proportionality of outlet performances by types of outlets is shown in Figure 5.2.4-3, where Type A (Hs = 0.3 x D, Y = Hs), Type B (Hs = 0.46 x D, Y = 0.23 x D), Type C (Hs = 0.375 x D, Y = Hs) and Type D (Hs = 0.5 x D, Y = 0.3 x D). Considering discharge fluctuation of current condition as well as future increase of discharge, Hs and Y are proposed to be 0.375 x D for AOSM(Type C). Proportionality of outlet discharge by location of outlet for different designed water depth of parent canal are also studied and ensured for the Type C outlet selected above. Open flume shows better proportionality than AOSM at 0.9 x D (G: water-head above crest) depth as being installed so far. Outlet discharges(Q_{out}) are calculated;

$$Q_{out}(AOSM) = k \times Bt \times Y \times Hs^{0.5} \quad \text{and} \quad Q_{out}(\text{Open Flume}) = k \times Bt \times G^{1.5}$$

All outlets are to be renewed at the construction of lining. Pipe cum APM/AOSM with a outlet chamber is proposed generally. Operation head (Hm) = 0.82 x Hs - 0.5 x Bt are to be retained for the purpose of proportional operation of AOSM. Steel guide block for the adjusting part and covering (not air-tight) over the chamber are proposed. In case where operation head of outlet (waterhead between parent channel and watercourse) is not enough for proper function of AOSM or at each tail, Open Flume type is secondly proposed and Pipe Outlet is adopted at the case where the other types are inapplicable. Outlet discharge measuring gauge is proposed to be installed at the outlet mouth. Width of orifice or flume (Bt) are proposed to employ standard sizes such as 0.2, 0.25, 0.32, 0.4, 0.5 & 0.63 feet.

- Use of existing bridges with repair if necessary and replacement of Footpath Bridge by VR (Village Road) Bridge as well as new installation of VR Bridge if required among where bank damage by cattle was observed are proposed to improve rural transportation and minimize cattle passage over channel. As the results of the structure planning, total numbers of bridges tolerant for vehicle passage increase to be 442 (every 1.31 km) from 229 (every 2.53 km excluding the bridges fatally damaged).

- For the purpose of canal bank protection, 267 Buffalo Wallow (Cattle Ghat) are proposed nearby each bridges at watercourse head. Washing Steps, Drop and Spillway will be replaced disregarding the present condition. Canal Crossings (Aqueducts and pipe crossings), pipe culvert and railway bridges will be used as they are.

5.2.5 Lining Plan

(1) Construction Method

According to the references, study results of similar projects and field investigation results, construction methods applicable for distributaries and minors are a)temporary diversion method, b)construction of new canal by the original canal trace and c)construction on original trace while canal closure period. Compaction and trimming of canal slope are difficult and critical path for the construction within the canal closure period.

Proper supervision on earthwork quality control is one of the most important factor to achieve longer life expectancy of canal lining. Having the advantage of temporary diversion which would make continuous construction a year round activity, such quality control will be possible. Temporary diversion method is proposed to be used for the project in general. Breaks in continuity of construction due to meteorological conditions would be negligible. Steel slip form, would give good control on cement mix and longer curing under wet condition and are therefore proposed to be emphasized to reduce the seepage to the minimum through canal prism.

Lining sections at construction and at completion are shown in Figure 5.2.5-1

(2) Working Volume

Construction volumes for each king of works are decided by basic design based on the results of canal route survey executed within the Phase II field work period. Each work volumes are shown in Table 5.2.5-1. The canal route survey was conducted through 541.27 km (Total length of the canals selected at Interim Stage is 583.42 km and out of which 553.23 km was estimated total length to be surveyed) consisting baseline survey, cross section survey and structure inventory survey and designed total length came to be 539.51 km. Total acrage of land compensation is estimated to be 138 ha and 2.7 m width outside ROW in average. Average work volume per linear meter estimated based on canal sections surveyed and designed are; 4.15 m3 excavation, 8.69 m3 embankment and 0.5 m3 concrete. The work volumes show wide fluctuation according to surface condition within ROW and thus more detailed survey is recommended to be executed at the time of Detailed Design.

(3) Method of Construction

Specifications of earthwork and dimension of improved canal cross section are proposed as shown in Figure 5.2.5-1. Stripping thickness of 0.2 m is proposed respectively for outside and inside of canal prism. Bank cutting thickness within canal prism of 1.0 m or 2.0 m and over-embankment exceeding designed lining surface is proposed by 0.5 m or 1.0 m respectively for the cases that water depth is shallower than or equal to/deeper than 3.5 feet. Compaction is to be done up to designed lining height and earthen freeboard is formed by spoil banking. Width

and minimum embankment from field level for operation and maintenance road are 4.0 m and 0.3 m(1 foot) respectively. Bank width for filling section are proposed to be 1.0 m (Q < 50 cusec), 1.5 m (50 < Q < 150 cusec), 2.0 m (150 < Q < 300 cusec) and 2.5 m (Q > 300 cusec). Half width are respectively proposed for cutting section.

Earthworks is planned to start by stripping at the canal bottom and bank cut by combination of bulldozer and backhoe after completion of temporary diversion work by every 300 to 500 m according to site condition. Haulage of earth material is not considered for the diversion work. Succeedingly, embankment work including over-embankment portion which will be cut after compaction. Borrow of earth material is planned within ROW and areas where vitally salt affected and abandoned and average hauling distance is estimated to be 500 m. Embankment work is executed with emphasis on water content control by water bowser, bulldozer and roller. Cutting and trimming of lining surface is done by backhoe and by manual work.

Lining work is started with preparation of lining base layer by mortar, followed by spreading low-water-content-concrete with steel slip form and vibrator and finished with manual surfacing. Curing with supplying enough humidity (preferably kept under water or spraying water continuously) is strongly recommended to avoid surface crack.

5.3 Agricultural Improvement Plan

5.3.1 General

For the improvement of agriculture in the Project area, it should be targeted to increase the unit yield of crops. With the efficient use of irrigation water and application of recommended farming practices, improvement of agricultural productivity will be achieved.

5.3.2 Land Use and Cropping Pattern

The CCA of the Project area is 241,111 ha. There will be no change in CCA nor cropping pattern after the implementation of the Project, because the present cropping pattern has been evolved as a result of the past experience in agricultural practice reflecting the existing agro-climatic and socio-economic conditions of the area. The season-wise cultivated area in the Project area is shown in Table 5.3.2-1 and Figure 5.3.2-1. The cropping intensity in the Project area is estimated 133 %. However, the land utilization intensity is more than that, because sugarcane and tree crop (citrus) are perennial crops and standing throughout the year. Taking into consideration the high cropping intensity, it is not realistic to raise the cropping intensity any further. The cropping rotation system including fallow will be introduced after

the implementation of the project through the utilization of reclaimed land. Improvement of the soil fertility will be also achieved by adopting the crop rotation system.

5.3.3 Proposed Farming Practices

The proposed farming practises based on the concept of the Agricultural Improvement Plan are summarized below;

- Introduction of intensive irrigation farming through the biological effective water use,
  Each crop has some critical growth stage/periods severely affected by water stress. At this stage, if the crop suffers from severe moisture stress it has drastic effects on the growth and development of plants and the moisture stress has detrimental effect on the yields. Irrigation should be practised at critical growth periods of each crop.

- Extension of the proper farming practices,
  In the present farming practice in the Study area, the dosage of fertilizers is mainly applied as basal before planting due to the poor technical know-how. The application of recommendable amount of fertilizer at the right time and split application of fertilizer which rises the fertilizer utilization efficiency has much effect on the increase in crop yields, because of the low fertility of the soil in the area. The balance dosage of nitrogen, phosphorus and potash is essential.

  The farmyard manure application should be effective for improvement of both the soil fertility and the soil physical condition.

- The important matters for improvement of productivity of major crops (wheat, rice, sugarcane and cotton) are as followings;

Wheat:	to plant at right time (adopting early maturing of rice and cotton and utilization fallow)
Rice:	to adopt appropriate plant density
Cotton:	to improve agronomic practices of natural predators, reduce weeds and diseases against CLCV and breeding varieties resistant to CLCV
Sugarcane:	to increase efficiency of water use during the critical stage
Fodder:	to adopt recommendable varieties

  In the Study area, more than 30 % of irrigable land remains as fallow due to lack of water. In order to improve the effective land use, crop rotation system including fallow should be introduced. Proper crop rotation is very important in the Study area due to the following reasons ;

a) to avoid the conflict in the cotton-wheat, rice-wheat cropping pattern,
b) to maintain soil in good physical and chemical conditions,
c) to eradicate of insects, pests, diseases and weeds, and
d) to increase productivity of the soil.

Growing of the leguminous fodder as fallow crop is recommended in order to improve the soil fertility and increase the production of fodder.

- Improvement of salinity and waterlogging irrigation land and the prevention of the expansion of salinity and waterlogging

  The irrigation water saved by canal lining should be used as followings in order to improve and avoid salinity and waterlogging.
  a) to expand new irrigated land,
  b) to supply saved fresh water for saline ground water area, and
  c) to use for land reclamation purpose

5.3.4 Anticipated Yield

After the completion of the Project, it is expected that the yields of crops under the water stress condition would increase on account of increasing irrigation water supply by saving the seepage water loss. The anticipated yields after completion of the Project are estimated by using relationship between the yield response factor (Ky) for various crops and seepage saving rate. The anticipated unit yields and production are estimated and summarized as below;

Crops	Yield response factor	Yields (at present) (t/ha)	Anticipated Yields (t/ha)	Anticipated Production (1,000t/ha)
Wheat	1.00	2.26	2.50	243
Rice (Basmati)	1.20	1.18	1.33	12
Cotton	0.85	1.42	1.55	20
Sugarcane	1.20	40.98	46.26	1,222
Maize	0.90	1.43	1.57	51
K. Fodder	0.90	12.84	14.08	526
R. Fodder	0.70	30.71	33.02	570
Oilseeds	0.90	1.04	1.14	16
Pulses	1.00	0.51	0.56	3
Vegetable	1.10	20.03	22.39	55
Citrus	0.95	9.69	10.68	115

Source: Privatization of SCARP Tubewells EAN Project USAID, FAO 1977

5.3.5 Agricultural Supporting System Improvement Plan

- Creation of integrated agricultural support service for the agricultural extension

  Agricultural Research Institute, Adaptive Research Units, Extension wings of Agriculture and other related organizations should launch a extension enhancement programme. There is no any close relationship/cooperation among them at present. A farmer's desire to improve themselves is one of the most important factors. If farmers expect a higher return by adopting a new technology, there is far greater chance that they will try it. Both institutional and individual (farmers) "integrators" are needed to link research and production with an effective technology generation system, if improved technologies are to reach farmers.

