Table F.5.1 Staff and Duties of Provincial Departments and Agencies (1/20)

1. Irrigation Department, D.I. Khan

(1-1) CRBC Pharpur Division

BPS	Name of Post	Number of Post	Job Description
1. Office of Executive Engineer			
19	Executive Engineer	1	Head of office, field and office duty for CRBC Stage I
17	Sub-Divisional Officers	3	Field and office duty
13	Divisional Accountant	1	Accounts matters
11	Sub-Engineer	11	Field and office duty
11	Head Clerk	1	Office work
11	Accounts Clerk	2	Accounts matters
9	Senior Clerk	4	Office work
5	Junior Clerk	10	Office work
5	Store Keeper	1	Store in charge
12	Head Draftman	1	In charge of drawing, etc.
11	Draftman	1	Drawing, etc.
5	Tracer	2	Drawing work
4	Record Lifter	1	Maintenance of office records
1	Peon	10	Office cleaning
1	Daffadar	1	Messenger of mail
1	Barkandaz	3	Assistance of daffadar
1	Mali	5	Maintenance of the office garden
1	Chowkidar	43	Office watch and ward
1	Bahishti	1	Water carrier for cooler and for other purposes
1	Sweeper	5	Office cleaning
4	Driver	5	Vehicle operation
7	Foreman	4	Repair and maintenance of the vehicles
7	Electrician	2	Electric works
5	Work Munshi	13	Supervision of the field men
1	Cleaner	2	Assistance of the driver
4	Store Munshi	1	Assistance of the store keeper
5	Gauge Reader	15	Gauge reading work at minors
5	Telephone attended	5	Telephone operation
5	Road Roller Driver	1	Road roller operation
4	Operator	73	Tube well operation
4	Chowkidar cum Cook	3	Office watching and cooking
2	Regulation Beldar	4	Works in the field
2	Mates	32	Head of field workers
1	Coolies	54	Laborers
1	Beldar	145	Field workers
5	Fitters	3	Assistance of the mechanic
5	Black smith	1	Repair the small tools
2	Hammer man	1	Assistance of the black smith
5	Store Clerk	1	Works in store
1	Ferro Printer	1	Works on ammonia printing machine
7	Mechanic	1	Repairing of machinery
2. Revenue Establishment			
17	Deputy Collector	1	Supervise the revenue assessment
14	Zilladars	5	Survey and assessment of water rate
10	Head vernacular clerk	1	Office assistant to deputy collector & Ziladars
5	Vernacular Clerk	9	Office assistant to deputy collector & Ziladars
5	Patwaris	46	Assistant Zilladar in survey and assessment of water rates
1	Naib Qasid	3	Office cleaning

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (2/20)

(1-2) CRBC Ist Lift Division

BPS	Name of Post	Number of Post	Job Description
18	Executive Engineer	1	Overall administration and technical supervision of 1st Lift Irrigation Project
17	Sub Divisional Officer	3	Field duty & office duty
16	Sub Engineers	2	Field duty & office duty
16	Head Draftsman	1	In charge of drawing etc.
15	Head Clerk	1	Office work
13	Divisional Accountant	1	Office accounting
11	Accounts Clerk	1	Assist the Divisional Accountant
11	Draftsman	1	Drawing etc.
10	Accounts Clerk	1	Office duty
9	Senior Clerk	1	Office duty
7	Senior Clerk	2	Office duty
5	Tracers	2	Drawing etc.
2	Naib Qasid	2	Office cleaning
1	Naib Qasid	2	Office cleaning

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (3/20)

2. Agriculture Research, D.I. Khan

BPS	Name of Post	Number of Post	Job Description
19	Director	1	Overall control or administrative, financial and technical matters
18	Agronomist	1	Crop production technology research
18	Agri Chemist (soils)	1	Soil, water and plant relationship
18	Oilseed botanist	1	Oilseed crop research
18	Wheat Botanist	1	Wheat crop research
18	Millet Botanist	1	Millet crop research
18	Horticulturist	1	Fruit plants research
18	Vegetable Botanist	1	Vegetable crop research
18	Entomologist	1	Insect pest control research
18	Plant physiologist	1	Weed science research
18	Plant Pathologist	1	Crop disease research
17+	Additional Statistician	1	Statistical analysis of experimental data
17+	Assistant Botanist (Rice)	1	Crop research
17+	Assistant Botanist Tobacco	1	Miscellaneous crops research
17+	Assistant Food Technologist	1	Development of post harvest technology for fruit and vegetables
17+	Assistant Agronomist	1	Assistant to Agronomist
17+	Assistant Agriculture chemist	1	Assistant to Agriculture chemist
17+	Assistant Botanist Millet	1	Assistant to Millet Botanist
17+	Assistant Horticulture	1	Assistant to Horticulturist
17+	Assistant Vegetable Botanist	1	Assistant to Vegetable Botnist
17+	Assistant Entomologist	1	Assistant to Entomologist
17+	Assistant Plant Pathologist	1	Assistant to plant Pathologist
17	Agricultural Research Officer (Agronomy)	3	Responsible for field work
17	Agricultural Research Officer (Soil Chemistry)	6	Responsible for field work
17	Agricultural Research Officer (Oil seeds)	1	Responsible for field work
17	Agricultural Research Officer (Wheat)	2	Responsible for field work
17	Agricultural Research Officer (Millet)	3	Responsible for field work
17	Agricultural Research Office (Cotton)	3	Responsible for field work
17	Agricultural Research Office (Entomology)	2	Responsible for field work
17	Agricultural Research Officer (Physiology)	2	Responsible for field work
17	Agricultural Research Officer (Pathology)	1	Responsible for field work
16	Administrative Officer	1	Helps the Director in administration and accounts
16	Office Superintendent	1	-do-
15	Stenographer	2	Office secretary with Director and Crop Specialist
12	Steno Typist	5	Office secretary with Director and Crop Specialist
11	Office Assistant	7	Help in office work
11	Foreman	1	Repair and maintenance of machinery
7	Senior Clerk	7	Office work
7	Heavy vehicle Driver	1	Truck operation
6	Field Assistant	33	Assist Agricultural Officer in field work
6	Lab. assistant	10	Assist in laboratory work
5	Junior Clerk	8	Office work
5	Tractor Driver	6	Tractor operation
4	Vehicle Driver	6	Vehicle operation
3	Tube-well operator	1	Tube well operation
1	Naib Qasid	8	Office Cleaning
1	Miscellaneous	47	Laborers for the field operations

Note: (+); Supervisory bearing additional pay Rs. 150/month

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (4/20)

3. Agricultural Extension Department, D.I. Khan

BPS	Name of Post	Number of Post	Job Description
18	Deputy Director Agriculture D.I. Khan Division	1	Administrative & financial control on all agricultural extension activities in the Division. Implementation of the policy of the govern. with regards to crop production. Guidance of extension workers in new agriculture techniques. Coordination between various agriculture sector organizations.
17	Assistant Publicity Officer D.I. Khan	1	Publication of hand-outs, posters, bulletin etc. about the improved techniques of agriculture. Planning, launching and supervising agriculture publicity/grow more food campaign. Training of field staff in various agriculture extension methods, crop production technique
17	Extra Assistant Director (E&M) D.I. Khan	1	Establishment of Market Committees in all important market centers of D.I. Khan Division. Collection of whole sale/retail prices of agriculture commodities and their supply to the agriculture and livestock advisor, Karachi. Collection of market fee and issue of deal licences to the dealers
17	Extra Assistant Directors of Agriculture D.I. Khan and Bunnu	2	Supervision of govern. seed farms in the respective District. Supervision of extension and plant protection activities
17	Subject Matter Specialist (Pest control) Extension Project D.I. Khan	1	Serve as Training Officer in agriculture extension project in the field of plant protection, preparation of reports and acting as control authority in agricultre extension Project D.I. Khan
17	Subject Matter Specialist (Agronomy) Extension Project D.I. Khan	1	Train farmers and field staff in the field of agronomy. Supervision of plant protection and extension activities. Advise farmers on crop production
17	Subject Matter Specialist National Oil Seed Development Project	1	Extension duty, supervision of extension staff. Supervision of ministerial staff. Supervision of account. Oil seed production
17	Assistant Agronomist Barani Agricultural Development Project D.I. Khan	1	Planning, supervision and implementation of Barani Agriculture Development Project activities in the area. Demonstration of Barani crops cultural practices and farm machinery
17	Assistant Plant Protection Officers D.I. Khan and Bannu	2	Plant protection activities. Advising & guiding of growers for adoption of safe and efficient use of pesticides. Checking of private pesticides agencies
17	Agricultural Officer	35	Plan over all agricultural development in his circle, supervision of Field Assistants. Agriculture extension duty. Preparation and submission of routine reports & returns
6	Field Assistants	121	Agricultural extension duty & demonstrational activities of new varieties & cultural practices. Identification of insect, pest & diseases attack on crops, vegetables, orchards and their prescription for remedial and control measures. Supervision of field workers in the circles

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (5/20)

4. Agricultural Engineering Department, D.I. Khan

BPS	Name of Post	Number of Post	Job Description
19	Agricultural Engineer	1	Overall administration
16	Administrative Officer	1	Asist the Agricultural Engineer in administration
16	Office Superintendent	1	Office supervision
16	Store Keeper	1	Store in-charge
11	Office Assistant	1	Office work
11	Foreman	2	Supervision of the repair workshop
10	Draftsman	1	Drawing etc.
12	Stenographer	1	Type work
9	Electrician	1	Electric works
9	Senior Clerk	1	Office assistance
8	Mechanic	1	Repair works
8	Track chain Operator	1	Track chain repair
8	Senior Clerk	1	Office assistance
8	Tracer	1	Drawing etc.
7	Senior Clerk	3	Office assistance
7	Junior Clerk	3	Office assistance
7	Mechanic	7	Repair works
6	Senior Store Keeper	2	Management of store
6	Vehicle Driver	2	Vehicle operation
5	Junior Clerk	5	Office assistance
5	Time Keeper	1	Time keeping of workers
5	Turner	3	Assistance of the mechanic
5	Black Smith	2	Iron works
5	Security Sergeant	1	Security of the office
5	Junior Store Keeper	2	Store in-charge
5	Carpenter	2	Wood works
5	Senior Mechanic	1	Machines repair
5	Welder	1	Welding works
5	Crane Greaser	1	Greasing
5	Fuel Pump Mechanic	1	Fuel pump repair
5	Radiator repair Mechanic	1	Radiator repair
5	Fitter Mechanic	1	Fitting works
5	Bench Fitter	1	Work with different tool files
5	Assistant Moulder	1	Moulding works
5	Crane Operator	1	Crane operation
4	Vehicle Driver	1	Vehicle operation
2	Fitter	2	Fitting works
2	Painter	1	Painting works
2	Naib Qasid	2	Transit of files, etc.
2	Mali	1	Garden maintenance
2	Skilled Collie	3	Helper in carriage
1	Naib Qasid	1	Office cleaning
1	Behishti	1	Water carrier
1	Mali	1	Maintenance of office garden
1	Sweeper	2	Cleaning of office premises and baths
1	Chowkidar	14	Office watch and ward
1	Hammer man	2	Assistance of Black Smith
1	Gate Keeper	1	Duty at gate
1	Skilled Collie	32	Helper in carriage

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (6/20)

5. On farm Wate Management, CRBC stage II D.I. Khan

BPS	Name of Post	Number of Post	Job Description
1. Department Office			
18	Project Director on Farm Water Management CRBC Stage-II D.I. Khan	1	Overall supervision of the subordinate staff, registration of water users Association and prescision land leveling
17	Assistant Director Extension	1	Head of field Assistants engaged in Water Users. Association and precision land levellin
17	Assistant Director construction	1	Vehicle and store control
17	Water Management Officer	4	Head of sub-engineers engaged in water courses
17	Water Management Officer (Extension)	2	Head of sub-engineer engaged in precision land levelling
17	Assistant Director (Administration)	1	Assisting the Director in overall administration
15	Stenographer	1	Type work
15	Office Assistant	1	Office work
11	Office Assistant	1	Office work
11	Head Draftsman	1	In charge of Drawing etc
11	Sub Engineer	20	Physical works at water courses
7	Senior Clerk	2	Office assistance
7	Junior Clerk	3	Office assistance
6	Field Assistant	14	To work on water users association and precision land levelling
6	Senior Store Keeper	1	Store management
5	Junior Clerk	5	Office assistance
5	Tracer	5	Assistance of Head draftsman
4	Vehicle driver	5	Vehicle operation
1	Chowkidar	3	Watch and ward
1	Naib Qasid	4	Transition of files etc.
1	Beldar	40	Assistance of the sub-engineer at water courses
1	Sweeper	1	Cleaning of office premises and bath
2. Special Office			
17	Water Management Officer (Extension Specialist)	2	Head of Field Assistants engaged in water users Association and precision land levelling
17	Assistant Director Water Management	1	Vehicle and store control
17	Water Management Officer	3	Head of sub engineers engaged on water courses
11	Sub-Engineer	18	Physical works at water courses
11	Foreman	1	Supervising the vehicle maintenance
11	Head draftman	1	In charge of drawings etc.
4	Vehicle Driver	3	Vehicle operation
1	Beldar	30	Assistance of sub-engineer at water courses
1	Naib Qasid	2	Office cleaning

6. Soil Conservation Department, D.I. Khan

BPS	Name of Post	Number of Post	Job Description
17	District Soil Conservationist	1	District supervision regarding soil conservation activities
17	Soil Conservation Assistant	1	Supervision of soil conservation work/preparation of estimates
7	Senior Clerk	1	In charge of office work
6	Field Assistant	4	Supervision of field work and contact with farmers
5	Junior Clerk	1	Office work
4	Vehicle driver	1	Vehicle operation
1	Naib Qasid	1	Office cleaning
1	Chowkidar	2	Watch and ward
1	Field Watcher	7	Supervision of the field work

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (7/20)

7. Animal Husbandry Department, D.I. Khan

BPS	Name of Post	Number of Post	Job Description
18	Assistant Director	1	Over all supervision of office
18	Veterinary officer (health)	10	Treats the animals
17	Veterinary officer (health)	6	Treats the animals
15	Office Assistant	1	Office work
9	Senior Clerk	1	Office work
5	Junior Clerk	2	Office work
9	Stock Assistant	18	Helps in the treatment of animals
9	Veterinary Compounder	6	Helps in treating animals
6	Stock Assistant	51	Helps in the treatment of animals
2	Naib Qasid	1	Office cleaning
4	Driver	1	Vehicle operation
1	Naib Qasid	2	Office cleaning
1	Chowkidar	27	Watch and ward
1	Behishties	11	Water carrier
1	Sweeper	14	Cleaning of office premises and baths
1	Chowkidar cum Behishti	8	Carrying water and watching the office
1	Behishti cum Khakroob	19	Office cleaning and water carring
1	Sycee	7	Service man and attending the horse in breeding
1	Grass Cutter	7	Supplying grass for pet animals of department

8. Food Department, D.I. Khan

BPS	Name of Post	Number of Post	Job Description
16	District food Controller	1	Overall supervision of food handling and distribution
8	Assistant Food Controller	2	Storage, sale and purchase of food
6	Food Grain Inspector	2	Marketing rates control
5	Supervisor	2	Quality control and assistance of the district food controller and assistant food controller
11	Head clerk/ senior Assistant	1	Office work
11	Assistant	1	Office work
7	Senior Clerk	2	Office work
5	Junior Clerk	6	Office work
1	Naib Qasid	2	Office cleaning
1	Chowkidar	47	Godowns watch and ward
1	Mali	4	Maintain the garden
1	Sweeper	3	Cleaning of office premisis and baths
4	Driver	1	Vehicle operation

9. Cooperative Department, D.I. Khan

BPS	Name of Post	Number of Post	Job Description
18	Deputy Registrar	1	Overall in charge of office
16	Assistant Registrar	1	to cooperative societies
11	Inspectors	6	Supervision of cooperative societies, Recovery of loans
11	Assistant	1	Office work
5	Sub Inspector	14	Help in preparation of loan documents
5	Junior Clerk	6	Office work
1	Naib Qasid	4	Office cleaning
1	Chowkidar	1	Office watch and ward

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (8/20)

10. Agriculture Development Authority (Agricultural Supply), D.I. Khan

BPS	Name of Post	Number of Post	Job Description
16	District Agricultural Supply Officer	1	Overall supervision of procurement and supply
16	Procurement Officer	1	Procurement of seeds
11	Office Assistant	1	Office work
9	Account Clerk	1	Dealing with accounts
7	Senior Clerk	1	Office work
8	Procurement Supervisor	3	Procurement of seeds
7	Store keeper	7	Sale of seed and fertilizers
6	Field assistant	1	Procurement of seeds
5	Store Man	2	Storage and sale of seed
5	Junior Clerk	3	Office work
4	Driver	1	Vehicle operation
1	Naib Qasid	2	Office cleaning
1	Chowkidar	11	Watching seed stores

11. Fruit and Vegetable Development Board, D.I. Khan

BPS	Name of Post	Number of Post	Job Description
17	Assistant Horticulture Officer	1	Overall development and administration of fruit and vegetables
17	Farm manager	1	Maintain nurseries and production of fruit plants and seeds
17	Fruit and Vegetable Development officer	1	Transfer of fruit and vegetable production technology to farmers
17	Lady horticulture officer	1	Transfer of fruit and vegetable production technology to female women
9	Field Assistant	1	Assistance of the field work
7	Senior Clerk	1	Office work
6	Field Assistant	9	Assistance of the field work
5	Budders	6	Budding and grafting of fruit plants
4	Driver	6	Vehicle operation
3	Tube well operator	1	Tube well operation
1	Field Worker	2	Assistance of the field assistant in the field
1	Mali	4	Maintenance of the orchard and fruit nurseries
1	Naib Qasid	2	Office cleaning
1	Trainee budder	4	Training the farmer, malis in budding work
1	Chowkidar	7	Watching the office and store
1	Tractor cleaner	1	Assistance of the driver in maintenance of the tractor
6	Lady Field Assistant	6	Assistance of the field work
5	Lady Junior clerk	1	Office work
1	Lady Naib Qasid/Field worker	2	Office cleaning

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (9/20)

12. Foresting Department, D.I. Khan

BPS	Name of Post	Number of Post	Job Description
18	Divisional Forest Officer	1	Overall in charge of activities of D.I. Khan Forest Division
16	Range Forest Officer	1	Overall in charge of activities of D.I. Khan Forest Range
15	Head Clerk	1	Office work
9	Deputy Ranger	2	In charge of forest block
7	Senior Clerk	2	Office work
7	Pick Up Driver	1	Pick Up operation
6	Forester	11	In charge of forest block
6	Tanker Driver	1	Operation of water tanker
5	Forest Guard	47	In charge of a forest beat
5	Junior Clerk	3	Office work
5	Patwari	1	Maintenance of land record of forest areas and boundaries
4	Tractor Driver	1	Tractor operation
1	Naib Qasid	3	Office cleaning
1	Dak Runner	1	Delivery of mail and letter
1	Chowkidar	2	Watch and ward
1	Mali	1	Maintenance of divisional office lawn
1	Cleaner	1	Water tanker cleaning work

13. Wild Life Department, D.I. Khan

BPS	Name of Post	Number of Post	Job Description
17	Divisional Forest Officer (Wildlife)	1	Overall in charge of activities
16	Range Officer	2	In charge of field duty for D.I. Khan
15	Assistant	1	Office work
9	Senior Clerk	1	Office work
5	Field Assistant	1	Field assistance
5	Deputy Ranger	5	Field duty
4	Drivers	2	Vehicle operation
3	Head Watcher Wild Life	1	In charge of watch and ward of wildlife
3	Boat Man	1	Boat duty for field purposes
1	Wild Life Watchers	30	Watch and ward of wildlife
1	Niab Qasid	3	Office cleaning
1	Chowkidar	2	Watch and ward

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (10/20)

14. Fisheries Department, D.I. Khan

BPS	Name of Post	Number of Post	Job Description
17	Assistant Director Fisheries	1	In charge of D.I. Khan Division
16	Assistant Research Officer	1	Breeding/management of Fish Nurseries
16	Fisheries Extension Officer	1	Extension duties
11	Assistant Warden Fisheries	1	Conservation work in D.I. Khan
11	Fisheries Divisional Assistant	1	Development Work in D.I. Khan
11	Office Assistant	1	Office work
7	Senior Clerk	2	Office work
6	Fisheries Supervisor	2	Hatchery work/field work
5	Junior Clerk	1	Office work
3	Head Fisheries Watcher	1	In charge of watch and ward of fish
1	Fisheries Watcher	25	Watch and ward of fish
1	Niab Qasid	2	Office cleanig
1	Chowkidar	4	Watch and ward

15. Building Department, D.I. Khan

BPS	Name of Post	Number of Post	Job Description
19	Executive Engineer	1	Overall administration and technical supervision or building engineering in D.I. Khan
17	Sub Divisional Officer	5	Supervision of work of Sub-Division
16	Divisional Accountant	1	Accounts matter
15	Stenographer	1	Type work
12	Divisional Head Draftsman	1	In charge of drawing etc.
11	Head Clerk	1	Office work
11	Sub Engineer	13	Supervision of development work in sections
11	Draftsman	1	Drawing etc.
9	Accounts Clerk	1	Accounts matters
7	Senior Clerk	6	Office work
7	Junior Clerk	2	Office work
5	Junior Clerk	6	Office work
5	Tracer	1	Drawing etc.
2	Daffadar	2	Office work
2	Naib Qasid	4	Office cleaning

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (11/20)

16. High ways department D.I. Khan

BPS	Name of Post	Number of Post	Job Description
18	Executive Engineer	1	Overall in charge of the division
17	Sub Divisional officers	5	Overall in charge the work of the sub division
16	Sub Engineer	1	Supervision of the work etc. in their respective sections
16	Head Draftsman	1	In charge of drawing etc.
16	Superintendent E&M	1	Control and supervise ferry service
15	Divisional Accountant	1	To supervise all the accounts matter of the division
15	Stenographer	1	Type work
12	Work Supervisor	2	Supervision of the work
11	Sub Engineer	12	Supervision of the work etc. in their respective sections
11	Head Clerk	1	Office work
11	Charge Mechanic	11	Maintenance of Vehicles
9	Accounts Clerks	2	Accounts work
9	Draftsman	2	Drawing etc.
9	Machanic	9	Maintenance of Vehicle
9	Supervisor	2	Supervision of work
7	Crane shaft Grinder	1	Work shop duties
7	Turner	1	Work shop duties
7	Senior Clerks	5	Office work
7	Bulldozer operator	4	Operation of Bulldozer
6	Road Inspector	4	Supervision of Roads
6	Launch Captain	6	Operation of launch
6	Boat man with small boat	7	Small boat operation
6	Carpenter	4	Wood work
6	Blacksmith Grand II	1	Work in workshop
6	Blacksmith Grand III	2	Work in workshop
5	Tracers	2	Drawing work
5	Junior Clerks	10	Office work
5	Work Munshi	5	To assist in the supervision work
5	Work Taker	2	Supervise the workers
5	Driver	32	Operation of road rollers and Vehicles
5	Work observer	2	Assist in construction work
5	Grader operator	2	Operation of Grader
4	Work Mistri	2	Mason work
4	Mechanic Mistri	1	Mechanic of launches
4	Head Boatman	12	Operation of boat bridge
4	Bridge Khalasi	47	Boat bridge operation
4	Assistant Jamedar	6	Watch and ward on working of boat bridge
4	Mechanic	1	Repair of launches
4	Oil man	1	Assist in maintenance of Vehicles
4	Store Munshi	3	Assist in stores
4	Pump Operator	1	Operation of pump
4	Oil Engine driver	4	Operation of oil engine
4	Earth work Mistri	2	Earth work
4	Chowkidar cum cook	1	Cooking of food
4	Havaldar	1	Escort duties
2	Mates	73	Supervision of coolies
2	Head Mate	1	Supervision of coolies
2	Boat man	33	Assist in operation of boat bridge
2	Fireman	2	Assist in operation of steamers
2	Store Mate	2	Assist in stores
2	Cleaner	30	Assist in operation of road rollers
2	Painter	1	Painting work
2	Hammerman	3	Work in workshop
2	Fitter Coolies	2	Work in workshop
2	Earth work dresser	6	Dressing of earth in road construction
2	Skilled Coolie	5	Skilled labourers
2	Head Chowkidar	10	In charge of watch and ward
2	Store Coolies	11	Assist in store
2	Badragga	9	Escort duties
1	Naib Qasid	10	Office cleaning
1	Chowkidar	5	Watch and ward
1	Brakandaz	4	Office security
1	Coolies	377	Physical labour on roads
1	Assistant Pumping Operator	1	Pump Operation
1	Store Chowkidar	2	Store watch and ward
1	Bahishti	1	Water carrier

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (12/20)

17. Public Health Department, D.I. Khan

BPS	Name of Post	Number of Post	Job Description
19	Superintending Engineer Circle D.I. Khan	1	Overall administration of Public Health Engineering Division D.I. Khan/Bannu
18	Executive Engineer Division D.I. Khan/Bannu	2	Project execution and maintenance of completed works in Public Health Engineering Division D.I. Khan/Bannu
17	Sub Divisional Officers	9	Project executive/maintenance of completed schemes in their Sub Divisions
16	Office Superintendent	1	In charge of ministerial work
16	Stenographer (Circle)	1	Typing work
13	Circle Head Draftsman	1	Check to estimate/drawings receipt from Divisional offices
13	Divisional Accountant	2	Control over the budget/pre-audit the bills
12	Divisional Head Draftsman	2	In charge of drawing
12	Stenographer (Divisional)	2	Typing work etc.
11	Head Clerk	4	Office work
11	Draftsman	5	Drawing etc.
11	Sub Engineers	27	Supervision of work in respective sections
9	Accounts Clerks	6	Office work
7	Senior Clerks	12	Office work
5	Tracers	5	Drawning etc.
5	Junior Clerk	34	Office work
4	Drivers	12	Vehicle operation
1	Ferre Khalasi	3	Operation of F/Printer
1	Naib Qasid	17	Office cleaning
1	Sweepers	10	Office cleaning
1	Berkandaz	6	Office assistance

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (13/20)

18. Health Department
(18-1) District Health Office

BPS	Name of Post	Number of Post	Job Description
19	District Health Officer D.I. Khan	1	Supervision of all preventive/curative activities the district
18	Assistant District Health Officer	3	- do -
17	Drug Inspector	1	Supervision of Chemist/Druggists
18	Medical Officers	26	Treatment of Indoor/Outdoor patients
17	Medical Officers	85	- do -
17	Women M/officer	7	- do -
18	Women M/officer	5	- do -
17	Dental surgeon	9	Treatment of Dental Patients
9	Medical technician Male/Female	144	Working in BHU/RHC/SH centres, Medical Facility to patients
	Lady Health Vsitors	62	Medical Facility to female patient
12	Asstt. Inspectress	3	To Visit the MCH Centre/BHU/RHC &C.H.
11	Office assistant	1	Office work
7	Senior clerk	3	Office work
5	Junior clerk	5	Office work
9	Blood Bank technician	2	Work in Teh:Head Qr Hosp: Blood Transfusion
6	Radio grapher	8	Work in X Ray Block/Unit in C.H./THQR
5	Laboratory assistant	16	Work in C.H. RHC in Laboratory
6	Op: theatre assistant	4	Work in Operation Theatre
6	Anaesthesia assistant	2	- do -
9	Dental technician	10	Work in Dental Unit of Hospital
5	Vaccinators	12	Vaccination of Cholera etc.
6	Asstt supdt: Vaccination	1	Supervision of Vaccination work
10	District sanitary inspector	1	Supervision of Sanitation work
6	Tehsil sanitary inspector	4	Sanitation work of Tehsil
14	Leprosy supervisor	2	Supervision Lepresy cases
2	Midwife/Dais	2	Birth cses and help/work with lady health visitor
1	Sanitary Patrol	24	Work with DSI/TSI/ADHO & work in RHC
2	Dental attendant	5	Work in Dental unit
2	Laboratory attendant	4	Work with Lab: Assist
2	Blood Bank attendant	2	Work in Laboratory
1	Cooks	11	Cooking Work
2	X Ray attendant	7	Work in X Ray unit
1	Peons	31	Office cleaning
1	Mali	13	Maintenance of gardens
1	Behishti/Sweeper	140	Water carrier
1	Chowkidar	103	Watch and ward
2	Ward crderly	118	Work with dispensaries
4	Drivers	12	Ambulance van operation
6	Compounder	103	Dispensring work

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (14/20)

