STRATEGIES FOR EFFICIENT USE OF IRRIGATION WATER IN BHAIRHAWA LUMBINI GROUND WATER IRRIGATION PROJECT, NEPAL

A DISSERTATION

submitted in partial fulfillment of the
requirements for the award of the degree
of
MASTER OF ENGINEERING
in
WATER RESOURCES DEVELOPMENT

By

SHYAM BAHADUR KARKI

WATER RESOURCES DEVELOPMENT TRAINING CENTRE
INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE
ROORKEE - 247 667 (INDIA)
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CANDIDATE'S DECLARATION

I hereby declare that the dissertation entitled **"STRATEGIES FOR EFFICIENT USE OF IRRIGATION WATER IN BHAIRHAWA LUMBINI GROUND WATER IRRIGATION PROJECT, NEPAL"** in partial fulfilment of the requirement for the award of the degree of **MASTER OF** ENGINEERING **IN WATER RESOURCES DEVELOPMENT, (CIVIL),** submitted in Water Resources Development Training Centre, Indian Institute of Technology (I.I.T) Roorkee, is an authentic record of my own work carried out during the period 16th July 2001 to 3rd December 2001, under the guidance of **Sri R.P. Singh, Visiting Professor,** W.R.D.T.C. I.I.T. Roorkee and **Dr. M. L. Kansal Associate Professor**, W.R.D.T.C., I.I.T. Roorkee.

The matter embodied in this Dissertation has not been submitted by me for award of any other degree.

Dated : 3/12/2001

SHYAM BAHADUR KARKI
TRAINEE OFFICER
W.R.D.T.C., I.I.T., ROORKEE

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Dr. M.L. Kansal
Assoc. Professor
W.R.D.T.C., I.I.T., Roorkee
(U.A.) INDIA

R. P. Singh
Visiting Professor
W.R.D.T.C., I.I.T., Roorkee
(U.A.) INDIA

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Place: Roorkee
Dated: 3 / 12/ 2001

(SHYAM BAHADUR KARKI)
TRAINEE OFFICER
WRDTC, I.I.T. ROORKEE

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LIST OF ABBREVIATIONS

BLGWP	:	Bhairhawa Lumbini Ground Water Project
DOI	:	Department of Irrigation
DOA	:	Department of Agriculture
NEA	:	Nepal Electricity Authority
UNDP	:	United Nation Development Programs
NISP	:	Nepal Irrigation Sector Project
ILC	:	Irrigation Line of Credit
HMGN's	:	His Majesty's Government of Nepal
SAR	:	Staff Appraisal Report
WRD	:	Water Resources Development
USAID	:	United States International Agency for Development
AIC	:	Agriculture Input Corporation
ICB	:	International Competitive Bidding
LCB	:	Local Competitive Bidding
FMIS	:	Farmer Managed Irrigation System
T/W	:	Tube Well
STW	:	Shallow Tube Well
DTWs	:	Deep Tube Wells
AOs	:	Association Organizers
O & M	:	Operation and Maintenance
PA	:	Project Authority
JT	:	Junior Technicians
JTA	:	Assistant Junior Technicians
NRs	:	Nepalese Rupees
UPVC	:	Unplasticized Polyvinyl Chloride
ISP	:	Irrigation Sector Project
ADBN	:	Agriculture Development Bank Nepal
ADB	:	Asian Development Bank
FWP	:	Food for Work Program

CEDA	:	Centre for Economic Development and Administration
EC	:	Executive Committee
MOWR	:	Ministry of Water Resources
WUA	:	Water Users Association
RCC	:	Regional Coordination Committee
CCC	:	Central Coordination Committee
WUG	:	Water Users Group
IFAD	:	International Fund for Agriculture Development
JICA	:	Japan International Cooperation Agency
JADP	:	Janakpur Agriculture Development Project
lps	:	Litres per Second
TADP	:	Tangail Agricultural Development Project
m^3/hr	:	Cubic meter per hour
ϕ	:	Diameter
Vs	:	Versus
U.P	:	Uttar Pradesh
U.A	:	Uttarnchal
DN	:	Nominal Diameter
m/km	:	Metre per Kilometer
AE	:	Assistant Engineer
JE	:	Junior Engineer
VDC	:	Village Development Committee
DDC	:	District Development Committee
IMT	:	Irrigation Management Transfer
GWRDC	:	Gujarat Water Resources Development Corporation
GL	:	Ground Level

SYNOPSIS

Groundwater has been found very simple and more dependable source of water and so has been used since very long for the irrigation purpose. Quick yielding benefit and low investment cost (in comparison to surface) are major concern of Deep tube well (DTW) irrigation system. The project area, Bhairhava Lumbini Groundwater Project (BLGWP) is found to occupy an excellent alluvial aquifer of numerous layers. Some of its area lies in artesian belt. The water is drawn from the deep strata generally from 120 m to 200 m with the help of electric driven pumps. Each irrigation unit is independent. The project is implemented in three different stages. The stage I of the project is now complete with open channel with almost brick lined section, where as stage II and stage III comprises project with underground UPVC (Unplasticized Polyvinyl Chloride pipe) distribution system. The major lessons learned from stage I and II are desired to be included during stage III. The present study provides the information of stage III of the project. The farmer participation has covered the full O and M cost as well as certain share of capital cost, there by reducing the burden on HMGN's (His Majesty's Government, Nepal) budget. The average expenditure of operation and maintenance cost, is different for different operating hours. The total irrigated area of all three stages is about 20,200 ha from 169 individual irrigation systems. The stage III alone comprises of four different non-continuous parts covering an area of about 9200 ha, with total of 78 no. of Deep tube wells. The different objectives achieved under stage III of the project are construction of Deep tube well, pump installation, sub-station and power line construction, Construction of UPVC buried pipe distribution system, construction of sub-centers as well as construction of gravel road in the project area.

The improved technology of tube well construction and involvement of farmers from the beginning stage has ensured farmer interest and responsibility for DTWS (Deep Tube Wells) Irrigation. Transfer of tube well and its management to recognized water users association remain the common interest of the project and farmers. At present the takeover of all the tube well is complete. The completion of takeover of Tube well has saved the operation and maintenance cost of Government , However, the project authority

has to look after the preventive maintenance, machinary and equipment maintenance to run the system smoothly.

In the BLGW Project, the size of irrigation unit was essentially determined by yields of the wells. Thus, wells yielding 300 cu.m./hr.(83 lps) could meet water requirement of up to 120 ha . of planned crops & on that basis an area of 120 ha for, each units were designed. However, at present it is found difficult to supply water in the whole area as per the individual demand. The efficient use of water requires a thorough review of scheduling, rotation irrigation, Pumping hours etc which is essential to command the whole area. The schedules should be based on actual crops planned to be grown & on the type of soil on which the crops are grown.

Literature study on role of water users association (WUA) and farmers managed irrigation system in other states of India and in other countries are also made.

For the efficient use of irrigation water in the BLGWP project, which is the main focus of dissertation, is based on the construction and maintenance of on farm distribution system, rotational irrigation practices, shaping and land levelling, regular power supply, proper utilization of wells, formation of effective WUA and legal status to WUA, good management, training to operator and beneficiaries. In addition to this, the initial success and long run sustainability of WUAs are also dependant upon sufficient incentives for farmer to participate. The system of stage III also needs to continue support from the project, because unless the farmer are willing and able to assume the responsibilities and costs, the irrigation system, which are handed over, will deteriorate. For this, project has proposed to continue the activities for next two years as a project transition period, so that the WUA will be perfectly able to take the sole responsibility for operation and maintenance of all individual irrigation system.

irrigate about 350,000 ha land in Nepal and a conjunctive use of both surface and ground water is estimated to potentially irrigate an additional 150 000 ha. So, ground water is an important water resources throughout Nepal to meet the increasing demand of water specially for agriculture and domestic purpose in the Terai area. The Terai which occupies about two third of total cultivable land, is covered by a thick sequence of saturated materials like sand and sediment of alluvial and colluvial material which forms a productive aquifer in that area. Aquifers are the groundwater reservoirs or water bearing formations or permeable geologic formations that permit appreciable amount of water through them and so, are the strata within the saturated zone below ground surface. The thickness of zone of saturation is different which vary from place to place. Also the occurrence, distribution and movement of ground water depends upon the aquifer characteristics. The ever ending increasing population and migration attitude of people from hill to Terai requires increased agriculture production which can be obtained to some extent by developing new irrigation facilities and improving the existing methods of practice of irrigation. Rainfall and ground water are the major resources for irrigation in Nepal. The western Terai, where an average rainfall is 1500-1800 mm per annum (CEDA Report July 2000) is covered by a sequence of alluvial deposits. The northern part of the project area is the Bhabar zone. Course fragmented rocks of Bhabar zone consists mainly of gravel with an admixture of sand. The Bhabar zone is recharged by infiltration of rainfall and by seepage losses from water ponded on the paddy fields and traversing rivers from the riverbed. In the project area the rivers Rohani, Dano and Tinau has recharged the water table to a great extent. It is also felt that if the natural recharging are not sufficient, special measures for recharging of ground water should be thought for sustained and successful use of ground water.

1.3 WATER QUALITY

Irrigation and intensified agriculture may primarily add salts in the soil due to evapo-transpiration of irrigation water and leached fertilizers. Shallow aquifers are also expected to be affected by such irrigation, and type of fertilizers, pesticides, fungicides etc.

The upper most aquifer layer underlying the cultivated fields is probably more or less contaminated. Concentration of nitrogen in the shallow ground water may be increased. The shallow water is used by rural populations for domestic purposes. The chemicals and nitrogen should not be present in any concentrations for drinking water. The chances are more to further deteriorate the shallow ground water. So, for the drinking water, the existing project tube wells which are tapping the deep aquifer and is not contaminated, should be explored. The ground water used by the project for Irrigation is of a rather good quality. EC (Electric Conductivity) is about 0.35 mmho/cm, pH is about 8.0 and sodium percentage < 25%. On the other hand, the bicarbonates comprise about 90% among the anions. This shows the tendency towards the increasing sodium percentage upon evaporation.

1.4 PROJECT PLANNING AND IMPLEMENTATION:

Generally there exists two basic strategies for planning an irrigation project.

i. Technical planning

ii. Planning through farmer request.

Among these two, farmer request route can be considered more effective for sustainable project. The overall planning process should be such that, the system is neither project orientated approach nor purely on farmer request basis which may create problem to O & M (particularly these problems are created by richer farmers). So, compromise approaches between WUG farmers and the agency should be adopted in planning and implementation.

In BLGWP, stage III, the following steps were carried out for farmer involvement in the project,

i) In the initial stage, Aos (association organizers) were send in the field in the development process to motivate farmers to participate in the implementation process and O & M.

ii) Give idea to organize and form WUG before design the system and built. Thus before construction of each DTW, the concerned farmer would have to make a formal request for the deep tube well and agree to establish the WUG, contribute their shear for construction cost and eventually take over O & M of the system.

iii) The demand for their project is collected and in this connection farmer submit an official request for irrigation and sign an agreement with the BLGWP.

iv) The agreement includes the portion of the system to be completed by the project and the farmers.

v) The farmer then participated in different decision making processes and construction activities after signing the agreement.

vi) The excavation of pipeline trenches and back filling the trenches were parts to be completed by the farmer. It was found that small holding farmers dug the trenches while the large holding farmers completed the same work in sub contract. In addition to this, as per Staff Appraisal Report (SAR), each DTW farmer group would initially contribute an "earnest money" cash contribution equal to its estimated electricity bill for the first season, before construction of DTW.

vii) The land for pump house was to be contributed by farmers which they performed in each tube well.

viii) Each DTW after completion will be handed over to farmer for their management. Such that O & M services will be brone by them.

1.5 OBJECTIVE OF THE PRESENT STUDY

The importance of irrigation in increasing food production is well recognized. In order to provide the year round irrigation, the Deep tube wells are constructed in cluster in the project area. The project has been found to be completed in three stages. The information of existing situation of stage III is used for the study of this dissertation. The main objective of this dissertation is the study of existing system as well as provide strategies for effective and efficient utilization of ground water irrigation in BLGW project, Rupandihi Nepal, which is based upon irrigation scheduling, management and maintenance. The scheduling is done by rotational irrigation. Thus efforts has been made towards irrigation management for efficient use which depends on the following

1. Irrigation system design including on farm distribution
2. Operation-maintenance
3. Availability of water and farmer attitude
4. Land leveling
5. WUA role
6. Training and follow up of handed over tube wells

In addition to the above, the following plays an important role which may affect the above objectives.

(i) Selection of proper crop,
(ii) proper drainage,
(iii) adopting intensive irrigations systems
(iv) subsidies in electricity
(v) night irrigation
(vi) capacity building of beneficiaries through various trainings
(vii) proper water distribution
(viii) incentives to farmers

These have been discussed in the present study so as to adopt strategies for efficient use of irrigation water in BLGW project, Nepal.

PROJECT DETAILS

2.1 THE PROJECT AREA AND LOCATION:

Physical features: After the successful implementation of stage I and II, the stage III of the project is implemented by DOI, Ministry of water resources and financed by world bank to be executed under farmer participation approach. BLGWP is located in Rupandehi District in the western region of Nepal's Terai between Kothi and Turia rivers, aimed to intensify the agriculture production in its domain.Terai is actually a part of Gangetic plain which in Nepal, extends from Siwalik (Churia) hill in north to Indian border in south.

The total irrigated area in the three stages has reached to about 20, 200 ha from 169 individual irrigation systems. The phasewise development of the project are as under:

Table 2.1

Stage	Area (ha.)	No. of DTWS (nos.)	Period of development		Investment in thousands Rs.
			Start	Completion	
I	7200	64	1978	1982	171638
II	3800	38	1984 & 86	1991	465867
III	9200	79	1991	1999	1712038
Total	20200	181			

Source: BLGWP, February 2001.

In addition to deep tube wells, project has constructed the following features viz. Pump house, control chamber, UPVC pipe line distribution network, distribution outlet, drainage canals, gravel roads and culverts, agriculture sub centre, staff accommodation quarters and electric sub stations.

The stage III comprises of four different non continuos parts covering an area of about 9200 ha. The four parts are as under:

Ist Part: The western part, Kothi river in west and longitude 83^0 15" E in east.

2^{nd} Part: Central western part, Between Dano and Tinau rivers and latitudes 27^0 32" N and 27^0 34" N.

3^{rd} Part: Central eastern part, between longitudes 83^0 25" E and 83^0 27" E and latitudes 27^0 32" N and 27^0 35" E.

4^{th} Part: Eastern part, between Rohani and Turia river and latitude 27^0 35" E in north and Indian border in south.

The different parts are shown in fig. No. 1 Annex 1.

2.2 WATER DELIVERY AND DISTRIBUTION SYSTEM

The project has been completed in three different stages beginning from 1978 to the end 1999. The approach of different stages are different. In stage I, the project has been planned constructed, operated of mentioned by DOI (Department of Irrigation). There was no any input or role from farmers side. The distribution system of Ist.phase is open channel. They were first constructed by earthen embankment and later converted to brick lining. In this stage 64 DTWS were installed of which 4 DTWS became inactive. A total of 60 DTWS were taken over by the WUG.

In stage II, the distribution system in UPVC buried pipe line system. In this stage 38 DTWS were installed of which 7 DTWS became inactive. A total of 31 DTWS were taken over by the WUG.

In stage III also, the distribution system is UPVC buried pipe system. In this stage 79 DTWS were installed of which one DTWS became inactive. A total of 78 DTWS were taken over by the WUG.

The stage III, buried pipe irrigation system comprises the following aspects. The pumped water is carried by 200 mm and 160 mm dia. low pressure plastic pipes. Two to four (normally four) loops are connected to each tube well depending upon the pumped discharge and the command area to be irrigated. Outlets are provided to each loops such that one outlet command to about 4 to 5 ha. land. The loops are fed from the elevated tank (control chamber) generally 4 m to 5 m high and located near the pump house. Each loop is provided with a surge riser pipe at its heighest elevation to release the entrapped air and reduction of water hammer effects. The water for irrigation is released from the outlet as per rotation unit.

2.3 OPERATION, MAINTENANCE AND MANAGEMENT

In BLGWP stage III area, for the operation of the system, the demand for water is highest in late may and June but the tendency of farmer is to wait for rainwater. It is seen that the peak demand is increased in the case when the monsoon rain is delayed. In such a case, pumping hour has to be increased to meet the demand.

Paddy is the main crop growing over most of the cultivated area in rainy season. The water supply is mainly from rain and supplemented from pumped ground water when needed. Formers are reluctant to use pumped water for land preparation & transplantation, which requires more water. This might result the delay in plantation. This further leads the delay in harvesting & reduction in yields.

The rainwater is not sufficient for winter wheat and mostly requires supplementary irrigation from pumped water. To reduce the pumping cost the tendency of farmer seems to cultivate only 50% of the cultivable area. Reducing the cultivable area, the pumping cost is reduced but this does not attain the design production of the project. The application of pumped water is done by rotation unit.

The maintenance of the system as a whole comprises the following :

i) Maintenance of wells
ii) Maintenance of pump and motor
iii) Maintenance of control panel
iv) Maintenance of transformer
v) Maintenance of transmission line
vi) Maintenance of sub-stations
vii) Maintenance of UPVC pipe line system
viii) Maintenance of roads (access and service)
ix) Maintenance of buildings and vehicles.

The management of irrigation water is a complex process. The role of supporting government agencies and the farmers who are the ultimate beneficiary, both plays an important part for good management. So, management is a process by which actions are directed towards achieving common goals. The function of the management are to follow policies, rules, regulations, duties of the agencies, decision making, staff organization, to see legal aspects, planning communications, relationship between agency and WUG etc.

The practice in general in the irrigation system are, upto the outlet head it is constructed by the engineering experts of the project. Beyond the outlet it is left in the hand of farmer. The farmer who is consumer and beneficiary of the irrigation water is also a primary managers of irrigation at the farm level. The responsibility of management lies on both farmer and officials of Irrigation Department. For effective management of available system the farmer needs to understand the three basic requirements of the system.

1. How to irrigate
2. When to irrigate and
3. How much to irrigate.

To meet all the above requirements, the basic primary parameters may be considered as adequacy, equity and timeliness of water. The systems managed by active farmer – participation is found to perform very well. So, farmer involvement in the whole process starting from the project planning to implementation and operation maintenance and management is must.

2.4 OBJECTIVES OF THE PROJECT

Under stage – III of the project, each irrigation system consists of a deep tubewell, elevated control chamber and buried UPVC pipe net works of closed loops and branches. All the tubewells are linked with all weather gravel roads and electrical transmission lines. Each tubewell is run by electrically driven pumps.

The following are the objectives BLGWP stage III-

i. Drilling 79 DTWS in stage III area and installing pumps, motors, transformers and electric panels in all DTWS.

ii. Drilling additional 8 DWTS in stage II area and installing pumps, motors transformers, and electric panels in these DTWS.

iii. Construction of 22 km of 11 KV power lines in stage II area

iv. Construction of 134 km of 11 KV power lines in stage III area.

v. Construction of 2 substations, one in stage II area and another in stage III area

vi. Construction of 79 buried UPVC pipe distribution systems in stage III and 16 systems in stage II area including pump house and elevated tank.

vii. Construction of 123 km of gravel road in stage III area.

viii. Construction of two agricultural subcenters and staff accommodations in stage III area.

ix. Study of possible groundwater development in Birigunj area (eastern terai) and at additional areas in the Rupandehi district adjoining earlier developed areas.

x. Provisions of farmer organization support, tech. Support, training and studies.

The steps involved and adopted for the tube well constructions are as follow

(i) Information dissemination

(ii) Demand collection, call upon general assembly of beneficiary farmers and agreement

(iii) Joint site selection

(iv) Drilling

(v) Planning design and estimate

(vi) Pre-qualification of contractors and tendering.

(vii) Construction of irrigation system and farmers participation as per irrigation policy.

(viii) Pump installation and electrification.

(ix) Testing of system and commissioning.

(x) Turn over the system to WUG.

2.5 ROADS AND ELECTRICITY

Road communication is provided by metal road from Bhairhawa to Butwal where the road is connected to east west highway. Numerous gravel roads constructed under the project which joins all the tube wells of the project and provide all weather access to the villages. Regular scheduled airline flights also connect from Bhairhawa to Kathmandu.

At present 33 kv line for electricity is conveyed to the area by Nepal electricity Authority's (NEA) to four sub stations through 132 kv line which is fed mainly by hydro electric station of Nepal and a 33 KV line from India where it is stepped down to 11 KV and distributed to all tubewells. It is also used for rural electrification. At the BLGWP, at the earlier period there was only one 33 KV line crossing the district, supplied from India.

2.6 CLIMATE

The project has a sub tropical monsoon climate with a warm wet from mid June to Sept, a cool dry season from October to February, and a wet dry season from March to mid June. The mean annual rainfall is about 1700 mm and about 85% of it fall during wet season. The climate is suited to year round cropping if irrigation is provided during the dry months.

The rainfall data is as per table 1 Annex 2.

2.7 TOPOGRAPHY OF THE AREA

The topography of the area is flat with a mild uniform north south slope. The elevations ranges from about 100 m at south to 150 m at north. The rivers which drains the area flows from north to south. The river emerges from hills and flows in the plain of the project area recharging the 'Bhabar Zone' by infiltration from the bed of river.

2.8 SOIL AND SOIL TYPE

Soil, in the project area are alluvial comprising silty and clayey loams, generally low in organic matter and most of the soils are capable to produce a wide variety of crops. The soils are non-saline and have varying content of nitrogen, phosphate and potash. No water logging problem is in the up land of project area: A table 2.2 shows the soil type of the project area.

Table 2.2
Soil type in the project area and their characteristic

Land form	Soil texture	Color	Drainage	Infiltration	Other specific feature	Crop sustainability	Approx. area in %
High terrace (up land)	Sandy loam to silty loam	Light yellow brown	Good to moderatel y good	Moderate to high	Contains lime generally in the lower part of profile	Suitable for vegetable fruits, mustard and up land paddy	33
mid terrace (up land)	Laom to silty loam also silty clay loam	Pale brown and light gray brown	Moderate	Moderately slow	Contain lime in the sub soil	Suitable for up land paddy wheat and pulses	13
Low terrace (middle land)	Silty clay loam and silty clay to clay	Grey brown to brown	Imperfect	Slow	Contains lime and iron and magnese at lower part	Suitable for low land paddy and wheat mixed with lentile and linseed	22
River basin (low land)	Silty clay to heavy clay	Brown to dark brown	Poor	Very slow	Contains lime in sub soil	Suitable for monsoon and spring low land paddy	15
River leave (up land)	Sandy loam to silty loam	Yellowish brown	Good	Moderate to high	Contain lime	Suitable for vegetable and mustard	8
Others / depressi ons (low land)	Silty clay to clay	Grayish brown to yellowish brown	Imperfect to poor	Slow	Variable	Suitable for low land paddy and wheat mixed with lentil and linseed.	9

Source: Environmental assessment study, Tahal consulting engineer Ltd., November 1993.

2.9 FARM SIZE AND OWNERSHIP

The average farm size in the project area in about 1.64 ha. About 4.6 % of land owners own a land size between 5-10 hectares. Similarly about 50-60% of land owners own a land size between 1-4 hectares while the rest land owners own land between 0.05-1 hectare. Most farms are owner operated and only about 5-10 percent of the land is farmed by tenants. The distribution of land holding size in Rupandihi district is as follows

Table 2.3

Size of holding (ha)	Holding (%)	Areas (%)	Average holding (ha)
<0.5	29.4	5.0	0.28
0.5-1.0	23.0	11.5	0.82
1.0-3.0	35.4	44.9	2.07
3.0-5.0	8.1	19.2	3.89
>5.0	4.1	19.4	7.72

2.10 POPULATION AND SETTLEMENT

The house holds in the project area tend to be large. The populations of BLGWP, stage III are estimated to be about 42000. The estimated average house hold size is 7-8, compared to 5.7 as average in the terai region and 5.5 in the entire country. The increases in population in the project area is mainly due to migration of people from the hillside. Most of the populations belong to Hindu religion (approx. 90%) the rest are Muslims and Buddhists. The literacy rate in the project area is 44% (1991). According to the 1991 census the female population has slightly exceeded the males. Women participate in agricultural activities such as paddy transplanting, harvesting, store and vegetable gardening. Most of the village houses are of mud with thatched roof and some have tile roofs. In the village area a separate animal shed are generally annexed to the living quarters.

2.11 HYDROGEOLOGY

The project area is underlained by a sequence of alluvial deposits. The thickness of alluvial in found as upto 450 m. Coarse fragmented rock deposits predominates in the section towards the northern edge of Terai adjacent to Siwalik (Churia) hills. In the project area clean, water yielding zones of sand and gravel forms on average upto 60% of the section between 40 to 200 m depth. So the screen can be placed to a range of 40-60% of the DTWS from 40 m down upto 200 m. Some of the wells carries artesian flow.

2.12 EXISTING IRRIGATION

There is no surface irrigation system in the project area. Farmers solely depend on monsoon for paddy crops. Farmer do not prefer the winter crop as the top soil generally remains dry in summer and winter. The rainfall is also not regular in that period.