  In order to achieve the effective extension through the close relationship/cooperation among the related organizations, the establishment of the Agricultural Research and Agricultural Extension Council (a tentative name) is recommended.

- Raising Agricultural Extension Efficiency

  For the achievement of the effective agricultural extension within the limits of the budget, the reinforcement of the extension system by the broadcast and multimedia approach should be introduced.

- Dissemination of Information on Institutional Credit

  In addition to the dissemination of agricultural technology, knowledge about procedure in utilizing institutional credit should be also disseminated. By disseminating the knowledge on institutional credit to the farmers, farmers will know what is necessary for obtaining loan and, accordingly, it will be difficult for the officers to impose unfair demand on the farmers for disbursing credit. This can be the first step to make the utilization of institutional credit easier. Besides, accesses for institutional credit through the Farmers' Organizations should be also considered so that farmers can have the option for rural credit as much as possible.

- Education on Farmers' Organization

  Considering the fact that cooperatives are not functioning well, there should be more opportunity for the farmers to know about cooperative, especially about its basic concept and operation. Ignorance about the concept, function and operation of cooperative or farmers' organization will lead to the monopolization of them or extinction of organization. Therefore, enhancement of education opportunity on the knowledge of farmers' organization (principle, operation, function, etc.) will be effective for attaining the sustainability and activation of FOs.

5.3.6 Benefits Derived from the Increased Crop Production

Crop production will increase corresponding to the incremental of irrigation water, which is attributed to the saved water by means of lining of the channels. It is assumed in the Study that the incremental benefits derived from the increased irrigation water are from the SGW area with more than 1,000 ppm in salt concentration. On the contrary, in the FGW area, where the salt concentration of the groundwater is less than 1,000 ppm, it is assumed that no additional benefits are derived from the saved water, because the leaked water is being use by means of tubewells. This is attributed to the fact that the groundwater table is lowering in the current stage, in other words, the groundwater (including leaked water) is 100% utilized.

It is assumed in the Study that there is no change in CCA, crops to be cultivated and crop intensity as discussed in the foregoing, but that there is a increase in the unit yield of crops as estimated using the relation between the yield response factor (Ky) and seepage saving rate, which will result in a conservative estimate of benefit. It is noted that the Government of Punjab has a considerable reputation for agricultural supporting services such as agricultural research and extenuation. In this regard, it is anticipated that the increment of the unit yields would be much higher than the calculated figures owing to the multiplier effect of increased water and improved farming practices.

5.4 Institutional Development Plan for O&M

5.4.1 Basic Institutional Development Concept

As stated earlier, the Government of Pakistan, the Government of the Provinces and the donor agencies are presently debating the transformation and reorganization of the irrigation departments of the four provinces into autonomous Provincial Irrigation and Drainage Authorities (PIDAs) who should have equally autonomous Area Water Boards for each canal command or a group of canal commands. The Farmers' organization on a pilot basis should be set up at each of the distributary / minor with equal autonomy for the area under the distributary. These bodies should be self financing after an initial period of 3 to 7 years.

While this top-bottom institutional reform presently being considered by a task force, falls in line with the concept of JICA study team, the team would recommend the setting up of the farmer's organizations at the distributary level on pilot basis in the pilot project of Lining of Distributaries and Minors in Punjab. It would concentrate on the formation of farmers' organizations, their method of election and selection of office bearers, their registration under the corporate law as non profit entities, their structures with appropriate checks and balances, the legal requirements for delegation of suitable legal and financial powers and the transfer of

facilities from Irrigation department to the FOs. This bottom-top approach could be introduced irrespective of the fact whether the over all system remains with irrigation department or it is transformed into PIDAs/Area water boards - an issue which may take some time to resolve. However, the transfer of the secondary distribution system and the lining of distributaries and minors should be so linked that the institutional reforms become a compulsory part of the lining project. Since both the interventions are being tried on pilot basis it would be necessary to finance both the interventions together making the hard ware (lining of distributaries & minors) as incentive for the institutional reforms (soft ware)

5.4.2 Proposed Farmers Organization

It is proposed that farmers should be organized at two levels for operation and maintenance of irrigation system at distributary level;

1) Water users' associations at water course level (WUAs).
2) Distributary Farmers' organizations (FOs).

During the meetings with the farmers along the 12 selected distributaries some of them suggested that instead of each out let represented on the distributary farmers association (FO) one member from a group of outlets irrigating a village or a chuk, may represent such group of out lets. This was particularly a view of the farmers where the distributary was very long and had many outlets. The augment has a weightage for seven out of the 12 distributaries which have more than 70 out lets each.

Distributary	Length in Km	CCA Acres	No. of out lets	No. of group members
Hujjan	80.13	62,359	122	28
Kirana	107.13	89,754	188	52
Nasrana	81.42	85,686	175	49
Mungi	41.29	47,347	97	28
Pir Mahal	82.13	46,196	103	28
Killianwala	52.71	51,938	114	34
China	33.27	40,498	88	23

Since the number of out lets are large, the distances are long and the communication facilities are poor it will be very difficult and costly for the farmers to attend the meetings of the FO. Besides such a big gathering of farmers can barely make any cogent and serious decisions and their meeting will turn into social gathering rather than putting out any concrete work.

The out lets on these seven distributaries have therefore been so grouped together that each group will represent one two or three villages comprising of three to six out lets and the three to

six water users associations will select one group leader among themselves to represent them at the level of farmers organization.

However this arrangement will only be used to make meetings more convenient for the farmers and the distributary farmers organization more compact and workable. Reference is made to the schematic diagrams of these seven distributaries (Fig-9 Typical) in which a preliminary grouping based on the villages/chuks has been made and thus the number of working members of FO has been reduced to 23 to 52 members per distributary. This grouping will be finally decided by the farmers themselves and in case they decide against the grouping it may not be pushed as farmers should be given full freedom to make their own decisions.

1) Water Users Associations (WUAs):

The water courses usually serve 20 to 100 farmers. The water course Farmers' associations to be called the Water users' association (WUAs) should have all the farmers of the water courses as its members. The formation of the water users associations will be a compulsory requirement for lining of the distributary. The farmers shall include the owner farmers and the lessee farmers and not the share croppers.

The owner farmers shall be defined to be the farmer in whose name the land is recorded in the revenue record. In case of a deceased farmer where the land has not yet been transferred, only one member of that family shall be considered as the farmer. All members of the Water users' associations will have one vote each irrespective of the size of the land (for example, farmers having a land of two acres and having land of 200 acres will have one vote each).

Election of Managing Committee by WUAs:

The member of the Water users' associations (WUAs) will elect their Chairman, Secretary and three members Managing committee for a period of two years. The Secretary during the 1st term may be elected for a period of one year so that their term is staggered and experience is passed on to the next elected body. The Chairman, Secretary and members of the Managing committee should be on rotation so that a farmer once elected should not be re-elected unless 100% of the farmers vote for the same person.

Duties, Responsibilities and Powers of the Water users' Association:

i) To elect their Chairman, Secretary and Managing Committee.

ii) To keep the water course and the field drains in a good state of operation.

iii) To decide the warabandi (water turns) cases by majority in pursuance of the rules under canal & drainage act.

iv) To collect the water rates from farmers according to agreed rates on flat rate basis and transfer the major amount to distributary Farmers' association. Some portion of the water rates to the agreed between WUAs and FOs shall be retained by them for emergency repairs to the water courses and paying commission to the collector of water charges.

v) The funds shall be kept by the Secretary of the association and the books should be available to be checked by any farmer.

vi) The Chairman of the Water users' association should have the same powers as hither to exercised Numberdar of the village.

vii) Since the water charges will be recovered on flat rate basis the Secretary of the association shall have the basic land record of owner ship of all the farmers and the water charges based on the area shall be payable once in six months, i-e, in June and December.

viii) In case of default in payment of Abiana or theft of water by any farmer, a meeting of the association shall decide by majority regarding the punishment to be given to the farmer. In case of a split the Chairman shall have the casting vote.

ix) Any expenditure from the funds shall be decided by the Managing committee in emergency but such decision shall be placed before the water users association in their next meeting.

x) Ordinarily decision regarding the deployment of funds shall be done by majority of the farmers attending the meeting of the association. However, for such decision the quorum shall be more than 50 % of the farmers, whereas for ordinary meeting the quorum shall be 33 % of the farmers.

2) Distributary Farmers' Organization:

i) The distributary level Farmers' organization should be called FOs. In order to give equal participation to all farmers' associations at the distributary level the Chairman of the water course Water users' association shall be the member of the distributary Farmers' organization. However, in cases where the distributary is very long and is having more than 70 water users associations, 3 to 6 out lets will be grouped together to avoid crowding at the level of farmers organization. A group leader may be elected by the chairman of water users associations from among themselves. Thus FOs will be federation of basic Water users' associations. This will save them from involving in politics and at the same time it will give equal representation to all the water users. The members of the distributary Farmers' organization will elect their Chairman, member technical, member finance and four more member to form Managing

committee subject to the conditions that at least four members of the seven members of the managing committee are to represent the tail half of the distributary. All the members should have a two years term or a term of his own election at the water course level which ever is earlier. The Managing committee will however, continue for a period of three months after fresh elections, without any powers, to smoothly transfer their responsibilities to the new committee. The members of the Managing committee including the Chairman member technical and member finance should be elected on rotation so that a farmer once elected should have the chance of re-election after a long time.