18. Health Department
(18-2) District Head Quarters Hospital D.I.Khan

BPS	Name of Post	Number of Post	Job Description
19	Medical Superintendent	1	Overall I/C of district head quarter hospital, Zanana hospital, Tuber closis hospital D.I. Khan
19	Eye Specialist	1	To Supervise Eye Department
19	Surgical Specialist	2	In charge surgical units
18/19	Dental Surgeons	2	Treat Dental Patients
19	Medicoleagal Officer	1	To Supervise MLC work
19	WMO (DMS) ZH D.I. Khan	1	I/C Govt. Zanana hospital
18/19	Gynaecologists	2	I/C of Gynae:/Obstt: work
18	Physicians	2	I/C Medical Unit
18	Anaesthetists	2	To Supervise Anaesthesia work in operation Theatres
18	Gardiologist	1	I/C Cardiology Unit
18	Children Specialist	1	I/C Paeditcic Unit
18	ENT Specialist	1	I/C Ear, Nose and Throat Unit
18	Mental Specialist	1	I/C Psychiatry Unit/OPD
18	Pathologist	1	I/C Laboratory for Tests etc.
18	Radiologist	1	Radiology work/X ray Department
18	Medical Officers	17	To work in Various Wards
18	Woman medical officer	1	To deal women cases in ZH, D.I. Khan
18	Chief Nursing Superintendent	1	In charge of Nursing staff
17	Medical Officers	18	To work in arious wards
17	Woman Medical Officer	7	To work in Zanana hospital
17	Nursing Superintendent	1	To deal with Nursing staff
17	Pharmacist	1	To work in Medicine store
17	Sister Tutors	2	To teach under training students
16	Head Nurse	2	To supervise Nursing Staff
16	Public Health Supervisor	1	To work in Public health school
16	Social Medical Officer	2	To deal with/Assist in Administration
16	Chief L/Technician	1	In charge of Laboratory
16	Chief Blood Bank Technician	1	In charge of Blood Transfusion etc.
16	Chief Operation Theatre Technician	1	To assist in Anaesthesia work
16	Chief Dispenser	1	To supervise the Dispenser work
16	Chief Radiographer	1	To assist the Radiologist
16	Chief Dental Technical	1	To assist the Dental Surgeon
16	Chief Anaesthesia Technician	1	To assist in Anaesthesia work
16	Chief Tutor	1	To deal with U/Trg: Candidate in Health Technology
14	Charge Nurse	36	Nursing Care of Patients
11	Office Assistant	1	Office work
9	ECG Technician	2	To dealth with ECG of I/Pts
9	Operation Theater Technician	3	To work in Operation Theatre
9	Anaesthesia Technician	4	To work under Anaesthetist
9	House Keeper	1	I/C Linen Store (Bedding/Clothing)
9	Lady Technician	2	To work in Laboratory
9	Lady health visitor	2	To work in B.H school
8	Head Dispensers	4	To Supervisor the dispensers
7	Senior Radiograhper	1	To assist Radiology in X Ray department
7	Senior Clerk	1	To work in Administration Office
6	Radiographer	2	To work in X Ray Department
6	Head Lab: Assistant	3	To work under Pathologist Laboratory work
6	Compounders	28	Dispensing work
6	Midwives	4	To work in Zanana hospital D.I. Khan
6	Opertion Theatre Assistant	2	To work in Operation Theatre
6	Anaeshesia Assistant	2	To assist in Anaesthesia work
6	Electrician	1	To deal with Electrical work
5	Junior Clerks	6	Office work
5	Massure	1	To missage the Patients
5	TB Assistant	1	To assist I/C Tuber closis hospital
5	Plumber	1	Sanitary work etc.
5	Carpenter	1	To repair/replace broken wooden articles
4	Drivers	6	Ambulance Van Operation
4	Nurse Dai	1	To assist in Nursing work
3	Operation Theatre and attendant	2	Assist in Operation Theatre
3	T.Well Operator	1	Tube Well Operation
2	Dais	3	Assist in Zanana Hospital
2	Lab: Attendant	5	Assist in the Laboratory
2	Ward Orderlies	31	Assist the compounders in wards
2	X-Ray Attendant	4	Assist the Radio grapher
1	Behisti	13	Water Carrier
1	Attendant	1	Assist in various wards
1	Bearer	1	Assist in cooking and serving of food
1	Chowkidar	9	Watch and ward
1	Cleaner	2	Cleaning of dishes and Kitchen
1	Cook	11	Cooking meals for the patients
1	Dhoby	10	Washing of bed sheets etc.
1	Mali	11	Maintenance of garden in the hospital
1	Naib Qasid	11	Office cleaning
1	Sweeper	38	Cleaning of Hospital premises and baths

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (15/20)

19. Industries and Mineral Department D.I. Khan

BPS	Name of Post	Number of Post	Job Description
16	Industrial Development Officer	1	Overall supervision of the department activities. Education of people to avail loan facilities from the loan giving agencies. Collection of statistical data from different sources for industrial purposes. Assistance of the Industrial Units with the provision of infrastructure and other facilities. Maintenance of supply position of essential commodities in the market. Collection of P.O.L samples from various pumps/auto shop etc.
16	Mineral Development Officer	1	Motivation mining activities to Levy and recovery of tax on minerals
11	Assistant Industrial Development Officer	1	To assist the Industrial Development Officer in his duties
11	Assistant Price Stabilization Officer	1	To collect price data from market and co-ordinate with District Price Reiew Committee
11	Royalty Inspector	1	To check the unauthorized transport of minerals.
7	Senior Clerk	2	Office work
5	Junior Clerk	3	Office work
5	Tracer	1	Drawing work
1	Naib Qasid	2	Office Cleaning
1	Mali	1	Maintenance of lawn and garden
1	Chowkidar	1	Watch and ward
1	Mineral Guard	1	To help Royalty Inspector in his duties

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (16/20)

20. Education Department, D.I. Khan

BPS	Name of Post	Number of Post	Job Description
	Higher Secondry/Secondary Schools:		
19	Divisional Director School (Secondary)	1	Over all administration of schools within division
18	Dy divisional director (Secondary)	1	To assist the divisional director
18	Dy divisional directoress (Secondary)	1	To assist the divisional director
18	District Education Office (F&M) (Secondary)	2	Supervision of schools within district
18	District Education Office (F&M) (Primary)	2	Supervision of schools within district
17	Assistant district education office (M&F)	13	
17	Deputy district education officer	4	Administration of secondary schools
19	Principal (Higher secondary school)	6	Administration of higher secondary schools
18	Vice Principal	1	Assist in administration of Higher secondary schools
18	Head master/Head mistress	28	Administration of secondary schools
17	Head master/Head mistress	45	Administration of secondary schools
17&18	Subject specialist	34	Teaching work
17	Senior English Teacher	346	Teaching at Higher secondary schools
16	Librarian	4	Maintain and work in the library
16	Senior English Teacher		Teaching at Higher secondary schools
16	Director Physical education	4	Administration of physical education
16	Assistant Director Planning	1	Assist the divisional director in planning work
16	Assistant Director Establishment	1	Assist the divisional director on establishment of schools
16	Assistant Director Budget	1	Assist the director on budgeting and accounting of schools
16	Budget & account Officer	1	Work on budgets of the schools and office
16	Superintendent	1	Administration work
15	Stenographer	1	Office secretary with director
12	Stenographer	3	Office secretary with assistant directors
11	Assistant	15	Office work
10	Theology teacher	145	Teaching work
9	Certified teachers (C.T)	374	Teaching work
9	Senior vernacular teachers	230	Teaching work
9	Physical education teacher	153	Physical teaching
9	Drawing master	155	Drawing teaching
9	Arabic teacher	146	Arabic Teaching
8	Other teacher	74	Teaching work
7	Senior clerk	15	Office work
7	Qari teacher	95	Religious teaching
6	Store keeper	7	Store work
5	Laboratory assist	8	Assist in laboratory work
5	Assistant store keeper	3	Assist store keeper
5	Junior clerk	111	Office work
4	Driver	7	Vehicle operation
2	Daftri	5	Office work
1	Mali	15	Maintenance of office garden/lawn
1	Chowkidar	1,055	Office watch and ward
1	Dak runner	2	Office messenger
1	Naib Qasid	175	Office cleaning
1	Bahishti	96	Water carrier
1	Sweeper	152	Cleaning office premises and baths
1	Laboratory helper	80	Helps in laboratory work
1	Cook	23	Kitchen work
1	Workshop attendant	6	Workshop helper
1	Bearer	8	Serving food
1	Caller	19	To take the girls to schools and back home
1	Head Mat	1	
	Primary Schools		
18	District education officer (M&F)	2	Supervision of primary schools at district level
17	Sub-Divisional educatation officer(M&F)	2	Supervision of primary schools at Tehsil level
16	Assistant Sub-Divisional education officer (M&F)	12	Assist the sub divisional education officers in their duties
7	Teachers (M&F)	2,590	Teaching work

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (17/20)

21. Population and Welfare Department, D.I. Khan

BPS	Name of Post	Number of Post	Job Description
18	District Population Welfare Officer	1	Overall Administration of departmental activities
17	Deputy District Population Welfare Officer (Amin.)	1	Administration supervision of district and field staff
17	Deputy District Population Welfare Officer (C&T)	1	Arrangement of training of district staff as in I.E.C
17	Technical District Population Welfare Officer	2	Administration and overall supervision of Tehsil field staff
17	F.T.Os	2	Checking/supervision of FW-Centre staff and motivation of program
16	Assistant District Population Welfare Officer	1	Assistance of DDPWO (C&T) in training work and supervision of field staff
12	Steno typist	2	Type work
11	Accounts Assistant	1	Office work
11	Statistical Assistant	1	Keeping of statistics of the departmental activities
11	Office Assistant	1	Office work
11	FW-Councillor	5	In charge of FW-Centre
9	Projectionist	1	Exhibition of film show in the field
8	FW-Worker	15	In charge of FW-Centre
7	Senior Clerk	2	Office work
7	Storekeeper	1	In charge of store
5	Junior Clerk	5	Office work
5	FW-Assistant (Male)	20	Motivation and supply of C.Cs to health department and DDPs/RMPs and collection of sale proceeds thereof
5	FW-Assistant (Female)	20	Registration of eligible couples and house hold motivation work
4	Driver	5	Vehicle operation
1	Chowkidar	21	Watch and ward
1	Naib Qasid	3	Office cleaning
1	Mali	1	Maintenance of garden
1	Helpers/Aya	20	Assistance of centre in charge
1	Sweeper	1	Cleaning work

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (18/20)

22. Local Government and Rural Development Department

BPS	Name of Post	Number of Post	Job Description
17	Assistant Director	1	Overall in charge of District to coordinate development activities of the whole District and to help the MNAs, senators and MPA in planning & execution of development schemes
17	Assistant Engineer	2	Assistance of the MNA's, Senators and MPA's in Excution of Development Schemes on technical side
16	Progress Officer	1	Preparation of the progress reports of development schemes and collection of basic data for planning of development schemes by MNA, Senators and MPAs
12	Steno Typist	1	Type work
11	Sub Engineer	4	To help the MNA, Senators and MPAs in execution of development schemes on technical side
11	Office Assistant	1	Office work
9	Supervisors	2	Supervision of development and other connected functions of Union Councils in a sub division
7	Senior Clerk	1	Office work
6	Secretary Union Councils	33	Assist the Chairman Union Councils
6	Jeep Driver	1	Vehicle operation
5	Junior Clerks	4	Office work
1	Naib Qasid	7	Office cleaning
1	Chowkidar	3	Watch and ward

Note: MNAs; Member of National Assembly
MPAs; Member of Provincial Assembly

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (19/20)

23. Revenue Department. D.I.Khan

BPS	Name of Post	Number of Post	Job Description
18	Deputy Commissioner	1	A multi purpose post representing the Govt: at district level. He performs the duties of districts collector magistrate and the Captain of all the heads of departments working in the district.
17	Assistant Commissioner	2	Same as above process at the sub-divisional level.
17	Extra Assistant Commissioner	7	Assist the Assistant Commissioner in judicial work .
16	Tehsildar	6	Chief of Revenue departments at Tehsil level.
14	Naib Tehsildar	7	Assist the Tehsildar in his duties.
11	Head Vernacular Clerk	1	Translate Various vernacular returns of various kinds into English and submit to the collector
14	District Kanungo	1	A Revenue superintendent at district level. Collects Revenue returns of various kinds and communicates it to the provincial head quarters.
12	Assistant District Kanungo	2	Assist the district Kanungo in his duties
14	District Revenue Accountant	1	Maintain the Land Revenue and water charges accounts etc. at the district level
12	Assistant District Revenue Accountant	1	Assist the district Revenue accountant in his duties
10	Kanungo	21	To supervise to a few patwari's circles
5	Patwaris	122	The basic Revenue official at village level He performs his duties under Land Revenue Act in an estate (s) {Mauzas}. Maintains the land record pertaining to ownership, possession and soil type etc.
16	Superintendent	1	He is in charge of office work
15	Stenographer	1	Office Secretory to Deputy Commissioner
11	Office Assistant	6	Office work
7	Senior Clerk	11	Office work
5	Junior Clerk	57	Office work
1	Naib Qasid		Office cleaning
1	Sweeper & other class IV	35	Cleaning office premisis and baths etc.

Table F.5.1 Staff and Duties of Provincial Departments and Agencies (20/20)

24. Physical Planning and Housing Department D.I. Khan
Dera Development Authority

BPS	Name of Post	Number of Post	Job Description
19	Project Director	1	Overall in charge of the Project
17	Assistant Director	3	Site Engineers
16	Housing Officer	1	In charge housing
15	Stenographer	1	Type work
12	Draftsman	1	In charge Drawing branch
11	Assistant draftsman	1	Drawing etc.
11	Assistant	2	Office work
7	Senior Clerk	1	Office work
5	Junior Clerk	7	Office work
4	Drivers	7	Vehicle Operation
1	Peons	6	Office cleaning
1	Malis helper	16	Maintenance of lawns
16	Accounts Officer	1	In charge account section
11	Assistant Accountant	1	Assist in accounting
9	Accounts Clerk	1	Assists in accounts work
5	Laboratory Assistant	1	Laboratory in charge
1	Laboratory Helper	1	Helps in laboratory work
1	Chowkidar	3	Watch and ward
11	Building Inspector	1	In charge to control building construction
9	Assistant building Inspector	3	Assist the building inspector
5	Tracer	1	Drawing etc.
11	Sub Engineer	2	Site work supervision

Table F.6.1 Staffing for Proposed Office

(Implemantation Stage)

C.R.B.D.A. MAIN OFFICE

Item	Number of Staff
I. Board Members	4
Chairman (Grade 21/22)	1
Members (Grade 20/21)	
1. Irrigation	1
2. Agriculture	1
3. Socio-Economic Development	1
Advisor	(2)
II. Technical Staff (Grade 17-19)	71
1. Irrigation	
1-1 Superintending engineer	1
1-2 Super intending engineer	1
1-3 Senior engineer	6
2. Agriculture	
2-1 Director,extension	1
2-2 Director, adaptive research and seed develop	1
2-3 Director, marketing and credit	1
2-4 AD, land develop. and water manage.	1
2-5 AD, Extension	1
2-6 AD, Seed	1
2-7 AD, adaptive research	1
2-8 AD, marketing	1
2-9 AD, agricultural credit	1
2-10 Extension advisor	25
2-11 Seed expert	6
2-12 Agronomist	3
2-13 Insecticide expert	1
2-14 Fertilizer expert	1
2-15 Soil expert	1
3. Socio-Economic Development	
3-1 Director, Infrastructure	1
3-2 Land acquisition collector	1
3-3 Senior engineer	2
3-4 Junior engineer	4
4. Finance	
4-1 G.M.finance	1
4-2 Director finance	1
4-3 Director, audit	1
4-4 Accounts officer	2
4-5 Auditor	4
III. Supporting Staff (Grade 1-16)	165
(Secretary, assistant, typist, drivers, etc.)	
Total	240

→ After completion of construction work, the organization will be sifted.

(Operation & Maintenance Stage)

C.R.B.D.A. MAIN OFFICE

Item	Number of Staff
I. Board Members	4
Chairman (Grade 21/22)	1
Members (Grade 20/21)	
1. Irrigation	1
2. Agriculture	1
3. Socio-Economic Development	1
Advisor	(2)
II. Technical Staff (Grade 17-19)	67
1. Irrigation	
1-1 Superintending engineer	1
1-2 Senior engineer	3
2. Agriculture	
2-1 Director,extension	1
2-2 Director, adaptive research and seed develop	1
2-3 Director, marketing and credit	1
2-4 AD, land develop. and water manage.	1
2-5 AD, Extension	1
2-6 AD, Seed	1
2-7 AD, adaptive research	1
2-8 AD, marketing	1
2-9 AD, agricultural credit	1
2-10 Extension advisor	25
2-11 Seed expert	6
2-12 Agronomist	3
2-13 Insecticide expert	1
2-14 Fertilizer expert	1
2-15 Soil expert	1
3. Socio-Economic Development	
3-1 Director, Infrastructure	1
3-2 Land acquisition collector	1
3-3 Senior engineer	2
3-4 Junior engineer	4
4. Finance	
4-1 G.M.finance	1
4-1 Director finance	1
4-2 Director, audit	1
4-3 Accounts officer	2
4-4 Auditor	4
III. Supporting Staff (Grade 1-16)	139
(Secretary, assistant, typist, drivers, etc.)	
Total	210

INTAKE OPERATION OFFICE

Item	Number of Staff
Officer in charge (Grade 18)	(1/3)
Gauge reader	3
Total	3

PUMP OPERATION OFFICE

Item	Number of Staff
Officer in charge (Grade 18)	(1)
Technical Staff (Grade 17)	
Mechanical engineer	3
Electrical engineer	2
Supporting Staff (Grade 1-16)	
Technical assistant	6
Others	15
Total	26

FEEDER CANAL O&M OFFICE (F-1~2)

Item	Number of Staff
Officer in charge (Grade 18)	(1/3)
Supporting Staff (Grade 1-16)	
Technical assistant	2
Driver	2
Others	4
Total	8

MAIN CANAL O&M OFFICE (M-1~6)

Item	Number of Staff
Officer in charge (Grade 18)	(1/6)
Technical staff (Grade 17)	1/2
Supporting Staff (Grade 1-16)	
Technical assistant	2
Driver	3/2
Others	6
Total	10

DISTRIBUTARY O&M OFFICE (D-1~25)

Item	Number of Staff
Extension advisor	(1)
Supporting Staff (Grade 1-16)	
Technical assistant	2
Driver	1
Others	2
Total	5

Table F.6.2 Staffing of CRB Development Authority jointed with CRB Gravity Area

Item	Number of Staff		
	1st Lift	Gravity	Total
I. BOARD MEMBERS	4	0	4
Charirman (Grade 22/21)	1	-	1
Members (Grade 21/20)			
1. Irrigation	1	-	1
2. Agriculture	1	-	1
3. Socio-Economic Development	1	-	1
(Advisor)			
1. Financial Institute	(1)	(-)	(1)
2. Farmers Association	(1)	(-)	(1)
II. Technical Staff	71	24	95
(Grade 17-19)			
1. Irrigation			
1. Superintending engineer	1	-	1
2. Super intending engineer	1	-	1
3. Senior engineeer	6	-	6
2. Agriculture			
1. Director, extension	1	-	-
2. Director, adaptive research and seed development	1	-	1
3. Director, marketing and credit	1	-	1
4. Assistant director (AD), land development and water management	1	-	1
5. AD, Extension	1	1	2
6. AD, Seed	1	-	1
7. AD, adaptive research	1	-	1
8. AD, marketing	1	-	1
9. AD, agricultural credit	1	-	1
10. Extension advisor	25	23	48
11. Seed expert	6	-	6
12. Agronomist	3	-	3
13. Insecticide expert	1	-	1
14. Fertilizer expert	1	-	1
15. Soil expert	1	-	1
3. Socio-Economic Development			
1. Director, Infrastructure	1	-	1
2. Land aquisition collector	1	-	1
3. Senior engineer	2	-	2
4. Junior engineer	4	-	4
4. Finance			
1. G.M. finance	1	-	-
2. Director finance	1	-	1
3. Director, audit	1	-	1
4. Accounts officer	2	-	2
5. Auditor	4	-	4
III. Supporting Staff (Grade 1 - 16) (Secretary, assistant, typist, drivers, etc.)	165	48	208
Total	240	72	312

FIGURES

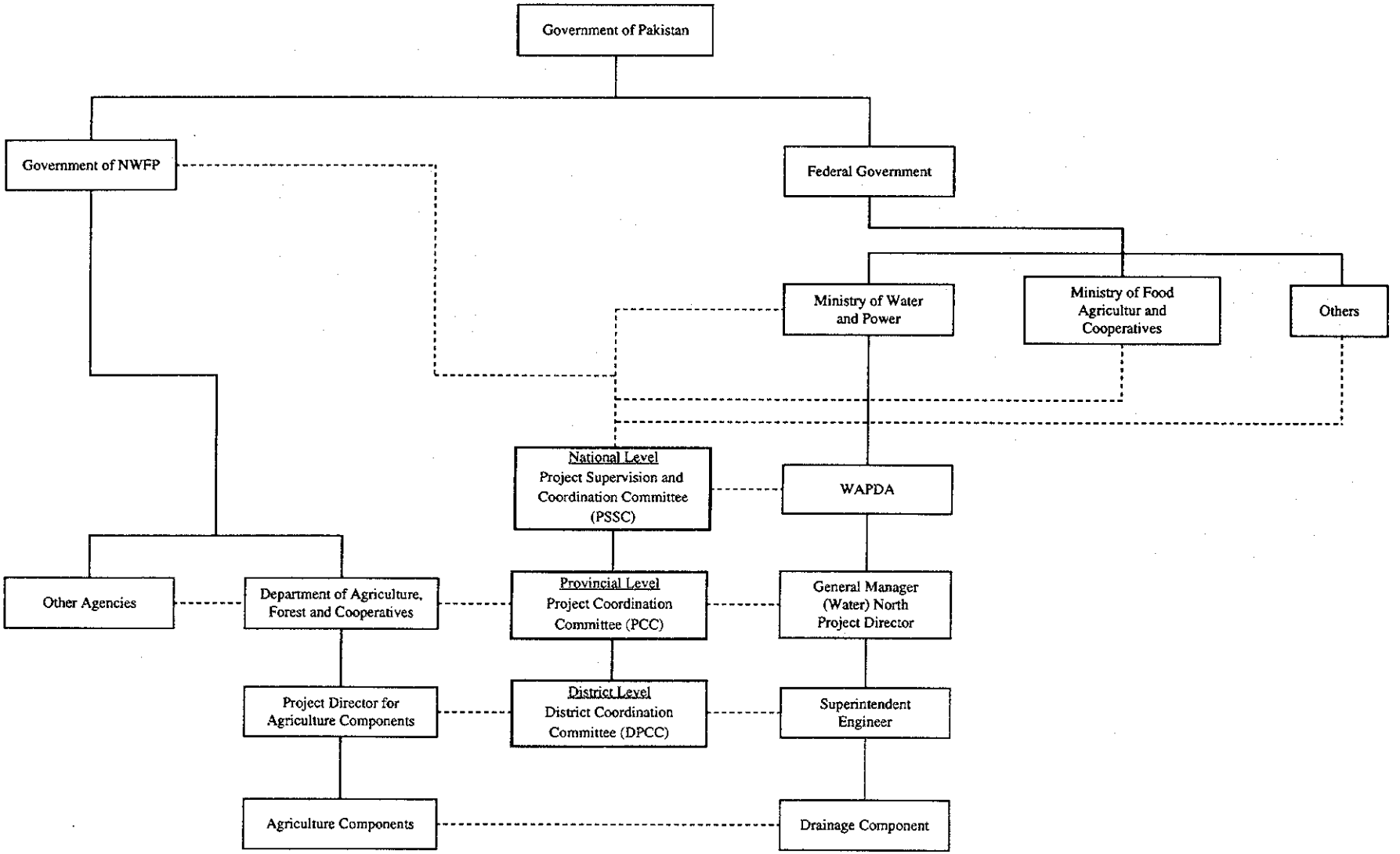
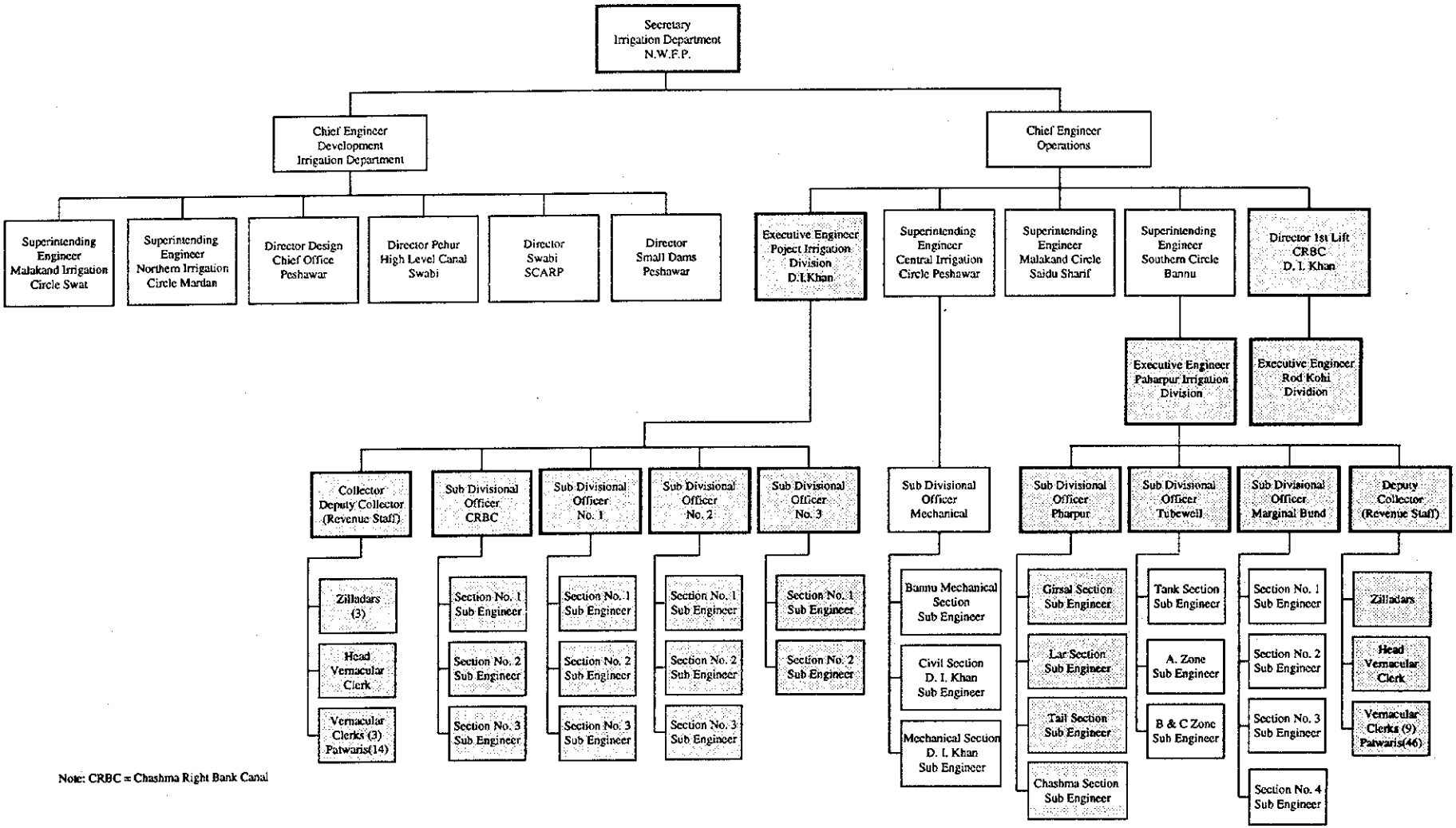