2.13 DRINKING WATER

The rural population uses hand dug wells and small diameter (1.5") shallow tube wells with hand pumps for the purpose of domestic water use.

2.14 EXISTING AGRICULTURE AND CULTIVATION PRACTICE

Agriculture in the main occupation of about 97% of population in the project area. Before the project, the traditional cultivation practice was mainly paddy, wheat, pulses and oil seeds. Other crops like potato vegetables are also grown in small scale. Cultivation is largely dependent on rainfall and if the farmer are luckey enough, they get timely monsoon. This is because farmers have no reliable source of irrigation and rely mainly on the monsoon for watering the crops. Crops could be increased considerably with effective irrigation which is adequacy, equity and timeliness. The important cropping pattern in the traditional agriculture system area as follows:

Monsoon	Winter
Rice	Fallow
Rice	Pulses
Rice nurseries	Oil crops
Rice nurseries	Vegetables

The cultivation practice depends mainly upon availability of soil moisture in the field. The traditional ploughing is done by bullocks or buffaloes for both paddy and wheat crops. The time and rate of manure and fertilizer application vary from farmer to farmer. The sowing and transplanting of various crops depends on factors like start of monsoon, land type, labour available etc. The commonly followed calendar for sowing and transplanting is as follows.

Crops	Sowing or transplanting time
Rice	July –Aug
Wheat	Nov-Dec
Pulses	Sept-Oct
Oilseeds	Sept-Oct
Potato	Oct-Nov
Vegetables (Summer)	May-June
Vegetables (Winter)	Sept –Oct

The time of harvesting of different crops in the project are as follows-

Crop	Time of harvesting
Rice	Oct-Nov
Wheat	March-April
Pulses (Winter)	March
Oilseeds	Jan-Feb
Potato	Feb

2.15 DEEP TUBE WELLS (DTWS)

Each DTWS unit comprises the well, pump unit, pump house and elevated control chamber. Most of the DTWS are of 110-200 m depth and yield about 300 m^3/hr (83 lps). Some 70 DTWS yield artesian flows with discharge varying from 24 m^3/hr to 400 m^3/hr. Except very few DTWS, pumping is required for design discharge in almost all tube wells. Wells are equipped with submersible pumps with electric motors of 40-45 kw capacity. The inside dia. Of well is 14" to 16" to a depth of 40 m to 50 m and the rest 10" dia. is provided. The average length of screen is kept to about 50 m.

2.16 NUMBER OF OPERATIONAL DTWS AND COMMAND AREA OF STAGE III

Table 2.4

	F.Y 90	F.Y91	F.Y.92	F.Y.93	F.Y.94	F.Y.95	F.Y.96	F.Y.97	F.Y.98	F.Y.99	F.Y.100	Total
Artesian well number	0	0	0	0	0	1	0	0	0	0	0	1
Area (ha)	0	0	0	0	0	55	0	0	0	0	0	55
Partially artesian well no.	0	0	0	0	0	0	0	5	31	0	15	51
Area (ha)								597	3701	0	1791	6089
Pump well (no)	0	0	0	0	0	0	0	7	5	0	14	26
Area	0	0	0	0	0	0	0	836	597	0	1672	3105
Total well	0	0	0	0	0	1	0	12	36	0	29	78
Total area (ha)	0	0	0	0	0	55	0	1433	4298	0	3463	9249

Source: BLGWP III Project, Implementation Completion Report. Dec. 27, 1999

2.17 PIPE LINE DISTRIBUTION SYSTEM

An underground pipe line water distribution system consists of buried pipes for conveying water to different point on the farm and allied structures. In BLGWP III project, buried UPVC pipe line irrigation network is provided to each DTW for the distribution purpose. This is done in closed loops and generally four loops in each DTW are provided in the project area. The four loop system where the discharge 300 m^3/hr serves about 120 ha area. Similarly the tube well with 225 m^3/hr discharge serves about 90 ha with three closed loop system. The UPVC pipes used in the system are 200 mm and 160 mm dia pipes with pressure rating of 2.5 kg/cm^2. In the distribution system, each loop serves about 30 ha from 8 to 10 outlets and each outlet are to serve about 4 to 5 ha in general. An outlet serves a specified number of farmers on a particular day of a week. The water users are grouped according to the day on which they are entitled to draw water. Water users group does the scheduling of the outlet operation. The pump operator is responsible for operation of tube well and outlets together with WUA member.

2.18 CROPPING PATTERN

The cropping pattern is directly governed by the water availability at farm level. It is also based on soil type, water available and climatic condition. Based on the above condition, an optimal cropping pattern has to be provided. The kharif paddy plays an important role for the rest crops. Because once paddy is sown in time the winter and spring crops can be planted in time and also increased the yield. The varieties of paddy and their sowing time should be so planned that, three crops in a year can be harvested. In addition to that, the following basis for crop selection is considered.

i. Crops that increases soil fertility (pulses)

ii. Demand based crops (pulses, oilseed and vegetables)

iii. Easily marketable crops

iv. Low cost, high production crop (spring paddy)

v. High value crop (vegetables)

The recommended cropping patterns for the three season per year are

(1) For upland (30%)

a.	Paddy	– Vegetable	– Vegetable
b.	Paddy	- Kidney bean	- Sunflower / Maize
c.	Paddy	- Mustard	- Sunflower
d.	Paddy	-Potato	-Sunflower / Maize
e.	Paddy	- Spring mustard	- Moong bean / Black gram
f.	All year vegetable		

(2) For medium land (40%)

a.	Paddy	– Wheat	– green manure
b.	Paddy	- Wheat	- Moong bean
c.	Paddy	- Lentil	- Pulse bean
d.	Paddy	-Mustard (yellow)	-Sunflower / Maize
e.	Paddy	- Sunflower	- Pulse bean
g.	Paddy	- Spring mustard	- Moong bean / green manure

(3) Low land (30%)

a. Paddy – Wheat – Green manure

b. Paddy - Spring mustard - Green manure

The land in the command area is assumed to be mixed type viz 30% upland 40% medium land and 30% low land.

Source: BLGWP project office Bhairhawa, Nepal.

2.19 CROPPING INTENSITY

The intensity of irrigation may be defined as sum of total area irrigated under different crops in a year, expressed as percentage of culturable command area. In the projects command area, paddy is the dominant crop and after irrigation also, local paddy has been shifted to HYV varieties. Under full irrigation, the annual cropping intensity (Kharif, Rabi and Spring season) reaches to an average of 201%, while without irrigation the intensity reaches to 138% and under partial irrigation, the average intensity is about 163%. Cropping intensities for three different situations viz irrigated area, partly irrigated area and unirrigated area is calculated and shown in table no.3 Annex 2. The information is based on measured averages for the year 1997 / 1998.

2.20 PRODUCTION VALUES

After the project, the yield per ha for most of the crops have almost doubled. The share of vegetables in the project area is not so large but there is also a notable increase in the production of fresh vegetables under irrigation. The production values in different three condition is farmed out. It is tabulated in table 6 Annex 2 and are based on the prices of 1997/98. The production values under Rainfed condition = NRS 32016 per ha.

Under partly irrigated condition = NRS 49780 per ha.

Under irrigated condition = NRS 88486 per ha.

2.21 TRAININGS AND TOURS

The Project has provided trainings on the following aspects.

(i) Planning and Design of Tube Well System to Project Staff.

(ii) Planning and Design of Distribution System to Project Staff.

(iii) Trainings for Association Organizers

(iv) Training to farmer organization

(v) Training to on farm management for WUA

(vi) Training on organization and procedures for WUA, DTW operation and maintenance rotational water supply, farm water management

CONDUCT OF STUDY TOURS:

The main purpose of study tours of officials of WUGs, RCCs and CCC is to provide knowledge about handed over irrigation systems in other locations, problems encountered in the process and how these were addressed. They will also share their experience with other organizations about cropping pattern, water applications etc.

2.22 INTENSIVE FARMING AND CROP MANAGEMENT

A new concept of intensive farming and crop management is being initiated *recently in stage III area. In the fiscal year 1999/2000, ten DTWS units were taken for* this programme with full farmer participation. The programme mainly consists of year round crop coverage in the entire tube well area along with planned and scientific farming, proper irrigation and crop management. The performance of this programme is found encourageous. This programme was initiated from winter crops, so, with the evaluation of winter crop, the cropping intensity of winter season is increased by 25% in comparison to last year. This program was also continued for third crop (spring crop). The following are essential factors to be considered for the said program.

i. Willingness of farmers of that DTW
ii. Timely inputs available
iii. Commitment of assured irrigation
iv. Capacity for capital investment for which banking agencies and cooperatives will be involved
v. Market management for proper marketing of the production.

2.23 AGRICULTURAL SUPPORTS

Provision of agriculture support services were being carried out throughout the project implementation period by training the farmers and demonstrations for introducing new cash crops such as kidney bean, sunflower, peas, soybean etc.

Training is given in groups, which also includes the study tour. Farmers are taken to other districts as well as some near parts of India for study tour from which farmers will learn agricultural activities. The most important factor to demonstrate to farmer is the cultivation techniques, use of proper inputs, and off season cultivation of vegetables.

In addition to training and tour, demonstration programmes are also conducted to show the performance of new varieties and new crops, practically in the farmer field. The following demonstration are conducted by the project.

i. Green manuring demonstration, for which seeds, fertilizers, pesticides are provided at free of cost from the project.
ii. Result demonstration: This will led the farmer to judge proper method, proper variety, proper doses of fertilizer etc.
iii. Production demonstration
iv. Minikit demonstration: This will give idea of new variety seeds distributed in small packet. If farmer feel better, they use for further cultivation.
v. Vegetable package demonstration: Farmers are supposed to get more benefit from vegetable. Knowledge required to farmer for veg. Production is provided by demonstrating in the farmer's field.
vi. Potato cultivation demonstration: New and high yielding varieties of potatoes are produced by demonstrating in farmer's field.

vii. Micro nutrient demonstration: This will give idea to the farmer regarding the importance and deficiency caused in plant due to lack of zinc, iron, copper, in addition to nitrogen, phosphorous, potus, sulfur etc.

viii. Off season vegetable production demonstration : The production of veg. before or after the main season provides more benefit to the farmer which requires specific care to provide such idea to the farmers. Above mentioned demonstration should be conducted to the farmer's field.

2.24 ACTIVITIES OF FARMER'S ORGANIZATION DIVISION (FOD)

It is the division in the project which provides training to WUG. AO,s (Association Organizers) work closely with WUGs. AOs prepare various plan and activities and report to FOD in the project for execution. The FOD of the project is responsible for the following tasks.

i. Training of WUG,s chariman and operator in system operation, management and maintenance.

ii. Training to WUG, RCC, CCC for institutional development.

iii. Establishing liaison between WUG & DOI.

iv. Arranging study tours to the member of WUG, RCC and CCC.

v. Fund raising by WUG for maintenance and deposit to CCC.

vi. Provide training to WUG chairman and member in water management for different crops.

There are 78 WUG in stage III of the project who require management support for at least 2 years more to make them perfect.

The area wise distribution of WUGs and requirement of AOs are as follows.

Table 2.5

Stage	Area	No. of WUGs	Req. No. of AOs
III	a. western area	16	1
	b. central west area	18	2
	c. central eastern area	9	1
	d. eastern area	35	2
Total		78	6

2.25 MARKETING MANAGEMENT

Marketing management is one of the important factor for farmer for their products. Local market consumes some product. Products which are not consumed locally have to reach the other market. So project has trained marketing group leaders and farmers regarding marketing principles.

The table below shows the training program provided which includes marketing principles and techniques.

Table 2.6

Participants	Main subjects	Location	No. of participants
Farmers leader	Cost of production, pricing calculating marketable surpluses, farm and whole sale prices, marketing plans and group approach	Project office agricultural sub centers in the field	72 nos.
Farmers group	Ditto	Ditto	165
JTS	Marketing concepts marketing strategies, small farm management, dynamics price analysis	Project office	8
JTAS	Ditto	Ditto	9
Enumerators	Collecting, processing and recording of data	Project office	35

The following table shows the status of periodic market under pre and post condition of stage III.

Table 2.7

Periodic markets	Village covered		Operating days	Major commodities
	Pre-project	Post-project		
Jogada	10	15	Tuesday	Paddy, wheat Potatoes, cauliflower, tomatoes and other seasonal vegetables
Jharbaira	4	6	Thursday	
Dhakdhai	20	5	Tuesday/ Friday	
Sadaniya	0	7	Saturday	
Kamhriya	2	4	Friday	
Bethari	10	5	Tuesday	
Total	49	42		

The no. of periodic markets covered by the project area = 6 days and the no. of families benefited by the market is approximately = 8370. Besides these local market, the largest regional markets are at Bhairhawa and Butwal operated twice a week and serving large number of urban and rural farmers.

OPERATION AND MAINTENANCE PRACTICE ON THE PROJECT

3.1 GENERAL

BLGWP was designed to provide reliable year round irrigation by deep tube wells where there is no possibility of surface water. For this, the projects provides deep tube wells, penetrating on an average depth of 120-200 m and tapping highly productive aquifers. These wells are capable of delivering on an average discharge of 300 m^3/hr (83 lps) and provides irrigation to about 120 ha. The stage III project also provides the facilities of access roads which joins each tube well by improving the rural roads as well as opening the new roads. Electrification is another important factor, which facilitates the rural electrification in addition to pump operation. The project has increased the farm income, social support as well as the land value.

In this project, participation of farmer has been involved since the starting of this project (BLGWP stage III). The project has now completed the construction work and handed over all the systems to WUGs and the O & M expenditure are to be brone by the user. Thus the sustainability of the project now lies in the hand of farmers.

3.2 OPERATIONAL PRACTICE OF PUMPED WELLS

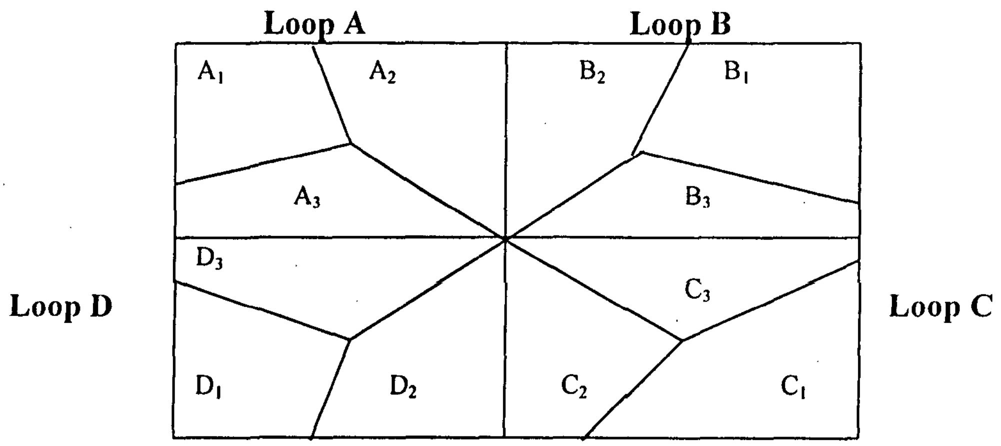
The irirgable area for each tube well system is 120 ha. and the system is divided into four loops. For smooth operation of tube well, there must be demand from each loop at a time, so that one outlet in each loop is opened. For this, the farmer need to be organized to cultivate their land in such a way that, demand could be created from each loop. The WUG chariman is the incharge for routine operation of non artesian wells. The WUG chariman in each T/W is responsible for setting and executing irrigation schedules which are to be decided in the WUG meeting as per crop and size of irrigation plot.

3.3 WATER ALLOCATION AND OPERATION PRINCIPLE

In the process of pump operation, water is pumped to the elevated tank called the control chamber which is constructed near the pump house. The loops are separately connected to the chamber and each loop is designed to carry ¼th of the total discharge i.e. about 21 lps. This discharge is taken by one outlet at a time. Some three to four farmer has to share the water of one outlet and as per the land holding. The irrigation is done in rotation unit. Generally there exists four loops in one irrigation unit.

The water is supplied on the basis of crop plan in each rotation group from Sunday to Friday. After every 3 days each rotation group gets the water and manages by themselves through field channel from each outlet. So, the important factor is to construct a field channel and prepare crop plan (3 crops / annum).

Fig. 3.1



Only one outlet in a loop is opened at a time. The discharge is fixed from the outlet so, with this fixed discharge, the farmer in their rotation, share water in accordance with crop requirement among them.

"Three day rotation group"

Rotation Method

One irrigation unit (120 ha block)

Four blocks of 30 ha each (i.e. four loops viz loop A loop B loop C and loop D).

Each loop area is divided in three major groups viz.

Loop A	A_1	A_2	A_3
Loop B	B_1	B_2	B_3
Loop C	C_1	C_2	C_3
Loop D	D_1	D_2	D_3

Each group gets water at every third day

So, for the above rotation, the total area is divided into three major groups for the 3 days irrigation rotation divided uniformly/ equally among the four loops A, B, C and D. The combination on of loop area for the irrigation groups and their irrigation days are given below.

Table 3.1

3 days irrigation groups	Irrigation days	Combination of subgroups	Areas
First	Sunday + Wednesday	$A_1+B_1+C_1+D_1$	40 ha
2nd	Monday + Thursday	$A_2+B_2+C_2+D_2$	40 ha
3rd	Tuesday + Friday	$A_3+B_3+C_3+D_3$	40ha

- Depending upon various factors, the operations of outlet will be either an 16 hour basis or 8 hour basis as decided by the WUG.
- The length of field channels are limited not exceeding to 150 m. A length of 100 m will be considered in design.
- The outlet discharge will be a nominal of $1/4^{th}$ of T/W discharge in 4 loop system.

Thus irrigation cycle will be six days in a week and one day in left for maintenance.

3.4 OPERATIONAL PRACTICE OF ARTESIAN WELLS

The operation practice of artesian well depends on artesian pressure and artesian discharge. The higher the artesian flow, the smaller the number of pumping hours required. The artesian pressure may not enough throughout the year/season to reach the discharge into the control chamber, in such a case, pumps are operated to deliver water to all outlets on the distribution system. Artesian flows are generally seen to be used to grow vegetables wherever soils are suitable.

3.5 OPERATION OF PUMPS

The actual no of pumping hours has been ranging very widely among the wells. The reason for large variation of pumping hour, other than climatic factors may be due to irregular power supply, lack of inputs seeds and fertilizer, no demand from the farmer.

The stage III has just completed, so it requires further trainings and attention towards the proper operation of pumps.

3.6 OPERATIONAL CONSTRAINTS

The following are some constraints for tube well operation.

i) Variation in land levels.

ii) Various sizes of land holding

iii) Scattered land

iv) Pipe line leaking

v) Break down of electrical equipments and power failure

vi) Others (lack of spare part in local market, no tariff incentive offered to off peak use of power, lack of timely maintenance and repair etc).

3.7 MAINTENANCE

Maintenance may be classified in the following heads.

1. **Regular maintenance :**
   - (a) Oiling greezing & checking all points.
   - (b) Procure spare part
   - (c) If spare part available in the project, get it at the cost price.
   - (d) Training to pump operator electrical and pump mechanics to be provided with support of project.
2. **Preventive Maintenance :**
   - (a) Servicing of pump as a whole after 3-4 years.
   - (b) Replacing of worn part and testing pump.
   - (c) Technical support and tools to be provided by the project for those WUG who need project support.

3. **Major Maintenance :**

(a) Major break-down of pump, control panel, rewinding transformer, motors etc.

(b) Cost should be more than 20000 which will be difficult to bear by WUG at a time.

(c) 25% of major maintenance cost should be beared by uses to fully develop the feeling of ownership which will completely check the stolen cases of transformer,wires etc.

3.8 STRATEGIES FOR MAINTENANCE

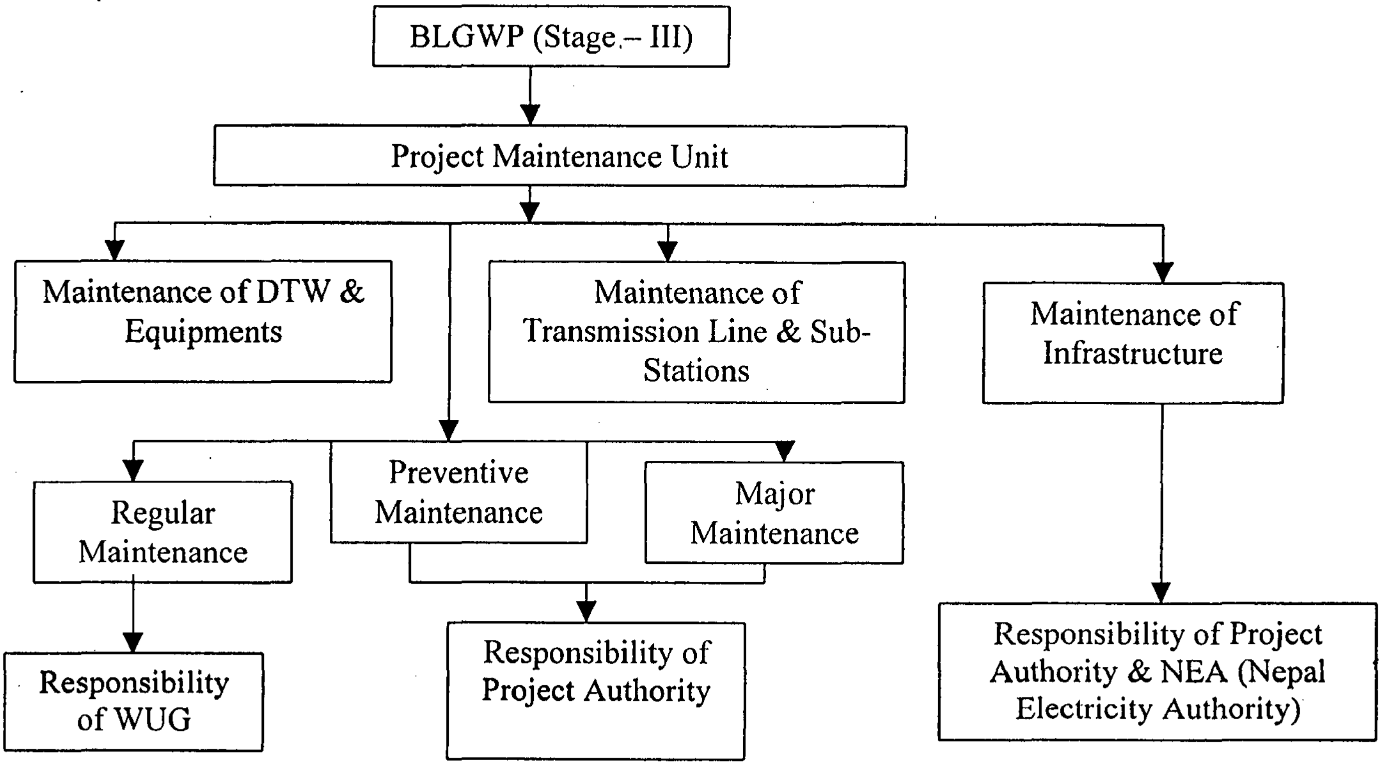
The following strategies of maintenance are suggested for the sustainability of the project.

1. Involvement of private sector maintenance group / Agencies / Centres should be started as early as possible.

   This will ensure the appropriate maintenance on a permanent basis. An annual maintenance cost of NRs 12000/well per year or about NRs 120 per ha. per year on the basis of one civil overseer, one electrician, one mechanics and one helper to serve about 30 wells has been tentatively prepared.
2. Project should select the local electrician and trained them for complicated work at the initial stages.
3. Give general idea to users through training so that small problems do not create obstruction on pumping.
4. Before completion of hand over to the WUG, a complete supervision to check all the systems are required by the project and WUG.
5. For major and preventive maintenance, the WUG still depend on the project's support. Project has also realized that to achieve the designed objectives as well as the sustainability, project support is needed for two years more.

For maintenance work, the project constitute the following line diagram.

Fig. 3.2



3.9 MAINTENANCE OF INFRASTRUCTURE

All the tubewell and systems in stage – III has recently been completed and handed over to users groups for operation, water distribution, management and minor repair and maintenance. It requires the maintenance of the following:

1. Maintenance of tubewell : The life of tubewell depends upon quality of water, type of aquifer, well screen type, gravel packing, development and pumping. The life of properly constructed tubewells are considered to be 30 years and so. Periodic maintenance is required to run the tubewell continuously, for which project support is needed. Because this type of maintenance and re-drilling of tubewell is not possible from the farmers as it requires machines and drilling techniques.
2. Maintenance of UPVC distribution system. The routine maintenance and repair work of the pipe line is to be done by WUG because good maintenance is a pre-requisite for efficient operation of the system. The maintenance of UPVC distribution system includes, the repair works of outlet values, leakage in control

chamber, leakage in the system and repair works in the pump houses. The project is to support for major maintenance problem.