The distributary farmers' organization should also form a vigilance committee of three members to over see the working of the managing committee and to report to the FO. at the time of its meeting. They should also participate in the meeting of the managing committee but should have no voting rights.

ii) Terms of Appointments:

The Chairman, member technical & Member finance shall be salaried office bearers of the organization paid out of the funds of the distributary at rates to be decided by the FOs in the absence of office bearers. The other four members shall be paid their daily and transport allowance for the meetings to be decided by the farmers organizations.

iii) Responsibilities and Powers of FOs:

a) To operate, manage and improve the irrigation and drainage infrastructure comprising of, minors, distributaries and drains together with any structure thereon located within the Area relevant to the FO concerned.

b) To obtain irrigation water from the PID. or its successor concerned at the head of the distributary and to supply the same to their members and other water users, if any. For this purpose they shall enter into negotiations with the PID for fixation of water charges after they have obtained the views of the farmers at the water course and distributary level. The charges to be paid to the PID for supply of water and disposal of drainage shall be commensurate with the services provided by the PID. The agreement with the PID shall also stipulate that the PID will supply water at the distributary head in accordance with a predecided schedule which should normally follow the authorized supply of the distributary or the last ten years hydrological record. The agreement should clearly indicate that any reduction in water supply, for example, by more than 5 % shall effect a corresponding reduction in water charges which reduction should be twice the reduction in water. A gauge shall be fixed at the head of each distributary and the gauge register maintained which will show the total discharge of the distributary each day. The register will be posted and

signed by the representative of the PID and the authorized representative of the FO at a predecided fixed time each day.

c) To receive the drainage effluent from their water users and to convey the same through field / collector drains to the designed nodal points of the drainage system.

d) To engage, hire or employ any consultants, advisors and employees as may be deemed necessary or be otherwise reasonably required for the due and effective performance of various powers and functions on such terms and conditions as may be prescribed including terms and conditions relevant to the continuation or premature termination of such engagement etc. of any consultants, advisors or employees, as the case may be.

e) To collect the agreed water charges and other dues from its water users and pay the agreed consideration for the supply of irrigation water and conveyance of drainage affluent to the PID. concerned.

f) The Chairman Farmers' organization shall have the same legal powers as that of Divisional canal Officer (DCO) and the member technical as that of a subdivisional canal officer (SDCO)with in the jurisdiction of the distributary to deal with defaulters committing unauthorized use of water, interference with outlets, cuts in distributary banks, use of siphons, wilful damage or ponding of water by animals and non payment of dues etc. Any other power and functions, not being inconsistent with the functions and powers given in the statue, may be vested in the FOs under the Bye-Laws and Regulations framed by the authority / government.

iv) FOs To Be Bodies Corporate:

FOs shall be bodies corporate under the normal law who may own and dispose off moveable and immovable property, and sue and be sued in their own names. All the proprietary rights of the Irrigation department with in the jurisdiction of the distributary including land, structures and buildings shall be transferred to the FOs. The FOs may own, buy or dispose off any property provided that the property transferred to FOs from Irrigation department / or its successor shall not be disposed off without the latter's consent.

v) Resolution of Disputes:

In order to resolve any disputes between the farmers organization & irrigation department/PIDA or among the farmers themselves, water commissioners should be appointed under the law in the three zones who may be the session judges of the distract in which the dispute takes place or the director of agriculture of the zone and their decision shall be final and binding on both parties.

5.4.3 Logic of Proposal for the Project

The logic of the proposal may be summarized as follows:

- The FO has to undertake the O&M of the Project Distributary and collection of water charges ; therefore, the O&M and water charge collection process are the basis for the functions, staffing, structure and financing of the FO.
- As the FO is a non-existent entity, a process of organization development has to be undertaken by the project to create and establish the FO and enable it to take over the distributary system.
- A process of technical assistance, including design and implementation phases, is needed to undertake the organizational development of the FO, as neither the Irrigation Department nor the farmers themselves are in a position to do this.

The conceptual basis of the design is, therefore, defined by three key processes, namely, O&M, Organization Development and Technical Assistance. Related to these, two additional processes are also outlined for action by the Government within the context of the proposed Project of Lining of Distributaries and Minors in Punjab. These are referred to as Provincial Government Policy Actions, and System Turnover. Together, these five processes completely describe the general prototype in terms of what is to be done, who will do it, at what stage of the project, and with what kind of resources.

- For the prototype of the O&M process, the benchmark is the standard operating procedures of the Irrigation Department, suitably modified for a new management system with farmer participation.
- For the prototype of the FO, the benchmarks for staffing and resource mobilization are the staffing and financing patterns associated in the Irrigation Department with the O&M of a distributary, while the benchmark for governance is that of an elected, two-tier local body managing its own human and financial resources.
- For the prototype of technical assistance, the benchmark is a project type technical assistance which may engage Pakistani resources from the private sector under a expatriate leader for organizing and setting up of FOs & WUAs.

The Key Processes

1. Provincial Government Policy Actions emphasize legal and institutional changes, and Government policy approvals for 'The Project' at certain key steps during design and implementation.
2. Technical Assistance in its Feasibility Phase consists of developing a general prototype (as in this report), and obtaining the Government's agreement to the

proposed prototype. The Feasibility Phase is expected to conclude in May 1997. The detailed area specific prototype will be developed at the stage of Basic Design.

3. Technical Assistance in the Implementation Phase of the Project will include two stages—before and after establishing the FO--of intense communication (testing), focusing on user acceptance of the prototype. After the first round of communication and motivation within the Project Area, the TA team will finalize the procedures of the FO and help establish the FO as a functioning, legal entity (within an expected time frame of 21 months after the commencement of the TA). It will assist the new entity at all stages of organization development, enable it to take over the Project Distributaries, and then concentrate on testing and improving the standard operating procedures for O&M.

4. The Organization Development of the FO will be facilitated by Technical Assistance during the entire period of the Project, starting from the formation of WUAs and the establishment of the FO and its offices, and including staffing, training, taking over of relevant records and documents, resource mobilization for the first year, taking over of the Project Distributary, and testing and improving the standard operating procedures.

5. The process of System Turnover describes the second set of Government responsibilities in the Project. Specific FO performance measures will guide the step-wise transfer of appropriate parts of the system, particularly, the buildings, vehicles, records and documents, financial resources for the first year of the FO, and the Project Distributary itself, from the Government to the new FO.

6. The Operation and Maintenance process commences in the Project once the lined (improved) Project Distributary is handed over to the FO. It includes the well-known functions of O&M, such as water acquisition, monitoring of water distribution, routine maintenance, special maintenance, assessment of water charges, collection of water charges, and the rendering of accounts and accountability. Standard operating procedures relating to these functions will be tested and improved with Technical Assistance after the take-over.

5.4.4 Provincial Government Role

Policy Actions

Policy Actions required in support of the proposed Project fall into two categories, namely legal cover and Government approvals for the Project.

Legal Cover

This includes:

1. Legal steps enabling the establishment of WUAs and FO as described in this proposal.
2. The delegation of appropriate powers to WUAs and FO under the Canal and Drainage Act 1973, including its sections 20 and 68.
3. Legal changes allowing farmers to trade water available to them below the outlet on competitive market principles.

Approvals for Project

Government approvals will be needed at the following stages during the life of the proposal:

1. When the interim report is ready for discussion with the Government (already approved in October 1996;)
2. When the draft final report is ready for discussion with the Government (in May 1997);
3. When the legal frame work and bye laws for WUAs and FO are prepared through Technical Assistance during project design /implementation;
4. When a draft System Turnover and Water Acquisition Contracts between the FO and the Government are prepared through Technical Assistance during project implementation; and,
5. When project distributaries are to be handed over to the FOs upon satisfactory completion of the pre-requisites by the Government.

System Turnover

The first step in preparing for System Turnover will be undertaken during the Technical Assistance, Implementation Phase, when a draft System Turnover Contract will be prepared. It will be reviewed and approved by the Government. Thereafter, System Turnover is envisaged as a series of hand-over/take-over measures between the Government and the FO. Spread over 12-18 months, the process will start soon after the formation of the FO and end with the take-over of the Project Distributary by the FO. Each step along the way would depend on the performance of the FO, for which performance measures have been specified. The completion of System Turnover would entail four main elements; these are elaborated below.

Turnover of Buildings and Vehicles

This element of System Turnover relates to the handing-over of those buildings (and vehicles and equipment, if any) that are being currently used by the Irrigation Department in the O&M of the Project Distributary. The pre-requisite (or performance measure) is that FO office-bearers must have been duly elected by a legally-constituted FO.

Turnover of Records

The turnover envisaged under this element relates to irrigation records, land revenue records, and the engineering, design documents and land plans pertaining to the Project Distributary. The pre-requisite for all of these is the conclusion of staff training by Pakistani consultants, and a short attachment of FO staff to the PID and Revenue Department.

Government Grant for First Year of FO Operations

During its first year, the FO will not take over the Project Distributary, but face the test of being the collection agent for PID or its successor(s). The pre-requisite for this is the formation of the FO as a legal entity, as witnessed by the election of its office-bearers. The rationale for the grant is to provide bridge financing to the FO for a one-year (or two-season) period. The size of the grant would equal the assessment of water charges expected to be collected by the FO less the amount to the transferred to PID or its successor(s).

Turnover of Project Distributary

This is a milestone; its trigger is the recovery of water charges & O & M for its first year of operations. The achievement of this milestone would trigger the System Turnover process, and initiate the O&M process to be managed by the FO. At the same time, the Technical Assistance, Implementation Phase, will commence the testing and improvement of standard operating procedures for maintenance, resource mobilization and accountability.

5.4.5 The Operation & Maintenance Cycle and Staff

The proposed O&M cycle consists largely of well-understood, routinised tasks, and repeats itself every year: it starts the moment water enters the head of the distributary, and ends when the assessed water charges are recovered by the water-supplier from the land owners. Each such cycle includes routine maintenance and the annual rendering of accounts. Every two-to-three years special maintenance is also carried out. The main O&M functions, benchmarked from the standard operating procedures of the Irrigation Department, are specified as follows:

1. Water acquisition;
2. Monitoring water distribution;
3. Routine maintenance;
4. Special maintenance;
5. Assessment of water charges;
6. Collection of water charges; and,
7. Rendering accounts.