Fig. F.3.1 Project Coordination for Chashma Command Area Development Project



Note: CRBC = Chashma Right Bank Canal

Fig. F.3.2.1 Organization Chart of Irrigation Department, D.I. Khan

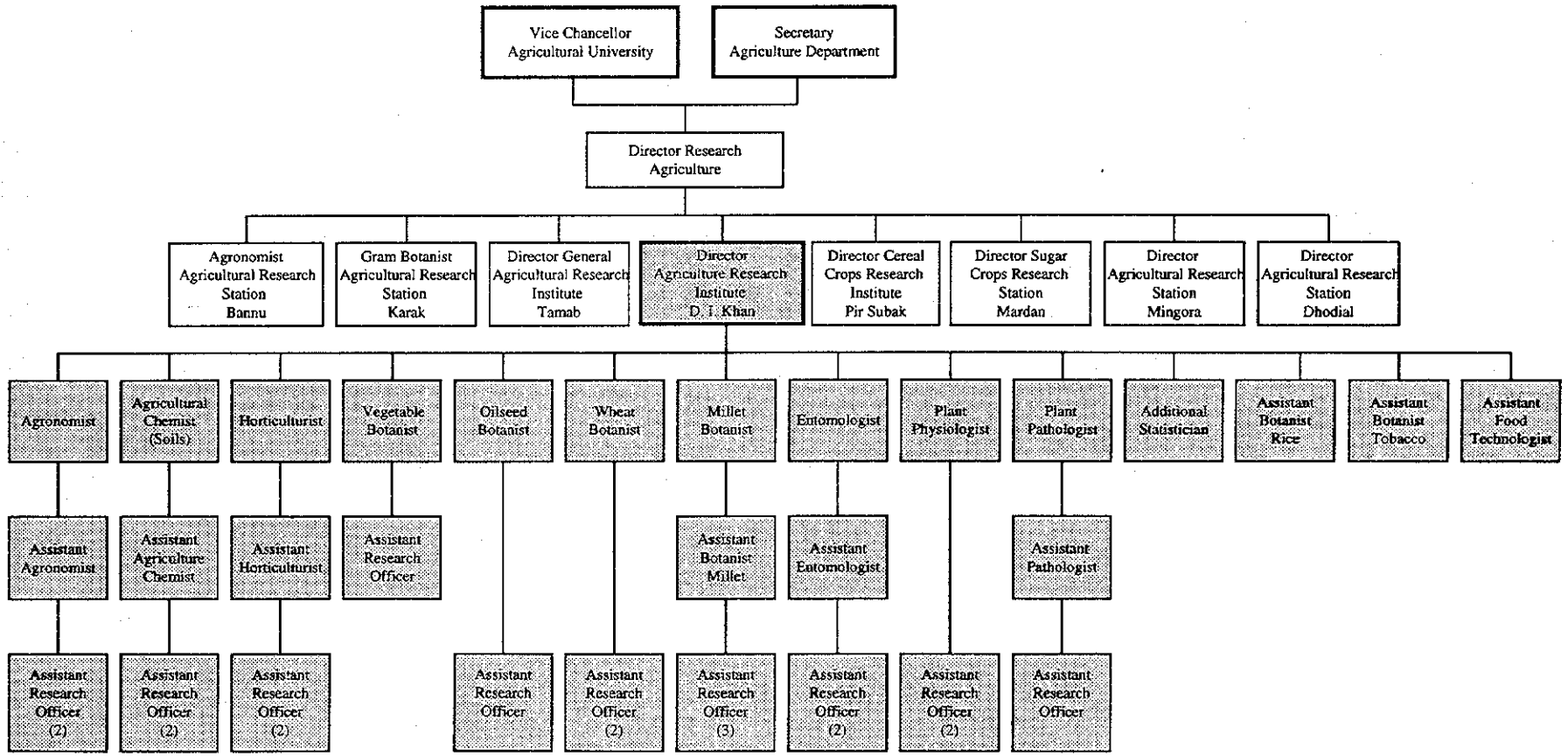


Fig. F.3.2.2 Organization Chart of Agriculture Research Station, D.I. Khan

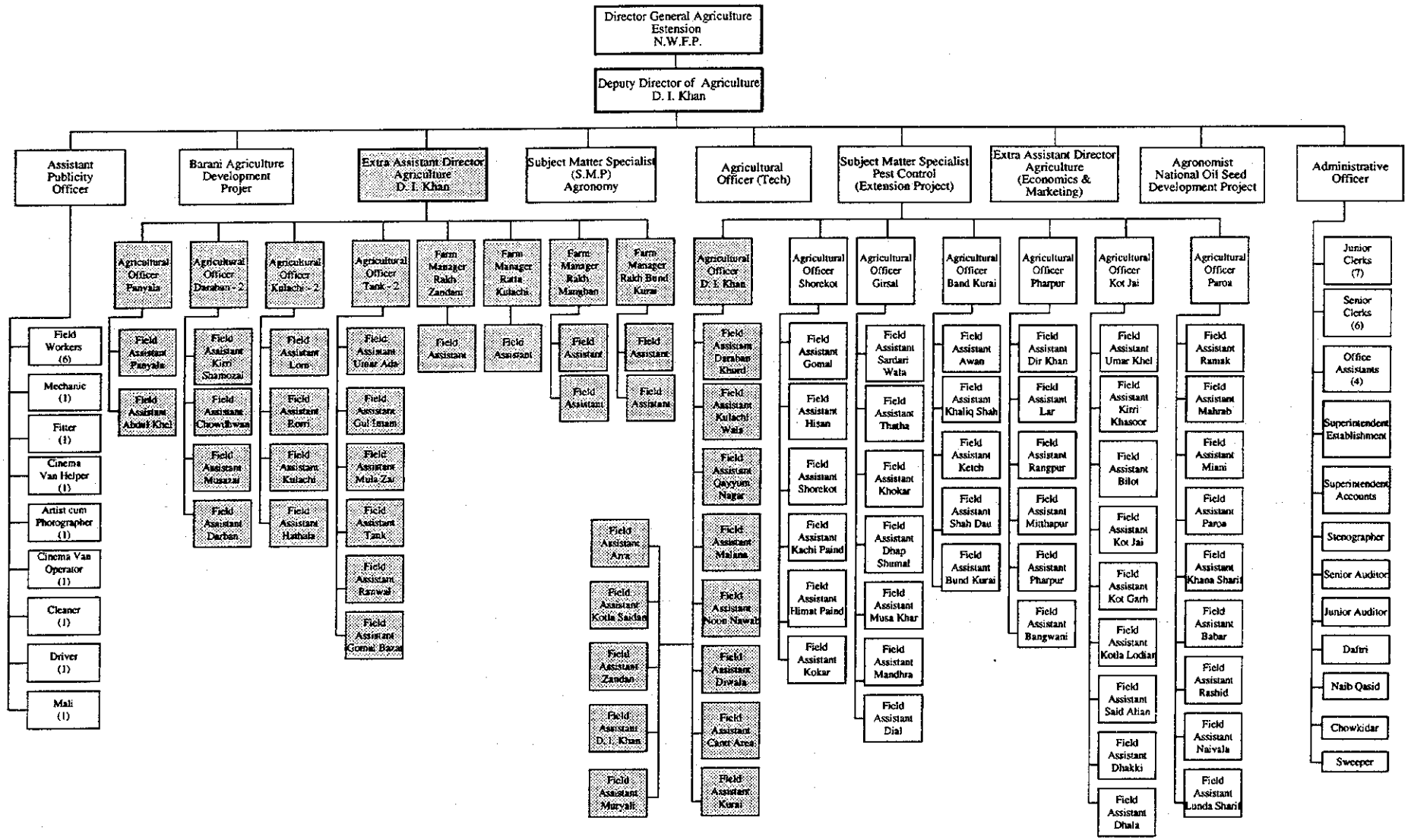


Fig. F.3.2.3 Organization Chart of Agricultural Extension, D.I. Khan

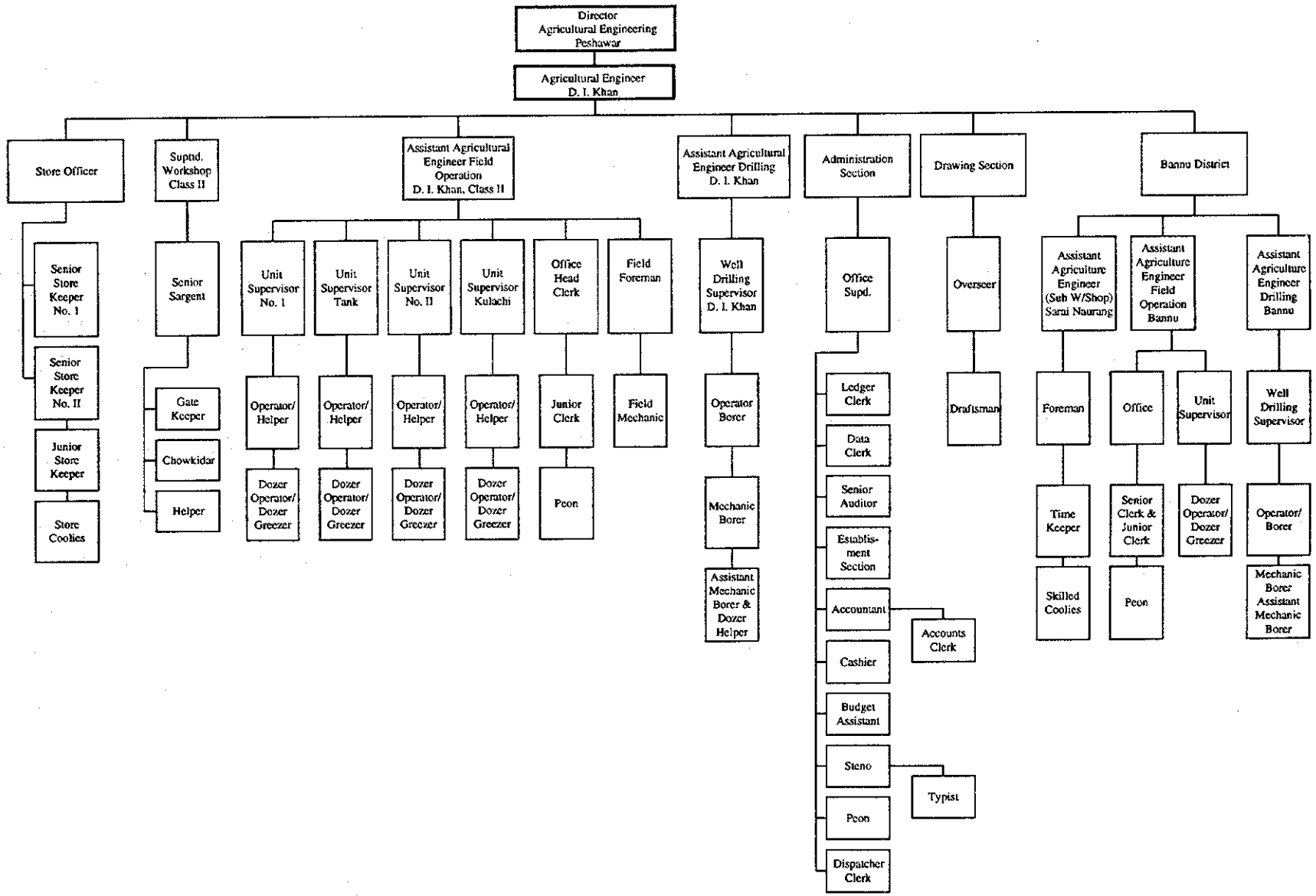


Fig. F.3.2.4 Organization Chart of Agricultural Engineering Department, D.I. Khan

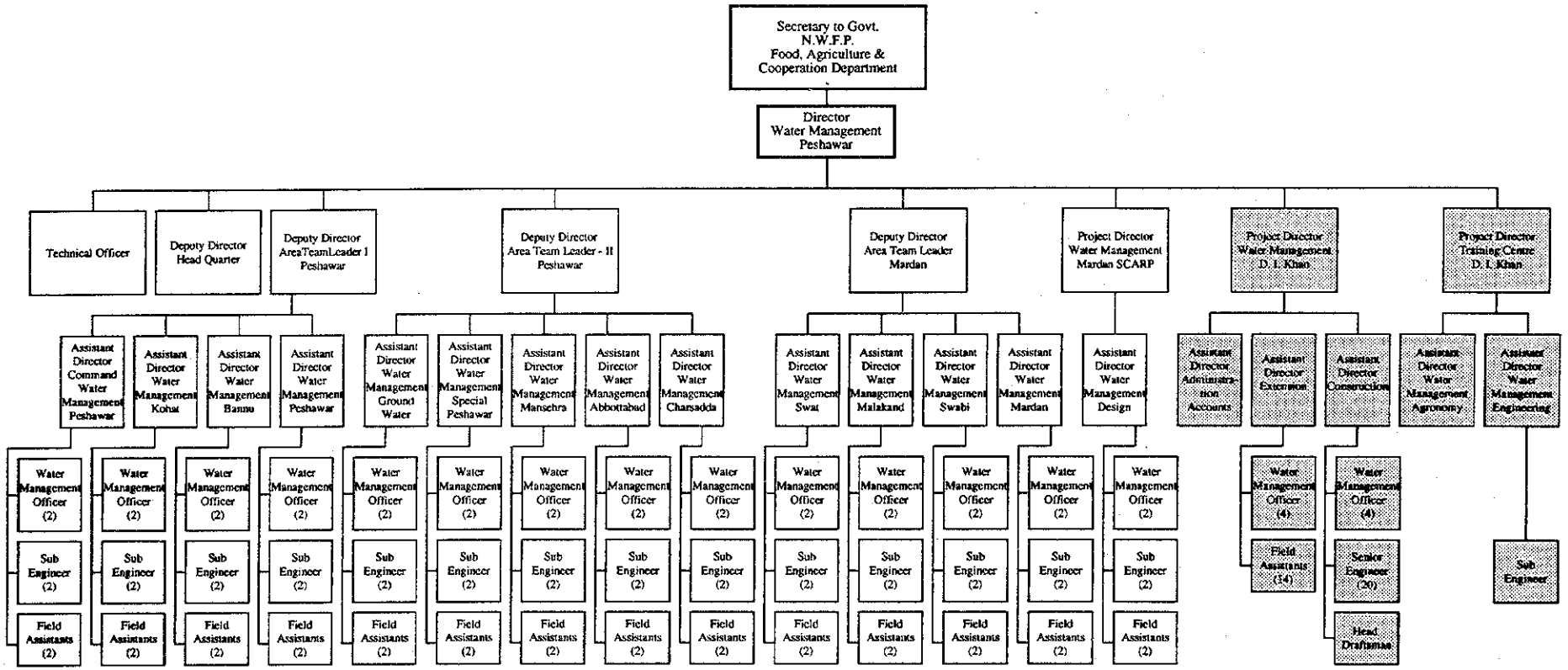


Fig. F.3.2.5 Organization Chart of Farm Water Management, D.I. Khan

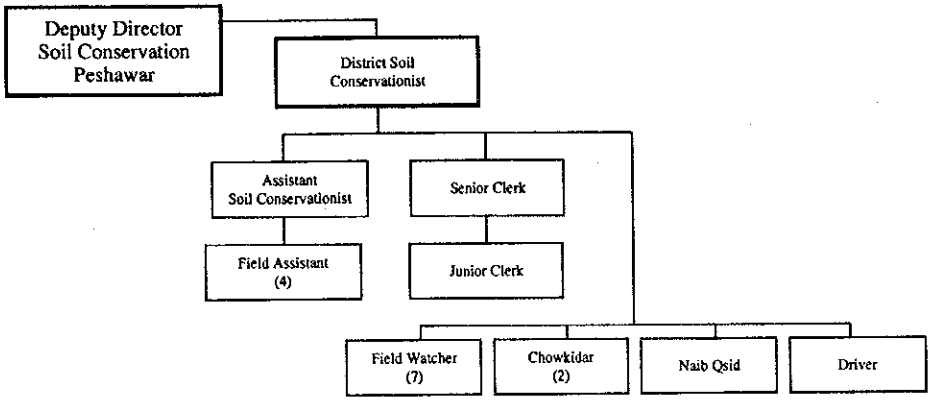


Fig. F.3.2.6 Organization Chart of Soil Conservation Department, D.I. Khan

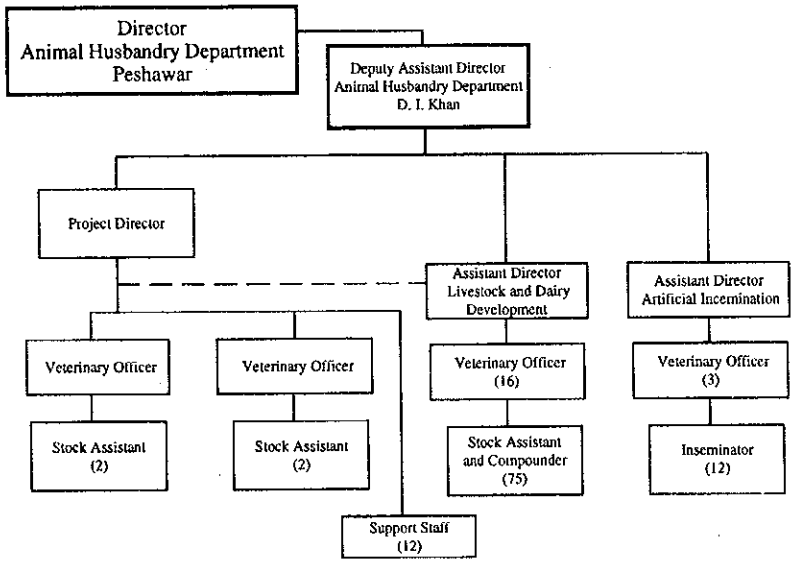


Fig. F.3.2.7 Organization Chart of Animal Husbandry Department, D.I. Khan

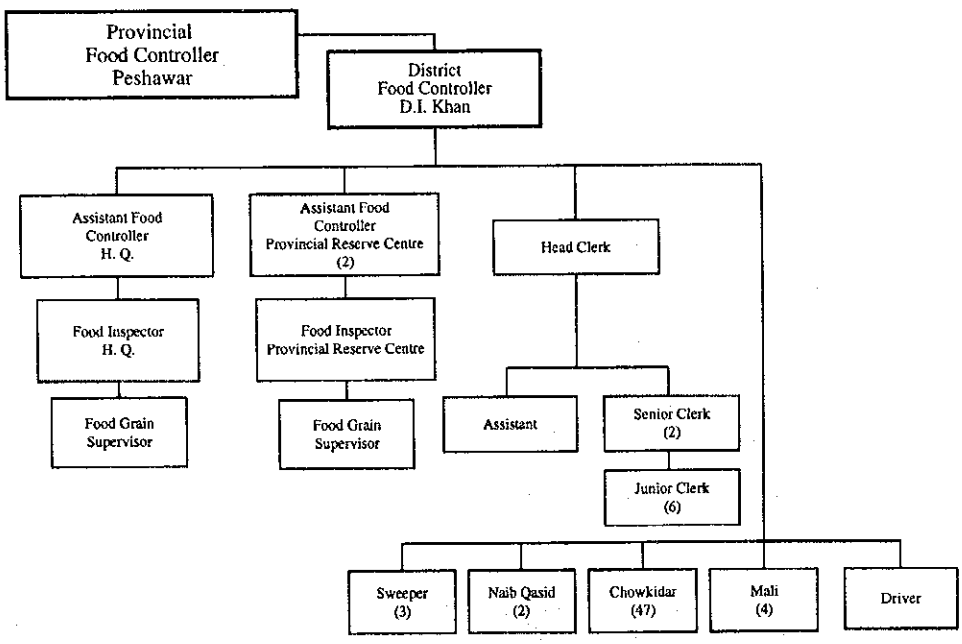


Fig. F.3.2.8 Organization Chart of Food Department, D.I. Khan

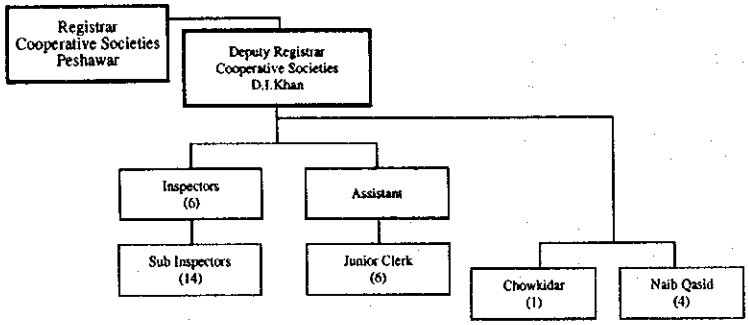


Fig. F.3.2.9 Organization Chart of Cooperative Department, D.I. Khan

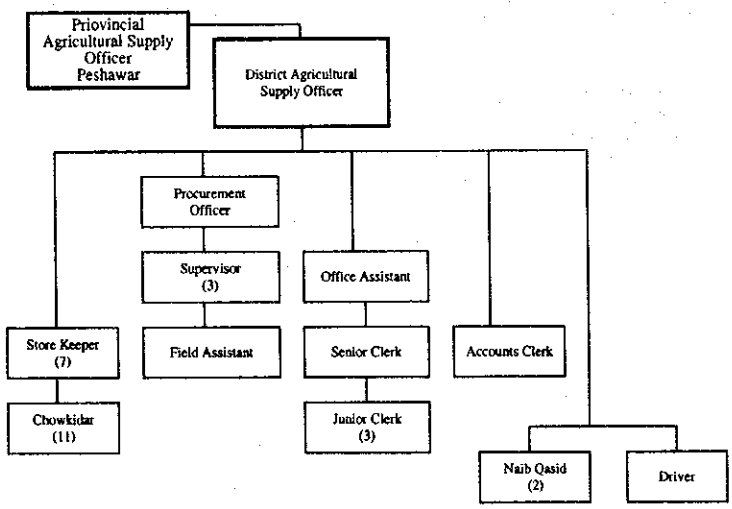


Fig. F.3.2.10 Organization Chart of Agricultural Development Authority, D.I. Khan

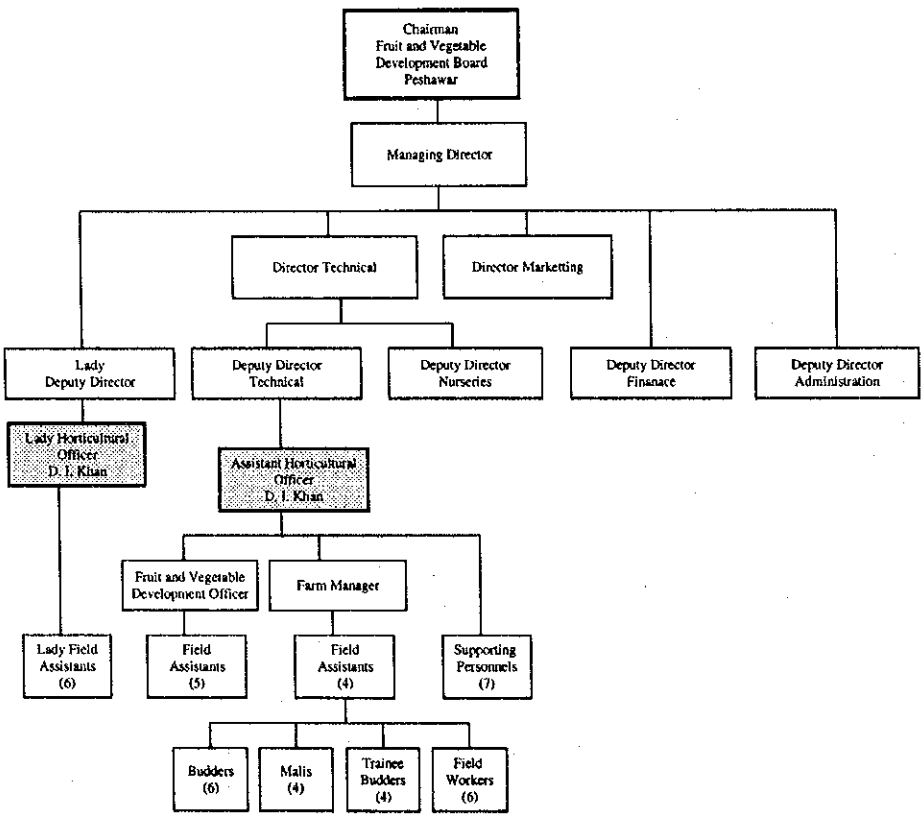


Fig. F.3.2.11 Organization Chart of Fruit and Vegetable Development Board, D.I. Khan

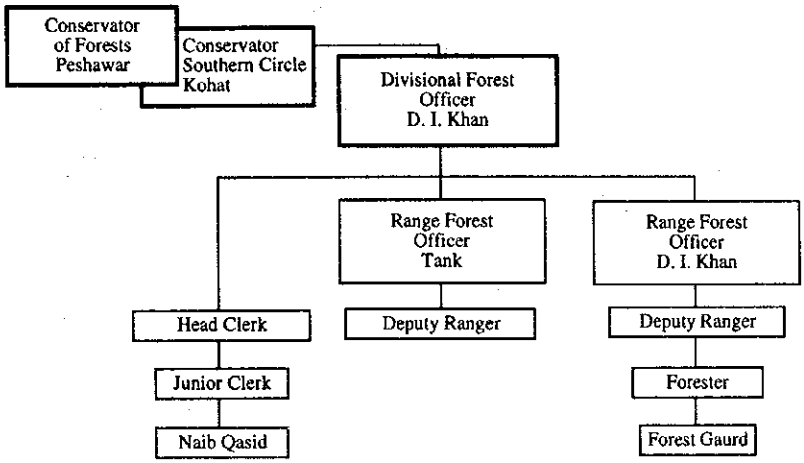


Fig. F.3.2.12 Organization Chart of Forest Department, D.I. Khan

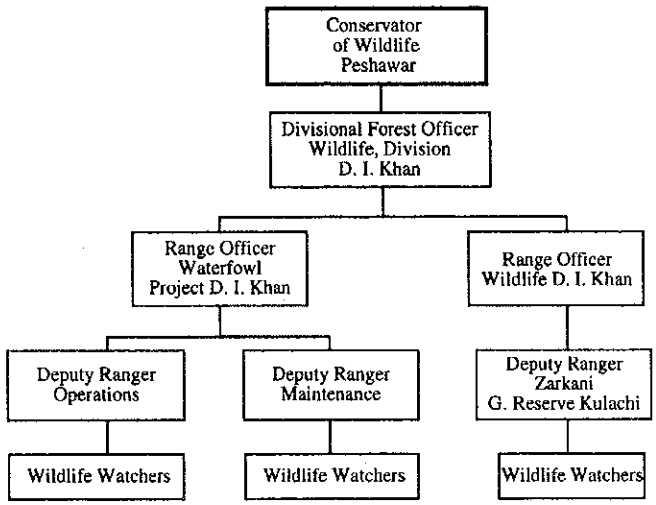


Fig. F.3.2.13 Organization Chart of Wildlife Department, D.I. Khan

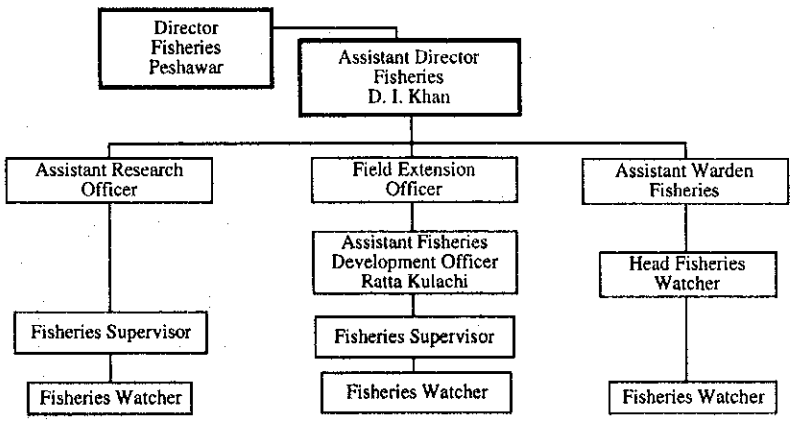


Fig. F.3.2.14 Organization Chart of Fishery Department, D.I. Khan

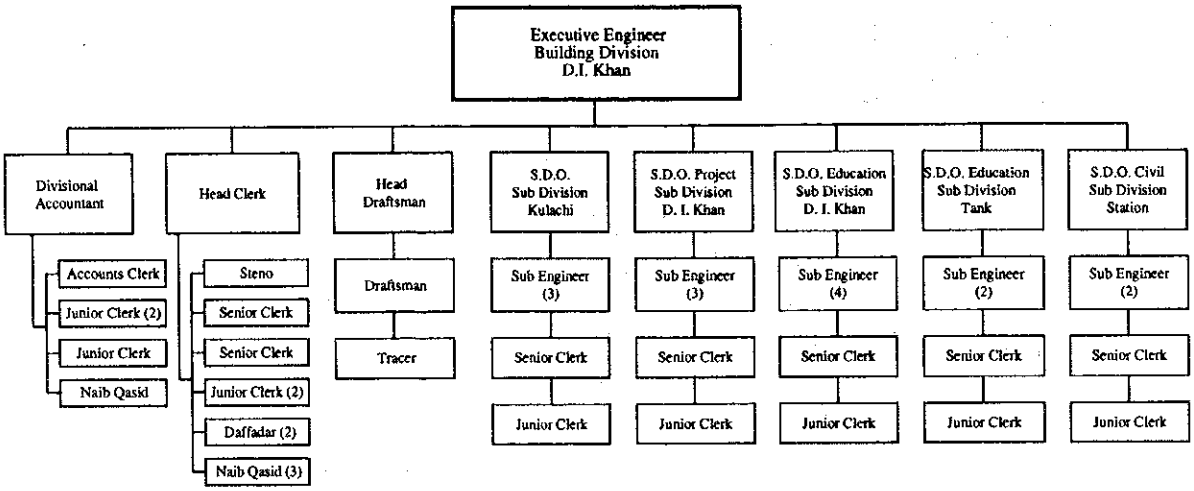


Fig. F.3.2.15 Organization Chart of Building Department, D.I. Khan

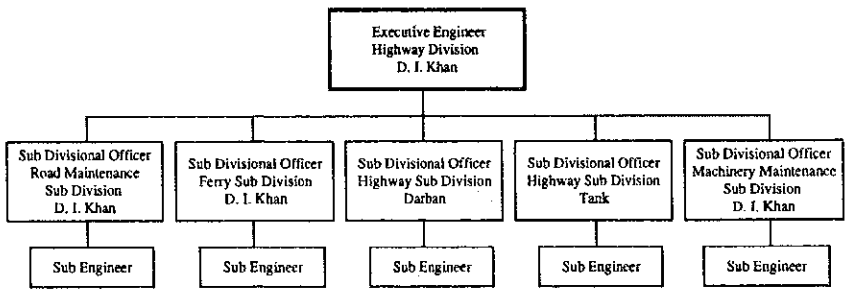


Fig. F.3.2.16 Organization Chart of Highway Department, D.I. Khan

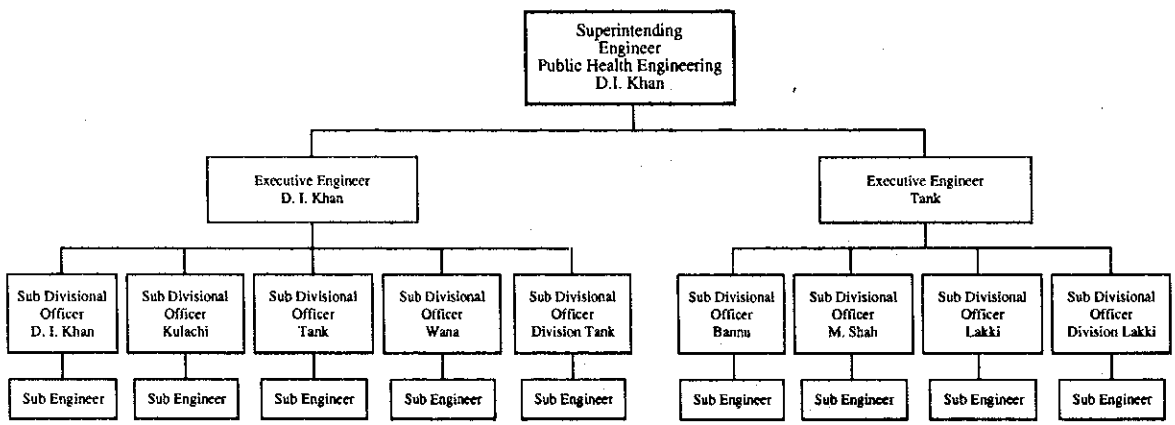


Fig. F.3.2.17 Organization Chart of Public Health Engineering Department, D.I. Khan