3. Maintenance of village & gravel roads:

The project has constructed to about 272 km of gravel roads which connects the tubewell of stage III area. The road not only serves the access to tubewell but also links to many village & small towns. To decrease or minimize the burden of maintenance cost for the project, the regular maintenance of the gravel road has to be done by revenue collection which is the part of VDC or DDC. So the hand-over process of all roads, constructed by the project should done as early as possible to the concerned VDC / DDC. Nothing has been handed over till Feb.2001 as it is known from the project.

4. Maintenance of Transmission Line & sub station.

Construction of substation & straining of transmission lines is one of the major-objective of the project. Project has built the transmission lines & sub stations in all the three stages. Till the end of third stage about 290 km long, 33 kv and 11 kv transmission lines and 3 numbers 5 MVA 33/11 kv sub-stations has been completed. About 200 km transmission lines & 2 sub-stations are operated & mentioned by NEA at the present situation. It is felt necessary that all the 33 & 11 KV lines including all sub-stations should be maintained and operated by NEA which is in the process of hand-over to NEA.

3.10 AVERAGE O & M COSTS AND CHARGES

For the average O & M cost of the DTW, the area severe by DTW is taken as 120 ha.

Average motor rating = 40 kw

Demand charge = NRS 25 /kw/month plus 3% energy loss for transformer

Energy charge = NRS 2.50 / kwh plus 3% energy loss for transformer

a. **Fixed cost**

i. Demand charge (NRS 25 x 40 x 12) x 1.03 = 12360

ii. Operator cost @ NRS 1500 / month = 12 x 1500 = 18000

iii. Maintenance cost estimated at NRS 300/ha = 120 x 300 = 36000

Total = 66360

∴ Cost per ha / year = NRS 553/-

b. Variable cost

(For different pumping hour)

Cost for pumping 300 hr/yr = 300 x 2.5 x 1.03 x 40 = 30900

Cost for pumping 500 hr/yr = 51500

Cost for pumping 1000 hr/yr = 1000 x 2.5 x 1.03 x 40 = 103000

Cost for pumping 1800 hr/yr = 1800 x 2.5 x 1.03 x 40 = 185400

	Pumping Hour			
Total cost per ha.	300 hr.	500 hr.	1000 hr.	1800 hr.
$= \frac{a+b}{120}$	97260/120	117860/120	169360/120	251760/120
	= 811	= 983	= 1412	= 2098

SURVEY OF TECHNICAL LITERATURE

4.1 GENERAL

An attempt has been made in this chapter to review the ground water study and groundwater development with reference to its use in different district of Nepal ,India , Egypt and the available literature with reference to farmer participation and water users association.

The objectives of the project is to built the DTW irrigation system including different infrastructures and develop the feeling of ownership of the user farmer towards the project.

The sustainability of the project depends mainly on involvement, attitudes and capacity of beneficiary farmers to operate and mention the tubewell equipment. Their motivation to do so depends on the benefits they derive from the irrigation development. Some important studies related to ground water and irrigation management will be highlighted which will have direct or indirect concern with the present study.

4.2 GROUND WATER STUDY OF TERAI, NEPAL

The terai of Nepal occupies about two third of cultivated land and the remaining one third lies in the hill area. The main terai forms a part of Indo-gangetic plain, which is flat alluvial and suitable for irrigated and rainfed cropping. It is therefore also called "The store of food grain" for Nepal.

To study the ground water strategy, World Bank made an investigation on deep and shallow tubewells in 1986-87. UNDP made another such study in 1987. Later, World Bank supported through ILC programme for shallow, medium and deep tubewells in 7 districts in terai.

International Fund For Agriculture Devlopment (IFAD) funded, for shallow tubewells in 5 districts (1995-1999) with UPVC buried pipe distribution system. Japan International Cooperation Agency (JICA) funded for both shallow and deep tubewells for Terai districts through Janakpur Agriculture Devlopment Project (JADP).The shallow, medium and deep tubewell has been categorized on the following basis

i) Shallow tubewell - Water table upto 7.0 m from ground level (GL)
ii) Medium tubewell - Water table between 7.0 m 45.0 m
iii) Deep tubewell - Water table at more than 45.0 m from (GL)

The total area covered under the different ground water system for 20 terai and inner terai districts has been tabulated and are summarized in Table 4.1.

Table 4.1

System	Total		Approximation in total
	Number	Area (ha.)	
Shallow tubewell	45898	161825	80%
Dug-well	4180	13894	7%
Artesian well	768	12689	6%
Medium tubewell	66	1382	0.7%
Deep tubewell	573	23572	6.3%
Total	51465	2,01,941	100%

Source : Ground Water Development Board (1999) Final report CEDA.

4.3 GROUND WATER DEVELOPMENT PERFORMANCE IN NEPAL

Departmental of Irrigation (DOI), Agricultural Development Bank Nepal (ADBN), Department of Agriculture (DOA) are the major institutions involved for the groundwater development in the country. ADBN has played a major role in the promotion and development of shallow tubewell in Nepal, since 1970. They provide loan to the farmer for shallow tubewell installation as well as finance together with the subsidy provided by HMGN. Out of total area 2,01,941 ha irrigated by different system, about 1,65,000 ha has been developed by ADBN

Groundwater Resources Development Board (GWRDB) is the main executing agency under department of irrigation and are supported by World Bank, Asian Development Bank and other funding agencies.

The shallow tubewell used for irrigation in terai are drilled manually and operated by diesel driven – centrifugal pumps. Farmers construct field channels to command the total area.

4.4 IRRIGATION MANAGEMENT IN INDIA

India is the seventh largest in area and the second most populous country in the world. It has a total area of 329 million hectares of which nearly 143 m ha (1992-93) constitutes a net cropped area and the gross cropped area is about 186 m ha. The land holding of the farmer are as follows :

Table 4.2

Sl. No.	Type of Farmer	Size of holding (ha)
1.	Marginal	Upto 1.00 ha
2.	Small	Between 1.00 to 2.00 ha
3.	Medium	Between 4.00 to 10.00 ha
4.	Large	10.00 ha and above

For higher productivity in agriculture, an optimum use of land and water is a pre-requisite. The most important factors which affects the efficient use, are inadequate knowledge of irrigation management, lack of resources, lack of incentives, scattered and fragmented holding, inadequate capacity of farmers to invest for adoption of new technology, inadequate infrastructural development etc.

In fact, the major problem in the irrigation sector today is in management aspect, mentioned as under.

(i) Unreliable supply of water : i.e. farmer do not get water when they need it and get surplus water when it is not required.

(ii) Poor maintenance of the system : Sometimes the system becomes non-functional due to poor and neglected maintenance.

(iii) The tendency of farmer to corner more than their share of water.

(iv) Inequity of water from head to tail reach.

(v) Poor recovery of water rates, because the revenue charged for surface irrigation in 1989-90 was Rs. 50/-ha whereas the maintenance cost was Rs. 270/ha. Regarding the maintenance of irrigation and drainage system "C.M. Desai, and M. Juniens" have pointed out that higher water charge can be collected if the irrigation services are reasonable. So for good services, farmer are ready to pay the economic price of water which can be seen from the study that "farmers irrigating from privately owned wells including tribal farmer, pay more than 5 times the higher than the canal water rates.

(vi) Excessive seepage losses

(vii) Insufficient drainage and water logging.

(viii) Farmers not given relevant information by irrigation agency staff and

(ix) Cropping pattern is not decided on the basis of total water available.

In regard to above deficiencies for effective water management, the national water policy was adopted in 1987 and stressed the need of farmer participation in irrigation management.

4.5 TUBEWELL IRRIGATION MANAGEMENT IN GUJARAT, INDIA

Similar to the case study of this dissertation, the tubewell of Gujarat Water Resources Development Corporation (GWRDC) comprises of a deep tubewell, pump house, tank to create the required head, underground distribution system with air vent and outlets. The tubewell is to serve about 100 ha.

The tubewell were provided in the area which were not served by any surface irrigation system, but the performance of these tubewells were not satisfactory. The reason may be the improper location of tubewells, irregular power supply, poor quality of water, and greater emphasis on construction rather than on utilization (Asopa and Dholakia 1983). The performance of the wells were analyzed and those wells which run less than 500 hours per year and discharging less than 10000 gallon per hour were closed as per the decision of GWRDC in 1992. In this connection nearly 800 tubewells were shut down and out of total 3623 wells installed till March 1993, only 2852 were functioning.

Since 1993, the tubewells were again drilled on demand driven approach where the users agreed to manage the well through cooperative society and the users also agreed to bear some part of total cost. In such option, only 23 new tubewells were constructed in 1993-94.

GWRDC receive some O&M subsidy for its support from the Government which were revised in many years 1973, 1976 and 1979. A committee in 1988-89 recommend about Rs. 59000 as maintenance and repair expenses per well per year. This O & M cost has increased to 112000/well/year as per the claim of GWRDC in 1994-95. The gap between the expenses was found more during 1992-93 period. The subsidies were reduced for those wells which were operated less then 20000 hours annually. Now the present situation of water charge collection has improved, which has increased to 80%. In recent years, the subsidy given ranges from 50%-70% of the amount claimed by GWRDC. Gujarat experiment with take over of state tubewells to farmers met with both success and failure.

4.6 TUBE WELL IRRIGATION IN UP, INDIA

4.6.1 General

Utter Pradesh (U.P) constitutes irrigation potential of 22.6% of the country's ultimate irrigation potential. The irrigated area in this state is 10.5 million ha of which 34% is irrigated by surface and 66% through ground water resources. Of the ground water irrigated, about 27% is irrigated by govt. owned state tube wells. Presently there are 28626 state tube well in U.P. each having a command area of about 100 ha.

In 1950-51, the state has attempt to provide irrigation by constructing 200 DTWS which has risen to 2300 by the year 1990 and presently about 28626 nos. The difficulties to operate the pump are due to power cut off, electrical and mechanical failure, badly operated and maintained water distribution system and lack of cooperation between the govt. agency and water users.

4.6.2 World Bank aided public tube wells (PTWs) in U.P.

In 1980-83, world bank financed for 559 PTWS in the Ist phase and in 1983-87, about 2400 PTWs in the second phase bringing to a total of about 3000 PTWS. PTW has been put in cluster of 25 each in the areas where economically backward people live. Each PTW irrigates to about 100 ha. The following conditions were fulfilled of the public tube wells:

i. Electricity is assured for 16-18 hours a day from a dedicated feeders.

ii. Agricultural extension service is provided.

i. Farmer involvement in the water distribution system.

A provision of farmer participation has been made in designing the layout. As per the status paper on PTW brought out by the department of agriculture in 1986, it is reported that the benefits are quite satisfactory. Compared to the base year, the yield of paddy and wheat have increased to 53 and 46 percent respectively. (people participation and irrigation management by S. Satish and A. Sundar).

4.6.3 The Irrigation System

The PTW irrigation system are analyzed with the following four component and system.

i. Physical system:

Consist tubewell, pump, control panel, distribution chamber, pump house etc.

ii. Water conveyance system

Each system generally consists two loops. The distribution of water to the field is done from Kundis (outlets). Two or three Kundis are operated in a day and users are grouped according to the day on which they are entitled to draw water. The operator is responsible for tube well operation and kundis. The water distribution is done by Day area committee (DAC) and Tube well area management committee (TAMC) on rotation system. The data and time for each kundis to operate is fixed and well in advance. The irrigation department take care for maintenance upto kundis and farmer maintains the field channel down below the kundis.

iii. Administrative system for PTWs

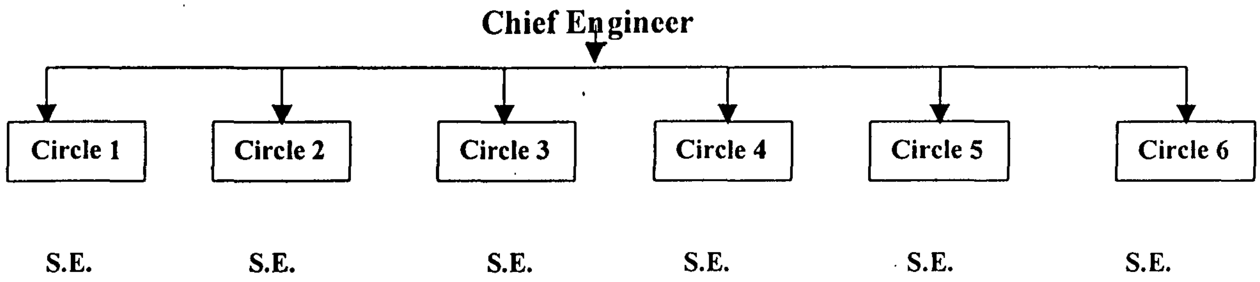


Fig . 4.1

Each circle is headed by S.E. (Superintendent Engineer) and has 5 to 6 divisions which is headed by Executive Engineer. Each division has four sub division with AE, JE and mechanics.

The number of tube wells which falls under the jurisdiction of each administration unit is as follows:

Circle	:	800 tube wells
Division	:	350-400 tube wells
Sub division	:	80-90 tube wells
Section	:	25 tube wells
Mechanic	:	12 tube wells

Farmer participation along with agriculture services and extension services were provided in phase 2.

ii. Management Control System

Farmers, agriculture department, and irrigation department all are responsible for the management of tube wells. The management of irrigation water distribution below kundis is done by DAC and TAMC.

TAMC look upto water distribution and DAC look after water distribution. There are 28626 states owned tube wells in UP and the average irrigation from these tube wells is much below their capacity. So, irrigation management transfer (IMT) is essential for sustainability of tube well.

4.7 GROUND WATER DEVELOPMENT FOR IRRIGATION (EGYPT)

Groundwater schemes are designed to satisfy irrigation water requirement or drainage requirement. Irrigation wells are generally designed and operated to fulfill the irrigation water requirements.

The cultivated and inhabitable area in Egypt is partially confined to the Nile valley and delta. Now-a-days Egypt imports more than half of its food intake. Egypt strategy to reduce food imports aims at increasing the agriculture production in the traditionally cultivated lands expanding the cultivable area through reclamation of new lands. For irrigation water distribution, ground water development is believed to reduce the constraints related to water management.

A study on the technical and economic feasibility of groundwater development is carried out in a pilot area in the Nile valley. The well field is designed to satisfy irrigation water requirement on a continuous flow basis for day time irrigation only. The pilot area consists of 73 wells. The design capacity of each well is 350 m^3/hr. The wells are located as per farmers requirement. Results indicate that groundwater abstraction if properly designed, are technically feasible and economically attractive to the country.

4.8 SPECIFIC CASE STUDY

Several cases have been studied by different experts. These studies demonstrates the important of farmer involvement right from the planning stage, formation of irrigation cooperative society, formation of water users association and similar other cases. Theses studies directly or indirectly focus on the strategies for efficient use of irrigation water.

(i) According to Chandra Brijesh and Raghuvanshi C.S. (1996), "Irrigation system should be operated" for the farmer by the farmer and of the farmer". These are two important areas where participation of farmer is very significant for efficient water use viz.

(i) on farm development works and

(ii) distribution of irrigation water below the outlet command.

The farmer is an "adopter" of technology i.e. the irrigation management technology and is a good source of first hand information right from the investigation to the operational stage of any irrigation system. Therefore farmer should be involved in the whole process starting from project planning to implementation, operation, maintenance and management of the system. This suggests formation of co-operative societies / farmer association on the pattern of Mohini Cooperative Society in Gujarat and Pani – Panchayats in Maharasthra. Besides these, farmer interest, perception, and attitude which determine their decision making process in irrigation water management should also be taken into consideration.

(ii) According to Dinesh Kumar, N. Kabaria (1989) : In a study of "Cooperative Irrigation System", it states that water is a costly input and scarce resources. Therefore its wastage reflects upon economic condition of the farmers. The inequitable distribution of water in many irrigation projects are mainly due to non-involvement of the farmers. The farmer is the actual beneficiary who uses water and therefore his involvement is necessary. Hence farmer involvement right from the stage of planning, designing, execution and operation of the irrigation system is most crucial. It also does help to improve communication between the officers and farmers.

The farmer's participation can be possible through on farm development work and distribution of irrigation water below the outlet command.

The study was intended to demonstrate that cooperation among farmers is necessary for efficient use of irrigation water and maintain the irrigation system beyond outlet. The concept of formation of irrigation cooperative society is the creative work, which can also play a great role by education and upliftment of the farmers.

The cooperative society in Gujarat (India) started in 1978-79 was studied based on encouraging results of farmer organization, which showed that irrigation cooperative society is much successful. This supports that the cooperative irrigation societies should be tried in other parts of the country as well.

(iii) **Kripa Shankar (1990) :** Explained in his paper, "The state tubewell in Uttar Pradesh" average area irrigated per state wells has continuously declined over the years and currently it is less than 30 hectare. It is also observed that about 5% of state tubewells are getting out of use every year (1990). The existing distribution system is very poor, the government can not further construct new channel, so losses are more and increasing every day. The dependence of the state tubewells is declining and in other side, private tubewell and pump sets have profited very rapidly. This calls for a drastic change in government policy viz. state tubewells, where the state should continue to install state tubewells, which draw water from deep aquifers and which is beyond the financial capacity of farmers. A Pani-Panchayat may be constituted in the command area of every state tubewell which should be given the responsibility to run and maintain it. They will have a regular income from the water charges and can properly maintain them including the water course. This seems a more efficient way of running the tubewells. In those cases when the village Panchayat is unwilling to take over the responsibility, such tubewells can be out rightly auctioned. All the state tubewells, which has gone out of order once, should be auctioned in the first instance and the money should be utilized to repay the capital cost.

(iv) **Virmani R.S. (1997)** studied, "Impact of Public and Private Tubewells", irrigation on cropping pattern, productivity, employment and farm income in Meerut District. A use study of Salawa Command was taken and found that agriculture is the main source of livelihood of great majority of the people.

Agricultural production is the function of many inputs of which the water is the essential and critical input, so, irrigation is a basic requirement for good farm, better land utilization and for higher crop production.

(v) **Raghuvanshi C.S. (1986) :** suggested that water users cooperative societies in India have failed, therefore water users association should be constituted. Such association should work under three tiers system i.e. primary at chak level, district level and apex body. Raghuvanshi further suggested that water users association should be constituted instead of cooperative societies. The membership and training should be given to farmer.

Raghuvanshi (1995) further suggested that the involvement of farmer can be affected at any stage of the project. At the investigation stage they could supply important local information such as highest flood levels in the years, the existing irrigations facilities and practices etc. In the process of adoption of irrigation management practice it is the farmer who gives us the vital information regarding the system operation and the major constraints. This helps a lot, in problem identification practice.

Any project which is designed to increase the agriculture production must improve the ability of farmers regarding the management, production input, O & M, new technology for improving farming systems. These are only possible where farmers put their active participation.

4.10 CONCLUSIONS

In the contest of Nepal, ground water has been explored for irrigation and till 1997, a total area of 10,56,617 ha has been irrigated from different ground water sources. Farmer have positive feeling on ground water utilization due to short-time for construction, subsidy provided by the government, proper drilling technique, less expenses, no water right, good quality water and can be under the control of farmer themselves. Many WUAs are formed in ground water development project on the basis of country's new irrigation policy which are found to have contributed a major role towards developing the real sense of ownership and the efficient use of irrigation water.

In the study of ground water development of Egypt, it is found technically feasible and economically attractive to the country. The strategy for increasing the agriculture production is effected by water management. The water distribution and drainage problems are there in old land and shortage of water in new land. The development of ground water is believed to reduce these constraints and is considered as economic alternative for surface water.

The study of tubewell irrigation in UP reveals that 66% of the total area is irrigated by ground water resources in UP, of which the area irrigated are mostly by public tubewells. The takeover of tubewell by society are very limited, however, there is an improvement after irrigation management transfer (IMT). The efficiency, cropping intensity, productivity, water control are increased after IMT, because most of the farmer have started getting water after IMT, So, for effective water management, state government must come out with acts and bylaws for tubewell cooperatives, tubewell management committees and WUAs,

In Gujarat, for the operation of public tubewell, it has to depend on government for large subsidies. The function of Gujarat water resource development cooperation (GWRDC) are to construct the tubewell, mention the tubewell, protect and preserve the tubewell, develop the ground water resources and manage the public tubewell using institutional finance. The GWRDC could not manage the takeover of tubewell to farmers properly. So, the Govt. of Gujarat has adopted the principles of participatory irrigation management forming WUA toward the success of take over of tubewells. Now, with the given responsibilities to WUA in various aspects, the take over of tubewells by farmer are increasing.

DESIGN OF UPVC DISTRIBUTION SYSTEM AND FIELD CHANNEL

5.1 GENERAL CONCEPT

The irrigation system is designed after the yield of the well is confirmed. All wells with the yield about 300 m^3/hr (83 lps) or more and is designed to cover 120 ha from four closed loops. The tubewell with smaller discharge is served by smaller area. The adopted irrigation duty is taken as 0.75 lps/ha. The tubewell which did not yield satisfactory discharge were either re-drilled or abandoned. The systems for 90 ha and 60 ha units are designed with three and two loops respectively.

An underground pipe line distribution system consists of buried UPVC pipes (2.5 kg/cm^2 pressure) for conveying water to different outlet points on the field. There exists various factors which motivates in the adoption of underground pipe line distribution system.

(i) The pipe line do not interfere the farming operation as the cultivation can be done above the pipes which are generally laid at 1.0 m below the ground level. This saves 2% to 4% of irrigable area that is required in the case of open channel system.

(ii) Saving in cost for land acquisition

(iii) Reduction in water losses as compared to open channel.

(iv) When properly laid and joined, they have long life and very low maintenance cost.

(v) This system is also suitable for undulating topography.

(vi) Since the underground pipelines operate under pressure, they can be laid uphill or downhill and providing water for irrigation to the areas which is normally not accessible by open channels.

(vii) The pipe lines are not clogged by vegetation and wind blown material as it happens in open channel system.

(viii) The initial cost of UPVC distribution system is high but if we consider the saving in land that would have been required for open channel and cost of culvert crossings, it can be taken the lower initial cost.

5.2 PIPE FOR THE SYSTEM

UPVC pipes are generally supplied in 6 m length. It is light. It is slightly flexible. It can be simple jointed and it has low friction loss. It is easy, quick to handle and install. Joints can be easily made leak proof and required diameter can be made available. The life of these pipes are considered to be about 50 years. The pipes used in the project for underground water distribution system are 200 mm ϕ and 160 mm ϕ UPVC pipes with working pressure class of 2.5 kg/cm^2. 200 mm ϕ are used for connection pipes and 160 mm ϕ for loops. The length of connection pipes and the length of loops depends upon the area to be irrigated, however in average, they can be taken as 140 m and 1900 m for 200 mm ϕ and 160 mm ϕ per loop respectively. The use of such type of pipes for irrigation purpose has been adopted successfully in Uttar Pradesh (U.P.), India, where some 900 DTW are operating with buried pipe line distribution system.

5.3 DESIGN CRITERIAOF UPVC DISTRIBUTION SYSTEM

Criteria for Design of UPVC System :

- Each tubewell serves one irrigation unit with an area of 120 ha.
- They are divided in four blocks of 30 ha each.
- The area irrigated is taken to be contineous i.e. the unirrigated gaps are not let to occur in between the irrigation unit, even though the irrigation unit have been planned separately. This is shown in the layout map of different stages of the project.

5.3.1 Location of Tubewell

- The location of tubewell should be such that it lies to about the centre of the proposed command area which also minimize the length of 200 mm ϕ connecting pipes.
- If feasible , tube well are located near the road side and at highest point of proposed command area.

5.3.2 Pipe line distribution network:

The control chamber is connected with four individual loops. Branches are provided where the loop does not pass through the outlet. Branches are generally provided where the ground slope is more than 6%.

- Hydraulic losses in the system is calculated for nominal discharge of each loop using Hazen Williams formula with 'C' factor equal to 140.
- Local loss (losses in control chamber, bends and branches) = 0.30 m (assumed)
- No additional air valves are provided in the network as the outlet provided will be enough for this.

  The pipeline are always filled with water.
- A surge riser to remove excessive pressure is provided in each loop network which is located at the farthest and highest point from the control chamber.

5.3.3 Control Chamber

- It is a reinforced concrete structure located near the pump house. The control chamber maintain the equitable division of tubewell discharge to all four loops and provide the necessary head, so that the farthest and highest outlet to be known as "critical outlet" can be served. Here a nominal tubewell discharge of 300 m^3/hr is divided into four equal streams of 75 m^3/hr each. The height of control chamber is 0.50 m above the maximum water level in the control chamber. So, it is different for different wells because they are determined particularly in each case. An acceptable free board of 0.30 m is provided above the maximum water level in the chamber and a spillway capable of discharging well's yield is also provided in the chamber. The spilled water are safely drained out.

The size of control chamber are kept as 2.90 m x 2.90 m with total net height of 2.00 m as shown in the fig. The flow is divided in four loops from the control chamber by means of rectangular weir. The discharge formula used for rectangular weir is

$$Q_l = CBh_d^{3/2} \qquad (5.1)$$

Where,

Q_l = The discharge in each loop ≈ 21 lps or ≈ 0.021 m^3/sec.