These functions are elaborated below. The FO will need the following staff (benchmarked mainly from the Irrigation Department, but modified where necessary for farmer participation) in order to discharge these functions:

1. In its Technical Wing, the FO will have:
   A Member Technical, elected by the farmers, who will head the Technical Wing;
   A Technical Supervisor (sub-engineer/overseer) responsible for day-to-day operations;
   One Canal Patrol for each 8-10 km length of the Project Distributary, for routine O&M;
   A Gauge Reader responsible for distributary regulation; and,
   Two Regulation Baildars assisting the Gauge Reader.

2. In its Revenue, accounts and administration Wing, the FO will have:
   A Member Revenue, elected by the farmers, who will head the Revenue Wing; and,
   A Revenue Supervisor / accountant responsible for day-to-day operations.

In addition to the above-mentioned personnel, the FO will contract the services of:
   A firm of chartered accountants, to be engaged for audit and corporate law matters;
   An O&M Consulting Engineer (short-term), for technical scrutiny during special maintenance;
   An O&M Contractor to undertake the special maintenance works; and,
   The WUAs, for collecting water charges.

Water Acquisition

The FO's objective in water acquisition is to acquire and monitor the authorized, discharge for the Project Distributary, or the average discharge for the last ten years, whichever is greater. The FO will sign a two years water supply contract for spacified 10 daily discharges with the PID. The FO will pay proportionately less if the actual discharge falls below the contracted amount by more than 5 per cent or any agreed figure. The PID may, if water is available, supply additional amounts to the FO at their request upon agreed terms. The FO's water supply contract with the PID will be reflected in its water supply contracts with the WUAs located on the distributary.

The overall (administrative) responsibility for water acquisition will rest with the Member Technical, while the Technical Supervisor will have technical responsibility for the subject. The steps involved in water acquisition are as follows:

1. Obtain the draft water supply contracts for the FO prepared through Technical Assistance. [Technical Supervisor]
2. Sign the contract for water supply with PID. [Office-bearers]

3. On the basis of this contract, sign the two years water supply contract with the WUAs. [Office-bearers]

Monitoring Water Distribution

The FO's objective in the monitoring of water distribution is to determine whether each outlet is receiving its designed discharge. The administrative responsibility will rest with the Member Technical, and the technical responsibility with the Technical Supervisor. The process involves the following steps:

1. Measure gauges at heads of distributary and minors daily, and co-sign the Gauge Book for the distributary with the roving gauge reader of the PID. [Gauge Reader]
2. Work out discharge at these sites and prepare gauge-discharge curves. [Technical Supervisor]
3. Check dimensions and setting of all outlets in relation to sanctioned parameters. [Technical Supervisor]
4. Check the supplies at heads of off-taking minors and adjust according to the supply. [Technical Supervisor]
5. Check for any leakage, overflow and unauthorized withdrawal on the way. [Canal Patrol]
6. Daily monitor the supply to individual outlets by observing the H-gauge fixed at the head of the outlets. [Canal Patrol]
7. Twice-monthly monitor the supply to individual outlets by observing the H-gauge fixed at the head of the water course. [Technical Supervisor]

Routine Maintenance of Distributary

The FO's objective in routine maintenance is to maintain the unobstructed flow of water in the distributary and minors. The administrative responsibility will rest with the Member Technical, and the technical responsibility with the Technical Supervisor. The process involves the following steps:

1. Patrol both banks of Project Distributary (and minors, if any) daily. [Canal Patrol]
2. Remove the floating debris from the canal. [Canal Patrol]
3. Clear bridges, falls and regulators of the obstruction, bushes and other debris. [Canal Patrol/Regulation Baildar]
4. Repair rain-cuts and clear weed growth and jungle. [Canal Patrol]
5. Check for leaks from banks and repair rodent holes. [Canal Patrol]
6. Check for overflow of banks and make up free board. [Canal Patrol]
7. Carry out killa-bushing (putting wooden stakes to check erosion) at ghat (Washing place) sites and at cattle crossing sites. [Canal Patrol]

8. Maintain service road along the Project Distributary (and the minors, if any). [Canal Patrol]
9. Lubricate gates and gearings of the regulator. [Regulation Baildar]

Special Maintenance of Distributary

Special maintenance is required:

- When there is deviation in "H" by more than +/- 0.1 foot; or,
- When free board is reduced to less than 0.5 feet; or,
- When the canal is silted, raising the FSL, resulting in over-drawal by outlets at head; or,
- When there is vast deviation between existing and designed parameters of canal prism/section.
- When the road along the distributary deteriorates.

The FO's objective under special maintenance is to restore and maintain the designed parameters of the Project Distributary. The administrative responsibility will rest with the Member Technical, and the technical responsibility with the Technical Supervisor. The work will be carried out:

- If its magnitude is not much, by pooling all the Canal Patrols, working under the supervision of the Technical Supervisor.
- Otherwise, through contract labour after going through the procedure of tendering.

In case tendering is required, the FO will follow a procedure with three main steps:

1. Preparation of estimate for contractor;
2. Tendering; and,
3. Contract management.

The important tendering procedure will be the responsibility of the FO's Technical supervisor. The overall responsibility for estimate preparation and contract management will rest with the Member Technical and his Technical Supervisor. An outside engineering consultant will also be involved in checking the estimates, and authenticating entries during contract management. The detailed steps under each of the three main steps are elaborated as follows:

Steps for preparation of estimate for contractor:

1. Inspect and report on state of design [Technical Supervisor]
2. Order special maintenance [Member Technical]
3. Carry out hydraulic survey for the canal, observe cross section of every 1,000 feet apart and prepare long section. [Technical Supervisor]
4. Draw existing cross sections and L sections of the canal. [Technical Supervisor]
5. Calculate various quantities of works to be executed like earth work from outside, silt clearance, berm cutting, repairs to lining, etc. [Technical Supervisor]

6. Prepare bill of quantities. [Technical Supervisor]
7. Work out the cost of the work based on approved unit costs. [Technical Supervisor]
8. Prepare estimate for the work which includes justification, need, design criteria, specifications, quantities of works and costs. [Technical Supervisor]
9. Check the estimate, justification, design & specifications.[Consulting Engineer]
10. Send estimate for approval by Managing Committee. [Member Technical]
11. Accord approved after due satisfaction. [Managing Committee]

Tendering:

12. Invite tender from approved contractors. [Chairman / Member Technical]
13. Scrutinize the tender. [Chairman /Member Technical]
14. Award work. [Managing Committee]

Contract Management:

15. Measure the completed or portion of the work done in the Measurement Book (MB). [Technical Supervisor]
16. Effect field check to authenticate entries made by Technical Supervisor, and incorporate the permissible difference [Consulting Engineer]
17. Order preparation of the contractor's bill [Member Technical]
18. Insert the approved unit rates [Accountant]
19. Ascertain that funds are available [Accountant]
20. Prepare the contractor's bill. [Accountant]
21. Sign the bill in token of its correctness and authorize payment. [Member Technical]
22. Make payment to the contractor. [Accountant]

Assessment of Water Charges

The FO's objective is to assess water charges so as to cover the entire expenditure of the Distributary Farmer Organization, including the charges assessed for payment to the PID under the annual water supply contract. Based on a favourable response from the farmers of the Project Area (as already observed in parts of the Study Area), water charges will be assessed on a flat rate, per acre basis. The administrative responsibility within the FO will rest with the Member Revenue, and the technical responsibility with the Revenue Supervisor. The steps in the process are as follows:

1. Provide details of land ownership. [WUAs]
2. Check land ownership against Revenue records. [Revenue Supervisor]
3. Remove discrepancies through WUA meetings. [Revenue Supervisor]
4. Discuss/decide applications for remission by WUAs. [Member Revenue]
5. Check demand statement prepared by WUAs on flat rate basis. [Revenue Supervisor]

6. Enter remission and other charges granted. [Revenue Supervisor]
7. Authenticate the demand statement for WUAs. [Member Revenue]

Collection of Water Charges

The FO's objective is to collect the assessed water charges from the WUAs by contracting the latter to perform the collection function for a percentage of the amount recovered. The objective of the WUAs is to collect assessed water charges from individual farmers and deposit them with the FO. The FO will hold the WUA collectively responsible for the recoveries assessed under the annual water supply contract between the FO and the WUA. The WUA may nominate any one of its members by consensus, and upon such terms as the members may decide, to make the recoveries from individual farmers.

The administrative responsibility within the FO will rest with the Member Revenue, and the technical responsibility with the Revenue Supervisor. The steps in the process are as follows:

1. Send demand statement/for a water course to WUAs. [Revenue Supervisor]
2. Collect water charges from WUAs farmers. [Contracted WUAs]
3. Report and deposit the receipts with FO [Contracted WUAs]
4. Reconcile the receipts with the demand statement prepared by WUAs and identify the defaulters [Revenue Supervisor]
5. Consider and decide penalty recommended by WUAs for defaulters [Office-bearers]
6. Take action against defaulters [Office-bearers]

Rendering of Accounts

The FO's objective is to manage and render transparent, audited accounts to its office-bearers and the WUAs. The overall responsibility for this will be with the Chairman of the FO. The Accountant will have day-to-day responsibility. Chartered accountants will be engaged to conduct the annual (or any other external) audit, and to handle any corporate law matters. The main functions are expected to be as follows:

1. Select auditors for the FO. [Office-bearers]
2. Prepare the annual budget. [Accountant & Technical supervisor]
3. Approve the annual budget. [Office-bearers]
4. Prepare monthly financial statements of the FO. [Accountant]
5. Display the monthly financial statements at an accessible part of the FO office. [Accountant]
6. Make payment of monthly salaries. [Accountant]
7. Make approved payments to vendors. [Accountant]
8. Make approved payments to contractors. [Accountant]
9. Perform annual audit and handle corporate law matters. [Auditors]

10. Distribute audited accounts to WUAs. [Chairman]

5.4.6 Technical assistance required for institutional reforms

The TA Team responsible for the Organization Development of the FO would have the following long-term experts (for five years each), one of whom or an additional person may be the Team Leader:

A Sociologist, with responsibility including:

- executing a communication strategy, and providing feedback, to test the detailed, area-specific prototype in the Project Area before the FO is formed;
- executing a communication strategy for the FO for the period between FO office-bearer elections and taking over of the Project Distributary by the FO;
- improving the process of communication and accountability as part of the standard operating procedures of the FO after it takes over the Project Distributary; and,
- recruiting and supervising Pakistani experts or communication agency (or agencies) in support of the preceding functions.