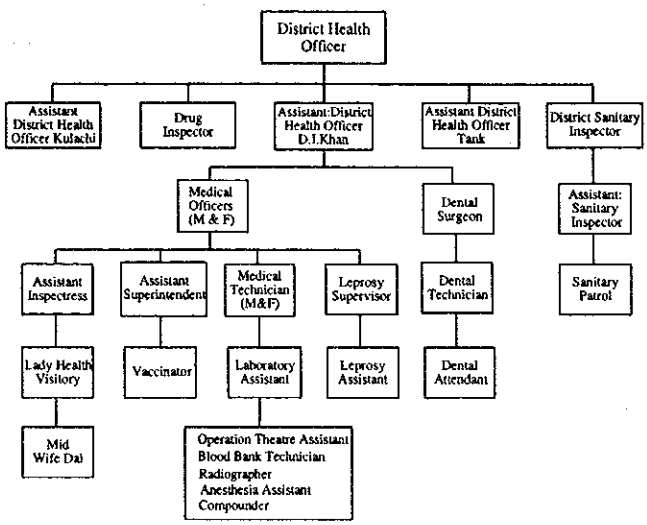


Fig. F.3.2.18 Organization Chart of Health Department, D.I. Khan

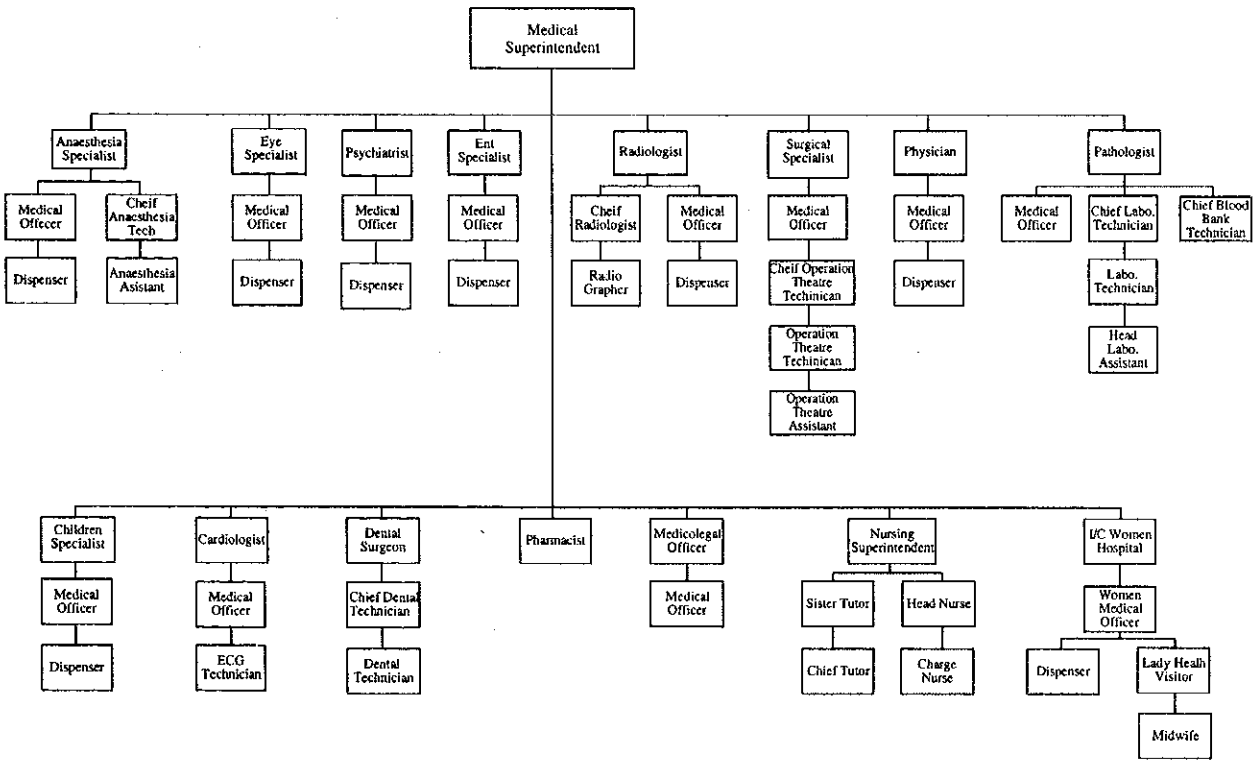


Fig. F.3.2.19 Organization Chart of District Headquarter Hospiral, D.I. Khan

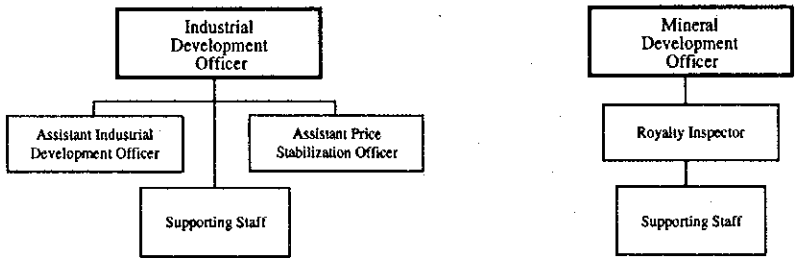


Fig. F.3.2.20 Organization Chart of Industries and Mineral Development Department, D.I. Khan

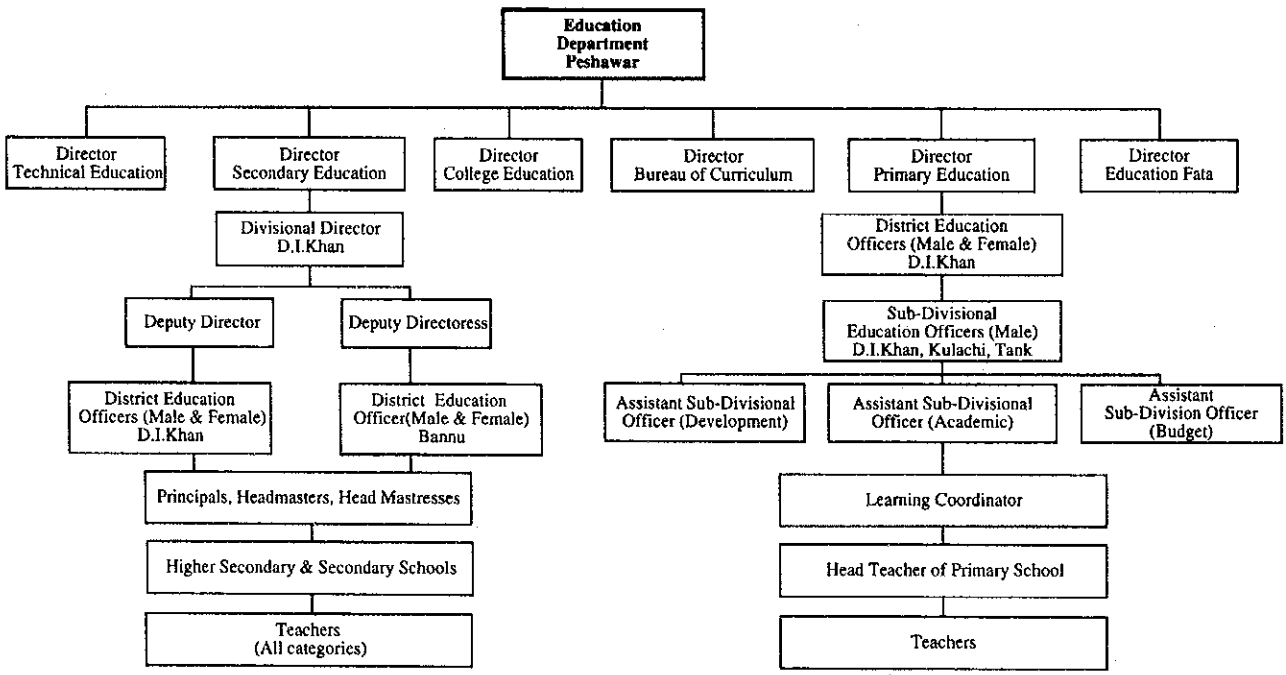


Fig. F.3.2.21 Organization Chart of Education Department, D.I. Khan

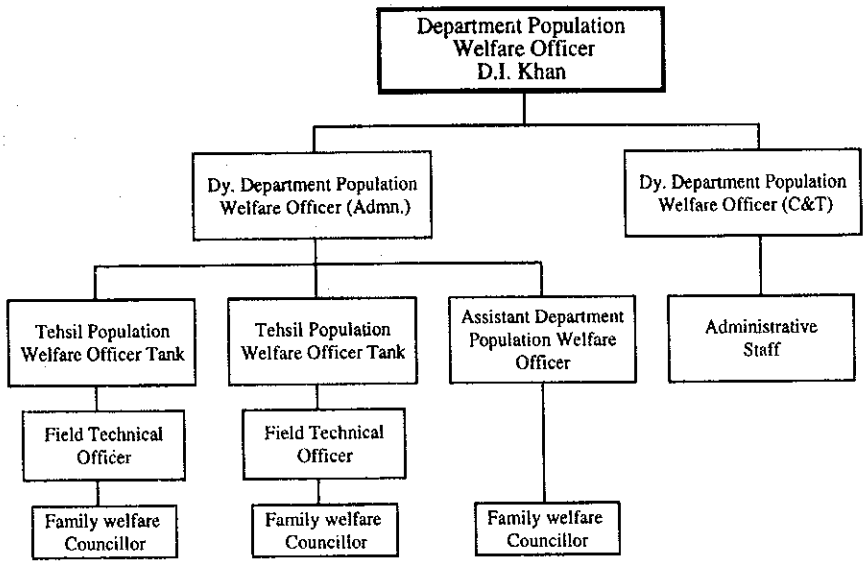


Fig. F.3.2.22 Organization Chart of Population Welfare Department, D.I. Khan

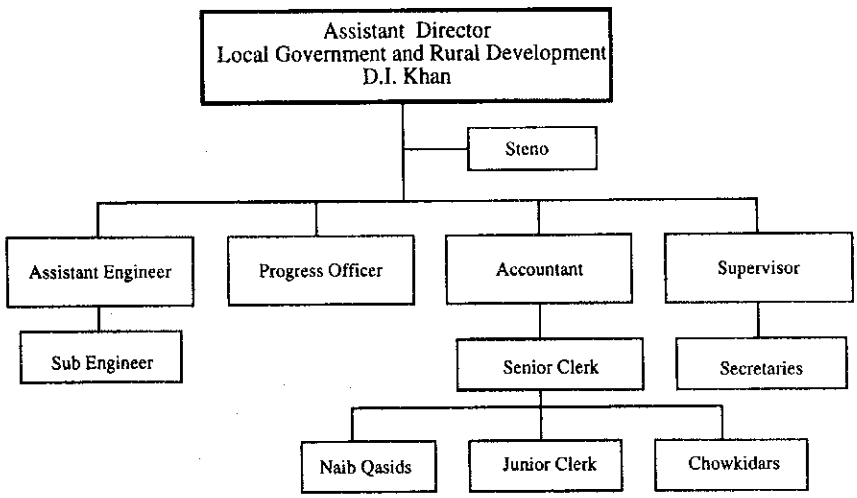


Fig. F.3.2.23 Organization Chart of Local Government and Rural Department, D.I. Khan

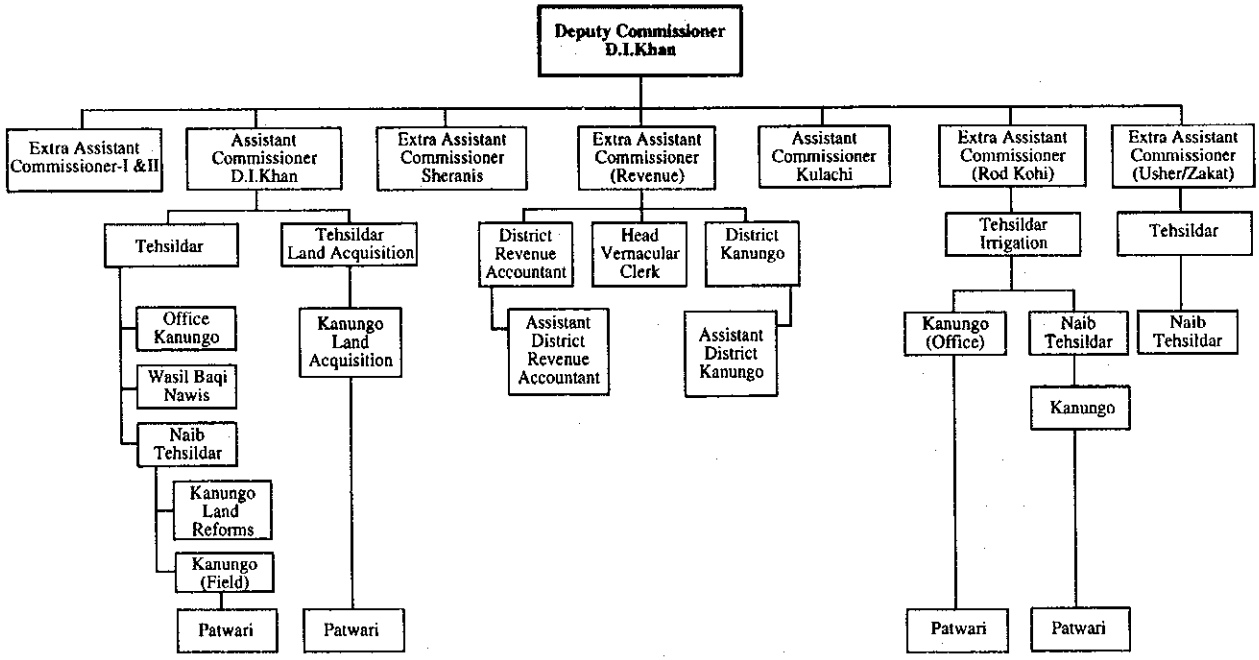


Fig. F.3.2.24 Organization Chart of Revenue Department, D.I. Khan

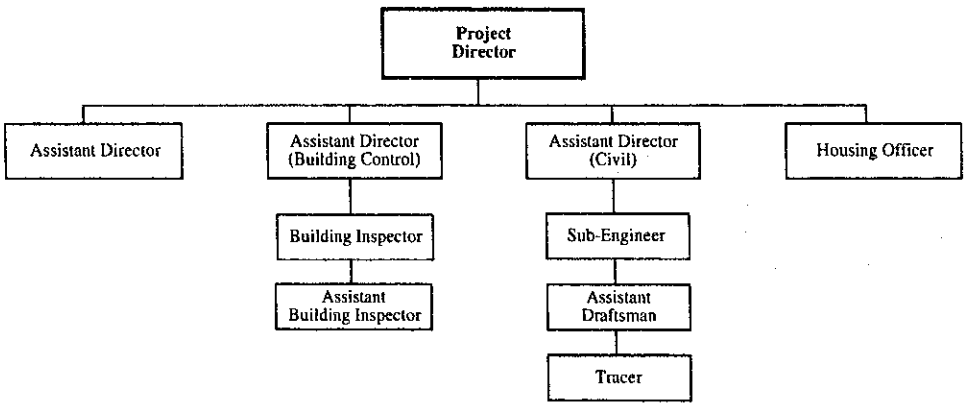
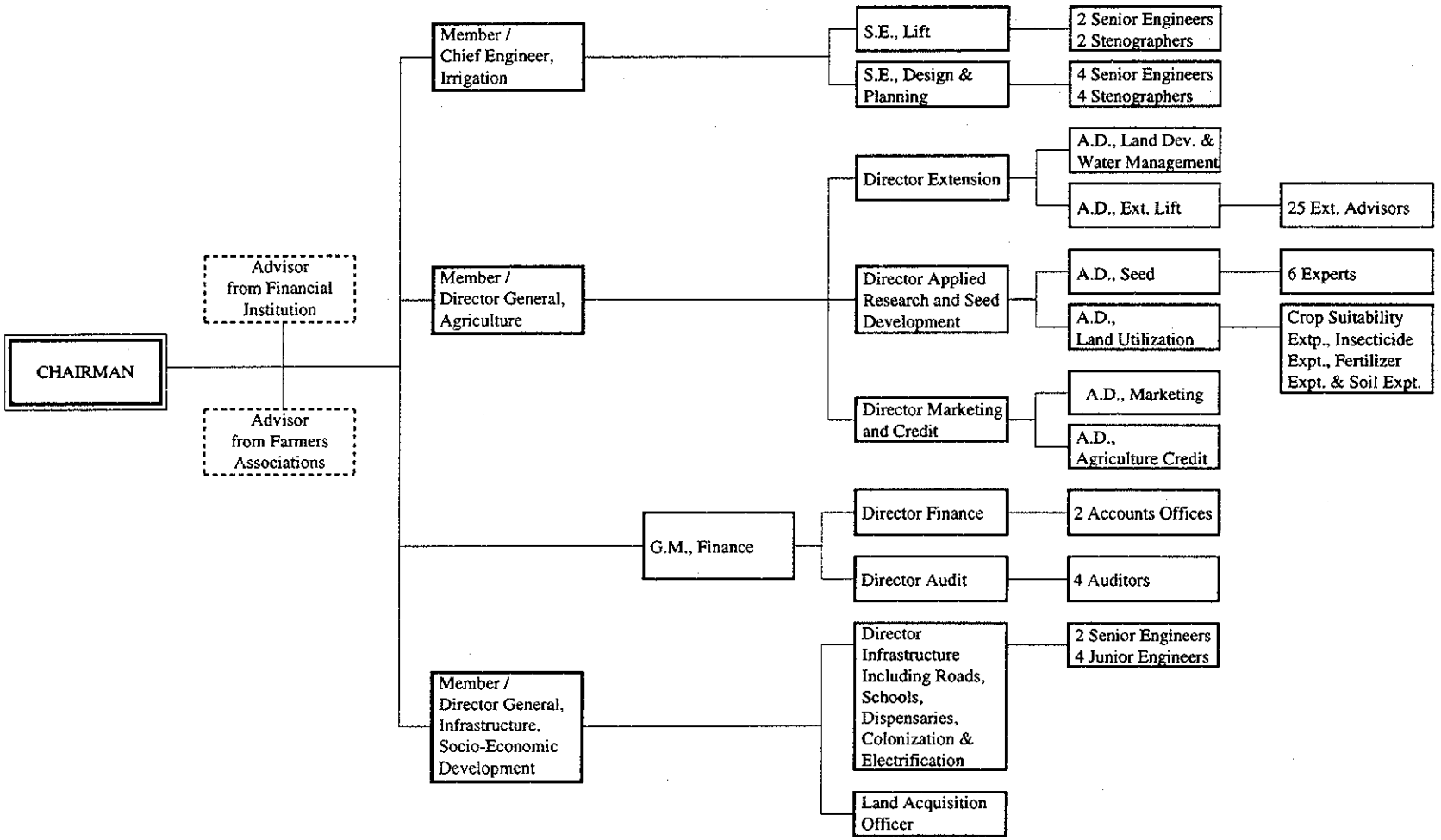
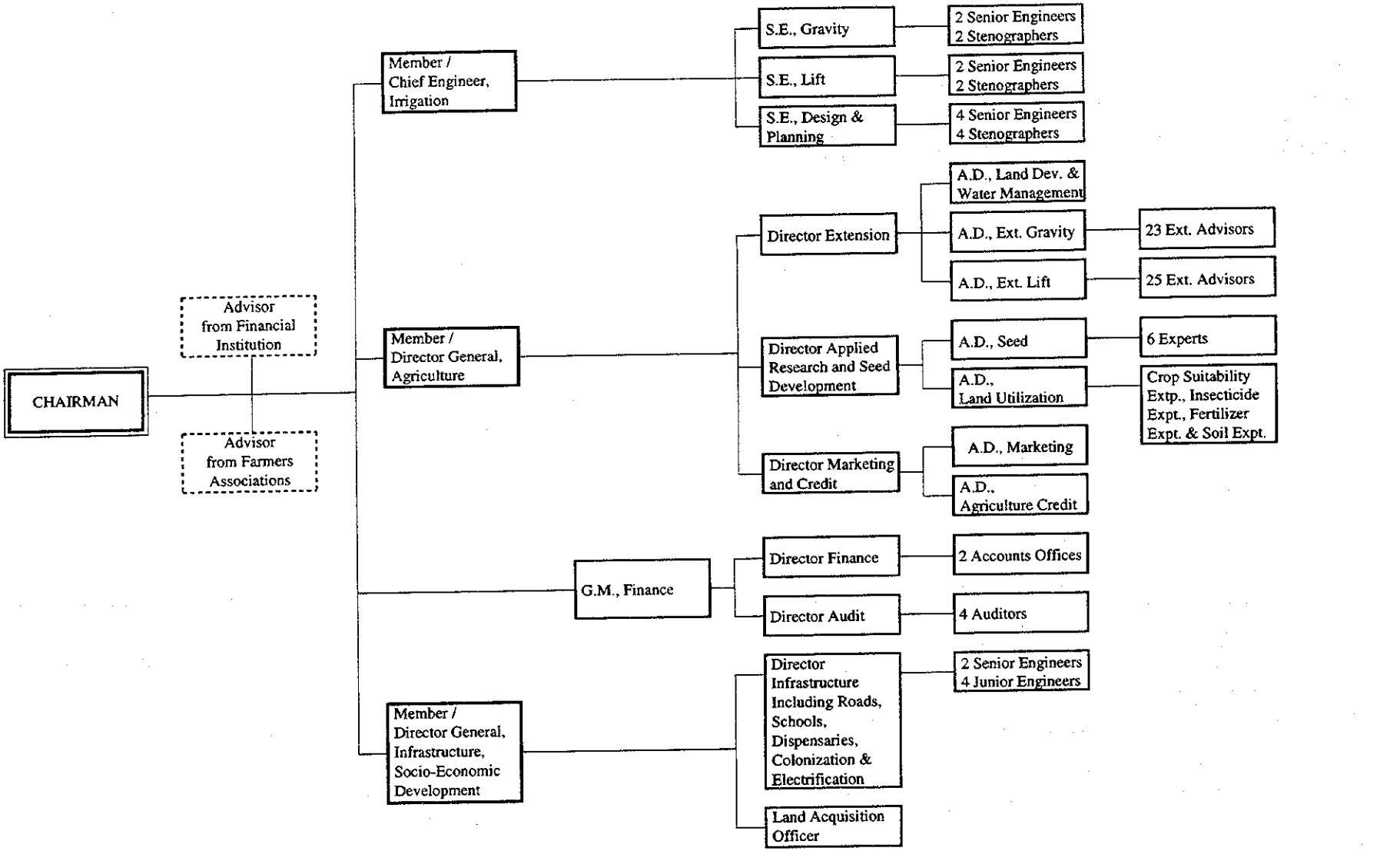


Fig. F.3.2.25 Organization Chart of Dera Development Authority



Note: 1. Extension Advisors should be located in the field at the rate of one Advisor for each Distributary. 10 Advisor should be recruited each year and given specialized training with foreign exposure. They will be the key functionaries and coordinate between the farmers and authority. They will help the farmers in demand based irrigation system, lay out of water courses, preparation of chack bandi and extension work.
2. The construction staff should be gradually reduced as the canal goes to completion. Operational staff should simultaneously be increased for future operation.
3. In view of a joint project with Punjab, the gravity canal may continue to remain with WAPDA. However, its Distribution System may be taken over by the Authority.
4. During construction stage the design and construction supervision should be done by the consultants. TheAuthority will provide top supervision only.

Fig. F.6.1 Organization of Proposed Chashma Right Bank Development Authority



Note: 1. Extension Advisors should be located in the field at the rate of one Advisor for each Distributary. 10 Advisor should be recruited each year and given specialized training with foreign exposure. They will be the key functionaries and coordinate between the farmers and authority. They will help the farmers in demand based irrigation system, lay out of water courses, preparation of chack bandi and extension work.
2. The construction staff should be gradually reduced as the canal goes to completion. Operational staff should simultaneously be increased for future operation.
3. In view of a joint project with Punjab, the gravity canal may continue to remain with WAPDA. However, its Distribution System may be taken over by the Authority.
4. During construction stage the design and construction supervision should be done by the consultants. TheAuthority will provide top supervision only.

Fig. F.6.2 Organization of Proposed Chashma Right Bank Development Authority jointed with CRB Gravity Area

ATTACHMENTS

PLAN FOR CHASHMA RIGHT BANK DEVELOPMENT AUTHORITY

1.1 Organization of the Authority

In order to achieve faster development of the area and to obtain optimum returns from Chashma Right Bank 1st Lift Irrigation Project, it is proposed to create a Chashma Right Bank Development Authority with the following composition and description :

i. Chairman
ii. Member Irrigation
iii. Member Agriculture
iv. Member Socio-Economic Development
v. Advisor Farmers' Representative
vi. Advisor Financial Institute's Representative

The Authority should be autonomous in nature with the same or more powers as that of WAPDA/TDA and be set under the statute of the government. It should be responsible for the integrated development of the area falling under this project. Under each of the above members for irrigation, agriculture, and socio-economic development, a department should be set up. The chairman and members of the authority should be appointed by the Government of NWFP. Once appointed they should have a tanure service of five years which may be extendible for 3 or 5 years once only. There services should neither be terminated nor transferred within the tanure period unless they are found guilty of gross misconduct such as corruption or they have been physically and mentally declared unfit for discharge of their duties.

1.2 Funding

The Authority during the development stage should be funded by the provincial government by passing the international loan directly to the authority and making provision for social welfare programme in the provincial budget. During the operational stage the authority should generate its own funds by realizing the water rates from the farmers associations to pay for the O & M cost of the irrigation system. For the social welfare programme, flood management and any other functions assigned to the authority by the government it should be provided with funds by government.

1.3 Staffing

The authority may from time to time recruit their own officers and other staff at such salaries and remunerations as they deem fit. Such staff may be recruited from the open market or be taken over from the government or other semi-autonomous agencies at such terms and conditions as mutually agreed between them. After five years of deputation the acquired staff will have the option to return to their parent departments or accept the terms and conditions of the authority on regular basis. The authority should have the minimum staff during construction by using the services of consultants so that they do not carry surplus staff to operation stage. The salaries and remuneration should be very lucrative and the ratio of experts to support staff should be much higher.

1.4 Rules and Regulations

The authority should frame their own financial and administrative rules and regulations for carrying out the work assigned to them. It should also make its own rules and regulations regarding operation of the system, methodology and amount of collection of water rates etc., and should act independent of the other canal systems. The farmers will need to be informed and agreements obtained that in order to operate the system they will have to pay much higher water rates then else where in the province/country. In fact the water rates have to be rationalized to pay for the operation and maintenance of the system. Subject to approval of the farmers' associations, the water rates should be charged according to consumptive use of water by their crops. For instance, the water rates for sugarcane consuming 81" of water during its maturity period should be 4 1/2 times of the water rate for wheat consuming only 18" of water in its life cycle. This change from adhoc application of water rates to a rationalized system of cost evaluation for the commodity supply will discourage the farmers from planting high delta crops and wastages and help against the manace of waterlogging and salinity.

1.5 Powers of the Authority

The authority should be assigned all powers to appoint consultants, and contractors for carrying out the development work with in its jurisdiction or on works assigned to it by the government. It should also be given powers under land acquisition act to acquire, lease and dispose off by selling or leasing any lands including houses etc. for the construction and development of the project including canal system, roads buildings, colonies and recreational areas etc. It should be empowered to determine

the water charges, collect directly or delegate powers to farmers association to collect the same from individual farmers. In case of any breach it should have the powers to collect the same as arears of land revenue.

1.6 Duties of the Authority

a) Development Stage

(i) To plan and construct the Chashma Right Bank 1st Lift Canal Project as conceived in the PC-I and as funded by the Government.

(ii) To plan and implement the land development program including land leveling, construction of water courses, construction of Rural Roads and designation of colonies and marketing centers in association with farmers. Land for growth centres (colonies) will have to be acquired along with land acquisition for the canal system.

(iii) To plan and organize the surface drainage and flood control system in a manner to be subsequently coordinated with sub surface drainage to keep the area free of water logging and salinity. Depending on the type of soil formation, the farmers have to be advised and warned against this menace well in advance and encouraged to grow crops which are tolerant and helpful in prevention of salinity and water logging.

(iv) To plan and carry out villages electrification programme in association with WAPDA.

(v) To plan for and encourage local farmers and business men to set-up semi process industries such as ginning mills, rice husking plants and oil extraction plants etc. in the area at appropriate locations to be indicated by the Authority.

(vi) To plan for and encourage local engineering industry to set up work shops for maintenance of agriculture machinery at appropriate locations.