C = weir coefficient which is taken to be = 1.84

B = weir width = 0.25 m.

h_d = operating head of weir,

from equation (5.1)

$0.021 = 1.84 \times 0.25 \times h_d^{3/2}$

$$h_d^{3/2} = \frac{0.021}{1.84 \times 0.25} = 0.0456$$

$$\therefore\ h_d = 0.1277 \ \approx 0.13\ \text{m}$$

∴ The normal water level required in the control chamber will be

$H_A = H_E + h_d + h_w$

where,

H_A = The normal water level in the control chamber in m.

H_E = hydraulic gradient elevation required at the entrance of pipe line distribution network.

h_d = operating head of the weir

h_w = minimum free fall height to avoid overflow submergence taken as 0.05 m.

Now,

$H_A = H_E + 0.13 + 0.05$

$$H_A = H_E + 0.18 \qquad (5.2)$$

5.3.4 Spill Way

For safety measure a spillway is provided in the control chamber which is capable to remove the entire tubewell discharge safely.

Type of spillway will be rectangular over flow type

Crest of spillway $= H_A + 0.35$

(∵ spillway is kept 0.35 m above the nominal water level in the control chamber)

Now,

$$Q = CB\, h_s^{3/2} \qquad (5.3)$$

Where,

Q = total tubewell discharge = 0.083 m^3/sec.

C = weir coefficient = 1.84

B = spillway width = 0.75 m

h_s = spillway operating head in m.

From eqn. (5.3).

$$0.083 = 1.84 \times 0.75 \times h_s^{3/2}$$

$$h_s^{3/2} = 0.0601$$

$\therefore h_s = 0.15$ m

Now, the top of control chamber is

$$H_T = H_A + 0.35 + h_s + f$$

Where,

H_T = top elevation of control chamber

H_A = nominal water level in the control chamber

h_s = spillway operating head

f = free board above spillway operating head = 0.15 m (assumed)

$$\therefore H_T = H_A + 0.35 + 0.15 + 0.15$$

$$= H_A + 0.65$$

Now, putting the value of H_A from eqn. (5.3), we get,

$$H_T = H_E + 0.18 + 0.65$$

$$= H_E + 0.83$$

Also,

$$H_E = H_G + h_{f160} + h_{f200} + 0.90$$

From eqn. (5.3)

$$\therefore H_T = H_G + h_{f160} + h_{f200} + 0.90 + 0.83$$

$$= H_G + h_{f160} + h_{f200} + 1.73$$

$\therefore$ Height of control chamber from the ground level is

$$H = H_T - H_W$$

Where,

H_W = elevation of ground level at the point where the control chamber is to be constructed.

5.3.5 Determination of height of control chamber

$H_H = H_G + h_v + h_0$ where

H_H = required elevation at the outlet point

H_G = ground elevation at that point

h_v = minimum height of valve outlet, above the ground level

$\approx$ 0.3 m (normally assumed value)

h_0 = minimum operating head at outlet = 0.3 m (assumed)

$$\therefore H_H = H_G + 0.6 \qquad (5.4)$$

If H_E = required elevation at entrance to the pipe line distribution network, then

$$H_E = H_H + h_{f160} + h_{f200} + h_l \qquad (5.5)$$

H_H = Elevation at the outlet point

h_{f160} = Hydraulic loss in loop of 160 mm dia pipe

h_{f200} = Hydraulic loss in loop of 200 mm dia pipe

h_l = local loss in the system is taken to be 0.30 m as miscellaneous loss

Putting the value of H_H, from equation (5.4) and (5.5) we get

$$H_E = H_G + 0.6 + h_{f160} + h_{f200} + 0.3$$

$$= H_G + h_{f160} + h_{f200} + 0.9 \qquad (5.6)$$

Therefore, the height of control chamber H_T is given by

$$H_T = H_A + 0.65$$

$$= H_E + 0.65 + 0.18 = H_E + 0.83$$

$$= H_G + h_{f160} + h_{f200} + 0.90 + 0.83$$

$$= H_G + h_{f160} + h_{f200} + 1.73$$

5.3.6 System Design:

The distribution pipes are laid below the ground level in the form of a closed loop, connecting distribution outlets. So, the layout of the pipe lines follow in such a way that it cover the area assigned for that particular loop. Two pipeline diameters are used for design.

- 200 mm UPVC pipe used for connecting lines which carry the entire water share of the particular network.
- 160 mm dia UPVC pipes used for loop and branch lines.

The diameter of connecting pipe is kept about 25% more than the dia of loop pipes. The head loss in the pipe can be computed by Darcy Weisbatch or Hazen William formula, because the discharge flowing through the pipes is known. The head loss in the pipe consists of head loss in pipe due to friction and minor losses. The frictional head loss (H_L) as per Hazen-William's formula is given by

$$H_L = \frac{1}{0.094}\left(\frac{Q}{C_H}\right)^{1.85} \frac{L}{d^{4.87}}$$

Where Q = discharge in loop in m^3/sec

d = diameter of pipe mm

C_H = friction factor

= 140 for very smooth pipes (UPVC pipes)

To avoid the cumbersome calculations, instead of using the formula, head loss is calculated using the pressure pipe calculator based on Hazen-William's Chart. The most important point to note is that, there should not be any leakage in the pipe system and the whole pipe line must be completely filled before operations of any outlet.

Hardy Cross Method:

The procedure suggested by Hardy and cross requires that the flow in each pipe is assumed by the designer (in magnitude as well as direction) in such a way that the principle of continuity is satisfied at each junction. (i.e. inflow in any junction becomes equal to the outflow at that junction).

Head loss $H_L = k\,Q^x$ where

H_L = Head loss

K = constant depending upon pipe characteristics and units used

Q = actual discharge

Or $Q = Q_a + \Delta$ where

Q_a = assumed flow and

Δ = correction

$\therefore H_L = k\,(Q_a + \Delta)^x$

$= [Q_a^x + x\,Q_a^{x-1}\,\Delta + \ldots\ldots$ Negligible terms containing higher power of x]

$= k\,[Q_a^x + x\,Q_a^{x-1}\,\Delta]$

Now around the closed loop, the summation of head losses must be zero

$$\therefore \sum k\left[Q_a^x + xQ_a^{x-1}\Delta\right] = 0$$

$$\Delta = -\frac{\sum kQ_a^x}{\sum kxQ_a^{x-1}} = -\frac{\sum k.Q_a^x}{\sum\left|x.kQ_a^{x-1}\right|}$$

Where H_L = head loss for assumed flow Q_a

The value of $x = 1.85$ for Hazen William's formula

$x = 2$ for Darcy-weisbach formula

This method is used for design of distribution systems which are generally divided into two or more loops.

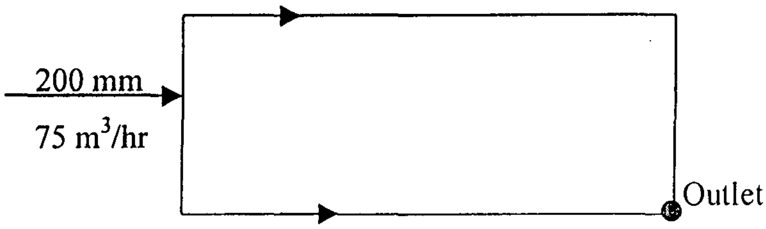
5.3.7 Sample calculation for losses in loop

When the water reaches to the loop, the flow will be divided into its arms proportionally which is withdrawn from the outlet. The outlets are generally located on the distribution loop. Hydraulic loses in the system is calculated for nominal discharge of 75 m^3/hr for 200 mm dia connecting pipes and when the discharge reaches to 160 mm network loop, the flow branches into either arm proportionally. The head loss depends as per the respective pipe-line length. The friction coefficient of c =140 is adopted in calculating hydraulic loss by Hazen Williams formula. Trial and error flow conditions are done till the head loss from both arm becomes approximately same.

$Q_1 = 35 m^3/hr$

DN = 160 mm, L = 1080 m

Fig. 5.1



DN = 160 mm, L = 880 m

$Q_2 = 40 m^3/hr$

Trial 1

Assume Q_1 = 33 m^3/hr, for this discharge the loss is

h_{f160} = 1.40 m/km

∴ h_{f160} for 1080 m = 1.512 m

Q_2 = (75-33) m^3/hr = 42 m^3/hr, for this discharge the loss is

h_{f160} = 2.20 m/km

∴ h_{f160} for 880 m = 1.936 m

h_{f160} (for Q_1 = 35 m^3/hr, L = 1080 m) ≠ h_{f160} (for Q = 40 m^3/hr, L = 880 m)

Trial 2

Assume Q_1 = 37 m^3/hr, for this discharge the loss is

h_{f160} = 1.8 m/km

∴ h_{f160} for 1080 m = 1.944 m

Q_2 = (75-37) m^3/hr =38 m^3/hr, for this discharge the loss is

h_{f160} = 1.90 m/km

∴ h_{f160} for 880 m = 1.672m

h_{f160} (for Q_1 = 37 m^3/hr, L = 1080 m) ≠ h_{f160} (for Q = 38 m^3/hr, L = 880 m)

Trial 3

Assume Q_1 = 35 m^3/hr, for this discharge the loss is

h_{f160} = 1.60 m/km

∴ h_{f160} for 1080 m = 1.73 m

Q_2 = (75-35) m^3/hr = 40 m^3/hr, for this discharge the loss is

h_{f160} = 2.0 m/km

∴ h_{f160} for 880 m = 1.76 m

h_{f160} (for Q_1 = 35 m^3/hr, L = 1080 m) ≈ h_{f160} (for Q = 40 m^3/hr, L = 880 m)

Head loss for Q_1 = 35 m^3/hr = 1.73 m

Head loss for Q_2 = 40 m^3/hr = 1.76 m

When the discharge reaches to DN 160 mm network loop, the flow branches into either arm proportionally. The loss for critical outlet is calculated for different length with different discharges in trial. The 3rd trial which showed to about equal loss is assumed to be the maximum loss in DN 160 mm pipe.

$\therefore$ The average loss in DN 160 mm = $\frac{1.73 + 1.76}{2} = 1.75$ m

Head loss for 200 mm of pipe

Q = 75 m^3/hr,

The head loss = 2.20 m/m

$\therefore$ Head loss for 200 m = 0.44 m

The entire discharge passes through the pipe DN 200 m. The loss in 200 mm of pipe for the length of 200 m (in above case) is calculated which is

$$h_{f200} = 0.44 \text{ m}$$

If, H_G (Ground elevation) = 100, (Assumed)

Then the top elevation of control chamber is

$H_T = H_G + h_{f160} + h_{f200} + 1.73$

$= 100 + 1.75 + 0.44 + 1.73$

$= 103.92$ say 104 i.e. height of control chamber above theG.L= 4.0 m

Finally, the total structure height will be

$H = H_T - H_W$

Where H_W is the ground elevation where the control chambers is to be located.

5.4 DESIGN AND CONSTRUCTION OF FIELD CHANNEL

5.4.1 General

The canal and structures required in the farm level are the main measures of success of each irrigation system. There exists a great gap between the target and achievements in many projects. Sometimes they are also found below the satisfactory level. The improvement can be made with better management of field channel.

An outlet is an structure from which water is delivered in the field through field channel. So, the important factor for efficient use of irrigation water is the construction of proper field channels from the outlet.

The design of the field channel depends upon discharge. Here the outlet discharge id taken to about 21 lps, which is a loop capacity. The system is therefore designed to carry the whole outlet discharge so that all the water can be concentrated in one area in its rotation to maximize the irrigation efficiency. Care should be taken to manage the whole discharge in one field. Farmer's experience in Indonesia also suggests that they like to divert the whole discharge to one field in rotation for which, field channel should be constructed up to that capacity.

5.4.2 Design of field channel

- The location of the outlet is nearly at the centre of its channel.
- The length of field channel is assumed to be constructed about 100 m in all directions from the outlet.
- The head available over the outlet is about 30 cm So, the channel constructed will have slope for this available operating head.
- The land is approximately plane are and the field channel is also approximately straight.

The channel section are very small and design curves are used for such small section.The curves used are taken from Design Manual and are attached here Fig. 2 Annex-1.

The following values are taken for design,

For Q = 30 lps, i (slope)= 0.0025 (1/400)

D = 0.16 m (from curve i) For this depth ⇒ v = 0.42 m/sec (from curve ii)

n = 0.025 suitable value for earth channel

Using manning formula;.

$$V = \frac{1}{n} R^2/3\ S^{1/2} \qquad \text{(a)}$$

$$\text{Area, A} = \frac{8.16 + B + 0.16 + B}{2} x0.16$$

$$= 0.16^2 + 0.16\,B$$

$$\text{Perimeter, P} = 2x0.16\sqrt{2} + B = 0.452 + B$$

From equation (a)

$$0.42 = \frac{1}{0.025}\left(\frac{0.16B + 0.16^2}{B + 0.425}\right)^{2/3} (0.0025)^{1/2}$$

$$0.16\,B + 0.0256 = 0.0962\,B + 0.0409$$

$$B = 0.239 \approx 0.24\ \text{m}$$

With the above design consideration, a free board of about 15 cm is provided and top of both banks are kept to about 0.30 m.

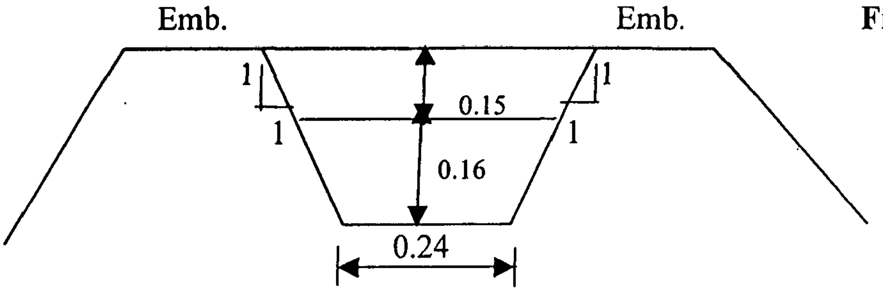


Fig. 5.2

5.4.3 Channel lining

The poorly compacted embankment and more rat holes need the check of water loss from canal. Lining is recommended to check these problems as well as to check the seepage loss. However the earthen channel is a low cost channel and can be easily modified. In the project area the soil type is sandy loam, so a well built, properly compacted earthen channel with proper operation and maintenance may be the best choice for field channels. It can be clearly understand that poor field channel results low irrigation efficiencies, suffering the yields.

5.5 OUTLET

The outlet valves from the buried pipe line system is comprised with Alfalfa valves. The basic design of Alfalfa valve was developed under Tangail Agricultural Development Project (TADP) in Bangladesh. Following are the objectives of Alfalfa valves

- Operation if not difficult but needs some tools to operate.
- For minimum water hammer the outlet valve should be designed for slow closure.
- The head loss effects are minimum.
- The water deliver for irrigation in the outlet will be as per rotation unit.
- The nominal sizes of one rotation unit is approximately 4 to 5 ha.
- The discharge at outlet is 75 m^3/hr (21 lps)
- The operation hour of each outlet will be decided by the WUG which will depend on type of soil, length of field channel, crop type etc.

The field outlets are designed to discharge into a division box which is also supposed to provide the facility for energy dissipation in the case of high driving head. The distribution box will also facilitate the operation in rotational distribution.

5.6 CONSTRAINTS DURING IMPLEMENTATION AND ACHIEVEMENTS:

Project Manager has been responsible as a chief executive officer of BLGWP stage III, as were in the previous stages. He is to look after day to day work as well as all implementation work in accordance with the time schedule.

The stipulated construction completion date of this stage III was December 31, 1998 and final completion took place on June 30, 1999, six months delayed in schedule. But this date is also the credit closing date. The major part in delay in implementation was turn over activities in the last hour. The following are the striking factors for delay in implementation.

1) Frequent change of Government. The change in Government has made the untimely change of many senior staff. This change has affected delay in the award of ICB/LCB contracts.
2) Lack of co-ordination between govt. agencies particularly DOI, DOA and NEA.
3) Untimely or late approval of annual work programs.
4) Delay in budget release.
5) Lack of coordination and supervision with project staff
6) Delay in farmers contribution work for trench excavation and back filling for buried pipe system.
7) Increase in civil works for stage II tube wells.
8) Construction of 6 additional DTW in stage III
9) Re-drilling of tube wells in stage II area.
10) More repair and leakage in piped distribution system.

All targeted work have been achieved and is shown as per the following table

Targeted and achieved DTWS under stage III

Table 5.1

S.No.	Area	Drilled wells		Pump and motor		Electric panel		Transformers		Energized	
		Target	Achieved	Target	Achieved	Target	Achieved	Target	Achieved	Target	Achieved
1.	East	35	35	35	35	35	35	35	35	35	35
2.	Central east	9	9	9	9	9	9	9	9	9	9
3.	Central west	18	18	18	17*	18	17	18	17	18	17
4.	West	17	17	17	16**	17	16	17	16	17	16
Total		79	79							79	77

* In tube well CW 11, pump is not installed due to adequate artesian discharge

** The tube well no. WW 6 was abounded due to very low discharge.

PARTICIPITORY IRRIGATION MANAGEMENT

6.1 INTRODUCTION

Participation is not a new word for irrigation management. From the very beginning of civilization, people join together in the construction and management like flood control work, well digging work, irrigation work, road making work and etc.

As the time passes, govt. and related authority started constructing and operating many new irrigation systems. It was also observed that many problems encountered in the projects where sole responsibility was taken by them, even though the government invest huge capital for the construction work.

It is therefore realized that farmer participation and their involvement from the very beginning to operation, management and maintenance is felt essential.

6.2 OBJECTIVES OF FARMER INVOLVEMENT

The objectives for involvement of farmers in the irrigation project are to develop the feeling of ownership among them. The attempts are made to achieve this motto. The objectives and the need for farmer participation or the principles participatory approach are discussed as under.

Farmer involvement would mean having farmer participation in the decision making while planing, design, implementation, and operation maintenance of the irrigation project.

With the reduced financial assistance from government agencies, the farmer makes increased profitability with lower overhead cost, is the main achievement of farmer involvement. Farmer are innocent but cleaver too, because always they like to produce more profitable crop with given irrigation facility. Since farming is the business of farmers, they have a vested interest in their success. This may be one of the reason that for the survival of farmer, sustainability of the system is must. The involvement of farmers can be taken in different ways like.

i) In identifying major problems / constraints

ii) In developing solutions

iii) In planning activities for implementation and improvement

iv) In providing time, labour and other resource in implementing a project

v) To cooperate in the successful operation and maintenance of improved system.

The group of farmer is a mixed society, sometimes the involvement of farmer also creates adverse effect on the project. The following are the causes.

i. When farmer manipulates for political purpose

ii. When only elite farmer is involved. The elite farmer mobilizes the simple farmers in the community for their benefit.

<u>The additional objective of farmer involvement are as follows:</u>

i. When past knowledge and past practices are required.

ii. When co-operates and acceptance are required.

iii. When turnover of the system to WUG is required

iv. When technology transfer is required

v. When the organizations are required to be more responsible to local needs.

vi. For effective maintenance, control and operation of the system.

6.3 IRRIGATION POLICY OF NEPAL (PARTICIPATORY APPROACH PROGRAMME)

Irrigation policy of His Majesty's Govt. of Nepal (HMGN) has developed in 2049 (1992 AD) which is also the modified version of irrigation policy developed in 2045 (1988 AD). The main focus of this policy is towards the irrigation projects, which will be conducted under the participatory approach programme. Farmers need to be involved form the beginning of irrigation development. They need to be involved in design, implementation, operation and maintenance of the project. So for this approach, it requires an organized participation of farmers. As per the prevailing rules of the country, the following are the cost shearing from the farmer (WUG) either by cash or by labor or both.

		Share	
(1)	**New Project**		
	Terai	WUG Portion	HMGN Portion
	Surface irrigation	10%	90%
	Ground water deep tube well irr.	16%	84%
	Hill (surface irrigation)		
	Hilly areas	7%	93%
	High hill (mountain) area	5%	95%
(2)	**Rehabilitation Project**		
	Terai		
	Surface and deep tube well irr.	15%	85%
	Hill		
	Hilly area	12%	88%
	High hill area	7%	93%
(3)	**System (Project) to be handed over to WUG (after completion i.e. turnover system)**		
	Surface and deep tube well irr.	5%	95%
(4)	**System to remain under joint management of WUG and agency**		
	New project		
a.	Terai		
	Water course (command area < 10ha)	100%	-
	Tertiary canal (command area10-30ha)	25%	75%
	Secondary canal (command area 30-500ha)	-	100%
	H/W, Main canal	-	100%
b.	Hill		
	Surface irrigation	5%	95%
c.	Rehabilitation project		
	Terai	12%	88%
	Hill	10%	90%
5.	**Private Irrigation System**		
	Ground water shallow tube well irr.	60%	40%
	Sprinkler / drip irr.	40%	60%

Turbine solar pump lift	25%	75%
Wind pump lift	40%	60%
Surface irrigation	40%	60%

Of the above, cost shearing of beneficiary farmer, for the turn over project is 5% of the total cost. An agreement is generally done with WUG for their shear portion only, so that the beneficiary farmer contribute in term of cash / labour or both.

6.4 TURN OVER AND TRANSFER OF MANAGEMENT TO WUG

This is the transfer of management of a group of deep tube well from project authority (PA) to their users.

The major objectives of the turn over program were to set the foundation for effective management of each irrigation unit after project completion and to reduce the burden of operation and maintenance cost on HMGN budget.

The turnover process was based on the concept of following principles and purposes.

i) After the turnover of each irrigation unit to WUG, the ownership of tube well unit will be transferred to WUG, the project authority (PA) will have no role to provide the management service. Upon completion of the turn over process each unit should be a farmer managed irrigation system (FMIS) and WUG should pay for pump operator, watchmen and the electricity bills. The project authority however will assist technically and financially to WUG in regular basis and specially in those rehabilitation works that are found beyond the capacity of WUG.

ii) The users have to cover all cost of operation and maintenance.

iii) Sustainability is the main objective of the project and turnover process make system sustainable by ensuring the real sense of ownership and strengthening farmer's management.

6.5 WATER CHARGES, FEES COLLECTED AND STATUS OF PAYMENTS FOR ELECTRICITY IN STAGE – III

Since 1987 / 88 Govt. had imposed water charge of NRs 200/ha/yr. In 1990 / 1991 the water charge was raised to NRs 400/ha/yr.

From 1992/93, after completion of takeover by WUG, the water charge was cancelled. Thus after handover of DTWs, the WUG were required to pay both fixed cost and variable cost. The fixed cost comprises a fixed dammed charge imposed by NEA and based on installed KW (motor rating puls 3% for transformation & transmission losses) & cost of operator. This fixed cost was raised on the basis of land holding size. Variable costs were charged to users on the basis of pumping hours.

Water charge collected and payment done by the project for electricity is as follows

Table 6.1

Year	Water charge NRs/ha	(fixed)assessed irrigated land ha	Assessed water fees as per the assessed area NRs	Collected water fees NRs	Electricity bill paid by the project NRs	% of recovered electricity water by collected fees NRs
1987/88	200	3800	760,000	548460	3669947	14.9%
1988/89	200	4843	968600	543518	3966788	13.7%
1989/90	200	4843	968600	615696	2610781	23.6%
1990/91	400	4843	1937200	51252	3075789	17.%
1991/92	400	4843	1937200	1717787	4398745	39.1%
1992/93	Take over the DTWs. By WUG.					

Source : PCR, Tahal Consulting Engineers Ltd.

6.6 FORMATION OF WATER USERS ASSOCIATION (WUA) IN BLGWP

6.6.1 General

Farmer associations of water users exists in several East Asian Countries (eg. Japan, Taiwan, Bali,(Indonesia), as well as in Spain and United States.

The main aim of formation of water users association are to promote and secure distribution of water among its users, adequate maintenance of the irrigation system, efficient and economic utilization of water to optimize agricultural production and to protect the environment by involving the farmers as well as creating a real sense of ownership of the irrigation system.

The WUA, in general should perform the following activities

i. Prepare the irrigation schedule

ii. Prepare a plan of action for maintenance of the system.

iii. Maintain register of land holders.

iv. Resolve the disputes / conflict between members

v. Raise resources

vi. Maintain annual accounts and arrange annual audit of the account

vii. Deposit collections and conduct regular water budget.

6.6.2 Background:

Formation of WUG / WUA is not a new for BLGWP. For each DTW, WUA has been established under irrigation policy of 2045 (1988). The organization of water users in the project comprises the general body of all users of every irrigation unit. Each WUG consists of 7 to 9 executive persons including chairperson, vice chairperson, secretary treasurer and members. Each WUG must be represented by at least two female member. For each DTW, small farmer group in each turnout would comprise users groups in each loop. All farmers are the member of WUA.

6.6.3 Function and Activities of WUA in the Project

The following functions of WUA exists in the project:

- Collect membership fee (Rs. 10/- per member)
- Collect electricity tariff
- Supervise the system
- WUA are not concerned to cost recovery of the system.

In the project the general body elects an executive committee (EC) that comprises a chairperson, a vice-chairperson, a secretary, a joint secretary, treasures and 2 to 6 additional members. Chairman or chairwomen are elected by secret ballot, while other positions are elected by open ballots. There should be at least two women representative in the executive committee.