A Management Specialist, with responsibility including:

- finalizing the detailed, area-specific prototype of the FO after the first round of communication with farmers in the Project Area;
- drafting the System Turnover Contract and getting it approved by the Government;
- selecting the Trustees of the FO, if required, and assisting them in organizing FO elections;
- assisting the office-bearers of the FO in staff recruitment and training procedures;
- through the Communication Specialist, testing the acceptance of the functioning FO among its users (farmers and employees), and modifying the design accordingly; and,
- executing a complete organization development strategy for the FO, including policies, procedures, job descriptions and information technology for all operations of the FO (except accounting and financial management).

A legal expert (2 years and mine months):

- preparation of law, rules and regulations regarding the elections, financial and technical powers of the FO's, its approval by Government, drafting agreements of water acquisition and distribution of financial resources between the FO & PIDA/ Area Water Boards/ Irrigation Department/ Registration of FOs & WUAs with the

corporate law authority and giving legal advice and pursuing the cases if any on behalf of farmers.;

A Financial Management Specialist, with responsibility including:

- assisting the office-bearers of the FO in negotiating a grant /loan from the Government for the first year of operations of the FO;
- assisting the office-bearers of the FO in recruiting and training revenue and accounts staff;
- assisting the revenue staff of the FO in taking over the land revenue records from the Revenue Department;
- installing a complete system of accounting and financial management for the FO, including financial policies, procedures, job descriptions and information technology.

An Irrigation O&M Specialist, with responsibility including:

- assisting the office-bearers of the FO in recruiting and training technical staff;
- assisting the technical staff in taking over buildings from the PID;
- assisting the technical staff in taking over irrigation records, and engineering and design documents including Land plans from the PID;
- assisting technical staff in taking over forestation with in the right of way from the Forest Department
- documenting and analyzing the Irrigation Department's standard operating procedures for O&M before the FO takes over the Project Distributary; and,
- designing, testing and improving O&M SOPs for the FO after it takes over the Project Distributary.

Four social organizers one each for LJC, CBDC and two for LCC to be in constant contact with the village motivators and farmers of each distributary explaining the advantages of water users associations and the farmers organization, their internal inter action, their powers and responsibilities.

- registration of farmers on each water course, making record of their land holdings and checking it with irrigation and revenue record.
- helping in holding elections of WUA's & FO's, arranging office accommodations by inter action with the government;
- arranging and organizing the meetings of WUAs and FOs in accordance with a time table to be prepared by him and approved by the FOs;

- arranging and helping FOs to take over technical record of distributary land plans buildings and tools and plants from the Government and training the farmers organization's staff to handle and store such record, arranging cabinets, chairs and tables for the FO offices;
- helping farmers in operation and maintenance of the distributary in the post take over period and assessment and collection of water charges.;

Twelve local Village Motivators - one for each distributary, with responsibilities including:

- explaining WUA and FO purposes and design to farmers;
- recording and analyzing feedback from farmers;
- assisting the Sociologist in preparing a communication strategy;
- explaining the highlights of the various procedures manuals of the FO to the farmers; and,
- making a list of WUAs and their members, and assisting WUAs with registration.

All the above experts could be engaged from amongst the local experts except the team leader who may be a foreigner.

Key Processes in Technical Assistance

Although outside the scope of work of the Institutional Study, the proposed Technical Assistance is key to the Organization Development of the FO. The key processes in which Technical Assistance will be engaged are introduced below as a summary of its role:

1. Establishing the TA Team in the Project Area.
2. First communication with farmers and stakeholders on the first distributary, including analysis of the feedback received from farmers.
3. Finalizing the management procedures in view of feedback from the farmers. These would include election procedures, registration procedures for WUAs and FO, staff training arrangements, bye laws and contracts.
4. Finalizing the financial management procedures in view of feedback from the farmers. These would include local assessment and collection procedures, and obtaining the first-year loan / grant from the Government.
5. Finalizing the irrigation O&M design and procedures in view of feedback from the farmers. These would include design changes recommended in view of the JICA Study, and improvements in the O&M procedures followed locally.

6. Establishing the FO. This would include communication of procedures to the farmers, selecting and supporting the FO Trustees, enabling them to organize elections, assisting the FO in obtaining a grant /loan from the Government and establishing its office, assisting the FO in staff recruitment and training, and preparing draft contracts for System Turnover and water supply.

7. Testing post-take-over farmer acceptance, and helping the FO improve its standard operating procedures in terms of FO and WUA management, irrigation O&M, assessment and collection, and farmer communication and accountability.

5.5 Environmental considerations

5.5.1 Initial Environmental Examination

An Initial Environmental Examination (IEE) of the Study area was carried out during phase I to assess whether an Environmental Impact Assessment (EIA) was necessary or not, having taken into consideration 19 items that could cause impacts. The results of the preliminary evaluation is given in Table 5.5.1-1. It indicated that there will not be any major significant environmental impacts envisaged due to the project and that an EIA was not necessary. Further study during phase II on the following items, and the impacts on the selected project canal command areas due to proposed activities was carried out.

1. Land requirements and the Canal Right of Way (Reservation)
2. Restoration of equitable water rights
3. Institutional changes
4. Farmers income and living standards
5. Forest plantations on canal side
6. Health and sanitation
7. Drinking water supply
8. Impediment to Livestock
9. Ground watertable
10 Water quality
11. Water quantity
12 Soil salinisation
13. Salt balance

The findings on these and the mitigative measures where necessary are as follows.

(1) Land requirements and the Canal Right of Way

Land will be required for temporary canal diversions, for borrow areas and other temporary works. The construction procedure proposed would not require any major land acquisition as the full right of way (reservation) will be used for this purpose. This procedure also virtually eliminates the need for any re-settlement. The reservation available on the canals is given in Tables 5.5.1-2, 3 & 4. The highest available reservation is in LJC and the smallest in CBDC. A large extent of the reservation is presently encroached. The encroached reservation will be made available by the PID to the project, after removing the encroachments by giving due notice to the encroachers. PID has informed that no compensation is required for this purpose. Those who are cultivating this land would loose the income that they got from cultivating it, as they will not be getting this land back for cultivation, after the lining is completed. It is proposed that the full reservation, free of encumbrances should be handed over to the Farmer Organization with the canal.

Extra land will be required mainly for construction of temporary diversion canals. A total of 138 hectares will be required for this purpose. The average extra width of land required for construction work has been estimated at 5.53m in CBDC, 2.24m in LCC and 1.40m. in LJC. In those instances where the width of the reservation is not sufficient, land will have to be obtained from the land owners for the construction of the diversion canals. These lands would no longer be required after completion of lining that particular section of the canal and hence could be returned to the owners. It is not necessary for such land to be permanently owned by acquiring. It is suggested that the use of this land be negotiated with the owners, on the basis of loss and damage. The land should be returned as far as possible in a similar condition to what it was before being taking over. In the event of inability to take over the land by negotiations, it may have to be acquired. However taking over of land under the Land Acquisition Act of 1894 is a long time consuming procedure and it could take many years. It is suggested, that this be best avoided and direct procurement procedure be adopted by the project.

The use of the land adjacent to the canal being used as a borrow area is to be discouraged, as it will be difficult to be levelled and brought back to the original condition. Such land would end up being an environmental hazard as they could get waterlogged with no proper drainage, and be the breeding grounds for disease carrying vectors such as mosquitoes

(2) Restoration of equitable water rights

The project is expected to make a significant redistribution of water, with those presently having water shortages, which are mainly at the tail end benefiting. Those who are mostly at the head and have been getting excess water will be able to receive there fair share. There will

be an additional quantity of water made available for irrigation, after completion of the lining and with the reduction of seepage. This combined with the new canal design and the proposed institutional changes is expected to make the restoration of equitable water rights, a reality.

The impact of this is of a high benefit to the farmers, who sees the present system, (the details of which is given in section 3.5) as an inequitable distribution system. The benefit that would occur is almost totally dependent on the success of the implementation of the institutional changes proposed.

(3) Institutional changes

The proposed Institutional changes given in section 5.4, are to be the most far reaching changes that would be occurring in the irrigation management of the distributary system in Punjab since its introduction over a century ago. The existing system created during the colonial times mainly for its interests, have served its purpose and outlived it with little modifications but has not met the requirements of the changing political, economic and social order. Little or no attempt has been made in participatory management. The existing system continues to deteriorate in all aspects of management at the distributary level which eventually would result in environmental degradation.

The proposed institutional changes would be attempting to arrest this deterioration by the involvement of participatory management on a pilot basis. Changing of a management system built on old colonial traditions would bring in conflicts of interest and resentment from interested parties, who would prefer to see the continuation of the present system.

The success of the Institutional changes would bring in many benefits, both environmentally and socio economically. The failure of the pilot scheme would cause the reverting back to the existing system.

(4) Farmers income and living standards

A major impact of the project would be the increase in farmers income following improved farming practices and greater agricultural productivity. The anticipated incomes with and without the project are given in Table 8.5-1. The highest percentage increase in disposable incomes in each of the canal systems are for the marginal farmers and lowest for the large farmers. The increase in disposable incomes vary from a high of 21.5% for the marginal farmers in LJC to a low of 4% for the large farmers in CBDC. The institutional changes would cause a positive impact on the social environment.

A higher disposable income realized through greater productivity, would produce a better living standard for the farmers.