(vii) To plan and organize social welfare programme including setting up of schools, dispensaries and rural health centres in association with the education & health departments.

(viii) To plan and organize through local entrepreneurs and in consultations with farmers associations agriculture input facilities such as fertilizers pesticides and implements at appropriate locations.

(ix) To train and activate its agriculture extension wing to encourage the formation of farmers' association around the minors and distributaries and dissemination of information on the irrigated agriculture with specific reference to the cropping pattern planned for the project.

(x) To plan and organize resources through Agriculture Development Bank and Cooperative Department in the form of loans and credits to the farmers to help in preparation and farming of their lands.

(xi) To plan and arrange discussions and seminars with the farmers on the integrated development of the area by involving PARD Peshawar and other federal agencies such as PARC etc.

(xii) To plan and reorganize the agriculture research wing to carry out applied / adoptive research to guide the farmers towards the crops for which their lands have optimum productive capacity, advise on number and interval of watering, type and quantity of fertilizer input, type and intervals of pesticides and the type and treatment of seed most suitable for these lands.

(xiii) To inform and obtain agreements from individual farmers that they will have to pay a cash equivalent of a certain percentage of their crop as water rates which may be different for gravity and lift system. The crop production per acre will have to be decided in advance in accordance with general production indices in the country.

(xiv) To plan and carry out adoptive research on one distributary of gravity canal on pilot basis to obtain guideline data for operation of lift canal and gravity canal when the later is taken over in phases.

(xv) To take over maintenance and operation of CRBC gravity canal distribution system in phases and manage the system through farmers' association in accordance with operation manual to be prepared for the Project according to its cropping pattern.

(xvi) To plan, organize develop and assign water rights of Rod Kohi area falling under the canal to upper riparians.

(xvii) To consider any other activity that would help the people and the area to develop sustainable agriculture on fast track basis and improve socio-economic condition of the people.

Note: Services of appropriate consulting firms could be used for item (i) to (viii) above.

b. Post Development Stages

(i) To operate and maintain the canal system in accordance with the planned criteria.

(ii) To continue with the sustainance of farmers associations and advise the farmers on sustained agricultural growth.

(iii) To collect water rates and cess charges from the farmers through farmers association or as arrears of land revenue.

(iv) To create a fund to be contributed to as above and deployed for operation and maintenance of the system. The capital cost of the project should be considered as grant from the Provincial/Federal Government. The system shall be self sufficient in its resources and should throw up surpluses for further development.

(v) To continue with agriculture adoptive research and extension services and work in close association with farmers particularly on reorientation of the system to demand based irrigation. Advise on cropping pattern and assume the role of technical expert for the farmers' associations. The agriculture extension advisor placed in each distributary command area shall have the pivotal role of coordination between the farmers and the various wings of the authority through direct cross movement without going through his department. He should have a direct approach to all the members of the authority. He should be paired with all the experts of other wings including irrigation, land leveling, farm inputs, agricultural machinery, infrastructure experts etc.

1.7 Head Quarters of the Authority and Meetings of the Authority

The Head quarters of the authority shall be at D. I. Khan. Meetings of the authority shall be at D. I. Khan or at any such place which the chairman may declare in advance. In the absence of the members of the authority the chairman may exercise the powers of the authority to be approved by the authority later.

The administrate chart of the authority is given at Attachment II. The functions of some of the members are given here in after.

(1) Irrigation

The Member Irrigation will be responsible for construction of Chashma Right Bank Lift Canal and subsequent operation of Chashma Right Bank Canal System. He will have two Superintending Engineers (S.Es.) under him who will be responsible for the construction of lift canal and design office respectively. Since most of the design work and field supervision will be done by the consultants - (a requirement of all financial institutions for financing such projects) the field staff has to be kept at the minimum, to over see the work of consultants during construction and to operate the system after completion.

The lift circle will have two senior field officers each responsible for over seeing the diversion structure-cum-feeder canal, pump house, the main canal and the distribution system. The design and planning circle will check all the design work of all the consultants including the canal construction, drainage system and water management.

In case of transfer of gravity canal distribution system one more senior engineer should be added to supervise the O & M of the system till it is transferred to the farmers associations.

(2) Agriculture

Since basically it is an agricultural project with irrigation as its main input, it is this division of the authority which needs the maximum attention. It will need a senior and visionary agriculture officer to organize this division. The division will have three directorates - director extension, director applied research & seed development and director marketing & agriculture credit. The extension directorate will have two deputies and 25 extension advisors who will be agriculture graduates. These workers will have to be given special training in Pakistan Agricultural Research Department Peshawar, Pakistan Agricultural Research Council Islamabad and Pakistan Rural Development Academy Peshawar to enable them to carry out their work in close

cooperation with the farmers. In fact these may have to be recruited at the rate of ten each year so that the strength is built up gradually over a three year period before the project will go into operational stage. There will be one agriculture advisor for each distributary advising about one thousand farmers having 4,000 to 5,000 ha. Their jurisdiction should be the command of a distributary and should have a direct access to all the officers of the authority to resolve the problems of the farmers. In fact he should not only be an advisor to the farmers but be a link between the management and the farmers. He will perform the key role in the development of agriculture in the area and therefore he has to get the trust and support of the farmers. He should also be the Secretary of the DFA. His first action should be to organize unit farmers association (UFA) at water course/minor level and Disty farmers' association (DFA) at the distributary level in accordance with the framework to be given in the provincial act formulated for creation of the authority.

In the initial meetings of these associations the agriculture adviser has to train the members of the UFA and DFA in performance of their duties with regard to demand based water utilization, land leveling, infrastructure development and provision of agriculture inputs etc.

(3) Socio-Economic and Infrastructure Development

All socio-economic development other than land will fall under the jurisdiction of this office. It will acquire land for the development of new colonies particularly near the Disty head and regulating pond, plan the villages which are likely to develop into townships and marketing centres, encourage farmers to set up supply centres, workshops for repair of agricultural machinery and other services, plan for farm to market roads, schools, dispensaries and village electrification and have a close liaison with the Provincial Government and Federal Government for provision of funds or direct services. He should also regulate the private entrepreneurs in a manner that the townships develop in a planned manner and other services are provided in accordance with the future demand.

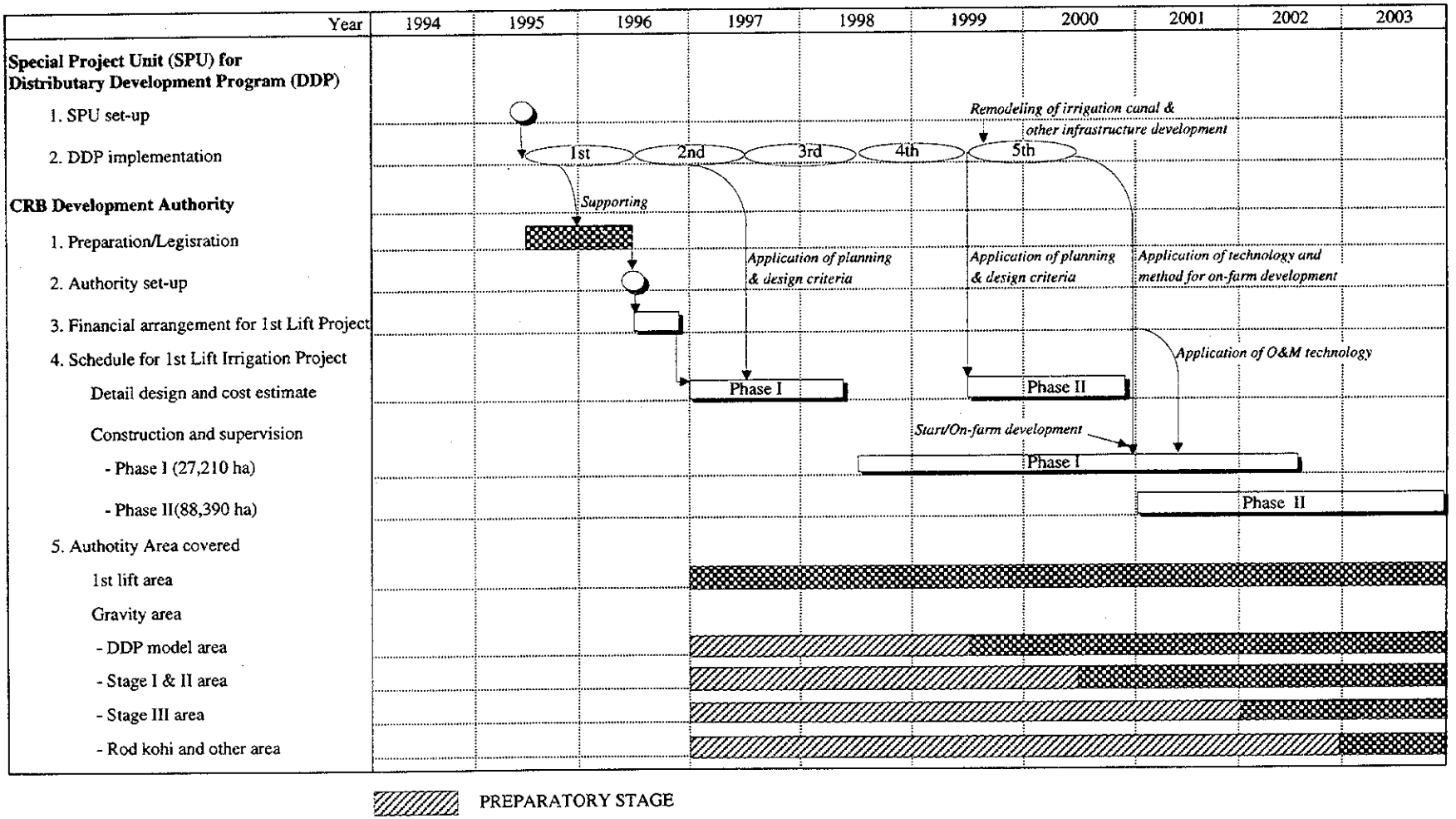
(4) Finance & Administration

The finance and administration headed each by a general manager should be placed under the chairman. The finance will have two branches one for preparation of budget and payment of bills of contractors and salaries of staff and the other for carrying out full audit of all the payments so made. The budget and payment wing will be advised by the engineering, agriculture and infrastructure wings for preparation of budget at the beginning of each financial year.

THE DEPARTMENTS TO BE ULTIMATELY REPLACED BY THE AUTHORITY WITH THEIR PRESENT STAFF STRENGTH

	Department	Officers 17-20	Technical Staff 11-16	Total Technical	Others 1-15	Grand Total
1)	Irrigation	9	20	29	411	440
2)	Agricultural research	45	1	46	143	189
3)	Agricultural extension	30	0	30	118	148
4)	Agricultural Engineering	1	2	3	117	120
5)	On-Farm Water Manag.	10	21	31	82	113
6)	Soil conservation	2	-	2	17	19
7)	Animal Husbandary	17	-	17	176	193
8)	Food	-	1	1	76	77
9)	Cooperative	-	7	7	26	33
10)	Agricultural Dev.Authority	-	2	2	33	35
11)	Fruit & Vegetable Board	4	0	4	53	57
12)	Forest Depart	1	1	2	78	80
13)	Wild Life	1	2	3	47	50
14)	Fisheries	1	4	5	38	43
15)	Highway Department	6	18	24	771	795
16)	Public Health Engg.Deptt.	12	37	49	98	147
17)	Department of Industries	-	5	5	9	14
18)	Population Welfare	7	1	8	107	115
19)	Local Govt. & Rural Dev.	3	5	8	53	61
20)	Revenue Department	11	-	11	416	427
21)	Dera Dev. Authority	5	1	6	56	62
Total		*165*	128	*293*	*2,925*	*3,218*
WAPDA (Water Wing)		100	103	203	511	714
Grand Total		265	231	496	3,436	3,932

Organization and Activities of Special Project Unit and CRB Development Authority



Attachment F.4

SPECIAL PROJECTS UNIT FOR DISTRIBUTARY DEVELOPMENT PROGRAM (DDP)

-DRAFT-

PREPARED BY JICA CHASHMA 1ST LIFT IRRIGATION STUDY TEAM

I. OBJECTIVES

(1) Establishment of rational irrigation system covering one distributary of CRBC gravity irrigation area (CRBC Disty No. 5, 15,000 acres/6,700 ha, tentatively) by Distributary Development (DDP) at trial basis,

(2) Extension of appropriate technologies and irrigation farming system created by DDP to the other distributaries of CRBC gravity irrigation area, and

(3) Application of DDP's technologies to the planning and design of CRB 1st Lift Irrigation Project.

Through;

a. Adoptive research and extension of proper irrigation farming,

b. Organization and activation of farmers' association for O&M of irrigation facilities and other farming and marketing activities,

c. Improvement of irrigation, drainage and other rural infrastructures based on the farmers' requirement and economic viability covering;
   - distributary, minor and sub-minor canals, water courses, and their related structures,
   - land leveling, drainage canals and their structures
   - Production and marketing facilities for farmers association.

II. ACTIVITIES

(1) Adaptive research and extension

Diagnose operational constraints to improve management and the use of water and land,

- Select five(5) model areas at suitable sites for generating new farm technologies for farmers' adoption,

- Measure the impact of changes in water management on cropping pattern, input use and timing of farm operations,
- Conduct research with alternative crops and cropping sequences in order to prepare contingency cropping patterns in case of water shortage,
- Clarification of constraints and applicable countermeasures for crop-demand based irrigation system, and
- Demonstrate to the farmers a judicial use of precious irrigation water and explain the results obtained from consumptive use of water and economic benefits obtained.

(2) Organization and activation of farmers' association

- Convince the farmers to organize an association explaining its merits and advantages through farmers' training,
- Clarify land holding and tenure situation on the map and prepare member lists in order to organize a Unit Farmers Association (UFA) by water course or minor/sub-minor canal,
- Organize UFAs by water course or minor/sub-minor canal, and elect the following management staff through a fair election by secret ballot;

  UFA manager
  UFA accountant
  UFA water coordinator
- Organize a Distributary Farmers Association(DFA) through a meeting with UFA manager (by water course) and elect the following managing staff or DFA;

  DFA manager
  accountant
  Water coordinator
  Marketing coordinator
- Impart training on water management and other activities to the FAs,
- Mobilize FAs to hold frequent meetings regarding their activities of fixing fair water rights and cropping patterns, collection of water charges, and operation and maintenance of the irrigation facilities, and
- Motivate FAs to establish inputs availability and farm produce sale centers.

(3) Facility improvement

- Prepare training programs and implement training to water coordinators and production coordinators for proper water management, daily and seasonal maintenance practices by water course and distributary,
- Investigate constraints to realize crop-demand based irrigation at water course,
- Prepare an economical irrigation and drainage improvement plan covering remodeling of distributary, minors and sub-minors, drainage canals and related

structure, if necessary

- Prepare a necessary improvement pan for lining of water courses and land leveling based on the consultation of UFAs,
- Prepare facility improvement and development plans covering rural road, marketing facilities, DFA office, etc. based on the UFAs requirement, and
- Supervise and assist FAs for facility developments.

III ORGANIZATION

(1) Special Project Unit for DDP (Attached to Planning and Development Department)

- Project director (1/ Grade 19)
- Research and extension
- Three(3) deputy directors (Grade 18)
  - Research and extension
  - Farmers' organization
  - Irrigation and drainage planning
- supporting staff (5/ Grade 17)
  - Agronomist
  - Soil scientist
  - Agro-economist
  - Irrigation and drainage design engineer
  - Agricultural engineer

(2) Consultants (as required)

IV. IMPLEMENTATION SCHEDULE AND ACTIVITIES

Period: Five(5) years

1st: 1. Preparation of cadaster maps including tenurial situation and preparation of member list of UFAs.
2. Implementation of farmers' training
3. Organization of UFAs and DFA
4. Selection of adaptive research model areas and initiation of research
5. Preparation of inventory covering irrigation and drainage facilities, and other rural infrastructure
6. Preparation of a detail schedule and action programs of Distributary Development Program (DDP)

2nd : 1. Implementation of training program for managing staff of UFA, DFA, and member farmers
2. Adaptive research activities
3. Investigation on irrigation and drainage practices and constraints

3rd ; 1. Continuation of 2nd year activities (No. 1, 2)

2. survey on facility development and improvement

4th ; 1. Continuation of 2nd year activities *No. 1, 2)

2. Preparation of improvement plans for farming practices, water management, and irrigation and other rural facilities

3. Delegation of powers to DFA manager who collect water charges

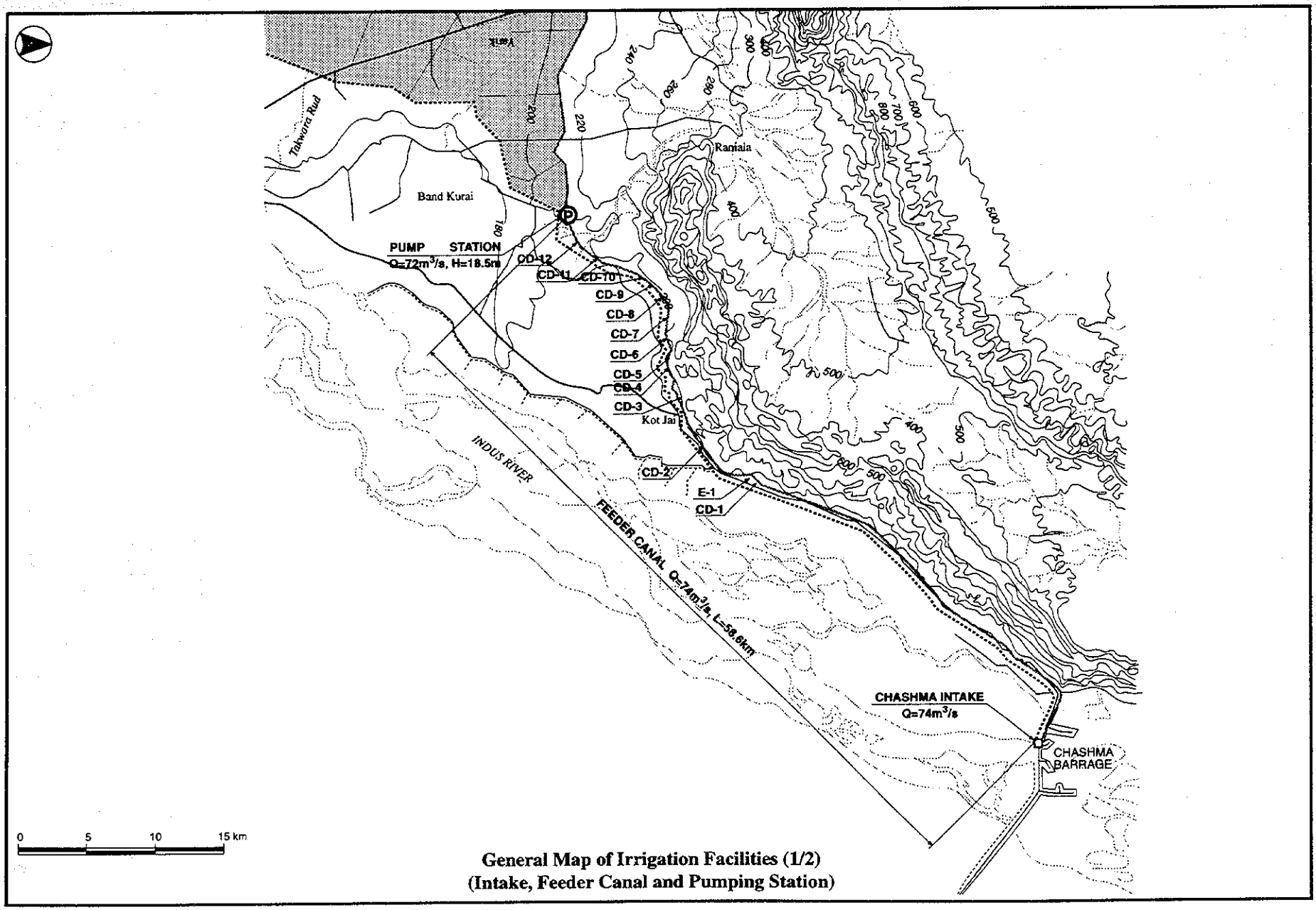
4. Preparation of account procedure for operation and maintenance of UFA accounts

5th ; 1. Implementation of improvement plans including facility construction

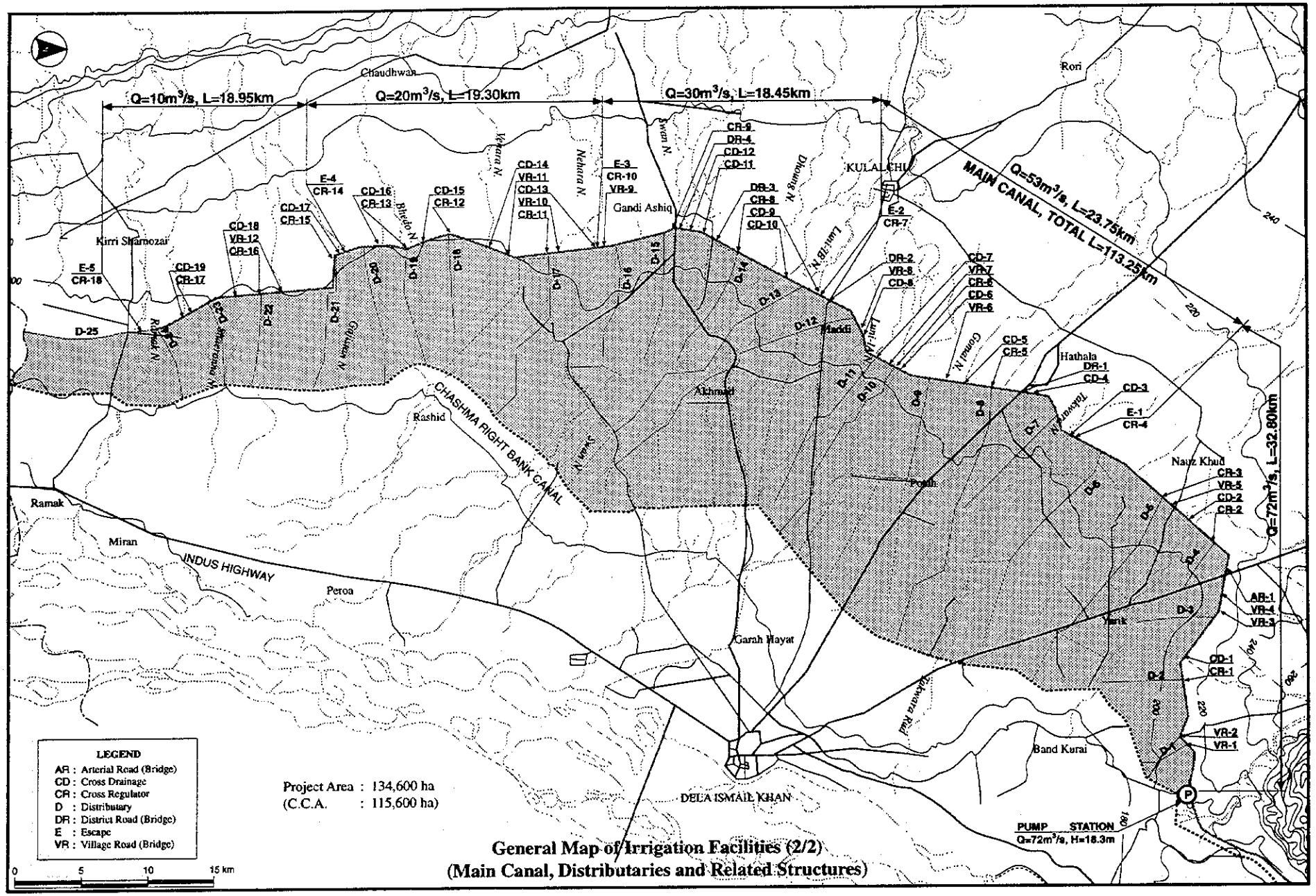
2. Assistance for improved farming and marketing activities, and operation and maintenance of facilities to FAs.

ANNEX G

PLAN AND DESIGN OF THE FACILITIES



General Map of Irrigation Facilities (1/2)
(Intake, Feeder Canal and Pumping Station)



General Map of Irrigation Facilities (2/2)
(Main Canal, Distributaries and Related Structures)

ANNEX-G

PLAN AND DESIGN OF THE FACILITIES

Table of Contents

List of Tables

List of Figures

ANNEX G PLAN AND DESIGN OF THE FACILITIES

General Description

Planning and design of the facilities have been carried out as follows in conformity with the basic concepts aforementioned in the ANNEX C. Irrigation and Drainage.

Irrigation System

Facilities	Function
1. Intake Structure	Effective and correct taking of Indus water into the feeder canal.
2. Feeder Canal	To convey water from the intake structure to the pumping station.
3. Pumping Station	To lift water from the feeder canal to the beginning point of the main canal.
4. Main Canal	To transmit and divert the lifted water to the command areas through Distributaries.
5. Distributary	timely and correct delivery of water from the main canal to command areas through moghas.

Drainage System

Facilities	Function
1. Flood Carrier Channel	To convey flood water to the cross-drains in CRBC
2. Supplemental Flood Drainage Channel	Flood drainage channel supplemental to the flood carrier channels.

Others

Facilities	Function
1. Farm Road	For traffic between villages, farm lands, markets, O&M offices of distributaries, etc.
2. On-farm Water Management Facilities	For irrigation and drainage of farm lands at the terminal level after moghas.

In advance to planning and design of the above, following surveying works and geological investigations have been carried out.

Topo-survey

1. Route survey for proposed main canal alignment.
2. Detailed plain survey at construction sites for intake structure, pumping station and other major structures.

Geo-technical Survey

Core boring with standard penetration tests at every 1m depth.

Intake site:	3 holes, 95 m in total depth
Pumping site:	5 holes, 160 m in total depth
Major structural site:	2 holes, 35 m in total depth

G.1 Intake

G.1.1 Location

Location of the intake has been decided at about 1.5 km in the right side of Chashma Barrage and about 200m in the left side of Right Spur Dike No. 1, beside Low Hydropower Plant site. This is because the land from this point to the barrage has already been occupied by the on-going power plant project and the vicinity between this point and the right bank is more difficult due to dredging of the existing Chashma Pond.

However, WAPDA has an intention to negotiate with the power project, whether the intake of the 1st Lift Irrigation Project can be provided at the head races of the hydropower plant or not. If it is possible to divert the lift irrigation water from the head races as an alternative plan, then the following advantages can be given.

1) Construction cost of the intake facilities can be saved because a cofferdam and future dredging of the pond are not required.
2) No silting problem will occur in future because elevation of the intake sill is much higher (approx. 17m) than the inlet sill of the power plant, and the diverted flow into the feeder canal is very small (3.7%) against that for the power plant, so that the maintenance cost may be negligible because of no pond dredging is required for the intake.

This alternative plan proposed by WAPDA has however not been included in the scope of works in this JICA Study because of the following reason.

1) A separate financial arrangement for the intake construction becomes necessary to carry out the work simultaneously with the power project.
2) It may take a long time to make necessary arrangements for the hydropower project . It requires to revise the design and contracts. Furthermore, construction of the plant has already been started and is now on-going.

If the alternative plan is agreed by the power project, some review studies shall be made on the hydraulic calculations for the intake and the feeder canal at the detailed design stage of the 1st Lift Irrigation Project. The length of the feeder canal may be extended by about 1.2 km upward by this.

G.1.2 Design Criteria

Design criteria of the intake are as follows.

- Design discharge including conveyance loss:	74 cms
- Design water level: (equal to N.W.L. of Chashma Pond: see Fig. G.1.2.1)	195.68 m (642 ft)
- High water level: (equal to Max. storage Level of Chashma Pond)	197.82 m (649 ft)
- Top of walls of structures: (same as that of the power plant)	199.40 m
- Intake gate sill:	192.06 m
- Intake gate: (electric-driven radial, operation at gate side)	4.8m x 6.0m x 4 gates

G.1.3 Structure

(1) Approach watercourse

An approach watercourse from Chashma Pond shall be dredged 700m from the upper end of the guide bank to the inlet of intake. The dredged soil can be used for land reclamation between the hydropower plant and the intake.

(2) Intake structure

An intake structure is of reinforced concrete consisting of an inlet, a gate portion, a transition and a flume part, and is connected to a box culvert under-crossing of Chashma Dike. Total length of the structure is approximately 70m, and the widths at gate and the flume portions are 21m and 16.5m, respectively.

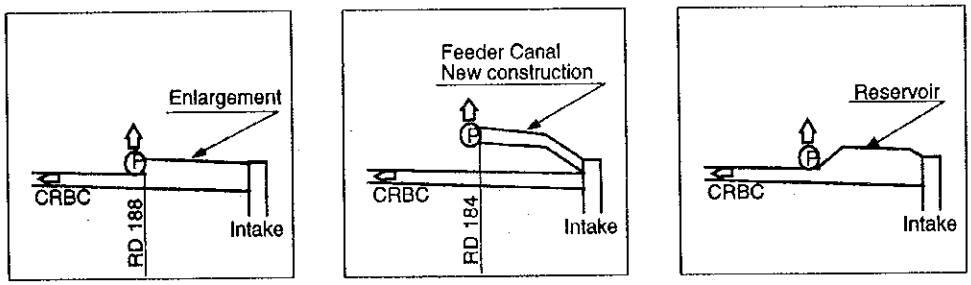
(3) Gate

Four radial gates are to be installed to regulate the intake discharge. The size of each gate is 4.8m in width and 6.0m in height. Radial gate has been found advantageous due to low height of operation flat form, lighter loads to the foundation and less operation power as compared with roller gate. The gates shall be electric-driven and operation at the gate sides. Remote control of the gates from the pumping station is not planned because of difficulties in maintenance. Instead, a wireless telephone system is to be installed for receiving instructions and communication with the central office.