General Assembly (GA): The GA fix the rules for O & M of DTW and sets costs and membership fees. The GA. elects the executive committee, approves annual programs and budgets.

Executive Committee (EC): The EC implement rules and programmes passed by GA, prepare income and expenditure statements. The EC also nominate the members, pays outstanding bills and attend the water management with loop leaders. The chairperson of EC is responsible to mobilize the labor contribution and settle the conflicts among the loop leaders if any.

Loop leaders: Loop leaders are responsible for appropriate distribution of water within the loop and delivery to outlets. They also settle conflicts between the outlet group leaders as well as assist the EC to collect the pumping charge and membership dues etc.

6.6.4 Regional Coordination Committees (RCC)

There are altogether four RCC. The no. of WUG's included in each RCC are as follows:

Table 6.2

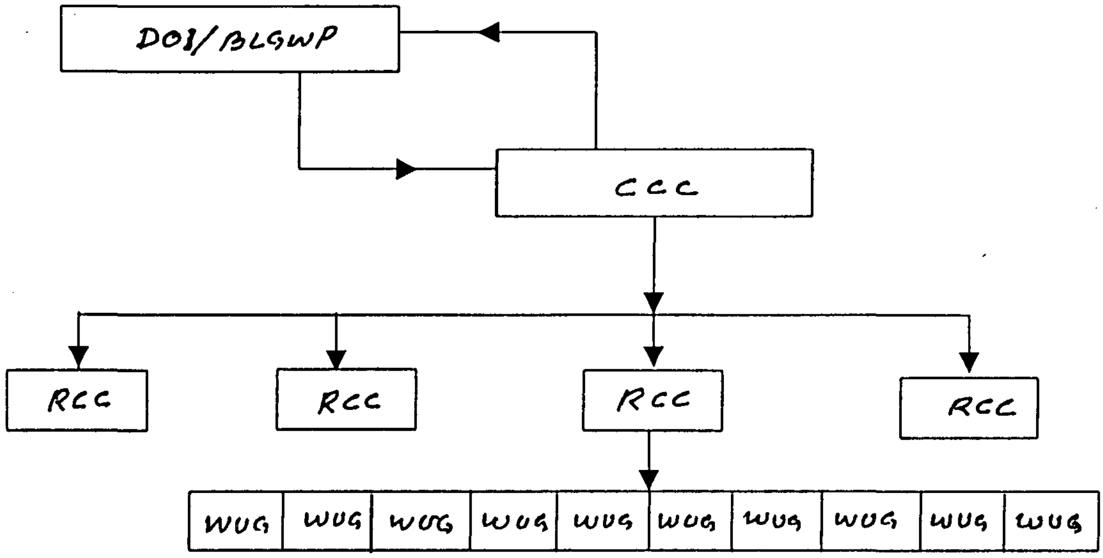
Sl.No.	Regional coordination committees	No. of WUG's	Date
1.	Central western RCC Stage I - 34 WUG's Stage III – 18 WUG's	52	Feb. 14, 1998
2.	Western RCC Stage II - 31 WUG's Stage III – 16 WUG's	47	Mar. 31, 1998
3.	Central RCC Stage I - 26 WUG's Stage III west – 9 WUG's	35	Feb. 14, 1999
4.	Eastern RCC Stage III (East) – 35 WUG's	35	July 31, 1998

The RCC are formed with combination of different stage WUG s of adjoining areas. The RCC is formed from among the members of WUGs.

6.6.5 Central Coordination Committee (CCC):

A CCC was formed to coordinate activates of all RCC and provide support in procurement and O & M problem to regional coordination committees. The CCC is formed from among the member of four RCC which comprises 5 executives (chairperson, vice-chairperson, secretary, joint secretary and treasurer) and six members.

The following flow chart shows the organization of WUA: **Fig. 6.1**



About 35 to 53 WUG in each RCC

6.7 FARMERS MANAGEMENT OF IRRIGATION SYSTEM AND FARMERS ORGANIZATION (ANDHRA PRADESH; INDIA)

Andhra Pradesh is an agricultural state depending on an efficient and equitable supply and distribution of water which is a national wealth, ensuring optimum utilization by farmers for improvement of agricultural production which is the immediate need. The scientific and systematic development and maintenance of irrigation system and infra structure is considered best possible through farmer organizations.

An act regarding the above subject matter was Ist published on 9th April 1997 in Andhra Pradesh Guzette for general information which defines the terms and scope of the following viz area of operation, ayacut road, command area corporation, distributory system, district collector, drainage system, farmers organization field channel, field drain, financial year, financing agency, government, land holder, maintenance, operational plan, prescribed, warabandi, water allocation and water users.

The command area for each irrigation system is described by the district collector, where a water users association can be formed. Every water users association shall consist of the following member

- All water users who are land holders and tenant,forms a general body.
- Every WUA constitutes a managing committee (MG)
- The president of (MG) is elected by secret ballot.
- The arrangement of election is done by district collector
- The managing committee exercise the power and perform the function of WUA

On the basis of command area covered,There exists committees viz.

1. Distributory committee
2. Project committee
3. Apex committee

Distributory Committee (DC): All president of WUA in the distributory area shall constitute the general body of the committee. Every distributory committee has managing committee. The election of president and members of this committee is done by secret ballot and limited to 5 in member from among the member of general body of distributory committee. The managing committees exercise the power and perform the function of distributory committee.

Project Committee (PC): All president of the distributory committee in the project area constitutes the general body of the project committee. Every PC has managing committee. The election of chairman of managing committee is done by method of secret ballot and limited to 9 members form among the member of general body of project committee. The managing committee exercise the power and perform the function of project committee.

Apex Committee: The Govt. may by notification, constitute an apex committee with such member of members as may be considered necessary and exercise the power in the project area as may be considered necessary.

Disqualification of candidates and members:

No village servant and no officer or servant of the govt. of India or any state govt. or of a local authority or an employee of any institution receiving aid from the funds of the govt. shall be qualified for being chosen as or for being a chairman, or president or a member of a managing committee. There are several other rules under this act.

Functions:

The WUA shall perform the following functions

i. To prepare and implement a warababdi schedule for each irrigation season as per the command area, soil and cropping pattern.

ii. To prepare the plan for maintenance and carryout the maintenance works with the available funds.

iii. To regulate the use of water among the various outlets according to the warabandi schedule.

iv. To promote economy in the use of water allocation

v. To collect the water rates and assist the revenue department

vi. To maintain the register of land holders

vii. To monitor flow of water for irrigation

viii. To resolve the disputes between members and water users if any. The decision of apex committee will be the final

ix. To raise resources and maintain accounts

x. To conduct the general body meeting as may be prescribed.

xi. To conduct regular water budgeting and also to conduct periodical and annual audit of its accounts.

Resources of WUA

i. Grants received from the govt., as a share of water tax collected in the area of operation.

ii. Grants received from state, central govt., and agency for the development of area.

iii. Fees collected from the members

iv. Amount received from any other sources.

Offences and penalties

Whoever without any lawful authority does any of the following acts namely

i. Damages, alter, enlarges or obstructs any irrigation system

ii. Interfere the water supply by increasing or decreasing the flow

iii. Uses water in an unauthorized manner

iv. Obstructs or removes any level, marks or gauges fixed by the authority.

Involvement of farmers from the beginning, their scope, their formation, objects and function, settlement of disputes, punishments and many miscellaneous headings like record keeping, auditing, meetings, resignation, election, filling vacancies, penalties, fund collections and deposition, preparing budget etc are clearly prescribed in the system act of Andhra Pradesh.

6.8 TURNOVER OF PUBLIC TUBE WELLS GUJARAT, INDIA

The objective behind the government stay in transferring tube wells to users is to reduce the financial burden on the state as well as improve the utilization of wells.

In the initial stage, any tube well that a group of users were interested in managing, was leased out. But the leased out wells remained close. A transfer of nearly 350 operated wells will result reduction in O & M cost. GWRDC has not succeeded in reducing the cost of field staff, (tube well operators) who are paid from the govt. and(still increasing the demands day by day)even then their performance are not found effective.

A survey of Shah & Bhattacharya (1992) indicates that the wells has been put to far better use, subsequent to transfer to users. Farmer have improved the utilization of water except where, the wells are technically not sound, power supply is irregular, lack of resources for timely repair and maintenance of well.

In north Gujarat (Mehsana, Sabarkantha etc) the depth of water is much below, leading the high pumping cost. The farmer response towards take over in this case was lukewarm. This is because in such a high pumping cost, farmer could not supply water at low rates as the public tube well are doing. Although the saving of investment in tube well can be done with successful turnover to farmers, the turnover programme which the GWRDC has experienced within the last five year has failed to succeed. There were several aspects, plan and pollicies regarding the hand-over to cooperative or lease to users whatever may be, the government is interested to hand over the public tube wells. As the response of the users has not been too enthusiastic, GWRDC has modified the terms of transfer. Outright sales of the tube well has also been recommended by the finance commission.

6.9 ROLE OF WATER USER ASSOCIATIONS IN IRRIGATION MANAGEMENT WEST JAVA - INDONESIA

The program for promoting and strengthening water users association in west java, commenced with presidential instruction No. 1 in 1969. The situation has been further clarified by instruction No. 2 in 1984, which defined the obligations of the WUA as.

i. Managing the water and irrigation network within a tertiary unit, so that the water can be used effectively by the members to meet crop water requirement and be distributed equally among the farmers.
ii. Maintaining the tertiary network in good working condition.
iii. Managing the payment of member contributions for O & M of the system and for other activities for development of group.
iv. Guiding and supervising the members.

The boundaries of WUA in west java is related with tertiary block boundaries.

The structure of WUA consists of

i. The member meeting, which elect the committee member
ii. The WUA committee which consists of chief, deputy chief, secretary and treasurer.
iii. The members., are the farmers who either own or rent paddy field within the tertiary unit or use irrigation water for some other use like fish farms.

A WUA would have an area of approximately 100-150 ha and member around 200 farmers. The member are divided into farmer groups by tertiary and quaternary blocks.

The performance of WUA is not satisfactory as was expected and the reasons are

a. Small landholding which involves more farmer.
b. The farmer still work as per their traditional culture.

c. Faulty design and construction.

d. Frequent change of tertiary network after construction.

e. Tendency of using water without paying the fee and wait for govt. funds for maintenance.

f. Lack of coordination between different govt. agencies like irrigation, agriculture, extension services etc.

To overcome from the above difficulties, training to WUA has been adopted in many project of west Java. The training course covers the following topics

i. Irrigation system tertiary network construction

ii. Organization and administration of WUA

iii. Functions and responsibilities of WUA

iv. Agriculture and water requirements

v. O & M of tertiary network

vi. Preparation of list of WUA members

vii. Preparation of WUA basic rules and internal affair operation rules

viii. Finance and planning

6.10 FARMER'S USERS ASSOCIATION IN LAO PDR

(Case study of Pakkhangoung Irrigation Project)

The agricultural sector is the foundation of Lao economy, generating almost 60% of Gross Domestic Product and employing nearly 85% of work force. More attention is given to rice production. There exists small, mediums large scale irrigation systems but the emphasis currently is on building and rehabilitation of small and medium size schemes. Past schemes had a high failure cases, specially large schemes due to lack of technical maintenance and community involvement.

For the study of farmers role and WUA, the existing water distribution practice, management and organization of Pakkhagnang irrigation project is considered.

The methodology conducted to analyze the study were, secondary data collection from the project and different published studies.

The farmer are the actual beneficiary who uses water and therefore his involvement is necessary, but generally in Lao PDR, the involvement is very poor, so is the result of inefficient and poor water distribution. The poor irrigation management in

Lao PDR may be due to lack of adequate communication between farmer and irrigation authorities.

Formation of water cooperatives and the cooperation among farmers is necessary for efficient use of irrigation water. The new concept of formation of water users association in the command area to operate and maintain the irrigation system beyond outlet is suggested. Such farmers association can play a great role by educating and upliftment of the farmer.

The involvement of farmer is very essential from planning stage till construction and implementations stage and finally in the O & M stage because the farmer organization is important for equitable water distribution. The Pakkhagnoung irrigation has improved the irrigation efficiency. However, the equity of water is not achieved. The success of this project lies in the leadership and member of the organization. The farmers of the project area are keen to take advantage of new opportunities and to assume new responsibilities.

6.11 MANAGEMENT OF IRRIGATION BY FARMERS OF SPAIN (HUERTA OF VALENCIA)

A study of irrigation management in Spain (Huerta of valencia) is also done, where the management is completely taken care by the community from last many centuries. The committee, which is the group of all owners of land is headed by sindic. The sindic is the main authority of the committee. The sindic is assisted by some members, who are also the representative from all command area. The member and the sindic together forms the ruling committee. It is the responsibility of the committee for making water available to the farmers. Water is supplied to each farmer in proportion to the area of land he irrigates.

The irrigation subscribes communities have legitimated its origin through the centuries. The irrigation subscribes made the regulations and ordinance at approx. 600 to 700 years ago. Later on, 100 years ago, the water law of Spain was enacted on the 13th June 1879. The law was the outcome of their traditional customs and habits, which were finally gathered, in a juridic code of laws. It was also the first water law in Europe and America, which was also liked by all. This law-based communities enjoy all the necessary juridic power for carrying out its purposes.

The syndic is elected by a majority of general assembly. The "Tribunal De Las Aguas" is the popular court. The guilty farmers pay the fines and damages according to the particular ordinances of his community. The penalties are also based on what extent the damage has occurred for example taking water out of turn, flooding a neighbors field, install unauthorized check on canal etc.

6.12 FARMER PARTICIPATION AND IRRIGATION MANAGEMENT WITH RESPECT TO DIFFERENT COUNTRIES

GENERAL

Farmer involvement in the design, implementation, operation and maintenance of the project is the key to sustainability. It is necessary to develop an infrastructure in order to operate the system, but for effective use of irrigation water, farmer participation and the training are must. The following represents directly or indirectly the role of farmer management aspects in different countries.

6.12.1 Irrigator Associantions in South-West France and Their Relations with C.A. C.G. R.,Lesbats, H. Tardieu, and M. Heritier (France)

Since the 70's, eighty-five 'self-managed' irrigator associations have been established where the irrigators are responsible for operating the irrigation project. This approach has reduced the need for subsidies. The Compagnie Amenagent Des Coteaux De Gascogne (CACG), a French Development Agency provides support to the Associations with a contract for management and maintenance.

With 25 years of experience, the success of 'participatory water management approach is based on:

1. Each association has a high sense of responsibilities and operate democratically
2. The CACG takes on the 'investment phase' by direct management of the project.
3. Clear responsibilities are written into the maintenance and monitoring contracts between CACG and the Associations.

The CACG has adopted 'self-management without abandonment' practice by transferring responsibilities to the association that fits their size and capability.

6.12.2 Operation and Maintenance of Irrigation System and Strengthening of Farmer's Organization, E. Hoshine (Japan)

In 1970, the Union Nasunogahara Land Improvement Districts of 10 irrigation districts was established to communally operate and maintain common facilities constructed in the project. Allotment for operation and maintenance responsibilities and costs were agreed between the irrigation districts and the Union. An elected committee structure was established in which each subcommittee had a specified role along with responsibilities. Training was also provided by the Union to transfer the necessary technical skills associated with operation and maintenance of the irrigation facilities. In 1993, a Farming promotion committee was established to promote irrigated agriculture, land improvement, and stabilizing farm management practices.

Committee members must have the consent of the family, especially the wives. Women play an active role in educative seminars, as clerks in the district offices and in the operation and maintenance activities.

Key elements that contribute to the success of the association are that of keeping a positive spirit, self confidence, pride, strong grass roots leadership, idealistic vision, a supportive organization and above all a strong sense of communication.

6.12.3 Sustainability of Three Types of Small Scale Irrigation Improvements in Nepal, K. R. Sharma (Nepal)

The farmer managed irrigation systems (FMIS) operated below their potential due to physical and institutional deficiencies. The introduction of a participatory approach to the design and construction was instrumental to ensure sustainability. With the formation of WUA s the ultimate success was dependent on the implementing agency's management acceptance of fully tested processes and procedures involving farmers. Long term training, monitoring and evaluation is also required. It was necessary to be careful toward contracts to farmers that were profit orientated. A thorough understanding between beneficiaries and their WUA's was required. Operational plans required farmer input. For long term sustainability, farm groups need to be integrated with their activities for their social life. Based on the lesson learned it is recommended:

1. Training areas need to be identified to ensure sustainability;
2. Programs need to be demand driven;

3. Identify experienced farmers and secure their active participation
4. Use local skills, technologies and resources that could be maintained and operated by local farmers
5. Use a cost sharing approach to encourage local ownership
6. Agency staff should work with farmers in the field;
7. Co-ordinate agricultural development with sister agencies to increase and sustain production.

6.12.4 Farmers Participation to the Sustainable Irrigated Agriculture: Legal, Soico-Economic Technical and Managerial Aspects. Attar Haj (Morocco)

The elements of the sustainable development strategy are found in the International Action Program "Water and Sustainable Agriculture Development" by FAO in 1991. A critical analysis of the sustainable irrigation strategy in Morocco emphasizing the strength and weakness of the strategy indicates:

- There are positive benefits to have an infrastructure and management based on a hydrological basins.
- The gaps in the strategy are the need for modern irrigation technology, land and water management to improve productivity and prevent water pollution.

Proposals have been formulated to ensure sustainable development within a framework of a sustained concerted action that includes:

- Improvement in the operation and maintenance
- More emphasis placed on small and medium-sized hydrologic units;
- And improved environmental protection of land and water.

Within an institutional framework, there is a need to:

- Improve cultural practices, education and agronomic research;
- Increase user participation in operational maintenance and water allocation and equipment maintenance;
- Adopt legal interventions such as political, economic and government;

- Support professional organizations and associations dedicated to a more productive and competitive agriculture.

6.12.5 Sustainable Irrigated Agriculture: The Role of Farmers Participation in Egypt,Y. A. Aziz (Egypt)

Improvement of irrigation system performance is not only achieved by technical interventions, but, more importantly by a reformation of institutional framework that determines the effectiveness and efficiency of system operation and maintenance. Enhancing farmer's participation in the O& M of the irrigation system is now an adopted policy in Egypt. Eight key lessons learned are:

1. Effective WUA development ensuring full sustainability, requires a long time horizon and continuing top-level commitment of Government.
2. WUA's, whose size and structure is based on hydrological features should focus only on water issues and not made into a multi-purposes organization;
3. A flexible learning process and approach adapted to local conditions is ESSENTIAL;
4. Human resource development and communication from the farm to the top-level government ministry is required. Training of all parties should be a continual programme;
5. Staff on the Irrigation Advisory Service must be motivated and professionally qualified and should include women;
6. WUA training should focus on leadership and other specialty skills (i.e. new technologies, finances, record keeping, farm management, etc) as required;
7. On-farm water management programs should be implemented as soon as micro-system improvements are made;
8. Monitoring and evaluation is required to continually improve the WUA development process.

6.13 COMPARATIVE STUDY OF INVOLVEMENT OF MAN AND WOMEN IN SRI LANKA & NEPAL

Table 6.3

The table below shows the involvement of women in the cultivation practice in both the countries.

Gender division of tasks in irrigation in Sri Lanka and Nepal

Rice Cultivation	Sri Lanka	Nepal
First irrigation	Women and men	Mostly men
Ploughing	Men only	Men only
Cleaning bunds	Women an men	Women and men
Building bunds	Mostly men	Mostly men
Puddling	Men only	Men only
Levelling	Women and men	Mostly men
Making nurseries	Women and men	Mostly men
Irrigating seedlings	Women and men	Women and men
Fertilizing	Mostly men	Women and men
Transplanting	Mostly women	Mostly women
Manual weed control	Mostly women	Mostly women
Thinning and secondary transplanting	Mostly women	Mostly women
Irrigating	Women and men	Mostly women
Harvesting / bundling	Women and men	Women and men
Threshing	Men only	Men only
Transport	Women and men	Mostly men
Storage: straw	-	MENONLY
Storage: grain	Mostly women	Mostly women
Winnowing	Women and men	Women and men
Marketing	Mostly men	Mostly men
Other crops	**Sri Lanka (chili)**	**Nepal (wheat and maize)**
First irrigation	Women and men	Women and men
Land preparation	Women and men	Women and men
Bed preparation	Women and men	-
Sowing/nurseries	Mostly women	Men only (wheat) mostly women (maize)
Planting	Mostly women	-
Fertilizing	Mostly men	Mostly men (chemical fertilizer) women and men (manure)
Weeding	Mostly women	Mostly women
Irrigating	Women and men	Women and men
Harvesting	Mostly women	Women and men
Cleaning/storage	Mostly women	Mostly women
Marketing	Mostly men	Mostly men

6.14 WOMEN IN DEVELOPMENT

Women were always considered a working partner in agriculture. Project started works on women in development. Women have participated in farming activities since the beginning of time. Women in rural areas of the developing countries are generally responsible for productive activities and community work. Women participates in irrigation aspects, particularly, in land preparation, transplanting paddy, watering, weed removing, irrigating seedlings, fertilizing, harvesting and storage.

Thus there is role of women in the effective use of irrigation water management directly or indirectly as agricultural development. The major difference between the two genders is literacy. A sincere effort should be made to remove the illiteracy by providing free education to women. This will raise the socio-economic status of women, improve women's knowledge in agricultural technology, improve women's knowledge in-financial saving and marketing home made products.

The activities carried out from the project under the women in development programs includes the joint meeting of different group of women with project, training in irrigation management, agriculture, live stock, sanitation, women participation in WUA, training in gender awareness and literacy. This program has made the women more mobile then before and more active towards involvement in WUA committees and effective use of water.

The policies has been male domination in the society and the literacy has been a major constraint for women in achieving the above goal, so every village in the project area must be furnished with schools, at least up to middle standard.

CHAPTER – VII

DISCUSSION

7.1 GENERAL:

Irrigation plays an important role in agricultural development for which the irrigation water is obtained from variety of surface and ground water sources. The principle source of ground water are wells and springs. DTWS has been used for irrigation purposes in this study.

For centuries, farmers in Nepal have been developing the surface and ground water resources of the country for irrigated agriculture.

The ground water pumped directly from the tube wells, has been used for irrigation through the buried UPVC pipe system in BLGW Project. The cost of pumped water mainly depends upon the power tariffs, however, several factors like cost of construction of well, conveyance system, transmission line, road net work, well discharge, operation hours, layout of well, spacing between wells and command area also affect the pumping cost. The cost of tube well is shown as per table 2 annex 3

7.2 DISCUSSION OF RESULTS:

The present study includes the various strategies for efficient use of irrigation water in the BLGW project. An effort has been made with rotational irrigation system along with system management.

The stage I and II of the systems are organized and managed by the agency and later, the experience showed that the farmers, who are end users i.e. beneficiary, is the key man. They plays an important role in irrigation management. The stage III of the project then focused towards the farmer, who are the target group and are good source of first hand information as well as the adopter of technology in respect of irrigation management. They were therefore involved in the whole process, starting from project planning to implementation, operation and maintenance and management of the system.

The discussion aspects of the topic under the scope of study are as follows:

On farm development works and distribution of water

The project has constructed UPVC buried pipe distribution system upto the outlet point. Below the outlet, construction of field channel and its operation-maintenance is the responsibility of farmer. The on farm distribution is the construction of field channel, field drains, land shaping and leveling, consolidation of holdings and realignment etc. All these aspects can be better done with direct involvement of the beneficiaries. The irrigation policy of the country has also given emphasis on farmer participation for better management and efficient use of irrigation water. The project has already formed the WUA for each unit, but the field channels are yet to develop, without which the efficient distribution is not possible. So, the present water distribution practice in most cases, do not provide equal opportunity or assured supply of water. The poorly mentioned field channel should be properly strengthened.

Farmer participation

Farmer participation has old history in the irrigation development of Nepal. This has been studied in this report and discussed in chapter 6 as participatory irrigation management. For constructing and improving water course and achieving control over the water and timing at the field outlet, farmer needs to be organized to a group. So, the main lesson learned for implementation of stage III from previous developments of stage I & II in the project, was the need to promote and include farmer participation as an integral part of the project and the development of private service centres in the project area. The project has formed WUA of each tube well and in addition, 3 nos. regional co-ordinate committee and one no. central coordinate committee has been formed. All the tube wells has been handed over to respective WUA so that its management and O & M cost is borne by WUA.

For effective irrigation, farmers must have adequate knowledge about information of water requirements to crops, cropping patterns, rotational irrigation, time, frequency and method of irrigation. Project had provided trainings which cover the above subject matter as discussed in chapter 2.21.

In developing countries, more attention has been paid towards the development of irrigation resources but the problem of optimum use of irrigation water and its scientific management on the farmers field has not yet received due attention. However, it is most required for the effective use of irrigation water. The effective use, which avoids the wastage of water, has the following benefits.

i. Additional area may be brought under irrigation
ii. productivity may be increased
iii. water logging and salinity problems could be avoided.
iv. resolution of distribution problems may be quickly resolved.