(5) Canalside Forest plantations

The project would require the clearing of the forest plantations completely, at least on one side of the reservation for the construction of the diversion canals. This is an adverse environmental impact caused by the project. The 12 canal reservations has 73,148 trees as given in Table 5.5.1-5 comprising mainly of Shisham and Kikar, with an approximate value of about Rs. 360 million. The clearing of trees from the canalside plantations which are presently managed by the Forest department require a certain procedure to be followed. Fig. 5.5.1-1, indicates the procedure to be followed which includes the approval of the Chief Minister of Punjab, who has banned the cutting of these plantations. The overall procedure is expected to take about 6 months, including the physical clearing.

The management of the forest plantations is presently done by the Forest department. Following the institutional changes and the formation of Farmer Organizations, the viability of FO taking over such plantations should be addressed.

As a mitigative measure to the removal of trees, it is proposed that the canal reservation be completely replanted after completion of the project.

(6) Health and sanitation

The health and sanitation conditions in the project area is very poor. Survey carried out in the study area revealed that 50% of the population were affected by frequent illnesses, and this affects the farmers productivity. This survey indicated that during the previous year, 83% of the families were affected by flu or fever while 51% by malaria 47% with dysentery and 15% by typhoid as the main causes of illnesses. Although there are certain minimum basic infrastructure facilities provided, it was found that approximately only 27% of the population use these government facilities with the main reasons for non use being, absence of treatment center/doctor, lack of medical supplies and expensive medicines. However Health statistics are available only with the Health department but these would represent the treatment carried out at the government hospitals and is based on administrative districts of the department. The data for 1995 which is given below indicates the high incidence of many water related diseases.

District	Population	Diarrhoea	Dysentry	Malaria	Typhoid
Lahore	5,835,000	149,202	90,313	46,253	18,199
Kasur	2,302,000	10,428	8,569	118	
Faisalabad	4,307,000	113,941	64,100	16,634	14,286
TT Singh	1,191,000	27,508	16,660	761	1,348
Jhang	3,011,000	69,259	34,301	11,056	3,907
Sargodha	2,628,000	52,871	34,897	979	6,022
Total		450,908	264,208	80,891	43,672

Source: Health Department, Punjab

The high incidence of these diseases could be caused by poor quality drinking water, lack of sanitation facilities, poor preventive services and the prevailing cultural practices in the project area. Of the households surveyed 72% in LJC, 37% in LCC and 38% in CBDC had toilets in them. Overall only 23% had sewerage systems.

The prevention of livestock getting into the canals would reduce the pollution caused by it. The reduction in the water table would cause a reduced waterlogging problem, particularly in Hujjan, Kirana and Thamman distributaries, which is a beneficial impact. However the construction procedures including the resorting of borrowing from the reservation without the provision of proper drainage could lead to more surface water becoming stagnant. Such locations could become environmental hazards and be the breeding grounds of vectors of water related diseases such as mosquitoes. Because of this reason, the borrow areas has to be suitably identified at the detail design stage so as to minimize the adverse impacts that can be caused by them.

The canal lining project would not have any major impacts on the health and sanitation of the project area. It can be anticipated that the present incidence levels of water related diseases to continue.

(7) Drinking water supply

The drinking water quality survey carried out by the study team on 30 chaks within the 12 selected priority canals revealed that only 4 out of the 30 samples were fit for human consumption. Even these 4 had there chemical parameters above the WHO desirable level but below the maximum permissible level. 24 out of 30 samples tested were bacteriologically unfit for consumption while in addition many of the samples had their chemical parameters above the WHO maximum permissible level. This indicates a very poor condition in the availability of drinking water. The average values of the water quality of the 30 samples are as follows.

Parameter	Average value	WHO Desirable level	Parameter	Average value	WHO Desirable level
pH	7.86	7.0 - 8.5	Sulphate	498 mg/l	200
TDS	2,009 mg/l	500	Chloride	445 mg/l	200
Calcium	69 mg/l	75	Fluoride	0.34 mg/l	
Magnesium	62mg/l	50	Iron	0.13 mg/l	.1
Total Hardness	390 mg/l	100	Conductivity	2732 us/cm	
Total Alkalinity	630 mg/l		Nitrate	0 mg/l	
Nitrite	0 mg/l		Bacteriological Test	20% of samples acceptable	

The drinking water quality in the 30 chaks where the survey was carried out is given in Table 5.5.1-6.

Due to the lack of sufficient quantities of suitable fresh water for drinking in the saline zone, the Public Health Engineers Department (PHED) has constructed many minor water supply schemes, mainly by having tubewells by the canalside and drawing out the 'sweet' water from the underground aquifer. This fresh water aquifer is dependent mostly on the seepage water from the distributary canals. Some water schemes in the saline zone has its source as canal water which is taken directly and treated due to such water being bacteriologically contaminated. PHED then distributes the drinking water by pipelines to the Chaks. There are 32 such schemes in Kirana, 3 in Hujjan, on Nasrana 17 schemes are from tube wells with another 2 as a direct canal source, are to be installed. The Chaks served by these water supply schemes are given in Table 5.5.1-7. The population that is presently served by these schemes is estimated at 180,000. The PHED also plans more such schemes in the saline zone, as funds become available. The priority is presently a political matter. In addition there are 190 hand pumps installed within the reservation that draws water from the shallow fresh water.

The impact of the canal lining project would be a reduction in the amount of fresh water made available for the tubewells supplying drinking water to the 52 water supply schemes, after the completion of lining. The quantity required by most of these tube wells is less than 100,000 gallons per day and it is probable that there might be some fresh water that would seep after lining, although the projects aim is to reduce the loss of fresh canal water by seepage to the saline groundwater. In the long term it is unlikely that there will be sufficient fresh water available for extraction by these tubewells. The 190 hand pumps located on the canal reservation will also have to be removed for the construction work. The lining project would thus directly affect much of the population in the saline zone who now depend on the seepage water from the distributaries and minors for their drinking water.

With the reduction of canal water seepage into the fresh water aquifer, the possibility exists for the saline ground water intrusion into the present fresh water aquifer occurring. This would be

a major adverse impact that could occur. The monitoring programme is to include this item as part of their activities.

The projected impact of the lining project on the quantity of drinking water available, is adverse. As a mitigative measure, provision of drinking water to the affected persons during the construction period will be necessary. All hand pumps that will be removed for the construction work will have to be reinstalled by the project. Monitoring of the other tube well schemes after construction will be required and suitable action has to be taken in the event of non availability of suitable drinking water.

(8) Livestock impediment

Much damage has occurred to the canal embankments due to buffaloes and cattle getting into the canals. Such damaged locations have become weak points and they have even caused canal breaches. The livestock using the canal also increases the pollution of the canal water. The numbers of livestock has also increased in the project area and the problem would continue to escalate.

The lining project while eliminating the problem of livestock damaging the canal banks, would be impeding their free use of the canal water. After lining, the cattle and buffaloes would not be able to use the canal as a crossing as well as for bathing. As a mitigative measure, the canal design has provided Buffalo wallow/Cattle ghats within the reservation of the water courses . The number of bridge crossings has also been increased in the new design from the present average spacing of 2.53 km to 1.3 km apart. This would overcome the problems that would be faced by the livestock after lining of distributaries and minors.

The location of the buffalo wallow and the required sizes is a very important factor, that has to take in to consideration the fact, that livestock numbers will be continuously increasing and will be forming an economically important item mainly to the tail end farmers. The location and sizing should be done at the detail design stage, in consultation with FO.

(9) Groundwater table

The ground water table has generally lowered over the last 30 years since the introduction of the SCARPS programme, and it is only in a few areas that it is at the hazardous level of within 5 feet. The pre and post SCARP ground watertable depth in the study area was given in section 3.1.3.1. In the selected priority canal command areas, 6.2% of the total extent is within the hazardous level of within 5 feet as indicated in section 5.1.1. This is mainly in the Hujjan distributary where 34% is affected while Kirana distributary also in LJC has 7% and Thamman distributary in CBDC has 12% of the command area within the hazardous limit of within 5 feet

during October. In Kirana and to a lesser extent in Hujjan distributary, certain areas are having a high water table even during the June period. Fig 3.1.3-3 indicates the depth of ground water in October 1995 and Fig. 3.1.3-4 is the similar data for June 1996, obtained from the survey carried out by the study team.

The environmental impacts of Waterlogging are manifold. A high water table, generally less than 5 feet causes yield losses in crops. The yield loss increases with the rising water table. The percentage yield reduction due to high water tables is given in the following table.

Percentage yield reduction due to high water tables.

Water table depth (feet)	Mango	Cotton	Sugar cane	Wheat	Fodder
0.0' - 0.8'	100	98	91	79	80
0.8' - 1.6'	100	57	66	49	27
1.6' - 2.5'	100	35	46	28	0
2.5' - 3.2'	87	21	29	13	0
3.2' - 4.1'	63	12	14	5	0
4.1' - 4.9'	38	5	5	1	0
4.9' - 5.7'	14	1	1	0	0
>.5.7'	0	0	0	0	0

Source: Water Sector Investment Plan

From the above it can be seen that depending on the crop, waterlogging problems severity is felt more. The reduction of yield would initially lower the incomes of the farmers. The reduction of yield at around 3 feet will be that severe for the cultivation to be uneconomic. The environmental impact will be that the waterlogged land degrades to that level and finally becomes unproductive. Waterlogging also adds towards poor health conditions. The impact on the farmers would be lost income, land and livelihood.

The canal lining project would reduce the seepage from the distributaries and minors and that would directly contribute towards the reduction in the build up of the water table. The extraction of water by tube wells is another contributory factor towards the reduction, but this occurs only in the fresh water zone. This tube well extraction has caused the lowering of water table in certain areas as much as 45 cm a year. A too low ground water table would also have its problem. The possibility of saline water intrusion into the fresh water aquifer exists. The water table is an item that requires monitoring before and after the monsoons each year.

Overall, the lining project is expected to have a beneficial impact on this environmental parameter.

(10) Groundwater quality

The ground water quality in 39.8% of LJC, 40.2% of LCC and 51.5% of CBDC are saline with TDS of over 1000 ppm. In the 12 selected command areas, the saline area is 81%. The

ground water in the saline zone is not generally used for irrigation while in the fresh water zone it is heavily extracted by farmers tube wells for supplementary irrigation.