G.2 Feeder Canal

G.2.1 Canal Alignment

There may be a number of alternatives for feeder canal alignment in combination with functions of the existing CRBC Function of the feeder canal could be borne by CRBC by widening of the cross-section. Or, it could be completely independent and run parallel to CRBC Or, reservoir construction in the right bank of CRBC could serve as the feeder canal. Following 3 alternatives have been examined.



(A) CRBC Widening (B) New Canal Parallel (C) Reservoir Construction

Among the above alternatives, the alternative-A was temporarily planned for selection but, after detailed examination in the engineering and economic feasibility, the alternative-B has been decided for selection.

The feeder canal, aligned as long as 58.5 km, connects the intake and the pumping station. The alignment runs almost parallel to the existing CRBC on its right side. The upstream portion of the canal is exactly 77m apart from CRBC, while the downstream portion has some deviation at several sections due to hilly topography and keeping distance from the residential areas.

Standard radius of curvatures of the canal have been selected from 500m, 1,000m and 2,000m depending on the locational conditions. However, some shorter radius such as 100m or 200m have also been selected in some particular cases unless otherwise required.

G.2.2 Canal Lining

Concrete canal lining has carefully been examined and finally been adopted for not only the Feeder Canal but also the Main Canal and the distributaries. Objectives of concrete canal lining are such as reduction of hydraulic head loss and seepage, prevention growth of weeds, economy in maintenance, structural safety, etc. Cost for the lining , however, has a comparatively large share in the whole canal

construction cost. For the construction economy, minimum thickness of the concrete by using high-quality concrete and application of some appropriate construction methods for the quality are required. And for this, following considerations has to be made.

i) Complete sub-grade works:

Failure of lining concrete is due mostly to inadequate subgrade work; uneven subgrading, incomplete compaction, insufficient under-drain, etc.

ii) High-quality concrete:

High-quality concrete gives strong and durable lining. The quality can only be secured by adequate batching facilities for precise measuring of the materials, and particularly by strict control of W/C and S/A ratios, reduced rate of pea grave (5-10 mm in dia.), and the slump.

iii) Use of vibrator when placing

iv) Application of slip form lining method

Systematic placing, vibrating, screeding and finishing give an enhancement for the accelerated progress in the works and workmanship, and this results to the high quality and reduced cost.

Thickness of the lining has consequently been decided at 8 cm. Quality of concrete is a more important factor than the thickness for the durability, nevertheless reduction of concrete thickness drastically push down the construction cost.

Popular methods for concrete lining in common application are as follows.

i) Conventional canal lining method:

This is a simple hand-placing method by using a transversal-operating slip-form screed. Concrete is spread on the side slope. Screed guides are laid on the subgrade. The concrete is screeded upward along the slope by a slip-form screed. The screeded concrete is thoroughly and systematically vibrated atop the slip-form screed which is unvibrated and made of steel frames and plates. (See Fig. G.2.2.1)
The screed is hoisted up along the slope by a device on the berm or by a device

mounted on it. After placing some finishing is made by a trowel or a float with a long handle.

The lining is carried out alternately by panel for efficient placing, finishing and curing. Preferable width of a panel is approx. 4 m, while preferable size of a slip-form is 0.75 m wide, 4.2 m long and 0.2 m thick with a blade plate of 4.0 m wide and 0.5 m high to hold the spreaded concrete for vibration.

Speedy lining outputs may not be expected by this method but this can be carried out at many places by independent corps at the same time.

ii) Mechanized full-section canal lining method:

Various types of longitudinal-operatingslip-form machine for lining of full canal section for all sizes have been developed since 1910's in U.S.A. up to date. Targets for the development are placed on upgrading of efficiency and performance of the work.

Such machines are usually combined with other heavy equipment such as excavator, trimming machine and other equipment with balanced capacity of batching, mixing, hauling and handling concrete for the efficiency and performance.

This method requires accurate preparation of the subgrade and berms, experienced operators, close inspections and careful operation and combination of many equipment.

iii) Mechanized one-side slope lining method:

This method is usually applied to large-scale canal with a wide bed canal.

The lining is longitudinally separated into 3 portions; 2 side slopes and the bed. Many equipment combined with a lining machine are required for harmonized operation .

For the Project, the simple slop-form screed method has been employed by taking following considerations into account.

i) Lining works for the Feeder and the Main Canals are interrupted by many crossing structures, and therefore achievement of efficient performance is rather difficult even by employment of heavy equipment.
ii) For employment of longitudinal-operating slip-form machine method, many other machines for combination are required.
iii) Required number of simple slip-form can easily and locally be manufactured and purchased at reasonable price.

iv) Construction method is simple enough requiring no particularly specialized skilled labor for slip-form screed lining.
v) Lining cost by using the slip-form screed is more economical than the other methods.

G.2.3 Standard Cross-section

Earthwork in the cross-sections of the canal is mostly with fill in the upstream half of the route while cut-and-fill in the downstream half. The earthwork may involve considerable amount of rock excavation to run through hilly area.
The work for such cut and fill amounts to a huge volume. A standard cross-section has been designed as follows so as to minimize the volume. (See Fig. G2.3.1)

i) Design criteria of the feeder canal is similar to that of the main canal. The canal is lined with 8 cm-thick concrete as afore-mentioned. Manning's formula has been applied to the hydraulic calculations wherein coefficient of roughness is 0.016. Longitudinal gradient of the canal has been decided 1:14,000 as same as CRBC.
ii) Narrower and deeper canal prism as compared with CRBC has been applied because neither offtakes nor cross-drainage structures are required. (bed width/water depth = 9.0m / 4.5m = 2.0)
iii) Velocity and water depth are 1.0 m/s and 4.5m, respectively, and are kept unchanged through the route even if the cross-section changes from the ordinary prism to square cross-section at super passage sites. (See Table G.2.3.1)
iv) Slope of cut is 1:1 for common soils while 1:0.5 for rock.
v) Slope of fill is 1:1.5

G.2.4 Cross Drainage Structure

Eleven numbers of super passages have been planned for crossing above the feeder canal in order to avoid their choking, while one cross-drain of Nullah culvert type has to be planned to cross below the feeder canal due to the topography of the site. (See Table G.2.4.1)

G.2.5 Escape and Silt Ejector

In addition to the substantial amount of silt conveyed from the Indus through the intake, considerable amount of sand will be blown into the feeder canal by the seasonal wind since the route passes through a sand dune area as long as approx. 10 km in the upstream from pumping station. (See Table G2.4.1)

Sand particles give damage on impellers and vanes of pump much more than silt when flown into the pump. A settling basin has therefore been planned in front of the pump house.

The first escape and silt ejector has been planned at the midway of the feeder canal near the existing combined structure of CRBC (a combined structure of girder road bridge and canal aqueduct) to flush out the sediment conveyed through the intake.

The ejector consists of three desiltation gates (2m-high x 3m-wide each) with approach sluiceways separated by 50m-long partitions in the feeder canal. These gates can also be used as waste water gates.

Waste water and flushed water containing sediment is released into the CRBC escape, and the discharge has not to be interrupted on the way. The rate of desiltation discharge is 5 to 7% of the design discharge of the feeder canal. Water additionally taken for silt ejectors doesn't infringe on the Indus water right due to being escaped into Indus river.

However no additional water is proposed at a term of maximum discharge because it will not be silted due to adequate velocity.

The second escape and silt ejector has been planned at the end of the feeder canal. Waste water is released into CRBC drainage channel through an approx. 2 km-long new escape channel and the existing drainage siphon No. 12. The inlet sill of the existing siphon is higher than the bottom of the settling basin of the pumping station. Reconstruction of the siphon inlet is required to lower the sill by 2m from the present level, and widening of the drainage channel has also to be carried out to secure the capacity.

A desiltation system to flush the sediment from the bottom of settling basin consists of two box-conduits with gates connected to the escape channel and a diversion structure at about 300m downstream from the escape channel followed by a spoil area of the sediment. The spoil area is the lowest depression nearby and is located just right side of CRBC. The spoiled sediment is dredged and carried away when the spoil area is filled up till a certain level.

G.2.6 Bridge

Four types of bridge as arterial road (AR) bridge, district road (DR) bridge, village

road (VR) bridge and foot pass (FP) bridge, have been planned across the feeder canal based on the same design conception as the main canal. Each location corresponds to the existing CRBC bridge site.

G.2.7 Washing Step

No washing step is provided in the feeder canal because the similar washing steps have already been provided in CRBC

G.2.8 Canal Road

All canal roads (berms) are open to the public and no gate structures across the canal roads are provided.

G.3 Pumping Station

G.3.1 Location

The location of the pumping station should be selected after taking into consideration the irrigation area of the project, the topographical condition around the site, and the plan of the appurtenant facilities. Particularly the location is determined for the following reasons;

- Short length of delivery pipelines,
- Reservation of sufficient land for settling basin and escape structures,
- Reservation of land for outlet of escape channel.

The location of the pumping station has been determined at the side of sandy hill near CRBC/RD. 184.

G.3.2 Design Conditions

(1) Design Discharge

In accordance with the water requirement of the project, the design discharge of pumping facilities has been determined as follows;

a. Maximum Discharge $72.0m^3/s$

The result of water requirement shows that maximum water requirement is $71.17m^3/s$. Some allowance considered, the design maximum discharge is determined to be $72.0m^3/s$.

b. Regular Operation Range $30.0m^3/s$ - $50.0m^3/s$

c. Minimum Discharge $20.0m^3/s$

(2) Water Levels for Pump Operation

The suction water level and the discharge water level of pumps should be determined in accordance with the planning of other irrigation facilities of the project.
The suction water level is decided, based on the longitudinal gradient of the feeder canal which runs from the Chashma Pond to the pumping site.
Meanwhile, the discharge water level is decided in accordance with the selection of irrigation area. The irrigation area has been selected as economically feasible limitation, with various conditions considered.
Actual head, suction water level, and discharge water level of pumps are as follows;

a.	Actual Head	18.3m
b.	Design Suction Water Level (HWL)	190.7m
	Lowest Suction Water Level (LWL)	188.7m
c.	Design Discharge Water Level	209.0m

G.3.3 Pump

G.3.3.1 Type of Pump

(1) Design Criteria of Pump Units

Discharge capacity per unit and total head of pumps are the essencial design criteria to the selection of pump type. The most appropriate pump type is selected on the basis of pump efficiency and performance, suction condition of pumps, costs, operation and maintenance, etc.

- Discharge Capacity per Unit

Several units of pump are to be installed in order that the number of pumps in operation can be selected according to the various amount of discharge.
In each comparative case, the number of units is 5 to 12 nos., and discharge capacity per unit is 4.0 to 15.0m^3/s.

- Total Head of Pumps

Total head of pumps is given as follows;

Total head	=	actual head	18.3m
	+	difference between HWL and LWL	2.0m
	+	pump loss	1.5m
	+	pipe loss	1.2m

= 23.0m

There is no great difference in the value of total head according to number of pumps or diameter of delivery pipes. The value is about 22 or 23m. The reason is that total loss of head (pump loss and pipe loss) is very small (only 12% of the total head) because of short length of the delivery pipelines.

(2) Classification of Pumps

The great variety of pumps are hydraulically classified into three types as follows;

- Centrifugal pump (volute pump and diffuser pump)
- Mixed flow pump
- Axial flow pump

Characteristics of each type are shown below. The value of specific speed defined by the following equation is an essential criterion, which indicates impeller profiles and major pump characteristics, such as suction performance, pump head, pump efficiency, etc.

$$Ns = N.Q^{1/2} / H^{3/4}$$

where Ns : specific speed
N : speed of pump, r/min
Q : capacity, m^3/min
(for double suction impeller, Q/2)
H : total head, m
(for multistage pump, head per stage)

Table G.3.3.1 Characteristics of Pump

Pump Type	Characteristics
Centrifugal Pump (Volute Pump and Diffuser Pump)	Good suction performance. Cavitation can be easily prevented. Big change of discharge causes a small change of pump head. Pump efficiency is good in a wide range of discharge. Wide discharge range is available.
Mixed Flow Pump	Intermediate characteristics between centrifugal pump and axial flow pump.
Axial Flow Pump	Suction performance is not good. Cavitation is easy to occur. Small change of discharge causes a big change of pump head. Pump efficiency is good only in a limited range of discharge. On the contrary, wide head range is available.

Pump Type	Specific Speed (r/min.m^3/s.m)	Pump Bore (mm)	Head Range (m)
Single suction, single stage, volute	100 - 600	40 - 1000	3 - 85
Double suction, single stage, volute	120 - 600	150 - 1500	4 - 100
Multistage volute or diffuser	120 - 200	40 - 300	15 - 2400
Horizontal mixed flow	600 - 1400	200 - 2000	3 - 15
Vertical mixed flow	600 - 1400	200 - 4600	3 - 30
Horizontal axial flow	1300 - 2000	300 - 2000	0.5 - 3
Vertical axial flow	1300 - 2000	300 - 4600	1 - 6

(3) Selection of Pump Type

Pump types applicable to the case of large capacity required are mixed flow or axial flow pump. Centrifugal pump is of small specific speed, and is suitable for the condition of relatively small capacity and high lifting height. Centrifugal pump is generally unsuitable for a pump with capacity of $3m^3/s$ or larger, though in a special case the centrifugal pump with capacity up to $6m^3/s$ can be manufactured. Large scale of centrifugal pump requires so wide area for installation, and besides it is of so heavy weight, and its cost is so high that it has no practical use.

Axial flow pump is inferior to mixed flow pump in the suction performance, and of higher possibility of cavitation. Horizontal pump, with its impeller vane installed above the suction water level, is inferior to vertical pump in the suction performance, and of higher possibility of cavitation. The impeller vane of vertical pumps is installed below the suction water level, so it has an advantage over other types in the suction performance.

In case of large capacity pumps, a small change of water level or flow rate causes a large change of the suction condition. The suction performance is the most important element to the selection of pump type.

From another viewpoints, axial flow pumps are not suitable for the condition of more than 6m lifting height, and horizontal pumps require about one and a half times as wide area for installation as vertical pumps.

For the reasons mentioned above, the "Vertical Mixed Flow" pump is selected as the most appropriate type, considering the suction performance, the required area for installation, and the costs.

The vertical mixed flow pump is classified into the following 2 types;

a. Volute type

b. Non-volute type (diffuser type)

And the type of suction sump of the vertical mixed flow pump is classified into the following 2 types;

a. Umbrella type

b. Bend type

Table G.3.3.2 shows the comparison of these types.

As for the suction performance, the bend type has a little advantage over the umbrella type because of its smooth suction sump and its small suction loss. But the bend type requires deeper excavation, and its construction is not easy, so its construction cost amounts to a larger sum. Therefore, considering the cost and construction workability, the umbrella type is better.

Compared to the non-volute type pump, the volute type pump is advantageous from the viewpoint of pump efficiency, suction performance, operation and maintenance.

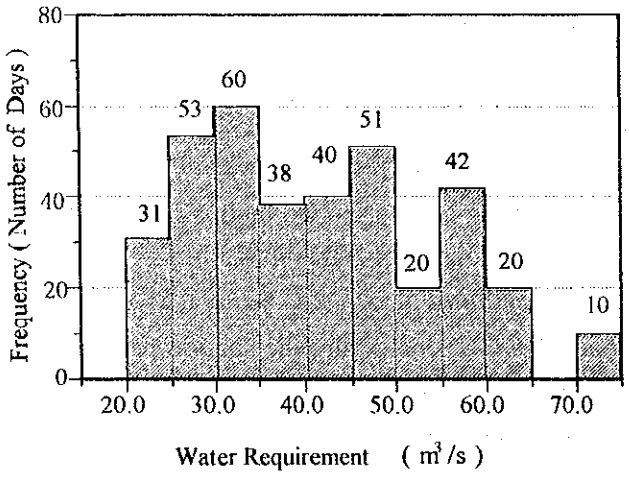
Consequently, the vertical volute type mixed flow pump (umbrella type) is selected as the most appropriate type.

G.3.3.2 Pump Bore and Number of Unit

(1) Requirements for the Number of Unit

1) Discharge control according to the various amount of the water requirement

The total water requirement of the project varies in a wide range from 20.0m^3/s to 72.0m^3/s. The values of the 10 days water requirement are shown in Table 5.3.3. in the Main Report. The histogram below shows the frequency of the water requirement.



Histogram of the Water Requirement

In accordance with the various amount of water requirement, the number of pumps in operation should be controlled in the efficient and unwasteful method. Pump Bore

and number of unit installed in the station should be selected in view of the most efficient pump operation.

2) Considering the case that every installed pump cannot be in operation

In case that every installed pump is not available for some reason, for example,

- Half number of pumps is not available due to the desiltation work of the settling basin, during the period when a small amount of water is required.
- Some trouble happens with pump equipments or delivery pipelines.
- In the initial stage of the project life, in which on-farm development is not fully progressed.

In these cases, it is necessary that the pump operation can follow the various amount of the water requirement to some extent. It is desirable that 3 or 4 units of pump are always available. In other words, at least 6 to 8 units of pump should be installed in the station.

3) Standby pumps as capacity allowances

In case of some trouble with pump equipments, if the total water requirement is small and several units of pump are standby, then one unit of standby pump can be driven instead of the unit being out of order. The problem is what countermeasure can be adopted in case that, while the total water requirement is large and the equipments are in full operation, one of the installed pumps becomes out of order.

If the maximum demand lasts many days throughout a year, some trouble may cause some losses to the constant water supply. But in this project, as is shown above in the histogram, over $70m^3/s$ water is required for 10 days, and $60\text{-}70m^3/s$ water is required for 20 days. There are so few days with the equipments in full operation, that some trouble during these days should not be dealt with by increasing the total capacity of pumps, but by utilizing the facilities other than pumps, or by applying some measures in the on-farm water management. In other words, the following measures are considered to be economical.

- to utilize the water of the regulating ponds.
- to economize on the use of water at the on-farm level.

In addition, it is necessary to inspect and maintain the equipments well at all times, so that any trouble does not happen while the equipments are in full operation.

Consequently, it is concluded that standby pumps as capacity allowances are not planned to be installed.

(2) Comparative cases

In the comparative study of pump bore and number of unit, the following cases are to be examined and evaluated.

Case I;	Several units of equal-capacity pump installed
I-1;	5 units of 14.4m^3/s pump installed
I-2;	6 units of 12m^3/s pump installed
I-3;	8 units of 9m^3/s pump installed
I-4;	12 units of 6m^3/s pump installed
Case II;	Several units of different-capacity pump installed
II-1	Several units of 15m^3/s pump and small pump installed
II-2	Several units of 12m^3/s pump and small pump installed
II-3	Several units of 10m^3/s pump and small pump installed

(3) Methodology of the study

The regulating pond is planned to be provided at the offtake of each distributary for the purpose of regulating the time lag or the difference between water supply and water demand. The discharge by pumps is the graduated value, because it is controlled by number of pumps in operation. The difference can be regulated by the following operation;

- in case of an oversupply, the surplus water is stored in regulating ponds,
- in case of an insufficient supply, the deficiency is made up for out of regulating ponds.

By means of the operation like this, the unused waste water can be minimized, and the O&M cost can be reduced. The pump operation pattern should be decided in accordance with the operation of regulating ponds.

However, the whole effective capacity of regulating ponds is not available for the following reasons;

- The water levels of regulating ponds are at the low elevation, so that the regulating ponds cannot command the whole command area of each distributary. In the upper area, the water of regulating ponds is not available.
- It is expected that some factors deciding water demand -for example, effective rainfall, planted crops, cropping area, etc- vary to some extent according to irrigation blocks. The regulating ponds must have a capacity for regulating the fluctuation of water demand individually in each distributary.

Consequently, the whole capacity of regulating ponds cannot be utilized as a buffer between water supply by pumps and water demand. Therefore, the comparative study is carried out in three cases, that the availability of regulating ponds is 100%, 50%, and 10%. The pump bore and number of unit is to be determined after comparing the pump operation pattern and the results of the water supply simulation by pumps and regulating ponds in each case.

(4) Results of the study and conclusion

The results of the comparative study are shown in Table G.3.3.3 and in Fig. G.3.3.1 - Fig. G.3.3.2, and the results of the water supply simulation by pumps and regulating ponds are shown in Table G.3.3.4 and in Fig. G.3.3.3 The results are summarized below.

Case	Capacity per unit (m^3/s)	No. of units (nos)	Capacity per unit (m^3/s)	No. of units (nos)	Construction Cost (1,000Rs.)	Annual O&M Cost (1,000Rs. /year)	Net Present Value (1,000Rs.)	Excess Water (MCM /year)
I-1	14.40	5			1,555,970	195,912	3,454,400	115.6
I-2	12.00	6			1,575,160	199,293	3,494,200	100.3
I-3	9.00	8			1,686,650	196,263	3,644,900	64.8
I-4	6.00	12			1,820,800	192,265	3,781,500	21.5
II-1	15.00	4	6.00	2	1,566,130	188,852	3,421,400	21.5
II-2	12.00	5	6.00	2	1,616,740	190,195	3,503,500	16.3
II-3a			6.00	2	1,617,400	188,144	3,483,400	4.7
II-3b	10.00	6	4.00	3	1,655,330	189,532	3,534,000	13.4
II-3c		5	5.50	4	1,690,230	191,203	3,606,900	16.4

The above table indicates the values in case that the availability of regulating ponds is 50%. There is no great difference in characteristics of each case according to the availability.

The construction cost is lowest in case II-1, and the annual O&M cost is lowest in case II-3a. In the net present value, case II-3a is approximately equivalent to case II-1. And in case II-1, the volume of excess water is larger than in case II-3a, because pumps of larger capacity are installed.

As compared with case II-3a, case II-1 is less adaptable to some trouble with pump facilities or fluctuation of water demand, because its capacity per unit is larger and its number of unit is smaller. The most efficient pump operation is considered to be possible in case II-3a.

Consequently, case II-3a is selected as the most appropriate combination of pumps in this pumping station. The capacity per unit and number of units is as follows.

Capacity per unit	Number of units
$10.0m^3/s$	6 nos.
$6.0m^3/s$	2 nos.

G.3.3.3 Remarks on Pump Operation

In order that the equipments can be continuously in regular operation, the following measures must be adopted;

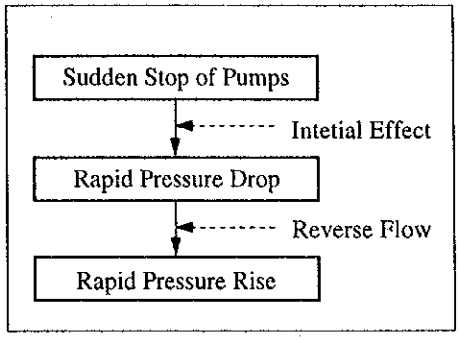
- to carry out the desiltation work of the settling basin and the cleaning of the suction pit, with half number of units out of operation, during the period when the discharge is rather small.
- to operate pumps by rotation during the period when the discharge is rather small, so that some pumps would not be intensively in operation.
- to maintain and inspect the equipments carefully during the period when the discharge is rather small, so that some trouble would not happen while the equipments are in full operation.

G.3.3.4 Water Hammer

(1) Explanation of Water Hammer Phenomena

When the power supply to pumps is suddenly interrupted due to a power failure, pressure drop and pressure rise is caused, and some damages may often ensue on the pumping system.

When the pumps are suddenly stopped, the shafts of motors continue to rotate by the inertial force, but pump speed and pump discharge is rapidly reduced. On the other hand, the water flow inside the delivery pipes intends to maintain the existing flow velocity by the inertial effect. The interaction of them causes the pressure drop at the discharge side of pumps. After that, the flow reversal occurs, and the pressure rise is caused by interruption of reverse flow by check valves. Thus, the typical pattern of pressure change is as follows;



The change in pressure is conveyed inside the delivery pipes as the pressure wave. The pressure drop wave, generated immediately after stop of pumps, reaches the outlet pond, reflects as the pressure rise wave, and returns to the pumping station.

When the pressure wave reflects at the outlet pond, the flow reversal occurs. In case that the check valves close almost simultaneously with the flow reversal, very little reverse flow occurs. And in case that, even after the closure of check valves, flow reversal does not occur and the inertial effect remains, the pressure continues to drop and the negative pressure grows large. On the contrary, in case that the check valves close after the flow reversal, rapid pressure rise occurs. And in case that, due to the time delay of the closure, the check valves close after the reverse flow rate becomes large, the pressure remarkably rises.

Thus, the conditions of the change in pressure after stop of pumps are dependent on the travel time of the pressure wave and the closure time of check valves.

The velocity of pressure wave is given as follows;

$$a = \frac{1425}{\sqrt{1 + \frac{K}{E} \cdot \frac{D}{t}}}$$

where a : Velocity of the pressure wave (m/s)

K : Volume modules of water (kgf/m^2)
$= 2.07 \times 10^8\ kgf/m^2$

E : Modules of elasticity of pipe material (kgf/m^2)
$= 2.1 \times 10^{10}\ kgf/m^2$, for steel pipe

D : Diameter of pipe (m)

t : Thickness of pipe (m)

3.200m substituted for D, and 0.019m for t,

then the velocity of the pressure wave: $a = 874 m/s.$

and the round trip travel time of the pressure wave: $T = 2L/a$

$= 2 \times 700 / 874$

$= 1.6$ sec

where L : Length of delivery pipeline (= 700m)

The pressure wave returns in only 1.6 seconds, due to the short length of the pipeline. So it is considered that the pressure drop does not practically occur, and that the flow reversal occurs immediately after stop of pumps. Therefore, it is apprehended that the mechanical shock and the pressure rise is caused by the time delay at closure of check valves. Some countermeasure is necessary for absorbing the shock accompanied by the pressure rise.

(2) Water Hammer Countermeasures

Typical countermeasures against the water hammer phenomena are enumerated below.

a. Fly wheel

A fly wheel should be mounted on the pump in order to moderate the deceleration of pump speed and to prevent rapid changes in flow. It is effective against both pressure drop and pressure rise. Most simple, but it is difficult to apply a fly wheel to submerged pump and vertical pump.

b. Conventional surge tank

Negative pressure can be prevented by supplementing water when down surge occurs. The surge tank must be located high enough to prevent overflow during pressure rise, and large enough to prevent being emptied during pressure drop. So the construction cost is high.

c. One-way surge tank

The one-way surge tank is separated from the pipeline by a check valve, and the water level can be below the static head of the pipeline. In case of a long pipeline, provision of several units is sometimes required.

d. Air-chamber

By forcing some quantity of water into the pipeline by compressed air, negative pressure growth can be prevented. And pressure rise can be prevented by absorbing water of the pipeline. Air-chambers can be made smaller than surge tanks. An air-chamber effectively prevents water hammer over the full pipeline even if the pipeline is long.

e. Rapid closing check valve

The time delay at closure can be minimized by the force of tilting-disc or torsion spring. In case of no time delay, the maximum pressure is about 200% of the actual head.

f. Slow closing check valve

The slow closing check valve restrain the head increase as well as reduce mechanical shock by delaying positive closure and releasing reverse flow for a certain time.
Two types are used. One type delays the disc closing action by means of a dashpot attached to the pivot shaft. This type is used only for low pressure.
The other type is the rapid closing swing check valve with a slow closing bypass valve. Reverse flow through the bypass valve can lower the head increase.
In case of the type with a dashpot the maximum pressure is about 150% of the actual head. And in case of the type with a bypass valve the maximum pressure is about 120-130% of the actual head.

Considering that in this pumping station the pressure drop does not occur, and considering the installation condition of pumps and the pressure condition of the pumping system, the slow closing check valve with a dashpot is selected as the most economical type for preventing the pressure rise.

G.3.3.5 Major Mechanical and Electrical Equipments

a. Pumps - Large pump

Type:	Vertical Volute Type Mixed Flow
Suction Bore:	2,000 mm
Discharge Bore:	1,800 mm
Capacity:	10.0 m^3/s
Total Head:	23.0 m
Number of Units:	6 nos.

- Small Pump

Type:	Vertical Volute Type Mixed Flow
Suction Bore:	1,650 mm
Discharge Bore:	1,500 mm
Capacity:	6.0 m^3/s
Total Head:	23.0 m
Number of Units:	2 nos.

b. Motos - Main Motor for Large Pump 6 nos.

Type:	Vertical Synchronous Motor or Vertical Wound Rotor Induction Motor with Starter
Output:	3,000kw x 20P, 11kv x 50Hz

- Main Motor for Small Pump 2 nos.

Type:	Vertical Synchronous Motor or Vertical Wound Rotor Induction Motor with Starter
Output:	1,800kw x 16P, 11kv x 50Hz

c. Motor Operated Butterfly Valve
- Discharge Valve for Large Pump 1,800mm, 6nos.
- Discharge Valve for Small Pump 1,500mm, 2nos.
- Maintenance Valve for Header Pipe 4,000mm, 2nos.
- Maintenance Valve for Delivery Pipe 3,200mm, 3nos.

d. Check Valve with Dashpot
- for Large Pump 1,800mm, 6nos.
- for Small Pump 1,500mm, 2nos.

e. Electric Overhead crane - 32 tons in capacity, 17.6m span

f. Auxiliary Equipments - 200mm Raw Water Pump 4nos.

Type:	Horizontal double suction volute pump

- 150mm Cooling Water Pump 6nos.