Environmental impact:

The study has revealed that the drawdown of deep aquifer has no impact on the shallow aquifer, as the shallow and deep aquifers are unconnected. Water table at shallow aquifer may increase due to irrigation with DTWs, which may also cause the water logging. Drainage canals may be the proper solution for water logging problem.

Cropping pattern, intensity, crop diversification

Under full irrigation, the cropping intensity has found to reach about 201% from 138%. Efforts should be made to bring more area under high yielding varieties (HYV) of crops. The suitable cropping pattern should be suggested to give optimal returns to the farmer. Farmer should be convinced to grow more vegetables, fruits, pulses, oilseeds etc. The benefit from the project has been studied and recorded. The year round crop coverage in the entire area is also suggested. For this, different demonstrations in the farmers field is found to have conducted.

System operation, transportation and communications

The importance of operation and maintenance of the system and road networks should be highlighted to the farmers, be-cause the properly mentioned field channel carries water to the field with little losses.

Based on the study, various data and observations regarding the project has been collected, compared and analyzed in the previous chapters including the design of UPVC irrigation system.

In the study of tubewell irrigation in UP India, the average irrigated area per tube well is quite low, being 15 ha for kharif and 35 ha for rabi. This may be due to poor distribution system and poor management. The takeover of tubewell in UP is very limited, which is found to be only 45 nos,till May 1994. The main reason behind it is the farmer dissatisfaction on water distribution done by operator and levied water charge. Before the turnover of tube wells to cooperative society, proper distribution system had to be constructed, so that water distribution can be done in rotation unit.

Society will bear the O & M cost and in addition govt. will provide some contribution in the initial stage.

In the study of management of irrigation of Andhra Pradesh India. It is found that the act published for the above subject matter covers many aspects which is discussed in chapter 67. It is considered that the effective operation and maintenance as well as reliable water distribution is best possible thorough farmer's organization, which needs certain rules and regulations to operate the act. Management of irrigation system act, 1997 was published by the legislative assembly of the state of Andhra Pradesh and shall come into force as per notification. The act covers all the factors related to irrigation and water distribution. The state govt. may make further rules to carryout the purposes of this act. The act of Andhra Pradesh is thus found very effective. India having large irrigated area developed by irrigation system over a long period has also taken up providing involvement of water users in management of distribution system.

In the study of irrigation management in Spain it reveals that the rules and regulations for irrigation management are very well documented and actually followed. The principal control structures are only operated on the order of syndic. The water distribution of valancia is according to turn basis, in which each farmer take water he needs for the period before the next farmer is served. In low water and in drought period non priority farmers do not receive water.

The organization and distribution of well water or ground water is also similar to that of surface irrigation subscribes communities. For well water, the cost of running the pump and motors should be paid by every irrigator on the basis of water of consumed or hours of operation.

In the study of changing local patterns in Taiwanese irrigation system, there are significant changes in water control methods. The water control method called the "rotation irrigation" is adopted for rice crop. With the adoption of this method larger area could be irrigated without increasing the water supply. Research has conducted that rice plant could tolerate periods without water on its field and needs standing water of 3 to 15 cm during its growth cycle and in maturity period only. So, in the rest period other than growth and maturity period, the periodic applications of water is sufficient for the need of field. The technique involved is the careful timing of water application as the water demand of rice plant very according to different stages. The experience of Taiwan has shown that rice plant need less water standing on their field than had traditionally been thought desirable. This method of periodic application of water on rotation supply would result in water saving, however it might take more time to convince the farmer in similar area.

Rice is the dominant crop of the study area in Nepal. This method of periodic application of water which is sufficient for the need of field can be introduced in the BLGW Project command area, however it will requires more field demonstration work to convince the farmer. The basic feature of this new method is that there is no water layer above the soil surface in rice fields during the growing season of rice after the stage of recovering. This technique not only saves water and increase the rice yields, but also reduces soil and water pollution, improve soil aeration and reduce diseases. The adoption of this rotational irrigation method would not only result in water saving but also reduce the labor cost, reduce water thievery and ultimately reduce the operation cost.

Many issues observed in previous stages has been rectified in stage III. The turnover of all the tube wells has been completed and there are many benefits to farmer as well as government with completion of turnover of tube well to WUAs. There are some issues in the areas where the tube well discharge is less and the layout of system is defective. These are particularly the issues of stage I & II where participation was not considered earlier.

In the study of project area, no serious and major conflicts have come to notice, yet there are reports of some minor conflicts among farmers on water distributions issues, which is managed by WUA staff and project staff together.

The construction of the whole system and water delivery performance in the BLGWP is found satisfactory. Farmers have positive acceptance towards the system which has positive impact on hand over. The hand over, which is the foundation for effective irrigation management, is now in complete stage. This has increased the upkeeping of real sense of ownership towards their systems. The project has also generated the employment as well as side business like poultry, dairy etc.

The low utilization of tube wells are recorded. The reasons are unreliable power supply, frequent breakdown of tube wells and no demand from the farmer.

Theft of transformer and electric wires, were recorded in the initial stage, however this has been checked after the hand over of tube well to WUA.

Cropping intensities are found to be 249%, 186% and 160% for small, medium and large farmer respectively with project.

On some of the tubewells covering part command, the water distribution is done on the basis of rotation unit. The irrigation scheduling is one of the key factors for improving the management of the irrigation system. The efficient use of water requires scheduling deliveries and rotation between the outlets. The technical know-how is required to prepare such schedules, which, the project must disseminate to all WUG members through different management training program. Efforts should be made to equalize demands among loops. The WUA chairmen is responsible for distribution of water, which is done as per the turn.

A thorough review towards the number of pumping hour should be conducted because in the present situation, the failure of power supply has become the general cause for low utilization of tube wells. This situation of power supply may be improved in future on priority basis and in such a condition the management must provide sufficient staff to operate the pump continuously together with proper maintenance of the pumps. The accountability of the management after the improved situation of power supply must be preciously defined and good work is to be recognized and must be encouraged, for improved efficiency in operation and maintenance of the project.

RECOMMANDATIONS

Based on the objectives of the present study, the following recommendations are made.

Project engineering infra structures and management

- The UPVC distribution network is highly technical and may be adopted as discussed in chapter v.
- UPVC pipes are suggested for further use of such work, because it is easy for laying, it is light, slightly flexible and can be made of simple joints.
- The maintenance of all infra structures including leakage in network should be done in time, inspect act and improve should be the philosophy of maintenance.
- The tubewell water is very costly, so to minimize the seepage loss and loss through rat holes, it is recommended for lining of at least 40 to 50% of initial trunk length of the water course. It will increase the efficiency and will also provide the control over damages that could be made by men and animals.
- Irrigation should be done through field channel. The field channels should be made free from vegetation and properly maintained to minimize seepage losses.
- Inadequate maintenance may cause heavy losses. So, the farmer be trained for this by awakening and by the extension technology to take better care of field channel and ensure better use of water. The water distribution should be done in rotation basis. Proper schedule of distribution as in warabandi in Indian canals should be encouraged.
- There must be adequate private service centers for maintenance and repair requirements. The technical capabilities of service centre should be reviewed in the initial stage of establishment of those facilities. Such services is quite effective, efficient and well suits to the farmers in tubewell irrigated commands in India.

Cropping Pattern, Production and Training:

- The recommended cropping pattern discussed in 2.18, should be encouraged by extension technology. The production has been found to be increased as per the recommended cropping pattern Table 6 and Annex.2.
- Training to farmer should be continued which provide knowledge about the new technology; optimal use of water and ultimately leading to higher yields and increased income.

- The cropping pattern be revised frequently to examine the response of farmers and suggest suitable changes normally farmers are quite response on this aspects.

Others:

- Power supply schedules should be fixed. Measure should be taken to increase the operation hours of pumps. Certain teriff incentives should be offered when there is off peak use of power. WUA be advised to keep a record of status of power supply and major breakdown and time taken to restore. This be also received and half-yearly report be sent,to correspond agency for further improvement.
- In Spain, where the management is quite well established and in practice for the last many centuries, the rules required for good and efficient management have been imbibed on their social traditions, the improvement can be recorded as follows:

i) As pure water by nature is colourless, so no colour of political or otherwise be added in its management.

ii) The syndic (President of WUA or Community) specially fed highly responsible to ensure that rules and regulations distribution of water by official are religiously followed and no body should at all think of or try to take share of others.

iii) The resolution of disputes and actions on any activity for wastage of water or creating obstruction in its distribution is specially very simple, effective and unique that is water court which are managed by farmers of dignity and high regard and can be tried in all communities just like traditional village panchayat in India, existing in some area even these days but were very popular and effective before establishment of British System of judiciary in India.

- In the study of farmer organization and water management of Andhra Pradesh it is found that an effective role in management and maintenance has been given to farmer organization. The WUA are given sufficient financial, legal support for good management. To start with WUA are not directly involved in water charge collection, because it may create unnecessary feeling and burden to WUA executives. So, they only assist the revenue dept. for this work. The success of WUAs management in Andhra Pradesh is because of the strong legal support and clear objectives in the irrigation system act provided by the state government. Once the system is established and users really feel responsible to make it the success, the financial responsibility may also be given for WUAs. As being practiced in so many countries.

APPENDICES

Number and Area Covered Under Different GW Systems by District

Table 1. Annex 1

DISTRICT	STW		DUGWELL		ARTESIAN		MTW		DTW		TOTAL	
	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Jhapa	3254	12980	426	1704	0	0	0	0	10	188	3690	14872
Morang	3702	14692	49	186	0	0	0	0	4	200	3755	15078
Sunsari	4242	16988	8	32	0	0	0	0	1	50	4251	17070
Saptari	972	2406	52	206	1	2	0	0	3	82	1028	2696
Siraha	1455	5238	86	337	0	0	0	0	30	889	1571	6464
Dhanusha	2377	3510	155	579	269	364	0	0	108	2950	2909	7403
Mahottari	1218	4683	76	286	347	672	26	793	21	840	1688	7274
Sarlahi	2627	10261	528	2074	2	4	0	0	32	1200	3189	13539
Rautahat	2652	6807	55	213	0	0	0	0	0	0	2707	7020
Bara	4517	19088	73	276	7	4	0	0	26	181	4623	19549
Parsa	673	2145	0	0	0	0	0	0	5	75	678	2220
Chitwan	450	1226	1470	5097	0	0	0	0	24	1400	1944	7723
Nawalparasi	1248	4445	329	1071	17	34	14	209	10	334	1618	6093
Rupendehi	3777	13686	115	418	72	114	0	0	176	12285	4140	26503
Kapilvastu	599	2402	32	125	4	5	26	380	20	518	681	3429
Dang	484	2010	660	1029	0	0	0	0	19	240	1163	3279
Banke	2387	7301	52	205	23	46	0	0	14	280	2476	7832
Bardia	1953	6577	10	40	1	2	0	0	12	400	1976	7019
Kailali	4850	17252	3	12	25	22	0	0	55	1400	4933	18686
Kanchanpur	2461	8128	1	4	0	0	0	0	3	60	2465	8192
Total	45898	161825	4180	13894	768	12689	66	1382	573	23572	51485	201941

Source: Ground Water Development Board; 1999.
(G W)

TARGET AND ACHIEVEMENT OF 8TH FIVE YEAR PLAN POLICIES FOR GROUNDWATER DEVELOPMENT

Table 2 **Annex 1**

Sl. No.	Programme / project	Achievement before 8th Plan (ha)	Achievement of 8th Plan (ha)	Total upto 8th Plan (ha)
1.	DOI Total	395857	138245	534102
	i. Surface irrigation	(346444)	(130484)	476928
	ii. Groundwater irrigation	(49413)	(7761)	57174
2.	ADB/N	71545	68156	139701
	i. Surface irrigation	(11860)	(15694)	(27554)
	ii. Ground water irrigation	(59685)	(52462)	(112147)
	iii. Other (various programs)	25066	30669	55735
	Total	467402	206401	673803
3.	Irrigated land developed by farmer	3,81,814	-	381814
	iii. Surface irrigation	(357098)	-	(357098)
	iv. Groundwater irrigation	(24716)	-	(24716)
	Grand Total	8,49,216	2,06,401	10,55,617

Source : Final report on BLGWP, Prepared by CEDA, July, 2000.

Table 1

Mentally Precipitation at Bhairhawa Agri... Station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1971	24	24	0	NA	33	340	356	365	143	139	0	0	-
1972	0	34	1	0	0	115	365	NA	NA	NA	NA	NA	-
1973	23	1	48	8	116	344	316	287	550	199	0	0	1,898
1974	5	2	25	12	37	136	556	461	172	NA	0	5	-
1975	36	26	21	16	8	28	126	456	337	350	62	0	1,447
1976	6	28	0	3	65	388	435	537	245	12	0	0	1,620
1977	3	10	0	24	139	83	698	314	60	76	0	15	1,413
1978	10	33	57	3	12	342	625	115	404	13	5	8	1,637
1979	8	5	1	11	7	165	642	303	180	107	4	45	1,476
1980	1	5	9	2	154	480	336	443	344	28	0	1	1,753
1981	76	3	19	58	65	450	763	375	529	0	34	0	2,377
1982	14	7	56	37	31	238	554	305	484	30	10	10	1,778
1983	25	0	11	27	NA	NA	NA	NA	269	178	0	27	-
1984	15	5	1	5	43	1,035	696	200	356	60	0	26	2,352
1985	12	9	0	22	59	158	537	298	402	174	0	30	1,701
1986	2	26	0	68	88	271	383	317	448	113	21	61	1,798
1987	2	6	19	74	19	78	573	428	264	117	0	9	1,589
Mean	14	12	16	23	55	291	513	332	326	87	5	15	1,755

Additional annual values

1988	2,217
1989	1,992
1990	2,089
1991	1,298
1992	1,305
Average	1,761

Source : BLWGP, Environmental Assessment Study, Tahal Consulting Engg. Ltd. Nov. 1993

ANNEXURE - 2

Table 2

BHAIRAWA LUMBINBI GROUNDWATER IRRIGATIN III PROJECT

Cropping Patterns

	Present and Future without			Future with		
Kharif	Small Farm (0.8 ha)	Medium Farm (2.1 ha)	Large Farm (5 ha)	Small Farm (0.8 ha)	Medium Farm (2.1 ha)	Large Farm (5ha)
Paddy, Local	0.78	1.68	3.75		0.11	0.35
Paddy, HYV		0.11	0.25	0.78	1.85	4.35
Pulses	0.02	0.06	0.15		0.06	0.15
Vegetables				0.02	0.02	0.05
	--------	--------	------	-------	-------	------
	0.80	1.86	4.15	0.80	2.04	4.90
Rabi						
Wheat	0.32	0.50	1.00	0.27	0.65	1.35
Maize				0.08	0.15	0.15
Gram		0.06	0.15	0.12	0.27	0.25
Mustard	0.10	0.19	0.30	0.12	0.34	0.80
Potatoes				0.08	0.08	0.15
	-----	-----	-------	-------	-------	------
	0.42	0.75	1.45	0.72	1.55	2.80
Hot						
Paddy, HYV				0.05	0.13	
Maize				0.18	0.08	0.08
Gram				0.10	0.10	0.12
Vegetables				0.14	0.09	0.10
	-----	------	-------	------	-------	-----
	0	0	0	0.47	0.40	0.30
Total	1.22	2.60	5.60	1.99	3.99	8.00
Cropping Intensity (X)	153	124	112	249	186	160
Landholding						
	Holdings	Area				
Small Farmers	52%	16%				
Medium Farmers	35%	45%				
Large Farmers	13%	39%				

Source : Staff Appraisal Report BLGWP, May 1990

BHAIRAWA LUMBINI GROUND WATER PROJECT
Stage III area
FY 1997/98 (2054/55)

Table 3 Annex 2

Cropping Intensity (%) for Stage III areas - FY 1997/98 (2054/55)

Season / Crop	Irrigated Area		Partly Irrigated Area		Unirrigated Area		Average of All	
Area interviewed	3009		3093		3119		9221	
No. Tubewells	25		27		26		78	
Area distribution	ha	%	ha	%	ha	%	ha	%
Kharif								
Paddy (Local)	160.0	5.3%	310.8	10.1%	553.9	17.8%	1,024.8	11.1%
Paddy (HYV)	2,731.0	90.8%	2,694.9	87.1%	2,464.9	79.0%	7,890.8	90.8%
Pulses	46.9	1.6%	25.7	0.8%	34.0	1.1%	106.6	1.6%
Vegetable and other	36.7	1.2%	7.6	0.2%	2.8	0.1%	47.1	1.2%
Sub- Total	**2,974.6**	**98.9%**	**3,039.1**	**98.3%**	**3,055.7**	**98.0%**	**9,069.4**	**104.7%**
Rabi (Winter)								
Wheat	1,590.9	52.9%	1,281.0	41.4%	1,018.0	32.6%	3,889.9	42.2%
Oilseeds	336.1	11.2%	227.0	7.3%	78.5	2.5%	641.6	7.0%
Pulses	303.0	10.1%	203.0	6.6%	80.5	2.6%	586.5	6.4%
Vegetable and other	151.1	5.0%	37.1	1.2%	10.8	0.3%	199.0	2.2%
Potato	84.0	2.8%	26.5	0.9%	7.4	0.2%	117.9	1.3%
Maize	86.4	2.9%	28.8	0.9%	3.9	0.1%	119.1	1.3%
Sub- Total	**2,551.3**	**84.8%**	**1,803.4**	**58.3%**	**1,199.1**	**38.4%**	**5,553.9**	**60.2%**
Hot Season								
Maize	153.5	5.1%	62.2	2.0%	11.6	0.4%	227.2	2.5%
Pulses	144.4	4.8%	59.2	1.9%	12.0	0.4%	215.6	2.3%
Vegetable and other	182.9	6.1%	73.3	2.4%	24.7	0.8%	281.0	3.0%
Sunflower	37.0	1.2%	7.5	0.2%	0.5	0.02%	45.0	0.49%
Sub- Total	**517.8**	**17.2%**	**202.1**	**6.5%**	**48.8**	**1.6%**	**768.8**	**8.3%**
Cropping Intensity (%)		**200.9%**		**163.1%**		**138.0%**		**173.2%**

Source: Project Completion Report (PCR)
Tahal Consulting Engineers Ltd.,May 1999

SUMMARY OF TUBEWELLS

STAGE III

Table 4A Annex 2

-Eastern Part

S No	TW No	Stage	Location	Drilled	Size mm/mm	Depth (m)	Housing	Screen Length	S.W.L(M)	Free flow m	Tested Discharge	Drawdown	Sand Content	Design Q m³/hr	Drawdown	Sand Content	T m²/day	K m/day	Specific Capacity
1	CEW/01	III	S. Tikuligarh	1994/95	400/200	103.00	43.65	30.00	-0.85	-	450	7.24	0.10	300	3.48	0	6.892	229.73	62.15
2	CEW/02	III	Durganagar	1994/95	400/200	108.00	39.95	27.00	-0.18	-	450	4.89	1.00	300	2.58	0	7.272	269.33	92.02
3	CEW 03	III	Renara	1995/96	400/200	116.00	42.95	25.00	+1.25	150	400	4.89	1.21	300	3.29	0	9.362	374.48	81.80
4	CEW/04	III	Chinia	1995/96	400/200	117.00	42.95	25.00	+3.71	270	440	6.65	5.33	300	4.20	1	8.644	345.76	66.16
5	CEW/05	III	Amuwa/Raknaun	1995/96	350/200	122.90	46.95	23.00	+2.85	170	325	6.21	23.37	300	5.59	16	9.606	417.65	52.33
6	CEW/06	III	Gularnagar	1995/96	350/200	118.00	46.95	21.00	+4.21	415	455	4.80	8.80	300	2.64	0	11.087	527.95	94.79
7	CEW/07	III	Nagthan	1995/96	350/250	133.00	46.95	20.00	2.61	320	450	4.86	43.76	300	2.75	13	7.695	384.75	92.59
8	CEW/08	III	Bagdhura	1996/97	400/250	118.30	40.95	23.00	+1.07	72	450	3.99	1.50	300	2.29	0	13.433	584.00	121.71
9	CEW 09	III	Kanchibazaar	1996/97	400/250	128.00	40.95	22.00	+0.60	18	400	11.27	9.33	300	8.12	4	4.648	211.27	35.49
10	EW/1	III	Dhekawar	1993/94	400/250	134.00	48.95	32.00	-0.08	-	480	5.75	2.51	300	2.84	1	4.264	133.25	83.48
11	EW/2	III	Petbania	1993/94	400/250	146.00	48.95	28.00	+1.71	144	450	6.12	84.00	300	3.79	23	6.542	233.64	73.53
12	EW/3	III	Shiktanantola	1994/95	400/300	117.45	40.95	22.00	-1.44	-	400	5.38	47.80	300	3.53	12	4.670	212.27	74.35
13	EW/4	III	Rajabari	1993/94	400/250	148.00	48.95	29.00	-0.01	-	450	8.77	18.20	300	5.14	7	4.687	161.62	51.31
14	EW/5	III	Bhawarabari	1993/94	400/250	176.00	48.95	28.00	+0.29	15	480	6.99	20.20	300	3.73	3	3.482	124.36	68.67
15	EW/6	III	Birta	1993/94	400/250	135.73	48.95	29.00	+1.75	142	450	6.59	0.37	300	4.25	0	3.238	111.66	68.28
16	EW/7	III	Siktahan	1993/94	400/250	126.00	47.95	24.00	+2.25	218	450	4.30	0.23	300	2.83	0	11,858	494.08	104.65
17	EW/8	III	Baaranatola	1993/94	400/250	175.00	48.95	26.00	-0.02	-	450	10.15	7.80	300	5.92	2	1,890	72.69	44.33
18	EW/9	III	Kadmipur	1993/94	400/250	174.00	48.95	26.00	+1.41	15	350	21.29	58.15	300	17.51	8	1,144	72.69	16.44
19	EW/10	III	Knurhuria	1995/96	400/250	159.00	42.95	23.00	+3.49	50	350	21.84	70.24	300	17.81	59	700	30.43	16.02
20	EW/11	III	Laxmipur	1995/96	350/250	118.50	48.65	20.00	+5.44	250	360	10.08	20.91	300	7.82	59	3,224	161.20	35.713
21	EW/12	III	Pokharbhindi	1995/96	400/250	135.50	36.95	24.00	+0.60	-	350	14.55	37.49	300	11.79	26	445	18.50	24.05
22	EW/13	III	Patarka	1996/97	400/250	140.00	38.95	25.00	+2.08	24	350	17.50	43.83	300	14.56	24	659	26.36	20.00
23	EW/14	III	Arnuwa	1996/97	400/250	121.00	39.45	23.00	-0.52	-	400	14.15	36.75	300	9.48	21	1.260	54.78	28.26
24	EW/16	III	Janaura	1995/96	400/200	129.00	46.95	21.00	+4.98	140	350	11.20	252.00	300	9.30	48	3.609	171.85	31.25
25	EW/17	III	Patkhauli	1994/95	400/250	119.92	40.95	24.00	+0.71	27	450	9.71	1.16	300	5.41	1	2.817	117.37	46.34
26	EW/18	III	Shankarnagar	1993/94	400/250	125.00	46.95	27.00	+1.25	108	450	6.35	28.12	300	3.89	1	4.054	150.15	70.86
27	EW/19	III	Narayanpur	1993/94	400/250	169.00	47.95	26.00	+2.08	144	450	8.21	7.58	300	4.61	1	4.430	166.54	54.81
28	EW/20	III	Belhia	1995/96	400/200	130.60	46.75	20.00	+5.32	140	400	17.04	37.33	300	11.82	17	1.728	86.40	23.47
29	EW/22	III	Majhaulia	1993/94	400/250	174.80	47.95	27.00	+3.76	140	450	11.66	32.50	300	7.36	2	2.163	80.11	38.59
30	EW/23	III	Brindaban	1993/94	400/250	163.00	48.95	28.00	+2.01	72	300	35.85	1.18	300	35.35	1	380	12.66	8.36
31	EW/24	III	Betaulia	1993/94	400/250	166.60	48.95	27.00	+4.88	150	400	14.49	37.50	300	10.48	5	1.589	58.85	27.60
32	EW/25	III	Kushmanatola	1995/96	400/200	151.00	45.95	23.00	+3.48	170	400	9.95	80.53	300	6.95	24	2.470	107.39	40.20
33	EW/26	III	Jamuhani	1993/94	400/250	162.00	48.95	30.00	+4.21	150	400	13.71	1.08	300	10.12	0	2.600	85.67	29.17
34	EW/27	III	Lodhpurwa	1995/96	400/250	158.00	48.95	26.00	+3.80	220	425	6.46	5.83	300	3.93	1	9.513	365.88	65.79
35	EW/29	III	Tarami	1995/96	400/250	121.28	46.95	24.00	+3.67	275	470	7.52	110.00	300	4.22	10	6.633	276.37	62.5
36	EW/30	III	Bhelai	1995/96	400/300	96.50	40.95	20.00	+2.80	48	350	18.03	80.79	300	14.30	59	1.136	58.95	19.41
37	EW/31	III	Gauri	1995/96	400/300	118.60	40.95	19.00	+4.21	170	400	10.13	58.60	300	7.24	19	2.587	136.16	19.41
38	EW/32	III	Sishania	1995/96	400/250	167.10	45.90	19.00	+2.85	162	400	13.09	52.85	300	8.76	19	3.155	166.05	30.55
39	EW/34	III	Ramnagar	1994/95	400/250	119.00	40.95	23.00	+4.21	216	350	9.96	1.37	300	8.38	1	2.856	124.17	35.14
40	EW/35	III	Tarkullah	1994/96	400/300	121.40	40.95	19.00	+3.90	90	400	15.15	40.30	300	10.58	13	1.457	76.68	26.40
41	EW/36	III	Chainpurwa	1995/96	400/300	92.00	30.95	21.00	+2.86	54	300	20.31	24.00	300	20.31	24	640	30.48	14.77
42	EW/37	III	Kadmahawa	1994/95	400/300	113.00	40.95	20.00	+3.71	242	450	9.30	46.75	300	5.37	6	5.354	267.70	48.39
43	EW/38	III	Shapahi	1995/96	400/250	121.00	46.63	21.00	+3.26	150	400	9.39	141.00	300	6.11	48	6.167	293.66	42.60
44	EW/39	III	Pakdihawa	1995/96	400/250	159.00	48.95	19.00	+6.12	72	275	30.95	19.83	225	23.32	5	474	24.95	8.88