The projected changes on the quality of ground water due to the lining project will arise from:

(a) increase use of agro chemicals

(b) reduction of seepage of fresh canal water from the canals in the saline zone

(a) There will be no increase in the extent of land or in cropping intensity than at present which would cause an increase use of agro chemicals. However the present cultivated extents would see a change in farming practice and a small increase in the use of agro chemicals. This would not contribute towards any appreciable changes in the groundwater quality.

(b) As indicated earlier, in the fresh water zone the watertable is falling at an excessively high level. The reduction of fresh canal water seepage to the ground water aquifer combined with over extraction of fresh water by tube wells for irrigation purposes could cause the saline water intruding unto the fresh water zone. This would result in a greater area becoming saline than at present. This can be a very adverse impact that could occur by the project.

The overall impact of lining of canals on the quality of groundwater is not expected to be adverse, but it is very necessary that constant monitoring of the water quality as well as the fresh water extraction by tube wells is done, to ascertain whether such an intrusion is occurring. Further studies on this parameter such as solute transport modelling should be undertaken.

(11) Water quantity

The project would be saving about 10.7% of the total present flow in the selected canals that would otherwise be lost to the saline ground water aquifer. The quantity thus saved is about 163 MCM. If this canal water was lost to the saline water aquifer, it would not be re-usable for irrigation. This water will be available for distribution to the farmers for increasing cropping intensity, increase of land under cultivation, for redistribution to other areas to meet their requirements or for land reclamation by leaching of salinized soils.

The impact of this project, to line distributaries and minors in the saline zone would be very beneficial towards increasing the quantity of water. Monitoring of this activity is necessary and very important to ascertain whether the benefit is occurring.

(12) Soils and soil salinisation

The soils in the area are mostly calcareous, with 97%, 93% and 64% being moderately to very strongly calcareous in LCC, LJC and CBDC areas respectively. Section 3.1.4 indicated the present condition of the soil in the study area.

The Land Capability map, Fig. 3.1.4-1 shows the present soil and land capability conditions of the study area. The different grades of soils in the three canal command areas are as follows.

Grade	LJC	LCC	CBDC
Grade I	21.3%	41.7%	60.1%
Grade II	26.0%	33.8%	30.8%
Grade III	26.0%	11.8%	8.8%
Grade IV	20.0%	8.8%	0.3%
Grade V	5.6%	3.9%	
Grade VI	1.1%	0.1%	

Land capability is a dynamic parameter and depending on the rating adopted, it can vary. The properties of the soils in the study area has also been changing over the years, following irrigation. The surface salinity in the project area of the selected priority canal commands is presently at 9% as indicated in Table 5.1.2-1. The use of saline ground water for irrigation has converted non saline - non sodic soils to saline soils and this process is continuing.

The impact of salinisation is somewhat similar to those caused by waterlogging. As salinity increases, yields decrease. The environmental impact will be that the salinity causes land degradation progressively until it becomes unproductive. The impact on the farmers would be lost income, land and livelihood.

It must also be emphasized that the saline soils could become non saline soils, if the excess soluble salts are leached. The water that is saved by the proposed project, which amounts to 163 MCM annually could be used to recover lost land. This would amount to creation of new land.

The Land Reclamation Division carries out reclamation of saline land. This is mainly by leaching of saline soils with water to wash the excessive salinity under well drained conditions, which is a technique of general applicability and hence has been adopted. The extra water supplies required for reclamation are at the rate of one cusec for 45 acres in perennial canals and for 60 acres for non perennial canals. This process is continued for 3 years. According to the Directorate of Land Reclamation a delta of about 250" to 300" is required to leach down salts from the root zone under well drained conditions. Divided into 3 years this amounts to 80" to 100" for each year. This delta of water is envisaged to be utilized during the Kharif season, in the shape of 24 irrigations of 4" each.

The soil salinisation has to be monitored as indicated in Table 5.5.3-1. It is suggested that to make full use of the proposed project with a greater beneficial impact, that some reasonable quantity of 'saved' water be allocated for rehabilitation of saline land by the DLR.

(13) Salt Balance

The study on the salt balance in the study area has indicated that there is a salt accumulation in the soils of both, the fresh water zones (average 4.7 tons /ha) and the saline zones (average 3.1 tones /ha). In the ground water of the fresh water zones and in the saline zones there is a reduction of salts. The annual salt addition to the soil in the fresh groundwater zones (FGW) and saline ground water zones (SGW) of all 3 canal systems is given below.

Area	LJC/SGW	LJC/FGW	LCC/FGW	LCC/SGW	CBD/FGW	CBD/SGW
Salt addition to soil (tons/ha)	2.5	1.4	5.5	3.8	5.3	3.0
Salt added to ground water (million tons))	-0.8	-0.9	-4.4	-2.2	-0.8	-0.7

The results indicate that through continuous irrigation that both in the fresh and saline ground water zones, salt moves to and accumulates in the soil and less salt remain in the ground water. The soils in the fresh water zones are more vulnerable for secondary salinisation than those in the saline zones. In the fresh water zones the higher salt accumulation is apparently caused by the tube well water being pumped for irrigation. In the saline area, capillary movement of water in evaporation is the cause for salt accumulation in soil. If the present condition continues, salt accumulation in the soil will be detrimental to irrigated agriculture in the study area. Considering the long term affects would be creation of waterlogging which is an environmental hazard.

From the salt balance study it is indicated that as far as the canal lining project is concerned the effects are:

(1) canal losses through fresh water zones assist in off setting tube well pumping and there by dampen aquifer mining,

(2) canal losses through saline zone has a negative impact, in that the water is lost forever for irrigation when it mixes with the saline water, and then it goes on to contribute towards water logging.

Canal lining in the saline zone would have a beneficial impact. The salts in the saline zone that have already accumulated cannot now be removed, without proper drainage and considerable leaching. Canal lining would contribute towards the lowering of the water table, and reduction

of evaporation would reduce the salts accumulation. Though canal lining will not remove the salts completely it will reduce it from getting worsened.

5.5.2 Environmental Management Plan

Based on the results of the Initial Environmental Examination and further study, the environmental management plan and monitoring plan is drawn up for future reference. The environmental management plan is given in Table 5.5.2-1. The inter departmental coordination between the PID, the implementing agency and the other related organizations such as Agriculture Department, Public Health Engineers Department, Forest Department, Health Department, WAPDA and others are very vital for this project and should be enhanced. Each of the activities that have been dealt with, require follow up action from pre commencement to completion and post completion. The table indicates the requirements. Detail implementation plan of the project should incorporate these recommendations into such plans. Certain mitigative actions that have to be carried out as a result of the project during the implementation will have to be done from the miscellaneous item of the cost estimate.

5.5.3. Environmental Monitoring plan

The environmental monitoring plan is given in Table 5.5.3-1 A committee should be formed within PIDA to implement the monitoring programme. The other related institutions should be co-opted to this committee. The main functions of this committee will be to:

(a) prepare a detail monitoring plan based on the recommendations given in this study

(b) to carryout through the various government agencies, research organizations, independent consultants and FO the required activities and to supervise the actual monitoring programme

(c) analyze the data, take mitigative actions and to decimate this information to others concerned

(d) to maintain a data base including all baseline data on the project

(e) to recommend any special studies that are required to be done

The monitoring items include drinking water quality, ground water quality, water table, extraction of ground water by tubewells, soil salinisation, restoration of equal water rights, canal seepage, farmers living standards, health conditions and issues raised by the farmers during the construction period regarding any unexpected changes occurring.

The monitoring and evaluation results should be considered for the future direction of the pilot project.

5.5.4 Conclusions

The project has environmentally beneficial as well as adverse impacts. The main benefit will arise from the improvement to the irrigation system with the lining, in better water management and the institutional reforms. This will result in a higher income for the farmers through higher productivity and a better standard of living. Certain negative impacts that arise due to the project could be overcome by the implementation of the mitigative actions proposed. These are to be carried out from the miscellaneous item, in the cost estimate. The shortage of good quality drinking water is a major problem faced presently by the people living in the saline zone. The canal lining project could cause a further decrease in the availability of drinking water and this has to be closely monitored. Impacts on environmental parameters such as water quality, water table, salt balance are dependent on many factors. Some are dependent on other programmes such as the drainage programme while some are outside the present scope of work and would require further study including modelling. The probability exists for saline water intrusion into the fresh water zone and for loss of aquifer potential due to reduced recharge following the lining of canals. These can be possible adverse impacts in the long term and require close monitoring. Overall, the project would have more beneficial impacts compared to the adverse impacts

CHAPTER 6 IMPLEMENTATION PROGRAM

6.1 General

In accordance with the institutional reforms of the water sectors, the Provincial Irrigation Departments (PIDs) will be transformed into Provincial Irrigation and Drainage Authorities (PIDAs). Below the PIDAs, financially self-accounting Area Water Boards (AWBs) will be created. Below the AWB level, farmers will be encouraged to form Water Users Formations at the distributary and minor level on a pilot concept basis. In the current critical time, establishment of implementation program not only for construction work, but also operation and maintenance program - with institutional reforms - is of paramount importance. In this regard, it is strongly recommended to organize an executing agency as shown in Table 6.1-1, for executing construction work and for promoting the farmers participation as well.

6.2 Implementation of Construction Work

6.2.1 Implementation Period

The executive agency for the Project would be PIDA, which would be responsible for the planning, design, bidding and supervision of the project work, and keep close coordination with the three irrigation systems of LJC, LCC and CBDC offices on the project approval, finance and project implementation. The Project would be implemented under the organization of PIDA, which would be reorganized from PID, and would be of great importance in the coordination of activities among the respective departments concerned.

Prior to the commencement of the project work, the Project Director would be appointed under the Managing Director of PIDA. Three Deputy Directors would be nominated as co-managers to assist the Project Director to cover the responsibilities of respective departments of Technical/Civil Engineering, WUA & FO/Agriculture and Legislation.