Type:	Vertical Axial Flow Pump
	300mm Auto Strainer 8nos.

- 80mm Sump Pump 8nos.

g. Emergency Generator Set	- Capacity:	150KVA, AC380V x 50Hz (for lighting, air conditioning, etc)
h. Bar Screen	- for Pump Suction Pit,	Trash Car Type
with Cleaning Machine	- for Inlet Channel,	Trash Car Type
i. Electrical Equipments		1 lot
j. Substation	- Main Transformer	66kV / 11kV, 30MVA

G.3.4 Settling Basin

Water in the feeder canal includes suspended and sedimented loads entered from the Indus and the lands along the canal. When the sand particles flow into the pump casing, or sediment at the pump suction sump, pump impellers are damaged, and the regular pump operation becomes impossible. What is required for the settling basin is to remove the suspended sand particles which is harmful to the pump impellers.
Whether sand particles is harmful to pump impellers or not is dependent on size, shape and hardness of them. But it is generally accepted that sand particles of 0.5 mm or more in diameter give damage on pump impellers, while those of less than 0.2-0.3 mm give no substantial damage on them. Therefore, the settling basin is designed to sediment sand particles of 0.3 mm or more in diameter.

(1) Size of the Basin

The width and the length of the settling basin is decided by the following process.

a. Width of the Settling Basin;

The velocity must be smaller than the critical velocity for suspension of sand particles to be settled. So the width of the basin is given as follows;

$$B = Q / h.u$$

where B : Width of the Basin (m)
Q : Design Discharge (m^3/s)
h : Water Depth of the Basin (m)
u : Mean Velocity in the Basin (m/s)

to be equal to the critical velocity for suspension of the smallest particles

to be settled.
u = 0.2m/s, or 0.3 mm in grain size
then,
B = 72.0 / (6.0 x 0.2) = 70.0m

The width is to be equal to that of the suction pit, so that the water flow into the pit would be uniform. Therefore,

B = 75.0m

b. Length of the Basin

The required length of the basin is calculated from the relationship between the flow velocity in the basin and the settling velocity of sand particles to be settled. The length is given as follows;

$L = K (h / Vg) u$

where L : Length of the Basin (m)
K : Safety Factor (= 1.5 - 2.0)
Vg : Critical Settling Velocity (m/s)
of the smallest particles to be settled
Vg = 0.025m/s, for 0.3 mm in grain size

then,

L = 2.0 x (6.0 / 0.025) x 0.2 = 96.0m

Design length is to be a round value, therefore,

L = 100.0m

(2) Behavior of Sand Particles in the Canal Flow

The suspended load and bed load in CRBC at RD 0+00 are as presented in Fig. G.3.4.1, indicating that D_{90} of the suspended load is far smaller than 0.3 mm as 0.04 mm in Sep.-May and 0.15 mm in May-Sep.
Discharge in the feeder canal varies from $20m^3/s$ to $72m^3/s$ before pumping. Since the dimensions of the settling basin are 100m in length, 75m in width and 6m in depth, the mean flow velocity becomes

when	$Q_{max} = 72m^3/s$	then	V = 0.16m/s,
when	$Q_{cen} = 40m^3/s$	then	V = 0.09m/s, and
when	$Q_{min} = 20m^3/s$	then	V = 0.04m/s.

Diameter of sand particles d entering from the feeder canal is given as;

$$d = \frac{H \cdot i}{1.6f \cdot (1 - \lambda)}$$

where H : Water Depth (= 4.5m)

i : Hydraulic gradient (= 1/14,000)

f : Frictional Coefficient (= 0.5)

λ : Void Ratio (= 0.3)

then,

d = 0.6mm

As aforementioned, sand particles supplied from the Indus is far smaller than the size, while those from ground surface and dune carried by rainwater and wind along the course are 0.6mm at D_{95}, 0.3 mm at D_{65} and 0.2 mm at D_{25}. (see Fig. G.3.4.2) Accordingly, sand particles subject to settling are those from the latter.

Theory of suspension of materials gives critical velocity for suspension of sand particles as;

when d < 1.5mm

$(r - 1)\, d_{max} = a^{1.2} \times 0.013\, (VH)^{0.55}$

where r : specific gravity of sand (= 2.65)

d_{max} : maximum diameter of suspended sand particles

a : coefficient by shape of particle (= 0.5)

V : mean flow velocity (m/s)

H : water depth = 6.00m)

then,

d_{max} (mm)	0.10	0.20	0.24	0.30	0.33	0.40	0.50	0.60
V (m/s)	0.02	0.06	0.09	0.13	0.16	0.22	0.33	0.46

Maximum particle size suspended in the settling basin is 0.33 mm when Q = 72 m^3/s, while 0.24 mm when Q = 40m^3/s. Accordingly it may be said that large sand particles harmful to pump impellers would not be suspended but settle down in the settling on the way to the pumps.

G.3.5 Foundation

(1) General Features

The pumping station is to be constructed in the sandy hill area. The following table shows the characteristics of the ground around the pumping site.

	Elevation (m)	Depth* (m)	Soil Texture	N-value
Natural Ground Surface	193.8 - 197.6	-	fine sand	-
Cutting Ground Surface	191.7	2.1 - 5.9	fine sand or medium sand	11 - 13
Foundation of the Structures	182.7 - 184.7	9.1 - 14.9	fine sand or silty sand	22 - 29

* Depth means the depth below the natural ground level.

The geologic profile shows that the soils around the pumping station consist of mainly fine sand and medium sand, and partially thin layers of sandy silt, silt, or clay. The foundation of the structures consists of relatively firm ground.
The grain size frequency of a sample of the dune sand has been examined, and its result is given as follows. (see Fig. G.3.4.2)

	Grain size (mm)	Weight (%)
Silt	0.005 - 0.074	5.0
Fine Sand	0.074 - 0.42	76.0
Medium Sand	0.42 - 2.0	19.0
D_{60} = 0.29mm, D_{50} = 0.25mm,	D_{30} = 0.18mm, D_{10} = 0.10mm	
Uniformity Coefficient	$Uc = D_{60} / D_{10} = 2.9$	
Coefficient of Curvature	$Uc' = D_{30}^2 / (D_{10} D_{60}) = 1.1$	

Generally, in case that uniformity coefficient Uc is less than 4 or 5, the sample is called ill-graded, that is, homogeneous. The sample of the dune sand is considered to be homogeneous fine sand. Taking into consideration the results of the borehole drilling, this sample shows the typical soil sample around the pumping site.

(2) Bearing Capacity

There is a correlation between bearing capacity and N-value of the sandy ground. The standard values of bearing capacity are given as follows. Because N-value at the foundation of the pumping station is 22-29, the bearing capacity is estimated to be approximately 20t/m^2.

Ground Type	N-value	Bearing Capacity (t/m^2)
Sandy Ground	less than 5	0
	5 - 10	5
	10 - 20	10
	20 - 30	20
	30 - 50	30

On the other hand, the load on the foundation is roughly estimated as follows. Load per unit area is calculated as $13.8t/m^2$. This value is smaller than the bearing capacity, so the ground has sufficient bearing capacity from the viewpoint of the load.

Item	Load (ton)
Basement	64,100
Pump House	6,800
Equipments	2,700
Water	5,000
Others	7,100

Average Load per Unit Area q;

$q = 85,700ton / 6,228m^2 = 13.8t/m^2$

(3) Sinkage of the Foundation

The sinkage is calculated by the following formula;

$$\delta v = \frac{1}{kv} \cdot \frac{V}{A}$$

where δv : Sinkage (cm)

kv : Coefficient of vertical subgrade reaction $= 0.3kg/cm^3$

V : Vertical load $= 85,700,000kg$

A : Area of the base $= 62,280,000cm^2$

$$\delta v = \frac{1}{0.3} \cdot \frac{85,700,000}{62,280,000} = 4.6cm$$

On the other hand, the value of allowable sinkage is given as follows;

- 3.0 - 4.0 cm; critical value, whether a harmful crack is caused or not
- 6.0 - 8.0 cm; probability of harmful cracks being caused is very high

Therefore, the ground does not have sufficient bearing capacity from the viewpoint of

the sinkage.

(4) Stability on earthquakes

Because the soil texture of the foundation around the pumping station consists of homogeneous fine sand, it is apprehended that the liquefaction phenomena, or quick sand phenomena, would occur in case of an earthquake. Generally, the liquefaction is easy to occur in the following cases;

a. Silt or clay content of the saturated sandy ground is low.
   - In case silt or clay content is less than 10%, the probability is high.
b. N-value is small, and the density is loose in the saturated sandy ground.
c. Ground water level is shallow.
d. Sand formation is not more than 15-20m in depth.
e. Grain size of the sandy ground is homogeneous.
   - In case average grain size D_{50}= 0.15-1.0mm, the probability is high
   - In case uniformity coefficient Uc<10, the probability is high.
   - In case uniformity coefficient Uc<5, the probability is very high.

Around the pumping station, the ground water level is now deep, but it is expected to rise when the irrigation starts by pumping system and lift canal. Compared between the above mentioned cases and the grain size of the dune sand, the ground of the pumping site is adapted to case a, c, d, e. Therefore, the probability of the liquefaction is very high.

(5) Conclusion

The bearing capacity of the foundation is not sufficient taking into account an effect of sinkage on the structures, and in case of earthquakes, it is apprehended that the liquefaction would occur and the bearing capacity would be remarkably reduced.
Taking these conditions into consideration, the concrete piles cast in-situ are used for the improvement and reinforcement of foundation of the structures.
The diameter of piles is 800 mm. The length of piles is 16 to 18m. The bearing formation of piles is selected at 3-3 formation, showing N-value of over 40.

G.3.6 Pump House

Pump House is planned to be a reinforced concrete structure with 32.5m in length and 76.0m in width consisting of a 6m-high basement floor and a 10m-high ground floor. The basement floor is for installation of pumps, valves, pipes and pipe fittings to

connect to the beginning of delivery pipeline, while the ground floor is for main motors, accessory machineries and electric equipments. A 32-ton overhead crane is also equipped in the house.

The structure of the house is to be as follows;

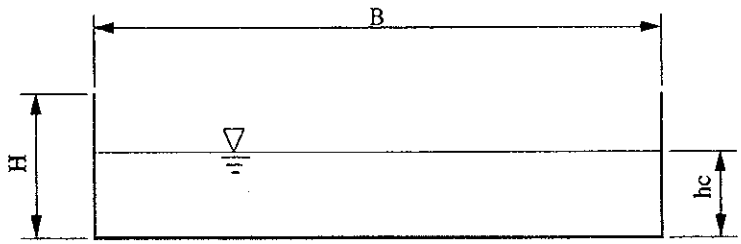
Column:	Reinforced Concrete
Beam:	Steel Flame
Wall:	Brick
Roof:	Slate or Steel Plate

The structure like this can make the construction cost lower than the structure with all parts made of reinforced concrete.

G.3.7 Spillway and Escape Channel

(1) Area of Overflowing Weir

The spillway is provided to spill out the surplus water at the settling basin. The spillway has a overflow fixed weir and the water is released to the escape channel after overflowing the weir. The spillway is required the capacity of the design maximum discharge. The area of the overflowing weir is given as follows;



The width is determined so that the critical depth hc equals to approximately 0.60m.

$$hc = 0.467\, q^{2/3}$$
$$q = Q / B$$

hc = 0.60m, then,

$$q = (hc / 0.467)^{3/2} = (0.60 / 0.467)^{3/2} = 1.46 m^3/s/m$$
$$B = Q / q = 72.0 / 1.46 = 49.3m$$

Therefore, B = 50.0m.

(2) Capacity of the Existing Cross-drainage Siphon

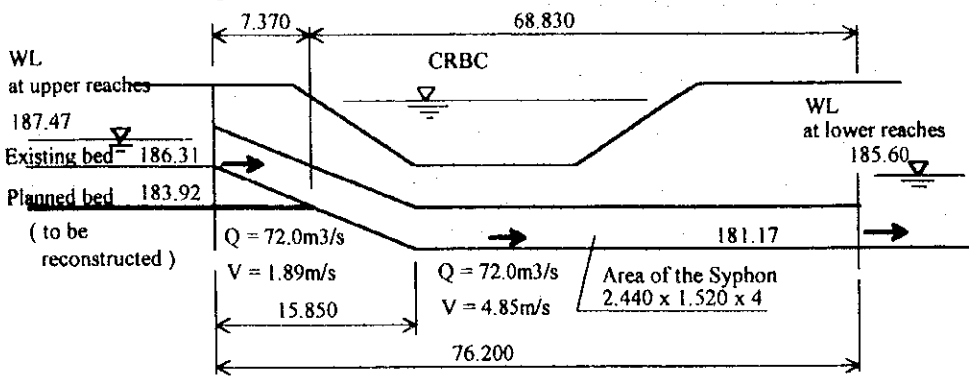
The escape channel is a 4.0 km long canal, and it is planned to convey the spilled

water to the existing Largi Nullah. Largi Nullah has been planned to cross over the CRBC by the structure of the super-passage, which is now under construction. The outlet of the escape channel is to be provided at the downside of the super-passage in Largi Nullah.

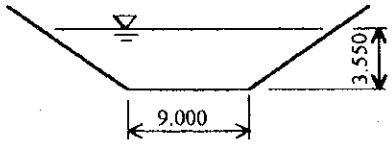
Therefore the escape channel must cross the CRBC, and for that purpose the existing cross-drainage siphon is available. The problems are the following three points;

- The inlet bed level is so high that the inlet of the siphon is to be reconstructed.
- The design discharge of the siphon is 55.0m^3/s. So it is necessary to check the capacity of the siphon, whether it has a capacity of 72.0m^3/s or not.
- Because of the discharge increased, the velocity becomes very large, and it is apprehended that the inner wall of the siphon is worn.

The section of the siphon is illustrated as follows;

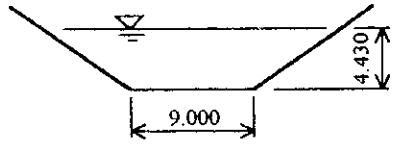


Section of the Escape Channel at upper reaches



Concrete Lining
L = 2.0km
i = 1 / 6,000
V = 1.51m/s

Section of the Escape Channel at lower reaches



Unlined
L = 2.0km
i = 1 / 4,000
V = 1.04m/s

The difference of the water levels between at the upper reaches and at the lower reaches is 187.47 - 185.60 = 1.87m. It should be checked whether there is a capacity of 72.0 m^3/s or not, subtracting the head loss in the siphon from the difference of the water level.

The head loss in the siphon when Q = 72.0m^3/s is given as follows;

a. inlet; hen = fe.$V^2/2g$ = 0.5 x $1.89^2/19.6$ = 0.09m

b. change of area; hgc = fgc.($V_2^2/2g$ - $V_1^2/2g$)
= 0.30 x ($4.85^2/19.6$ - $1.89^2/19.6$) = 0.31m

c. change of direction; $hbe = fbe.V^2/2g = 0.06 \times 4.85^2/19.6 \times 2 = 0.14m$

d. friction $hf = f.(L/R).\ fe.V^2/2g = f.L.(V^2/2gR)$

$= 0.00527 \times 7.37 \times \{1.89^2/(19.6 \times 0.7512)$

$+ 4.85^2/(19.6 \times 0.4684)\}/2$

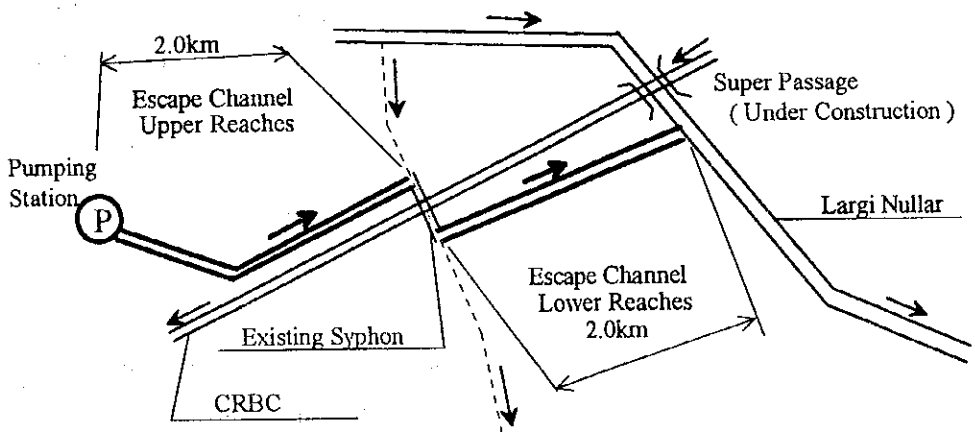
$+ 0.00568 \times 68.83 \times 4.85^2/(19.6 \times 0.4684) = 1.06m$

e. outlet; $hou = fo.\ V^2/2g = 1.0 \times 4.85^2/19.6 = 1.20m$

Total; 2.80m

The difference of the water levels 1.87m < the head loss in the siphon 2.80m, so there is not a capacity of $72.0m^3/s$ under the existing condition. Therefore the water level at the lower reaches is required to be lowered. If the bed level at lower reaches is lowered 2.80 - 1.87 = 0.93m, about 1.0m below the existing bed level, the required difference of the water levels can be reserved, and the capacity of $72.0m^3/s$ can be reserved. Since the bed level of the outlet of the escape is low enough, the bed level of lower reaches of the escape can be lowered.

The plan of the escape channel is illustrated below;



When the design discharge flows, the velocity in the siphon becomes very large as 4.85m/s. But this discharge is the released discharge from the spillway, and the large discharge flows in the siphon not continuously but temporarily. So it is considered that the inner wall of the siphon is not to be worn.

G.3.8 Delivery Pipeline

(1) Pipe Material

The length of the pipeline is approximately 700m from the pumping station to the beginning point of the main canal. The pipe material which can be used for the

pipeline is restricted because of its large discharge and its large diameter. The applicable pipe material is steel pipe (SP) or reinforced concrete box culvert (RC). Comparison between SP and RC is shown below. In case of RC, because of the inner pressure loaded, each member will be thick, and its cost may be high.

Material	Section	Velocity (m/s)	Cost Ratio	Remarks
SP	3,200 x 3	3.0	100	19.0 mm in thickness 1.90t/m in unit weight
RC	3,500x3,500x2	3.0	134	1.2m in thickness of member 38.0m^3/m in concrete volume

From the viewpoint of pipe loss, SP is advantageous. On the condition that the velocity is equal, the friction loss in the RC delivery is approximately 150% of that in SP delivery. But because of the short length of the pipeline, the amount of head loss is small compared to the total head of pumps, and there is no great difference in the total head of pumps, and in the construction cost or O&M cost. It can be said, however, that SP is a little more advantageous.

From another viewpoints, in case of RC the construction is difficult. The connection of the discharge pipes in the pumping station and the RC box, and the connection of the RC box and the outlet pond may be some complicated structures. So RC box has a disadvantage to SP delivery.

Under these conditions, inner-coated steel pipe is selected as pipe material of the delivery pipeline.

(2) Selection of the Diameter

If a small diameter is selected, the friction loss increases, pump head is large, and the construction cost and the O&M cost of the pumping station becomes high. On the contrary, if a large diameter is selected, the friction loss is small, pump head is small, and the construction cost and the O&M cost of the pumping station becomes low, but the construction cost of the pipeline becomes high. Therefore, the diameter should be selected, and the design velocity should be selected, in order that the sum of pump cost and pipe cost is minimized.

An alternative study has been made on the combination of three design velocity as 3.5, 3.0 and 2.5m/s and three number of series as 1, 2 and 3. Their evaluation has been made in terms of their net present values of construction and O&M costs. Results of the evaluation and the background data are as presented in Table G.3.3.5

It has been found that there is no substantial difference in terms of economy among the alternatives. That is caused by the short length of the pipeline, the small friction loss in pipes and the small difference in pump head.

The comparative table indicates the following things;

- Comparison of pipe cost in terms of number of series shows that the case of single series is most economical, and that the case of 3 series is most expensive.
- In case of 3.5m/s in design velocity, pump cost is high, but in case of 3.0m/s or 2.5m/s in design velocity, there is no difference in pump cost. So the cost comparison in terms of design velocity shows that the case of 3.0m/s is most economical.

There is no great difference in the costs in terms of number of series. Judging from the project implementation schedule and construction workability, the 3-series of pipeline is more realistic and advantaged by construction of a single series pipeline in Phase I implementation and less financial requirement in the Phase.

For the reasons stated above, a 3-series pipeline of 3,200 mm steel pipe has been selected.

(3) Thickness of Pipes

The thickness of steel pipes should be determined so as to be secure against the stress caused by the soil pressure and the internal water pressure. The stress is very large because of the large diameter, and it is necessary that reinforcement ribs are attached on pipes at one meter intervals.

The results of calculation of thickness for each case is presented in Table G.3.3.6

The pipes may be locally manufactured from 19 mm-thick steel coils which may be imported for the project.

(4) Cross Section of the Pipeline

The pipeline is to be embedded underground for physical security from external shock.

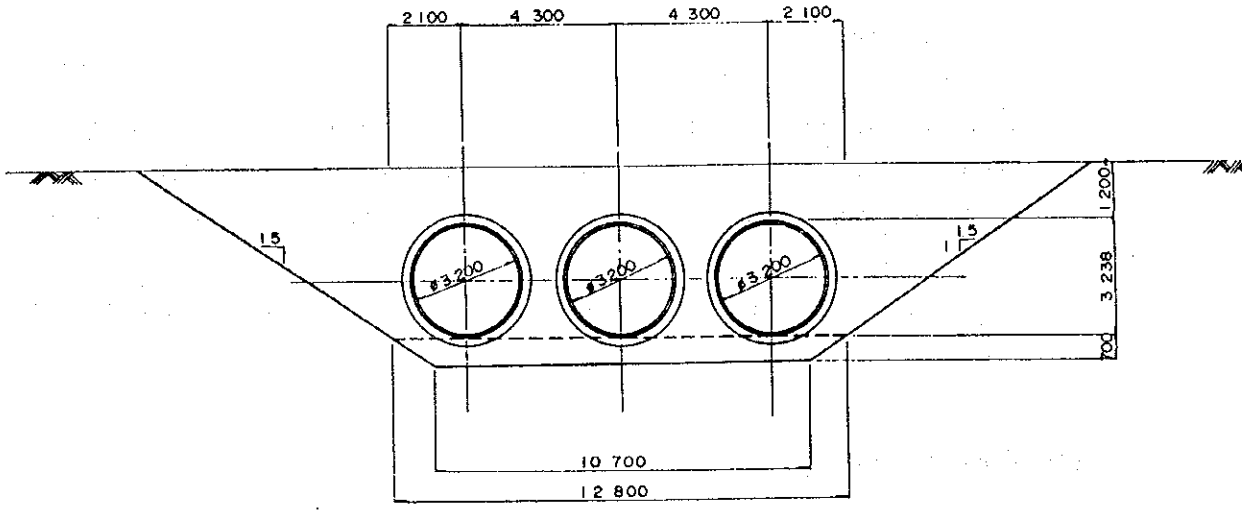
The soils around the pumping station mainly consist of fine or medium sand, and often contain a small amount of silt or clay. And N-value at the foundation of the pipeline is 10 to 20. The foundation is relatively firm ground.

Therefore, the soils at site can be utilized as materials for backfilling or foundation of pipes. But in backfilling, soils of high clayey content or gravels must be removed, and compaction must be fully done in order that the load on pipe is to be of uniformity.

The embedding depth of pipes is to be more than 1.2m below the ground surface above the top of pipes. Because the pumping station is constructed on the cutting ground, 4 to 5 meters below the natural ground surface, the embedding depth of the

pipeline is rather deep in the vicinity of the pumping station, but in the major part of the pipeline the depth is 1.2-1.5m.

The typical cross section of the pipeline is shown as follows. The section is determined taking into consideration the required space for welding work and compaction work, and the reservation of the firm foundation of the pipeline.



G.4 Main Canal

G.4.1 Canal Alignment

Alignment of the main canal has been decided in a manner that F.S.L. is slightly higher than the ground surface by taking the following conditions into consideration.

- Starting point of the canal shall be at N 876631.11, E3020135.00 about 2 km north-west from RD 185 due to the topography. F.S.L. at the point is El 209 m.
- Crossing structure of Nulls shall be Nullah culvert or culvert super passage to prevent choking by siltation.
- Volume of earth work shall be minimized.
- Smooth alignment but deviating from villages and public utilities.

Canal alignment has been studied based on the 4-inch-1-mile topo-maps (scale 1/15,840) of 1958-1961 edition. Curve-settings of the alignment have been made to employ the radii as long as possible and not less than 10 times of the water width. The alignment thus determined is as presented in Table G.4.1.1. The coordinates of turning points (T.P.), bench marks and references between surveyed and designed alignment are as presented in Table G.4.1.2 and Table G.4.1.3.

G.4.2 Design Criteria

(1) Design discharges of main canal, which are accumulations of design discharges of disributary canals and seepage losses in the course of run, are as presented in Table G.4.2.1.

(2) Hydraulic formula

Manning's formula is applied for hydraulic calculations. Manning's coefficient of roughness n is taken as 0.016 for concrete lined canal. Then,

$$V = 1/n \cdot R^{2/3} I^{1/2}$$

where, V as flow velocity in m/s,
n as coefficient of roughness (=0.016),
R as hydraulic radius in m, and
I as longitudinal gradient of canal bed.

(3) Design velocity

Advantages and disadvantages of rapid design velocity are as follows.

Advantage: - small cross-section and economic construction cost
- less siltation in the canal

Disadvantage: - steeper longitudinal canal gradient to lessen command area

Therefore, the design velocity has to be rapid enough to present siltation and mild enough not to lessen command area. A careful study on this issue has been made as follows and the design velocity at the maximum flow condition has been decided to be 1.0 m/s.

Diameter of soil particles suspended in irrigation water to cause no substantial hazards is generally accepted as 0.3 mm or less. Accordingly, critical velocities to flow down the 0.3 mm particles have been examined.

In order to flow down the 0.3 mm particles, experiments by Schaffernak indicate that the velocity in the canal shall be 0.20 m/s or more. Meanwhile the lowest velocity in the canal emerges at the time of smallest water requirement in the fields; i.e. December at 20.395 cms equivalent to 29% of the maximum. Aside from a short period of only December, flow velocity during the rest of the year is approximately 40% of the maximum.

From the assumed canal cross-sections (see Table G.4.3.1) as planned for 1.0 m/s design velocity, flow velocities at the downstream end of each flow sections are as follows.

Section No.	Design Q (cms)	Q at D/S End of Sec. (cms)	Min. Q at D/S End of Sec. (cms)	Flow Area (m^2)	Minimum Velocity (m/s)
1	72	58.6	23.4	70.57	0.33
2	53	37.6	15.0	55.76	0.27
3	30	22.8	9.1	30.94	0.29
4	20	11.1	4.4	20.78	0.21
5	10	4.7	1.9	10.04	0.19

As shown in the above table, minimum velocities are more than 0.16 m/s (velocity in the settling basin before pumping) in either section. Accordingly the design velocity of 1.0 m/s for the design discharges can flow down the soil particles of 0.3 mm or less.

(4) Side slope

Side slopes in the trapezoidal cross-section of the canal is decided to be 1 to 1.5 as same as in CRBC from economic point of view.

(5) Ratio of bed width (B) to water depth (D)

Ratio of B to D is 1.0-2.0 in the general design, however, the ratio 2.95-3.55 as same as in CRBC has been employed due to the following reasons.

- In order to avoid influences by ground water table on structural safety of the cabal, section forms of larger ratio of B to D (or shallower section) are preferable.
- In order to divert water at any flow rate, installation of cross-regulators is required. And, in order to secure larger command area, sill elevations of head regulators have to be as high as possible. Accordingly, employment of large ratio of B to D becomes more important to decrease the dead water area in the canal cross-section for effective use of irrigation water.

(6) Freeboard

The main canal is an quite important canal to serve for total beneficial area as large as 115,600 ha in C.C.A. so that its functions have to be continuously secured. Therefore, freeboard of the canal has been decided as follows to meet the design

discharges by taking account of canal size, velocity, inflow and outflow, fluctuation of water level by gate operations, etc. (see Fig. G.4.2.1)

Section No.	Discharge (m^3/s)	Freeboard		
		Lining (m)	Stone Pitching (m)	Total (m)
1	72	0.60	0.61	1.21
2	53	0.60	0.62	1.22
3	30	0.60	0.60	1.20
4	20	0.45	0.61	1.06
5	10	0.30	0.61	0.91

Lining: From Water Level to Top of Lining
Stone Pitching: From Top of Lining to Top of Dowel

(7) Longitudinal canal gradient

Longitudinal gradient of the canal has been decided so as to satisfy the velocity constraints and to expand the service area as much as possible.

G.4.3 Standard Cross-section of Canal

(1) Standard cross-section

It is not realistic for the main canal to employ a single standard cross-section throughout the route, since the velocity decreases in the downstream reaches to cause siltation in the canal. And unnecessarily large cross-section is uneconomical as well.

From economical points of view, the cross-section has to become smaller toward downstream and some escape structures (spillways) at five suitable places have to be constructed instead.

Five number of standard cross-sections, as shown in Table G.4.3.1 and Fig. G.4.3.1, have been designed by taking account of locations of the five escape structures.