SUMMARY OF TUBEWELLS
Stage III

Table 4B Annex 2

Western Part

S No	Tubewell	Stage III	Location	Drilled	Size mm/mm	Total Depth	Pump housing	Length of Screen(m)	S.W.L. (m)	Free flow m³/hr	Tested Q m³/hr	Drawdown (m)	Sand Conten (ppm)	Design Q m³/hr	Drawdown (m)	Sand Content (ppm)	T m²/day	K m/day	Specific Capacity m³/hr/m
45	WW/01	III	Jharbaira	1992/93	400/250	139 00	40 95	22 00	+6 28	108	300	21 0	9 75	300	21.00	10	590	26.82	10.07
46	WW/28	III	Dhauthi	1992/93	350/200	135.00	40 71	12.00	+5.50	100	250	15.29	24.00	225	13.35	24	1978	94 19	16.35
47	WW/03	III	Ashidnawa	1992/93	400/250	166 80	40 49	18 00	+1 89	108	350	30 07	11.97	300	23.63	4	2103	116 83	11 64
48	WW/04	III	Shivapur	1992/93	400/250	129.00	41.90	19 00	+1.42	24	300	19 50	12 00	300	19.50	12	474	24.94	15.38
49	WW/05	III	Bangain	1992/93	400/250	129 00	40.95	17.00	-1 61	52	400	11.50	1 42	300	7 74	0	2231	131 23	34.78
50	WW/06	III	Bhujauli	1992/93	400/250	133 00	40.10	20 00	+3 80	40	230	40.79	10.75	150	23.21	9	326	16.30	5.64
51	WW/07	III	Bagmaradanda	1992/93	400/250	157.77	43.95	25.00	+0.95	30	300	9.25	2 67	300	9.25	3	1388	66.09	32 54
52	WW/08	III	Sandi	1991/92	400/250	167 50	43.95	20.00	+3.12	61	350	15.22	44.40	300	12.57	16	926	46 30	22.99
53	WW/09	III	N Nanauli	1991/92	350/250	125.77	36.75	17.00	-0.72	-	325	10.73	0.77	300	10.37	1	777	45.70	30 29
54	WW/10	III	Sitapur	1991/92	350/250	165.00	45 15	17.00	+2.57	158	328	14.73	3.55	300	13.69	4	1532	90.12	22.28
55	WW/11	III	S. Nanauli	1992/93	400/250	125 00	40.52	21 00	+0.94	72	350	13 42	34.00	300	10.40	11	1978	94 19	26.11
56	WW/12	III	Sarhawa	1991/92	350/200	124 00	34.52	21.00	+0.92	56	400	12.69	5.27	300	8 42	5	1276	60 76	31.52
57	WW/14	III	Semara	1991/92	350/200	124 00	29.95	15.00	-0 20	-	200	8.40	6.16	150	5.87	4	718	47 86	23.81
58	WW/15	III	N Kharenchawa	1991/92	400/250	124 00	37.79	16.00	+3.26	32	325	11.07	10.44	300	10.05	5	2447	152 90	29 35
59	WW/16	III	S Kharenchawa	1991/92	350/250	121.00	36 95	15.00	+3.68	72	300	14.68	20 20	300	14 68	20	1550	103 40	20 43
60	WW/18	III	Chamkia	1992/93	400/250	177 50	43.95	17.00	+1.75	9	300	15.83	5.62	300	15.83	6	807	47 47	18 95
61	WW/19	III	Parora	1992/93	400/250	162 75	46.68	17.00	+3 01	65	300	17.34	36 00	300	17.34	36	1259	74 06	17 36

Central West

S No.	Tubewell	Stage III	Location	Drilled	Size mm/mm	Total Depth	Pump housing	Length of Screen(m)	S.W.L. (m)	Free flow m³/hr	Tested Q m³/hr	Drawdown (m)	Sand Conten (ppm)	Design Q m³/hr	Drawdown (m)	Sand Content (ppm)	T m²/day	K m/day	Specific Capacity m³/hr/m
62	CW/01	III	S. Kanary	1994/95	400/250	116.00	40.95	22.00	+1.40	230	450	4.02	0 47	300	2.32	0	14981	680 95	111.94
63	CW/03	III	Jagatha	1994/95	400/250	116.20	40.95	22.00	+3.25	300	480	6.73	23.23	300	3 42	4	19575	889 77	71.32
64	CW/07	III	Laxmipur	1994/95	400/250	114.13	40.95	20.00	+2.20	120	350	21 80	28.88	300	15.70	37	1512	75 60	16.05
65	CW/11	III	Kaithaulia	1994/95	400/200	142.00	38.95	24.00	+6.35	305	480	11.54	52.57	300	6.39	15	8340	347 50	41.59
66	CW/12	III	Tilauria	1994/95	400/250	113.90	46.95	24.00	+8.99	210	450	19.51	46.86	300	12.02	10	4765	198 54	23.06
67	CW/15	III	Garsari	1993/94	400/250	120.70	48.95	30.00	+4 41	400	484	6.36	0.96	300	2.66	0	14569	485 63	76.10
68	CW/17	III	Kamharia	1994/95	400/200	161.52	48.95	27.00	+7.20	343	480	11.70	20 05	300	5.91	4	7593	281 22	41.02
69	CW/18	III	Kanauli	1996/97	400/250	133.23	40.95	23.00	+4.90	48	400	16.40	86.67	300	11.62	25	2010	87 40	24.39
70	CW/22	III	Subba Semara	1993/94	400/250	132.00	46.60	26.00	+5.61	325	450	9 11	16.25	300	5.85	0	15274	587 46	49 39
71	CW/27	III	Dhamsaar	1994/95	400/200	116.33	40.95	24.00	+3.68	120	350	13 95	0.28	300	11.33	0	4933	205.54	25.09
72	CW/28	III	Bareba	1995/96	350/250	148.54	40.95	22.00	+4.76	195	375	13.88	20 68	300	9.93	10	2584	117 45	27 02
73	CW/29	III	E. Krishnapur	1994/95	400/200	113.00	40.95	24.00	+2.85	120	444	19.08	78.40	300	11.55	48	2153	89 71	23 06
74	CW/30	III	W Krishnapur	1994/95	400/250	128 00	40.95	24.00	+7.75	360	480	11.64	0.91	300	5.67	0	15812	658 83	41.23
75	CW/31	III	Orlahawa	1994/95	400/250	126.00	40.95	23.00	+3.08	108	450	12.31	8.67	300	7.42	5	3692	160 52	36.55
76	CW/32	III	Parsauni	1994/95	400/250	120 00	40.95	24 00	+3.23	160	400	9 54	24 37	300	6.69	5	9827	409 46	41.93
77	CW/33	III	S Chhapia	1994/95	400/250	114 31	42.45	23.00	+4.16	108	400	16.85	96.42	300	11.55	21	4740	206 08	23 74
78	CW/34	III	Patharai	1995/96	400/250	119.00	40.95	20.00	+2.85	86	325	13.84	62.34	300	12 10	21	7231	361.55	22 48
79	CW/35	III	Tilandihawa	1996/97	400/250	144 00	40.95	18 00	+4.90	108	400	14 08	117.00	300	9 97	34	5090	282.77	28.41

Source: Project Completion Report (PCR)
Tahal Consulting Engineers Ltd., May 1999

		Drilled
Stage	I	64
Stage	II	38
Stage	III	79
Total		181

Table 5 Annex 2

Table Activities of FOD (Farmers' Organization Division 1991/92-1998/99

Stage III

	Description		1991/92	1992/93	1993/9	1994/95	1995/96	1996/9	1997/98	1998/99
1	Training of AOs	No	4	6	6	6	6	6	6	6
		Days	10	16	4	4	4	4	4	2
		MD	40	96	24	24	24	24	24	12
2	Gen. Meetings of WUG at tubewells	No	4	19	21	18	19	19	25	50
		Days	3	5	6	6	7	7	5	3
		MD	12	95	126	108	133	133	125	150
3	Training of WUG Chairmen	No	0	0	0	16	32	46	77	77
		Days	0	0	0	2	2	3	3	3
		MD	0	0	0	32	64	138	231	231
4	Training of WUG Operators	No	0	0	0	16	16	36	75	77
		Days	0	0	0	3	3	3	4	4
		MD	0	0	0	48	48	108	300	308
5	Study Tours of WUG Chairmen and AOs	No	0	0	0	0	6	12	12	14
		Days	0	0	0	0	7	7	7	6
		MD	0	0	0	0	42	84	84	84
6	Gen. Meetings of WUGs at Wells for handing over	No	0	0	0	0	16	36	75	77
		Days	0	0	0	0	1	1	1	1
		MD	0	0	0	0	16	36	75	77
7	Supervison/Repair Committees org. by WUGs	No	0	0	0	0	0	0	77	0
		Days	0	0	0	0	0	0	0	0
		MD	0	0	0	0	0	0	0	0
8	Mobilization of WUGs for Construction	No of units	0	1	15	15	20	19	7	0
			0	0	0	0	0	0	0	0

Table 6
Production Values (NRs/ha) for Stage III areas-1997/98 (2054/55)

Season/Crop	Price NRs/ kg/*	Irrigated area			Partly irrigated area			Unirrigated Area		
		%	t/ha	NRs	%	t/ha	NRs	%	t/ha	NRs
Paddy (Local)	8.0	5.3%	2.4	1,0196	10.1%	2.1	1,686.3	17.8%	1.8	2,554.2
Paddy (HYV)	10.0	90.8%	3.4	30,495.4	87.1%	2.9	25,616.2	79.0%	2.4	18,651.1
Pulses	46.0	1.6%	1.2	861.4	0.8%	0.9	336.5	1.1%	0.7	341.0
Vegetables etc.	14.2	1.2%	16.8	2,900.2	0.2%	14.1	490.8	0.1%	10.8	137.5
Sub-Total		98.9%		35,276.5	98.3%		28,129.8	98.0%		21,683.9
Rabi (Winter)										
Wheat	11.0	52.9	2.8	16,225.8	41.4%	2.4	11,070.5	32.6%	2.1	7,683.2
Oilseeds	27.2	11.2	0.7	2,126.8	7.3%	0.5	1,0118.1	2.5%	0.4	273.8
Pulses	46.0	10.1%	0.8	3,799.4	6.6%	0.6	1,811.9	2.6%	0.5	593.8
Vegetables etc.	14.2	5.0%	15.8	11,223.2	1.2%	11.7	1,988.3	0.3%	10.1	495.9
Potatoes	10.7	2.8%	13.2	3,940.6	0.9%	8.4	766.2	0.2%	6.6	167.9
Maize	11.5	2.9%	2.6	861.4	0.9%	2.2	238.8	0.1%	2.0	28.3
Sub-Total		84.8%		38,177,2	58,3%		16,893.8	48.4%		9,243.0
Hot season										
Maize	11.5	5.1%	2.6	1,530.8	2.0%	2.3	538.6	0.4%	2.0	87.3
Pulses	46.0	4.8%	0.9	1,899.4	1.9%	0.7	607.7	0.4%	0.6	108.1
Vegetable and other	14.2	6.1%	13.1	11,270.2	2.4%	10.6	3,553.3	0.8%	7.9	890.9
Sunflower	30.0	1.2%	0.9	332.1	0.2%	0.8	57.4	0.0%	0.7	3.2
Sub-Total		17.2%		15,032.5	6.5%		4,756.9	1.6%		1,089.4
Production value (NRs/ha)				88,486.2			49,780.4			33,016.3

* Average for the period July 1998 – March 1999, based on retails price in local markets Bhairawa and Butwal.

1. Average for black gram, arahar, mung beans and lentil.

Source : Project Completion Report, Tahal Consulting Engg. Ltd. May 1999

F.Y. 1999-2000 (056 / 57)
Stage III East Area
Pumping hour at diff. Months
Sub center Birta

Table 1 Annex 3

S. No.	TW No	Location	Area (ha)	Srawan	Bhadra	Asoj	Kartik	Mansir	Paush	Magh	Phalgun	Chaitra	Baishakh	Jesth	Ashad	Total Pumping hr	Total Artusan hr.
1	EW/01	Dhekawar		-	-	-	-	46.00	107.00	-	11.00	95.00	45.00	44.00	79.00	427.00	-
2	EW/02	Petbaniya		-	-	-	-	23.00	40.00	14.00		126.00	12.00	27.00	69.00	329.00	
3	EW/04	Rajabri		-	-	-	-		63.00	8.00		27.00	54.00	14.00	5.00	176.00	-
4	EW/05	Bhanwarabari		-	-	-	-		59.00	7.00		20.00	20.00	20.00	4.00	146.00	-
5	EW/06	Birta		-	-	-	-	27.00	124.00	-		11.00	14.00	14.00	12.00	214.00	-
6	EW/07	Siktahan		-	-	-	-	-	53.00	-		-	-	-	-	53.00	-
7	EW/08	Barsaha Tola		-	-	-	-	49.00	56.00	-		12.00	7.00	18.00	16.00	164.00	-
8	EW/09	Kadmipur		-	-	-	-	43.00	81.00	3.00		-	-	-	-	127.00	-
9	EW/10	Khurhuriya		-	-	-	-	-	185.00	-		-	-	-	-	185.00	-
10	EW/11	Laxminagar		-	-	-	-	-	-	-		-	-	-	-	0.00	-
11	EW/12	Pokharbjindi		-	-	-	-	-	140.00	-		-	-	-	-	140.00	-
12	EW/13	Pajarkatti		-	-	-	-	29.00	167.00	-		-	-	-	-	196.00	-
13	EW/14	Amuwa		-	-	-	30.00	-	184.00	18.00		8.00	-	-	--	244.00	-
14	EW/16	Janaura		-	-	-	-	-	99.00	-		-	-	-	-	99.00	-
15	EW/17	Patkhauli		-	-	-	-	-	100.00	-		-	-	-	-	100.00	-
16	EW/18	Shankarpur		-	-	-	-	21.00	107.00	-		6.00	6.00	-	-	142.00	-
17	EW/19	Narayanpur		-	-	-	-	70.00	137.00	-		-	-	2.00	7.00	216.00	-
18	EW/20	Belahiya		-	-	-	-	-	41.00	-		-	-	-	-	41.00	-
19	EW/22	Majhauli		-	-	-	-	-	40.00	-		-	-	-	-	40.00	-
20	EW/23	Brindawan		-	-	-	-	22.00	97.00	-		-	-	-	-	119.00	-
21	EW/24	Betauliya		-	-	-	-	-	43.00	-		-	-	-	-	43.00	-
22	EW/25	Kushmahatola		-	-	-	-	-	66.00	-		-	-	-	-	161.00	-
23	EW/26	Jamuhani		-	-	-	-	-	4.00	-		-	-	-	-	4.00	-
24	EW/27	Lodhpurwa		-	-	-	-	-	40.00	-		-	-	-	-	40.00	-
25	EW/29	Taraini		-	-	-	-	-	34.00	-		-	-	-	-	34.00	-
26	EW/30	Bhelai		-	-	-	-	-	319.00	68.00		-	-	-	-	387.00	-
27	EW/31	Gauri		-	-	-	-	-	90.00	-		-	-	-	-	90.00	-
28	EW/32	Sishniya		-	-	-	-	-	-	-		-	-	-	-	0.00	-
29	EW/334	Ramnagar		-	-	-	-	-	67.00	-		-	-	-	-	67.00	-
30	EW/35	Tarkuliah		-	-	-	-	-	64.00	-		-	-	-	-	64.00	-
31	EW/36	Chainpur		-	-	-	-	-	78.00	-		-	-	-	-	78.00	-
32	EW/37	Kadmahawa		-	-	-	-	-	13.00	-		-	-	-	-	13.00	-
33	EW/38	Sapahi		-	-	-	-	-	-	-		-	-	-	-	0.00	-
34	EW/39	Pakdihawa		-	-	-	9.00	180.00	106.00	-		-	-		-	295.00	-
35	EW/50	Siktahan Tola		-	-	-			58.00	-		18.00	24.00	9.00	-	109.00	-
		Total	0	0.00	0.00	0.00	39.00	510.00	2862.00	169.00		323.00	182.00	148.00	192.00		-

BHAIRAWA LUMBINI GROUNDWATER IRRIGATION III PROJECT
120 Ha Tubewell Cost Summary

Table 2 Annex 3

	Base Cost (NRs , 000)	Physical Cont. (Z)	Cost + Cont. (NRs, 000)
Preliminary (survey & Design)	85	0	85.0
Land (include. Roads/ drainage)	69	10	75.9
Well Materials	341	10	375.1
Well construction	250	10	275.1
Well Developing and Testing	119	10	130.0
Pump Unit	706	5	741.3
Pump Unit Spares (15%)	106	5	111
Pump Unit Installation	103	5	108.2
Artesian Sealing	56	2	57.1
Pump House	165	2	57
Steel Pipe (250mm)	170	2	173.4
Control Chamber	214	2	218.3
Pipeline Installation	223	10	245.3
Alfalfa Valves	49	2	50.0
Construction of Outlets	116	2	169.3
Surge Risers	42	2	42.8
Unit Drain Earthwork	35	15	40.3
Unit Drain Structure	9	15	10.4
Main/secondary Drain Earthwork	110	10	121.0
Main/secondary Drain Structure	27	10	29.7
Main/secondary Drain Structure	27	10	29.7
L.T. Connection Material	18	0	18.0
L.T. Connection work	25	0	25.0
Transformer33/0.4 kv.	125	0	125
Erection to Transformer	10	0	10.0
Drinking Water Connection	40	10	44.0
Field Channels	110	10	121.0
Engineering and Admin. (7.5%)	319		340.2
Total On-site Cost	4,560		4,876.0
Total per Hectare			NRs 40,636
Infrastructure			
Proportion of 33 kv Line	416	5	436.8
Proportion of Access Roads	1,643	10	1,807.3
Total Infrastructure	2,059		2,244
Total per Hectare + Infr.			NRs 59,337

Source: SAR, May 7. 1990 BLGWP.

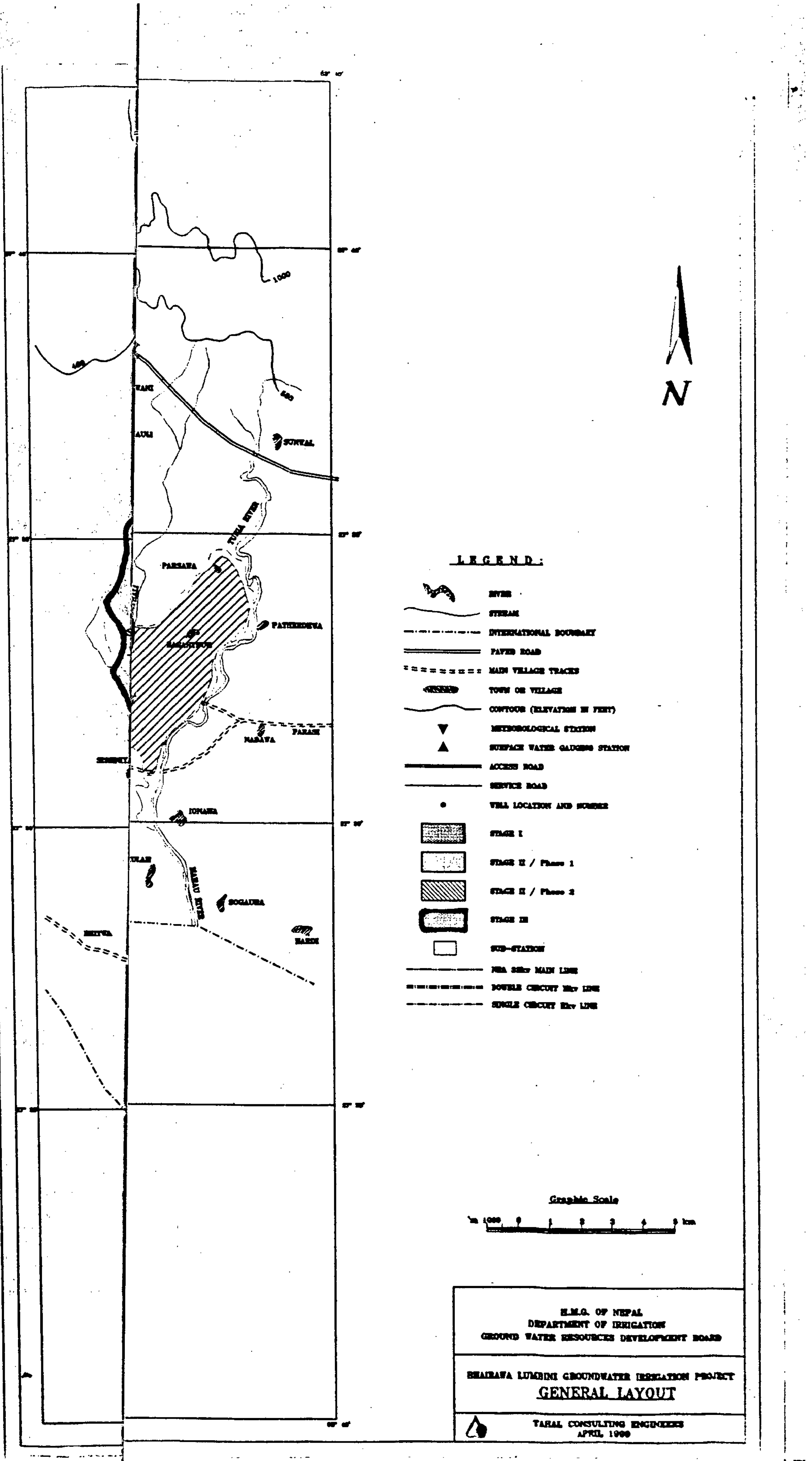
ANNEX : PRICES

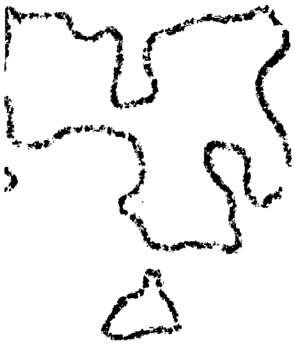
Table3 Annex 3

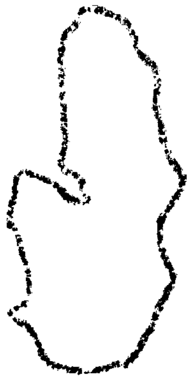
Prices	Unit	Value
Crop */		
Paddy (Local)	NRs/kg	8.0
Paddy (HYV)	NRs/kg	10.0
Pulses /1	NRs/kg	46.0
Vegetables	NRs/kg	14.2
Wheat	NRs/kg	11.0
Oilseeds	NRs/kg	27.2
Potatoes	NRs/kg	10.7
Maize	NRs/kg	11.5
Sunflower	NRs/kg	30.0
Farm Inputs		
Seeds		
Paddy (Local)	NRs/kg	8.5
Paddy (HYV)	NRs/kg	12.9
Pulses	NRs/kg	121.9
Vegetables	NRs/kg	604.2
Wheat	NRs/kg	12.9
Oilseeds	NRs/kg	58.5
Potatoes	NRs/kg	23.4
Maize	NRs/kg	13.9
Sunflower	NRs/kg	22.8
Fertilizers		
DAP	NRs/kg	18.6
Urea	NRs/kg	7.4
Murate of Potash	NRs/kg	9.4
Farm Manure	NRs/qtls	30.0
Labor		
Human	NRs/MD	55.0
Animal	NRs/AD	110.0
Other		
Land Revenue	NRs/ha	40.0
Energy	kw/h	2.50

*: Average for the period July 98 – March 99, based on retail prices in local markets, Bhairawa and Butwal.