Under the Technical Department, aiming at the smooth implementation, Planning, Engineering & Construction Section, Right-of-Way and Coordination Section, and Financial Section would be organized. Planning, Engineering & Construction Section would have the work for planning and monitoring of construction work, design and support of construction work and supervision of contract work. Right-of-Way and Coordination Section would deal with land acquisition, education and training to farmers, management of claim during the construction. Financial Department would be in charge of disbursement and accounting.

Regarding activities of the Departments of WUA & FO/Agriculture, and Legislation, description is made in the next Section 6.3.

6.2.2 Construction Mode and Method

The open international competitive bidding would be conducted with financial assistance from international institution. The procedure of pre-qualification and bidding for the contract work have not been authorized. According to the draft procedure, the Awarding Committee would be chaired by the Managing Director of PIDA. Every matter would be dealt with by the departments concerned under the proposed organization and approved by the committee, through administrative arrangement of Planning, Engineering & Construction Section.

6.2.3 Construction Schedule

Upon approval of the project, the detailed design as well as bidding documents, specifications and other documents/drawings necessary for the approval and implementation of the project work should be commenced and at the same time the selection of consultants would be carried out. The consultants would be selected first by the technical proposal. After approval of the selection, the contract conditions would be concluded. The prequalification documents would be revised by the consultants upon the commencement of consulting services and advertised after approval. The contract work would be bidden upon the approval of detailed design and construction drawings and started in the construction. The arrangement of all right-of-way should be accomplished before the construction with every efforts. These pre-construction activities are estimated to take about two years. Overall construction schedule is shown in Table 6.2.3-1.

6.3. Implementation Program of Institutional Reforms

The Institutional Reforms, being an integral part of main project of Lining of Distributaries and Minors in Punjab, shall be implemented along with the main project. The initial work shall be so started that the farmers organizations (FOs) are not only in place but are capable of taking over the distributary from irrigation department on its completion.

The recruitment of staff and the legal aspect shall therefore start at the detailed design stage of the project to enable the formalization and some reasonable training of the FO's and its staff before the completion of each distributary.

Some of the distributaries which are of shorter length and pose no construction problems, are likely to be completed much earlier than the others. The spatial implementation of institutional reforms shall, therefore, be so organized that the FO's are in place to take over such distributaries even before the completion of the total project. The organization of institutional reforms should always be in close coordination with the construction organization. In cases where the FO's have been formed during the Construction Stage they should be consulted and

associated with construction in a manner that a feeling of owner ship of the distributaries is developed among them.

The schedule of implementation is attached (Fig 6.3-1).

6.4 Project Monitoring Program

The Project is proposed to be a pilot project, consisting of 11% in acreage and 8% in length of the canals in the Study area. Therefore, monitoring is essential for the further implementation of the future projects. The contents of monitoring are quality and table of ground water, salinity of soil, saving rate of canal water, equitability of distribution, yield of crops, living standard of farmers, quality of drinking water and prevalence of institutional reforms. Items of investigation, procedure, monitoring agencies and monitoring periods are described in Table-5.5.3-1.

CHAPTER 7 COST ESTIMATE

7.1 General

Foreign currency portion corresponding to services and material imported and local currency portion corresponding to domestic services and material are separately estimated for each cost items for the purpose of project evaluation and planning of loan arrangement. The project cost comprises investiment cost, replacement cost and O&M cost. Institutional refom cost is included within the investiment cost. Cost estimates are based on current price at the time of May, 1996 for material, manpower and machinery refered from price index and statistices of import. Exchange rate of Rs. 34 to US$ 1.0 is applied for cost estimate at the same time.

7.2 Investiment Cost

Investiment cost consists of 1) Compensation Cost, 2) Direct Construction Cost, 3) Administration and Consultant Cost, 4) Institutaional Reform Cost, 5) Physical Contingency and 6) Price Contingency. Compensation cost of about Rs. 3.0 million includes land compensation cost for construction work outside of the Right of way and replacement cost of the facilities which would be damaged by the construction work. Direct construciton cost of about Rs. 1,985 million includes gate installation, earthwork, lining, work, related facilities and miscellaneous works. Miscellaneous works are estimated to be 3% of total cost of the other items in the direct construciton cost for temporaray outlets,discharge mesurement facilities, admixture of concrete and other uncounted items above while construction period. Administration and consultant cost comprises remuneration for expatriate consultants and local stuffs and office maintenance cost including procurement cost of equipments required in the project office. The administration and consultant cost is estimated to be Rs. 284 million and 14.3% of the direct construction cost. Institutional reform cost of about Rs. 76 million and 3.8% of the direct construction cost includes remuneration of espatriate consultant and stuffs (Rs. 64 million), procurement and operation cost of vehicle (Rs.8 million), office maintenance cost including procurement cost of equipments (Rs. 3 million) and activities and transmission cost (Rs. 1 million) and described in detail in chapter 5.4. Physical contingency is estimated to be 10 % of the direct construction cost. Price contingency is estimated to be about 20% based on price escaration of 3% per year in both foreign and local currency for 4 year net construction period by the year of 2004.

Project cost is thus estimated to be Rs. 3,120 million out of which the foreign currency portion turns to be Rs. 1,674 million and 54% and the local currency portion be Rs. 1,446 million and 46%. The project cost, unit cost and work volume of each work items are shown in Table 7.2-1. Distributary-wise project cost are shown in the Table 7.2-2 and Table 7.2-3 shows annual disbursement shcedule in accordance with the proposed project implementation schedule.

7.3 Replacement Cost and O&M Cost

Periodical repair of concrete lining portion as well as related facilities of the distributaries and minors to keep sustainable lined canal prism. The replacement cost is estimated to be 20% of the direct construction cost for every 20 years, namely Rs. 19.85 million and 1% of devaluation of canal is predicted and the replacement cost per 20 years comes to be Rs.397 million.

O&M cost is divided into facility maintenance cost and personnel cost. Consideration of safety factor, facility maintenance cost is estimated as high as the same item being spent for unlined channel of about Rs.17.80 million per year for desilting work and remedies against weeding, erosion and devastation of canal prizm. Personnel cost is estimated to be drastically reduced down to Rs. 5.03 million according to the stuff plan stated in chapter 5.4. Annual replacement cost and O&M cost are summarised in the following table.

Annual replacement cost and O&M cost (Unit: Rs. 1,000)

Item of Cost	LJC	LCC	CBDC	Total
(1) Direct Cost	677,290	1,078,770	229,440	1,985,500
(2) Annual replacement cost and O&M cost				
1) Replacement*1	6,773	10,788	2,294	19,850
2) O&M Cost				
a) Maintenance	5,990	9,602	2,210	17,802
b) Personnel	1,323	2,845	860	5,028
Total	14.087	21,901	5,356	41,344
(3) Annual replacement cost and O&M cost / Direct Cost (%)	2.1	2.0	2.3	2.1

7.4 Cost for institutional reforms

The institutional reforms in the Irrigation Sector as proposed in the project will be a new phenomenon with which the Irrigation Department is neither familiar nor they have shown any zeal and will to carry out these reforms. On the other hand the farmers have also perceived all along the history of irrigation that the problem of water supply was of an external nature and did not make a part of their responsibilities of every day lives. Water received from the distributaries and minors into their water courses was accepted as an external utility service for which the farmers paid the water charges regularly. It is therefore obvious that they have neither vision nor the training to organize themselves to take over the facility and the responsibility of its operation & maintenance.

The department of Agriculture has the experience of organizing the farmers at water course level but as described in other chapters it does not appear to be a very pleasant one as these water users associations disappeared soon after the improvement of the water courses.

In order to facilitate the W.U.As. and F.O's to be organized, the role of a catalytic outside agency can not be disputed. Such an agency must first persuade all the farmers of a distributary that getting organized is worth while and in their interest and then help them to do so. They will need advice on what organization structure to adopt, how to choose leaders, what laws need to be drafted, how to be registered, what powers should be given to them and how to use such powers. They will also need help in setting up the office, making rules and regulations, preparing registers and farms, employment of staff and negotiation of agreement regarding water supply and the sharing and fixation of water charges.

The farmers will need some one whom they trust and to train and guide them in these unfamiliar tasks. Since it will be the farmers first experience to form F.O's which will be their own entities and not be a part of the government, they consider it more effective to use a non-state organization such as a N.G.O or a good consultancy group. A major reason for the farmers to desire a consultancy technical help is that the inexperienced F.O. will need a strong support and better informed guidance in dealing with the state organizations such as irrigation department. Such dealings will involve negotiating water agreements, distribution of resources and division of responsibility. Farmers are unlikely to trust one state organization to help them in negotiating these issues with another nor there is any N.G.O available who are well informed and could help the farmers against the Government apparatus.

The technical assistance needs to be heavy in social organizers and such social organizers shall act as catalyst of the farmers ideas and experience rather than impose the " I know better than the ignorant farmers" attitude often found among government functionaries.

The project, therefore, shall provide the software of technical assistance for proper and organized implementation of the institutional reforms. Since the country has no experience of such institutions it will be appropriate to have foreign specialist in management who may cost about 40% of the total cost yet he will play the pivotal role of the chief motivator and organizer of the institutional reforms and therefore every success or failure will depend on the proper selection of this team leader.

The salaries and per diem expenses of local staff is also estimated on a higher scale as compared to government scales so as to solicit competent experts in the first instance and then to work with total indulgence once appointed. The recruitment of the local staff could be made strictly on merits with the one stipulation that they should be fully conversant in the local

language and dialect. Experts from rural areas should be given preference. The local staff could be used as trainers for subsequent reforms.

The main items of cost (details given in table 7) are:

(1)	pay and allowances of foreign expert	=	$1,016,000
(2)	pay and allowances of local experts and staff	=	$874,950
(3)	cost of transport office & utilities	=	$272,820
(4)	publicity & meetings	=	$25,000
	Total		$2,238,770
	Contingencies -10%	=	$223,877
	Grand Total		$2,462,647
	Say		$2,460,000

The cost of 2.46 million dollars on institutional reforms will be about 2.7% of the total cost of the project which is nominal when considered in terms of its impact on the Pakistan irrigation system efficiency to be achieved through the involvement of the beneficiaries.