Section No.	Station of Main Canal by Section (km)			Length (m^3/s)	Discharge
1	0+000	~	32+800	32.80	72
2	32+800	~	56+550	23.75	53
3	56+550	~	75+000	18.45	30
4	75+000	~	95+300	19.30	20
5	94+300	~	113+250	18.95	10

(2) Lining and underdrain

An examination has already been made in the G.2 Feeder Canal on the canal lining issues. Therefore the main canal has also been decided lined with 8 cm-thick concrete on three faces in the trapezoidal sections.

Two rows of underdrains are to be installed at both sides of the canal invert, and weepholes are at interval of 3.0m at 0.4m-high positions above the canal invert.

(3) Slope protection

Slopes between the top of concrete lining and top of dowel are to be protected by stone pitching in order to prevent rain wash and inflow of soils.

(4) Berm drain

Berm drains have been planned outside of banks in the following cases.

- N.S.L. is higher than the canal bank
- Flood embankment is planned for construction on the canal bank

Drain pits have also been planned at 300m-interval in the drain to empty the water into the canal.

G.4.4 Longitudinal Profile

Longitudinal profile has been planned in accordance with the afore-mentioned design criteria and standard sections. Hydraulic calculations have been made on friction losses in the canal and other head losses caused by appurtenant structures and facilities. Results of the calculations in head losses and F.S.L. in the respective canal sections are as presented in Table G.4.4.1.

G.4.5 Appurtenant Structure

(1) Cross regulator

Cross regulators have been planned to maintain stable water level in the main canal so as to enable precise diversion of water into the distributaries. Eighteen cross regulators have been set to regulate the water level fluctuation within 0.6 m below F.S.L. (See Table G.4.5.1)

Necessity for spillways attached to cross regulators has been examined on one of cross regulators (CR-6) whose locational conditions area typical among them. It has been found that fluctuation of water level by wrong operation of gates is only about 0.3m and the height is within the allowance of freeboard and even within the lining zone. Accordingly, spillways have not been planned at the cross regulators.

(2) Cross drain

Cross drainage structures have to be provided at crossings of the main canal by major Nullah so as to safely pass floods across it. Locations of cross drainage structures, say "cross drains", have been decided by taking account of the present river system, existing CRBC cross drains and drainage network in the Project area. (See Table G.4.5.2) Two types of the structure have been designed.

Culvert super passage:	9 places
Nullah culvert:	10 places

By construction of cross drains, water level in the drainage canal or Nullah in the upstream side becomes higher and therefore construction of flood embankments has also been planned to protect right bank of the main canal. In CRBC system required height of the embankment is given only for culvert super passages and not for Nullah culverts. In this Study, CD-3(Budh Nullah) has been selected as a representing cross drains of Nullah culverts for hydraulic routine study, and the results are as follows.

Results of Routine Study at CD-3

Return Period (years)	Peak Discharge of Inflow (cms)	Peak Discharge of Outflow (cms)	Water Depth (m)
40	722	661	2.6
100	867	722	2.7

Capacity of drains be that for once-in-40-year floods and height of flood embankment

be sufficient enough to cause no problem to the main canal even if floods exceed the design flood. The required height, as having been applied in CRBC system, has been standardized into three heights as follows.

Height of Flood Embankment

Type	Capacity	Height of Embank.
1. Culvert Super Passage	125 cms or less	1.8 m
	142 - 425 cms	2.1
	425 or more	2.4
2. Nullah Culvert	125 cms or less	2.1 m
	142 - 425 cms	2.4
	425 cms or more	2.7

N.B. Height of flood embankment is that above bed level of Nullah,

Freeboard of the embankment has been decided as same as in CRBC system as follows by taking account of results of field survey on the once-in-20-year flood (July 3-4, 1994).

Freeboard of Flood Embankment

Capacity of Cross Drain	Freeboard
142 cms or less	0.9 m
142 cms or more	1.2

(3) Escape structure

Escape structures have been planned in the main canal as shown in Table G.4.5.3 for the following purposes.

- To minimize construction cost
- To enhance safety of the canal
- To serve for easy O&M

Five escapes have been planned by taking account of discharge, length of canal and existing Nullah conditions. No silt ejector is accommodated in these escapes due to following reasons.

- Water in the canal, which is desilted and pumped beforehand, is supposed to be considerably free from silt.
- Sediment in the main canal is considered to be of smaller size and is suspended in the water, and therefore the sediment may be flown into distributaries.

(4) Head regulator

Total C.C.A. is divided into 25 independent command areas and each area is irrigated by a distributary through a head regulator in the main canal. Total required number of head regulators is 24 since no head regulator for D-25 at the end of the main canal. Sill level of head regulators has been adjusted to ensure diversion of required discharge into the distributary at any time at the water level controlled by the cross regulator. (See Table G.4.5.4)

(5) Bridge

Following four types of road crossing bridges have been designed. Arterial road bridge, district road bridge and village road bridge are to be built at the crossings with the existing and planned roads. Foot path bridges have been planned for construction in the middle of two bridges whose interval is 5 km or more. Location of the bridges are presented in Table G.4.5.5.

Type	Nos.
1. Arterial road bridge (AR)	2
2. District road bridge (DR)	3
3. Village road bridge (VR)	12
4. Foot path bridge (FP)	4

G.5 Distributary

G.5.1 Layout and Discharge

Demarcation of the Project area into each distriburary command area has been carried out considering the present river system, locations of existing CRBC cross drainage sturctures and alignment of the main canal. Particular attentions have been paid onto the following factors.

- Route of Nullah as flood watercourse should be a boundary of each distributary command area.
- Size of on-farm plots (contour-directional length approx. 3km at maximum) as mentioned in ANNEX C.

Twenty five numbers of distributary command areas have thus been demarcated. Alignment of the distributaries has been laid in the center zone of each area for reasonable alignment of Minors and convinience for O&M.

Command areas of twenty five distributaries have been estimated based on the 1:40,000 topo-maps, and their design discharges have been reckoned up accordingly. The results are as shown in Table G.5.1.1.

G.5.2 Sump Well Area

Two types of river structures across the main canal are culvert super passage and Nullah culvert. At where N.S.L. is higher than F.S.L., culvert super passage is employed and the vicinal land may not be included in the command area (say the land be out-of-command area) accordingly.

The out-of-command area may, however, be irrigated by the distributary and be included in the command area by installation of sump well and use of pumps. The areas thus irrigable, say sump well area, are 3,970 ha in total in G.I.A. and 3,660 ha in C.C.A. indicating approx. 3% of the total C.C.A. of the Project. (See Table G.5.2.1)

G.5.3 Design of Distributaries

Two model distributaries D-6 and D-18 have been selected for design according to the following conceptions.

- The project area is so large as 115,600 ha in C.C.A. that selection of model distributaries shall be one from a group of larger command areas and another from that of smaller ones than the average size of distributary command areas.
- Model distributaries shall be typical in size of the distributary command area, canal alignment and variety and scale of required structures.
- Shape of command area of model distributary shall be typical from on-farm points of view.

(1) Design criteria

a) Hydraulic formula

Manning's formula is applied for hydraulic calculations wherein coefficient of roughness is 0.016 as same as for the main canal.

b) Design velocity

As same for the main canal, design velocity is 1.0 m/s or nearly but less than 1.0 m/s.

c) Side slope

Side slopes of the cross-section be 1:1.5 as same as for the main canal.

d) Ratio of bed width (B) to water depth (D)

Ratio of B to D be 1.3 as same as in CRBC system due to following reasons.

- Ratio of B to D is 1.0 - 2.0 in general cases. However in case of smaller canals, smaller ratio of B to D is popular.
- Water depth in the distributary is 1.0m more or less and the banks are mostly by fill. Therefore, troubles due to groundwater may not be considered. Accordingly small ratio of B to D has been employed for construction economy.

e) Freeboard

Freeboard of distributary has been decided by taking the following factors into account.

Freeboard for concrete-lined side (Fb1)

Considering workability of concrete lining, deviation of n-value from the design coefficient of roughness by 0.001 may be foreseeable so that 5% of water depth has to be reserved. Velocity head has also to be reserved since it may elevate water level in the canal. In addition, for fluctuation of water level by structures in the canal or winds, 0.1 m may be required. Consequently,

$$Fb1 = 0.05\ D + V2 / 2g + 0.1\ (m)$$

where, Fb1 as freeboard for concrete-lined side in m,
D as water depth in m, and
V as velocity in m/s.

Freeboard above top of lined concrete (Fb2)

$$Fb2 = 0.3\ (m)$$

Total Freeboard (Fb)

$$Fb = Fb1 + Fb2$$

(2) Standard cross-section

Bed and both side slopes of distributaries are to be lined with 5cm-thick concrete. Their cross-sections have been designed in accordance with the above-mentioned

criteria and in standardized manners as shown in Table G.5.3.1.

For the all distributaries top of their left banks have been designed 4.5 m-wide to serve as their maintenance roads.

(3) Appurtenant structures

a) Fall with V.R. bridge

Falls have been planned by taking account of the followings.

- Topography and elevations of command area
- Longitudinal gradient of distributary
- Balance of N.S.L. and F.S.L.
- Construction economy regarding cut and fill for distributary

Falls have been planned equipped with V.R.bridge for O&M and farming activities and stop-logs for stable diversion of water to on-farm plots.

b) Culvert road bridge

At crossings of distributaries and Minors by the existing or planned roads, concrete box-type culvert road bridges have been planned.

c) Head regulator for Minor

Head regulators for Minor have been planned at diversions from distributary to Minor. For each of them, gates are to be installed in both distrributary and Minor to divert the flow by maintaining stable water level in the distriburary.

d) Side spillway

At upstream side of head regulators for Minor, side spillways have been planned to prevent the canal from erroneous operations of gates. Wasteways are also planned attached to the side spillways for maintenance of the canals.

e) Mogha

Moghas, structures to take water from distributary or Minor to main watercourse, have been planned. One Mogha corresponds to an on-farm unit. Capacity of each Mogha is dependent on size of each on-farm unit but its maximum has been set 85 l/s considering the fermers' capability for operation.

f) Village road bridge

Along distributaries and Minors, bridges of village road standard have been planned for convinience of O&M of canals and on-farm activities in the middle of two bridges if their interval exceeds 5 km.

g) Aqueduct

Aqueducts have been planned at crossings of Nullah by distributaries or Minors if channel section of a Nullah is large enough to secure sufficient clearance from an aqueduct.

h) Siphon

Siphons have been planned at crossings of Nullah by distributaries or Minors if channel section of a Nullah is relatively flat.

i) Tail cluster

Tail clusters have been planned at the downstream ends of distributaries and Minors to connect to drainage canals.

(4) Design of Disty 6 & 18

According to the above-mentioned design concept, the Disty 6 & 18 have been planned as the representatives of all the distributaries. The result of hydraulic design and the structural summary is as shown in Table G.5.3.2 to G.5.3.4.

G.6 Regulating Pond

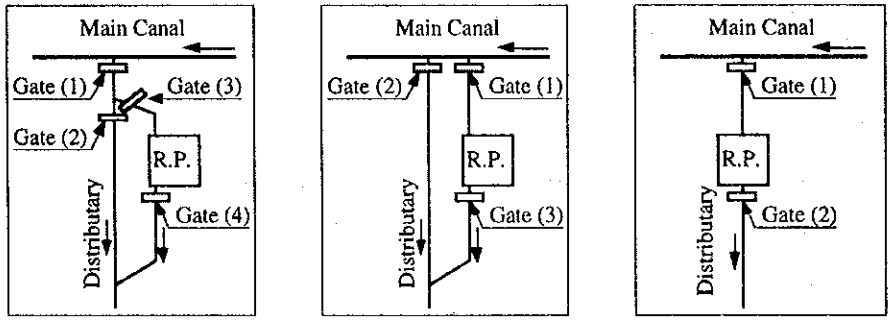
G.6.1 Location

Regulating ponds have been planned in each distributary command area near the offtake of the main canal due to following reasons.

- To establish quick response system from water request to water supply, since the location of water source is considerably far from the offtakes.
- To enhance effectiveness of water distribution and to minimize water management loss and waste water.
- A multi-purpose utility zone can be developed beside the pond including facilities of O&M office, farmers' hall, storage houses, etc. The ponds may also be

utilized for recreation by farmers.

Methods to lead water into a regulating pond from the main canal and their locational plans may be illustrated in the following three cases.



Case - A　　Case - B　　Case - C

*R.P.: Regulating Pond

Case-A has been employed due to following reasons.

- Case-B requires two offtake structures in the main canal for a distributary, and this makes operation of the pumping station and O&M of the main canal complicated.
- Case-C inevitably results low bed level of the distributary due to storage depth in the regulating pond, and this increases out-of-command area considerably. And when the pond has to be emptied for maintenance, water supply to the command area is not possible.

G.6.2 Capacity

Effective storage capacity of regulating ponds has been planned equal to one-day volume of maximum discharge of the correspondent distributaries due to following reasons.

- Irrigation operation is planned 6 days a week while on-farm irrigation is by 7-day rotation. Therefore one-day volume of demand has to be reserved somewhere.
- In case of incidental functional troubles in intake, pumps, gates, etc., it would take one day at minimum to take some measures.
- It would take one day at minimum to take some measures in case of erroneous operation of gates or some facilities by farmers.
- Water at the beginning of main canal takes 1.3 days to run 113 km until arriving at the end of the canal

Storage capacities of the regulating ponds for the distributaries are presented in

Table G.6.2.1. As for command areas of the model distributaries D-6 and D-18 excluding sump well areas, C.C.A. by regulating ponds amounts to 78% of the total C.C.A.

G.6.3 Structure

Regulating ponds have been designed to be 3.0 m for effective depth, 0.5 m for dead water depth, 1.0m for freeboard and stone pitching for revetment. Major dimensions of the ponds are as shown in Table G.6.2.1

G.7 Drainage Facilities

G.7.1 General Concept

Proposed drainage system is composed of flood carrier channels, supplemental drains and open collector drains. Flood carrier channels are the most important ones for the Project to minimize flood damages. In this regard, a large number of rivers shall be trained to have appropriate discharge capacity and to carry floods smoothly. (See Fig. G.7.1.1)

Individual irrigation systems in a distributary command area are separated by the flood carrier channels. However, the supplemental drains may be provided to collect water from open collector drains in a wide irrigated area. Open collector drains shall be planned in conformity with the conceptions of on-farm water management program.

Subsurface drains may, by referring the experience of Peharpur Canal Irrigation Scheme, be provided in 15 to 20 years after commissioning the irrigation systems. In this connection, an adequate number of observation wells are required for installation in the Project area, as already done in the CRBC area, to observe and monitor the groundwater behavior.

G.7.2 Flood Carrier Channel

(1) Design of channel

In order to pass floods in safe through the Project area located between the main canal and CRBC, the existing Nullah shall be trained to pass once-in-40-year flood. Discharge capacity of the existing Nullahs is mostly insufficient. Therefore, river training works such as excoriation of channel prism and new embankment of dikes

shall be carried out in most of them. (See Fig. G.7.2.1)

Design capacity of cross drains across the main canal is larger than that of CRBC flood carrier system. To avoid inundation in the Project area, flood discharges from Rod Kohi shall be diverted into new drainage channels to distribute the water to several cross drains of CRBC. Such diversion structures shall be of proportional sizes to the diverted discharges.

Height of fill for the embankment is 1.5 - 2.0m depending on the magnitude of design flood, and berm width is 6.0m for all channels. Dimensions of the channels are as follow.

Bed slope:	1:1,000 (approx. same as ground slope)
Side slope of channel:	1:1.5 (same for cut and fill slopes)
Coeff. of roughness:	0.03 for curt surface
	0.035 for untreated channel surface
Depth of cut:	3 m
Height of fill:	1.5 - 2.0m with 6m-wide berm

(2) Number of channels and volume of earthwork

Twenty numbers of flood carrier channels cross the main canal and the total length of the channels to be trained amounts to approx. 322 km. (See Table G.7.2.1)

Volume of cut is assumed at 50% of the prism section times total length of the channels due to the reason that one half portions of the existing rivers and zams will be trained for this purpose.

G.7.3 Supplemental Drains

In addition to the above drainage facilities, supplemental drains have been planned. Purposes for construction of the supplemental drains are:

- Drainage of flood water in case flood carrier channels are not existing between two adjacent distributaries.
- Drainage of flood water in case flood carrier channels are not existing between a distributary and the adjacent minor.
- To convey drained water from command areas along CRBC to the existing cross-drains of CRBC.

Supplemental drains are connected from open collector drains, which are subject to on-farm water management planning, to drain mainly surplus irrigation water. However, some aligned along CRBC are with the capacity to pass flood water across CRBC in safe. They are of two (2) types as follows and the locational alignment are as presented in Fig. G.7.1.1. (See Table G.7.3.1)

Type A: Drainage canal only for surplus irrigation water
(Total length 249.3 km)
Type B: Drainage canal for both surplus irrigation water and flood water
(Total length 8.7 km)

Supplemental drains have been designed unlined with the side slope at 1:1.5 and the bed slope as same as the ground surface slope.

G.7.4 Open Collector Drain

Open collector drains shall be provided to drain out surplus irrigation water and groundwater from farmland. The further explanation is discussed in G.9.3 "Open Collector Drain".

G.7.5 Observation Well

A total of 866 numbers of observation well have been provided in CRBC Project area for periodical observation of groundwater tables. Observations in the past one and a half years after commissioning of irrigation system of Stage-II, indicates that groundwater tables are still 20 to 30m below the ground surface. Seasonal fluctuations of groundwater tables differ so much well by well from 0.3m to 13m, and mechanisms of such fluctuation has not been clarified yet.

In order to observe behavior of groundwater tables after commissioning of the irrigation system, observation wells for monitoring shall also be provided in the Project area as well as in CRBC area. Providing approx. 3 km distance from one well to another, 120 numbers of observation wells are required.

Depths of the observation wells for installation may differ depending of the depth of aquifer from 3m to 30m. An observation well consists of a 50 mm PVC pipe (partially perforated) inserted into a drilled hole with adequate filter and plugs at top and bottom of the pipe. Sand filter shall be filled around the pipe at the lowest part of about 2m to 3m depth.

Bore hole diameter varies from 100 mm to 200 mm depending on the depth of well. Top of the pipe is extruded about 150 mm from the ground surface and fixed with concrete.

G.8 Farm Road System

G.8.1 Present Conditions

Three kinds of roads run in the command area and are maintained and managed by the following organizations.

- Arterial road: NHA (National Highway Authority)
- District Road: C&W (Communication and Works Department)
- Village Road: C&W and RDD (Rural Development Department)

These roads can be divided into three types from structural point of view, and lengths of the respective types are as follows.

Type	Length (km)	Remarks
Black top road	141.0	NHA/C&W
Shingle road	41.0	C&W/RDD
Katcha road	23.5	C&W/RDD

Distribution density of the existing roads is of 153 m/km^2. Network of the existing roads is presented in Fig. G.8.1.1.

G.8.2 Farm-to-market Road Project

The Farm-to-market Road Construction Project (a 20-year plan) is now under implementation by C&W and the total length of roads including those completed and uncompleted are as shown below. Outline of the Farm-to-market Road Project is also shown in Fig. G.8.1.1.

Type	Length (km)
Black top road	21.0
Shingle road	130.5
Katcha road	0

G.8.3 Proposed Farm Roads

In addition to the existing roads and those to be constructed under the Farm-to-market Road Project, maintenance roads along the main canal, distributaries and minors are also served as farm roads under the C.R.B. 1st Lift Project. The structural cross-sections of maintenance roads are as shown in each standard cross-section of canal, respectively. Lengths of the maintenance roads are as follows.

Canal	Length (km)
Main canal	113.3
Distributaries	275.6
Minors	167.0
Total	555.9 km

In this connection, some additional farm roads have been planned to link the maintenance roads to villages. Dimensions and length of the planned farm roads are as follows. Distribution density of roads in the Project area including those incompleted and planned has thus come to 702 m/km^2.

Type	Effec. width (m)	Total width (m)	Length (km)
Shingle road	3.0	4.5	32.5

The structural cross-section of additional farm road is shown in Fig. G.8.3.1.

G.9 On-farm Water Management

As afore-mentioned in ANNEX C IRRITATION AND DRAINAGE, the proposed water management system employs, as same as in CRBC system, DTW (distributary to watercourse) and MTW (Minor to watercourse) simultaneously. Following facilities have been planned for on-farm water management. (See Fig. G.9.1.1)

G.9.1 Watercourse

Watercourses are canals to take water directly from distributaries or Minors through offtakes (Mogha), and there area two types; main watercourse and secondary watercourse.

Maximum capacity of main watercources has been set 85 l/s (or 3.0 cfs) by taking farmers' capability in the gate operation.

G.9.2 Pucca Nucca

Pucca Nucca have been planned to function as diversion structures from main watercourses to secondary watercourses and as outles from watercourses to on-farm units.

Two types if Pucca Nucca, 2-way type and 3-way type, have been employed for application in ways to meet the on-farm requirements.

G.9.3 Open Collector Drain

Open collector drains have been planned to run in parallel with main watercourses along the downstream edges of the correspondent command areas of Moghas, and their downstream ends join flood carrier channels or supplemental drains.

Major purpose of open collector drain is to drain water unnecessarily wasted by water operation errors in command areas of Moghas. Therefore, maximum discharges for design of main watercourses has been set as same as those of main watercourses.

G.9.4 Field Road

Field roads have been planned for farming in command areas and maintenance of main watercourses. Field roads have been aligned along main watercourses and designed to be 1.5m-wide ketcha roads.

TABLES

Table G.2.3.1 Head Loss and F.S.L. of Feeder Canal

STA.	Distance	Feeder Canal		X-Drainage		Bridge	Escape	Head Loss		Full Supply Level		Bed Level	
	(m)	Q (m3/s)	Slope	NO.	Type	Type	NO.	Frict (m)	Str (m)	U/S (m)	D/S (m)	U/S (m)	D/S (m)
											195.68		
0-030	0	74						0.00	0.12	195.68	195.56	192.18	192.06
0+000	30	74	Level					0.00	0.00	195.56	195.56	191.06	191.06
0+164	164	74	1: 5,000					0.03	0.03	195.53	195.50	191.03	191.00
0+350	186	74	1:14,000			VR- 1		0.01	0.02	195.49	195.47	190.99	190.97
3+210	2,860	74	1:14,000			VR- 2		0.21	0.02	195.26	195.24	190.76	190.74
6+460	3,250	74	1:14,000			VR- 3		0.23	0.02	195.01	194.99	190.51	190.49
8+670	2,210	74	1:14,000			VR- 4		0.16	0.02	194.83	194.81	190.33	190.31
13+700	5,030	74	1:14,000			VR- 5		0.36	0.02	194.45	194.43	189.95	189.93
17+150	3,450	74	1:14,000			VR- 6		0.24	0.02	194.19	194.17	189.69	189.67
17+850	700	74	1:14,000			VR- 7		0.05	0.02	194.12	194.10	189.62	189.60
21+650	3,800	74	1:14,000			VR- 8		0.27	0.02	193.83	193.81	189.33	189.31
25+240	3,590	74	1:14,000			VR- 9		0.26	0.02	193.55	193.53	189.05	189.03
29+900	4,660	74	1:14,000			VR-10		0.33	0.02	193.20	193.18	188.70	188.68
31+380	1,480	74	1:14,000			DR- 1		0.11	0.03	193.07	193.04	188.57	188.54
31+823	443	74	1:14,000	CD- 1	C			0.03	0.00	193.01	193.01	188.51	188.51
32+700	877	74	1:14,000				E-1	0.06	0.04	192.95	192.91	188.45	188.41
36+550	3,850	74	1:14,000	CD- 2	SP			0.28	0.02	192.63	192.61	188.13	188.11
37+700	1,150	74	1:14,000			VR-11		0.08	0.02	192.53	192.51	188.03	188.01
39+980	2,280	74	1:14,000			VR-12		0.16	0.02	192.35	192.33	187.85	187.83
40+170	190	74	1:14,000	CD- 3	SP			0.02	0.02	192.31	192.29	187.81	187.79
42+340	2,170	74	1:14,000			VR-13		0.15	0.02	192.14	192.12	187.64	187.62
43+100	760	74	1:14,000	CD- 4	SP			0.06	0.02	192.06	192.04	187.56	187.54
44+000	900	74	1:14,000	CD- 5	SP			0.06	0.02	191.98	191.96	187.48	187.46
45+450	1,450	74	1:14,000			VR-14		0.10	0.02	191.86	191.84	187.36	187.34
45+700	250	74	1:14,000	CD- 6	SP			0.02	0.02	191.82	191.80	187.32	187.30
47+100	1,400	74	1:14,000	CD- 7	SP			0.10	0.02	191.70	191.68	187.20	187.18
48+300	1,200	74	1:14,000	CD- 8	SP			0.09	0.02	191.59	191.57	187.09	187.07
48+500	200	74	1:14,000			VR-15		0.01	0.02	191.56	191.54	187.06	187.04
49+350	850	74	1:14,000	CD- 9	SP			0.06	0.02	191.48	191.46	186.98	186.96
50+100	750	74	1:14,000	CD-10	SP			0.06	0.02	191.40	191.38	186.90	186.88
50+240	140	74	1:14,000			VR-16		0.01	0.02	191.37	191.35	186.87	186.85
54+560	4,320	74	1:14,000	CD-11	SP			0.31	0.02	191.04	191.02	186.54	186.52
56+700	2,140	74	1:14,000			VR-17		0.15	0.02	190.87	190.85	186.37	186.35
56+800	100	74	1:14,000	CD-12	SP			0.01	0.02	190.84	190.82	186.34	186.32
58+565	1,765	74	1:14,000					0.12	0.00	190.70	190.70	186.20	186.20

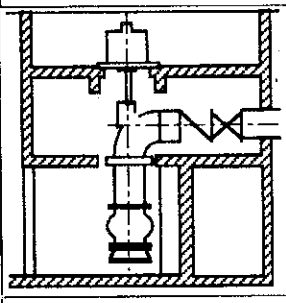
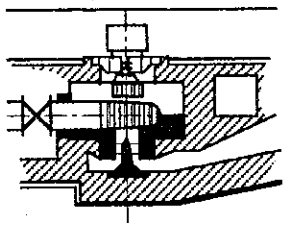
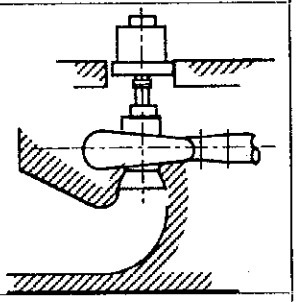
Suction Pit at P.S. 190.70

Table G.2.4.1 List of Structures in Feeder Canal

Bridges		Cross Drainage		Escape	
Station	Type	Station	Type	Station	Type
00+350	VR-1	31+823	CD-1, C	32+700	E-1
03+210	VR-2	36+550	CD-2, SP		(With Silt Ejector)
05+150	FP-1	40+170	CD-3, SP		
06+460	VR-3	43+100	CD-4, SP		
08+670	VR-4	44+000	CD-5, SP		
10+540	FP-2	45+700	CD-6, SP		
12+110	FP-3	47+100	CD-7, SP		
13+700	VR-5	48+300	CD-8, SP		
15+420	FP-4	49+350	CD-9, SP		
16+060	FP-5	50+100	CD-10, SP		
17+150	VR-6	54+560	CD-11, SP		
17+850	VR-7	56+800	CD-12, SP		
19+420	FP-6				
20+750	FP-7				
21+650	VR-8				
23+910	FP-8				
25+240	VR-9				
27+360	FP-9				
29+900	VR-10				
31+380	DR-1				
35+240	FP-10				
37+700	VR-11				
39+980	VR-12				
42+340	VR-13				
45+450	VR-14				
48+500	VR-15				
50+240	VR-16				
53+610	FP-11				
56+700	VR-17				

(Note) VR: Village Road Bridge
FP: Foot Path Bridge
DR: District Road Bridge
CD: Cross Drainage
SP: Culvert Super Passage
C: Nala Culvert
E: Escape

Table G.3.3.2 Comparative Table of Pump Types

Description	Vertical Mixed Flow (Non-volute Type)	Vertical Volute Type Mixed Flow (Umbrella Type)	Vertical Volute Type Mixed Flow (Bend Type)
Illustrated Section			
Excavation	Shallow. Civil work cost is low.	Shallow. Civil work cost is low.	Deep. Civil work cost is high.
Width of the Pit	Generally, narrow.	Generally, wide.	
	Width of the pit is determined according to not only the required area for installation of equipments, but also the access velocity of the pit. In order to prevent inflow of sand grains into the pit, it is necessary to widen the width of the pit and to make the access velocity slow. In that case, the width of the pit is not dependent on the pump type.		
Weight of Pumps	Heavy. Capacity of the crane must be large.	Light. Capacity of the crane may be small.	
Pump Efficiency	Not good. Large decrease of efficiency is shown by change of discharge.	Good. Small decrease of efficiency is shown by change of discharge.	Very good. Smallest decrease of efficiency is shown by change of discharge.
Operation Cost	High. Because of bad efficiency, operation cost increases much by change of discharge.	Low. Because of good efficiency, operation cost does not increase so much by change of discharge.	
Suction Performance	In case of large change of discharge, there is some apprehension of cavitation.	Good.	Very good.
Maintenance	When inspecting a pump, it is necessary to lift the pump casing up to the ground floor. Because of the complicated structure of the bearing, its maintenance is difficult.	It is possible to inspect a pump by removing only the casing cover and the bearing. Because of the simple structure of the bearing, its maintenance is relatively easy.	
Construction Workability	Easy.	Easy.	Difficult. Its cost is High.
Evaluation	Unfavorable.	Most favorable.	Favorable.