1 Average for black gram, arahar, mung beans and lentil.


LEGEND:
RIVER
STREAM
INTERNATIONAL BOUNDARY
PAVED ROAD
MAIN VILLAGE TRACKS
TOWN OR VILLAGE
CONTOUR (ELEVATION IN FEET)
METEOROLOGICAL STATION
SURFACE WATER GAUGING STATION
ACCESS ROAD
SERVICE ROAD
WELL LOCATION AND NUMBER
STAGE I
STAGE II / Phase 1
STAGE II / Phase 2
STAGE III
SUB-STATION
Graphic Scale
0 1 2 3 4 5 km
H.M.G. OF NEPAL
DEPARTMENT OF IRRIGATION
GROUND WATER RESOURCES DEVELOPMENT BOARD
BHAIRAWA LUMBINI GROUNDWATER IRRIGATION PROJECT
GENERAL LAYOUT
TAHAL CONSULTING ENGINEERS





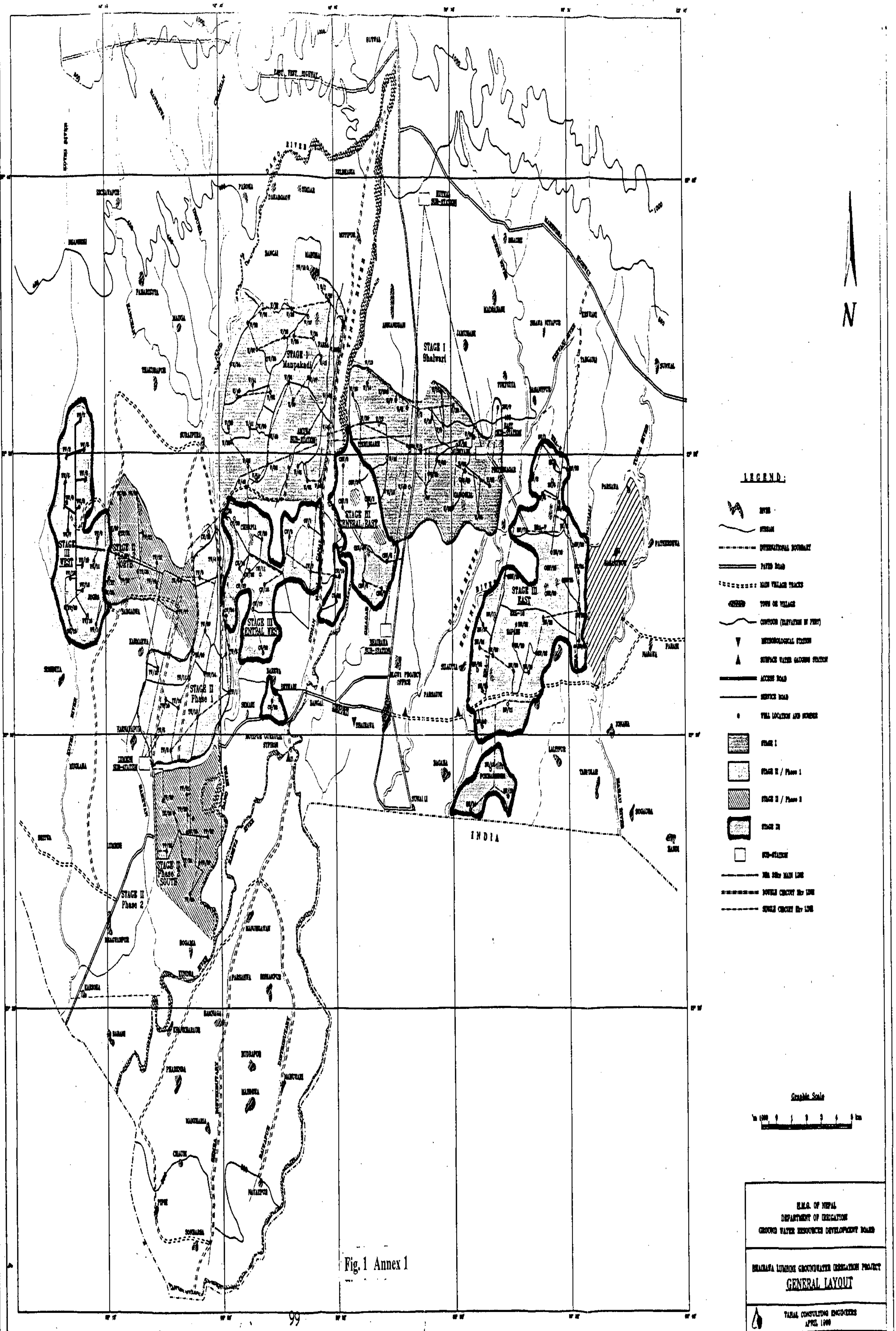

STAGE I
Manpakadi
STAGE I
Bhalvari
STAGE III
WEST
STAGE II
NORTH
STAGE III
CENTRAL EAST
STAGE III
CENTRAL WEST
STAGE III
EAST
STAGE II
Phase 1
STAGE II
Phase 2
STAGE II
Phase 2
SOUTH
INDIA
N
LEGEND:
Graphic Scale
GENERAL LAYOUT

Fig. 1 Annex 1

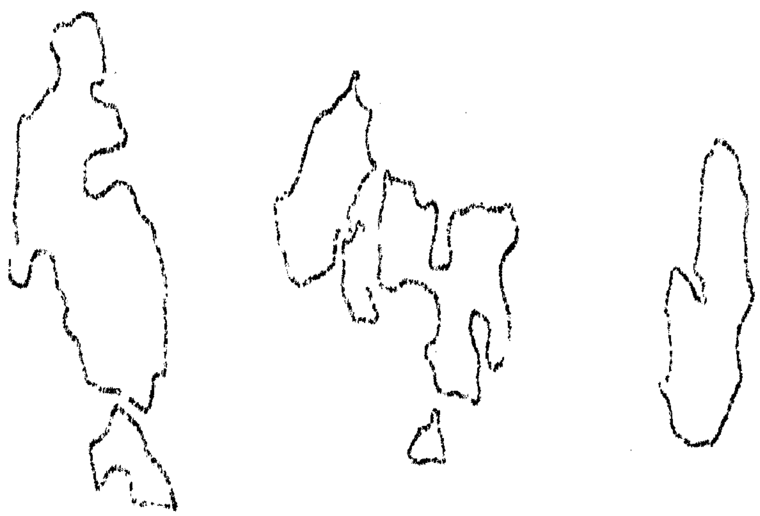
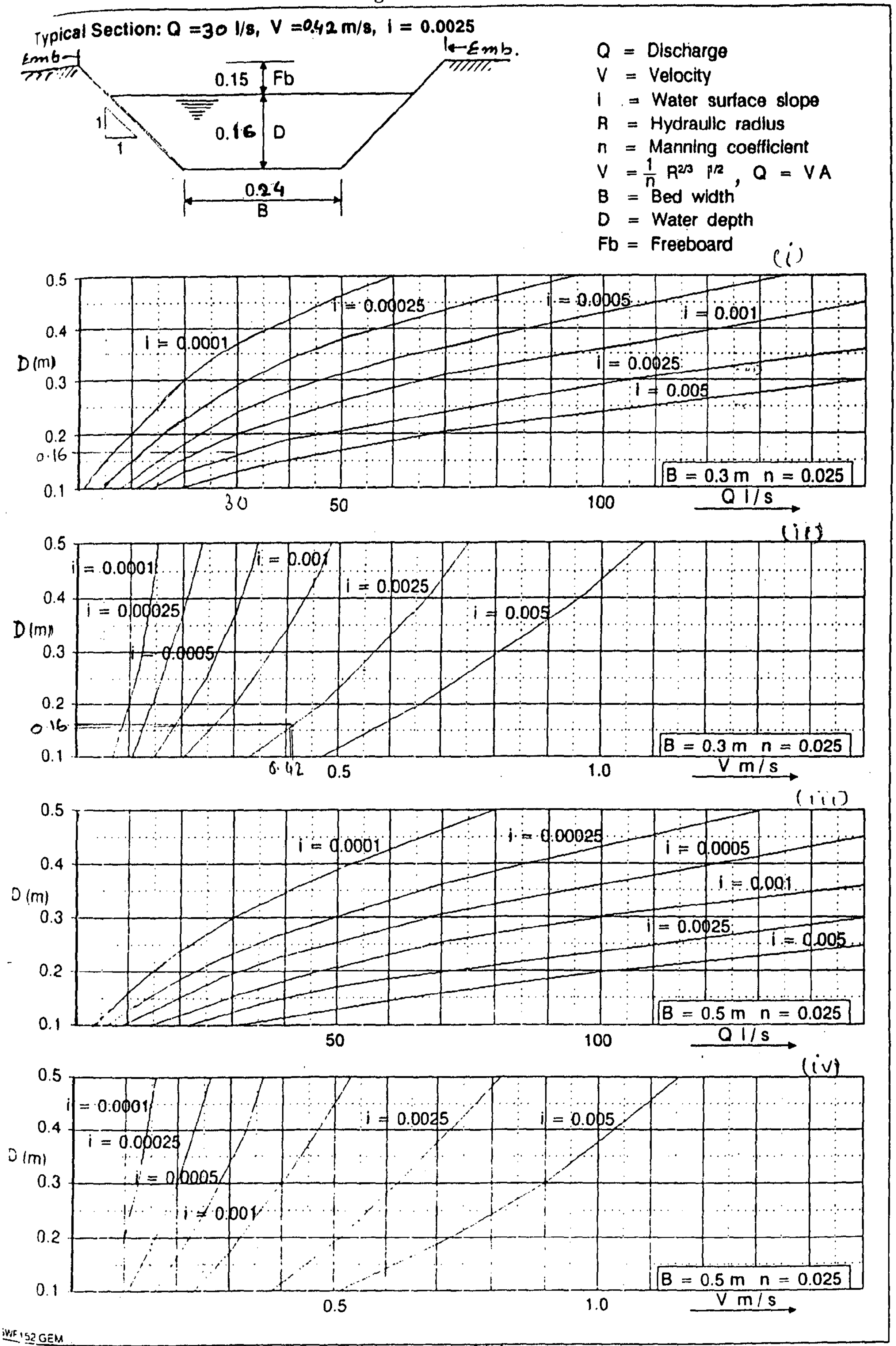


Fig. 2 Annex 1


Typical Section: Q =30 l/s, V =0.42 m/s, i = 0.0025
Emb.
Emb.
0.15 Fb
0.16 D
0.24
B
Q = Discharge
V = Velocity
i = Water surface slope
R = Hydraulic radius
n = Manning coefficient
V = 1/n R^2/3 i^1/2 , Q = VA
B = Bed width
D = Water depth
Fb = Freeboard
(i)
D (m)
i = 0.0001
i = 0.00025
i = 0.0005
i = 0.001
i = 0.0025
i = 0.005
B = 0.3 m n = 0.025
Q l/s
(ii)
V m/s
B = 0.3 m n = 0.025
(iii)
B = 0.5 m n = 0.025
Q l/s
(iv)
B = 0.5 m n = 0.025
V m/s
IWF 152 GEM

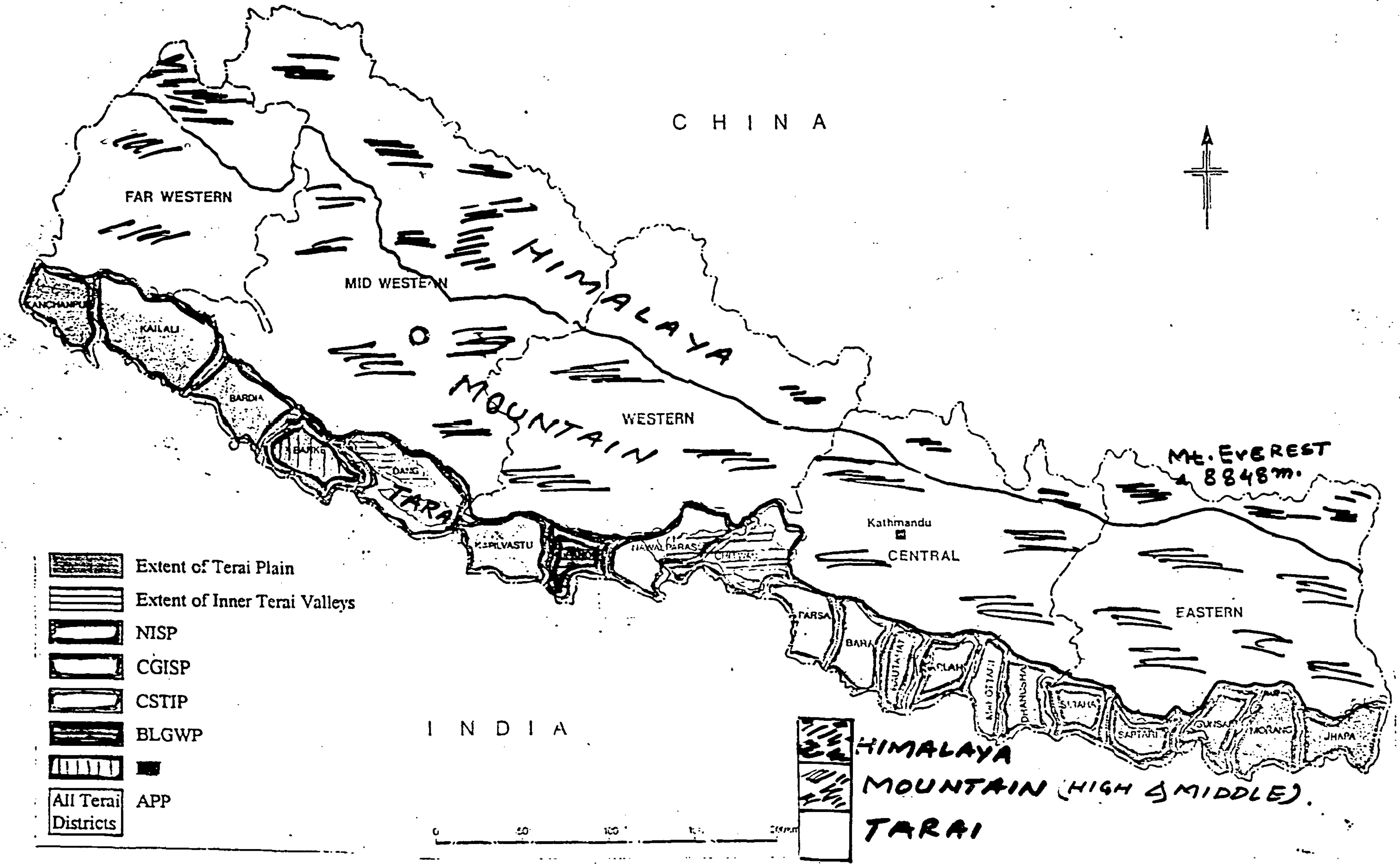

CHINA
FAR WESTERN
MID WESTERN
WESTERN
CENTRAL
EASTERN
Kathmandu
HIMALAYA
MOUNTAIN
TARAI
Mt. Everest 8848m.
KAILALI
BARDIA
DANG
KAPILVASTU
PARSA
DHANUSHA
SAPTARI
MORANG
JHAPA
INDIA
Extent of Terai Plain
Extent of Inner Terai Valleys
NISP
CGISP
CSTIP
BLGWP
All Terai Districts
APP
HIMALAYA
MOUNTAIN (HIGH & MIDDLE).
TARAI

Fig .3 Annex1

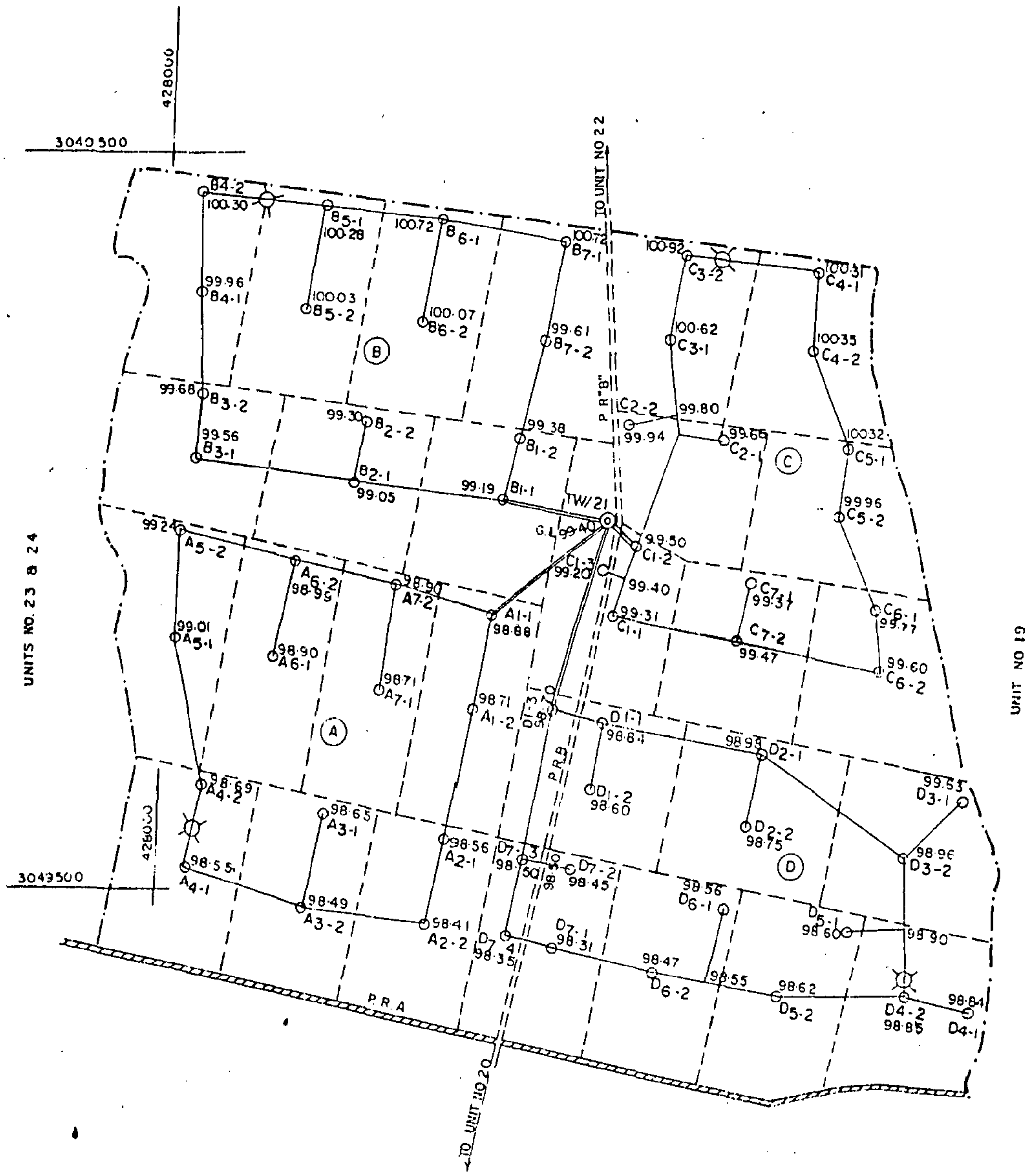
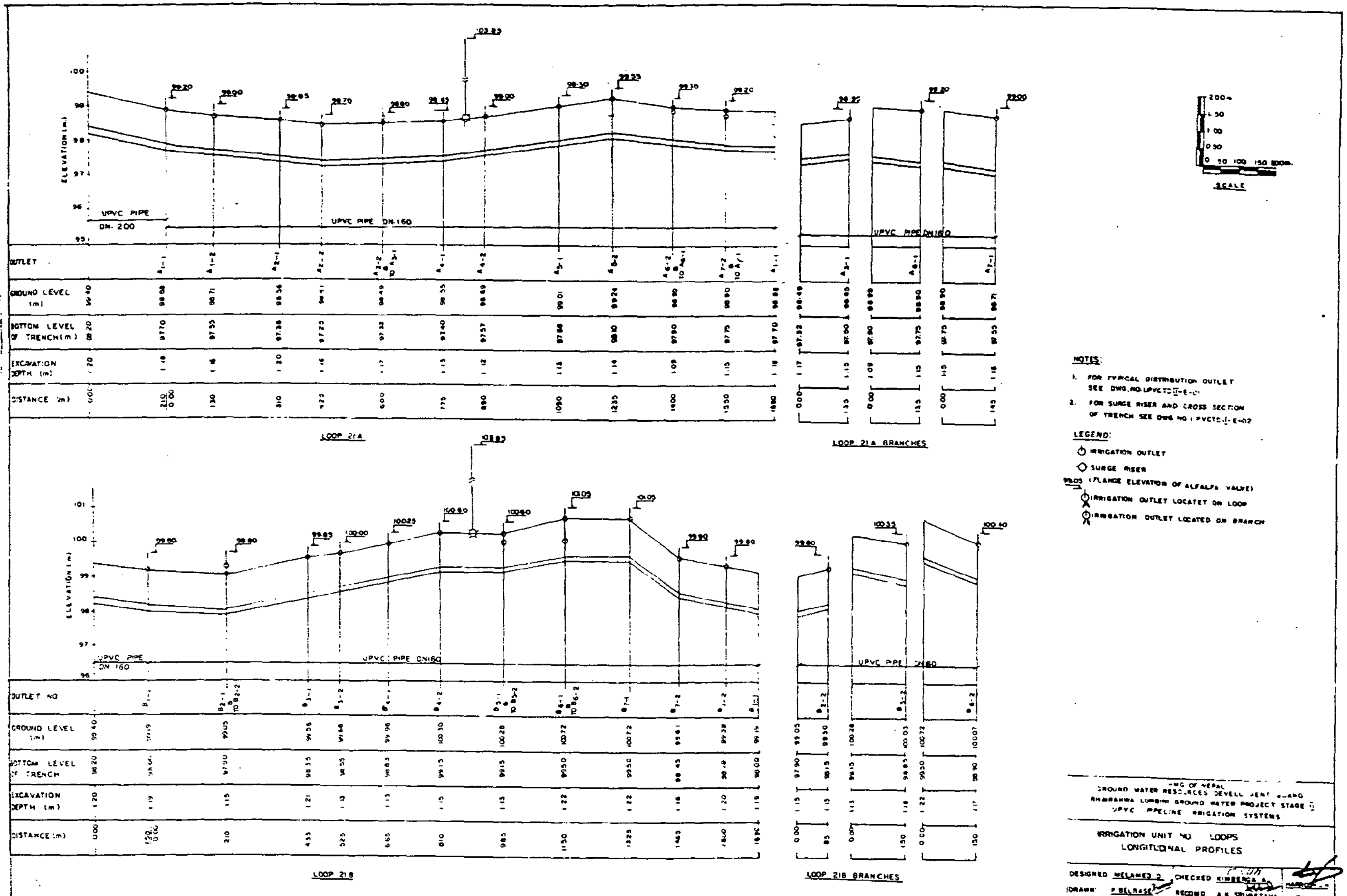

428000
3040500
TO UNIT NO 22
UNITS NO.23 & 24
UNIT NO 19
P.R.B
P.R.A
TW/21
G.L 99.40
TO UNIT NO 20
3043500
428000
A
B
C
D
B4-2 100.30
B5-1 100.28
B6-1 100.72
B7-1 100.72
B4-1 99.96
B5-2 100.03
B6-2 100.07
B7-2 99.61
B3-2 99.68
B2-2 99.30
B1-2 99.38
B3-1 99.56
B2-1 99.05
B1-1 99.19
C3-2 100.92
C4-1 100.31
C3-1 100.62
C4-2 100.35
C2-2 99.94
99.80
C2-1 99.66
C5-1 100.32
C5-2 99.96
C1-2 99.50
C1-3 99.20
99.40
C1-1 99.31
C7-1 99.37
C7-2 99.47
C6-1 99.77
C6-2 99.60
A5-2 99.24
A6-2 98.95
A7-2 98.90
A1-1 98.88
A5-1 99.01
A6-1 98.90
A7-1 98.71
A1-2 98.71
D1-1 98.84
D1-2 98.60
D2-1 98.95
D2-2 98.75
D3-1 99.63
D3-2 98.96
A4-2 98.69
A3-1 98.65
A2-1 98.56
D7-2 98.45
D6-1 98.56
D5-1 98.60
98.90
A4-1 98.55
A3-2 98.49
A2-2 98.41
D7-1 98.31
98.35
D6-2 98.47
98.55
D5-2 98.62
D4-2 98.85
D4-1 98.84

Fig.4 Annex 1



IRRIGATION UNIT NO. LOOPS
LONGITUDINAL PROFILES
UPVC PIPELINE IRRIGATION SYSTEMS
LOOP 21A
LOOP 21A BRANCHES
LOOP 21B
LOOP 21B BRANCHES
UPVC PIPE DN 200
UPVC PIPE DN 160
ELEVATION (m)
OUTLET
GROUND LEVEL (m)
BOTTOM LEVEL OF TRENCH (m)
EXCAVATION DEPTH (m)
DISTANCE (m)
NOTES:
LEGEND:
IRRIGATION OUTLET
SURGE RISER
SCALE

fig. 5 Annex 1

BHAIRAWA LUMBINI GROUNDWATER IRRIGATION III PROJECT
DTW Water User Association Organizational Structure

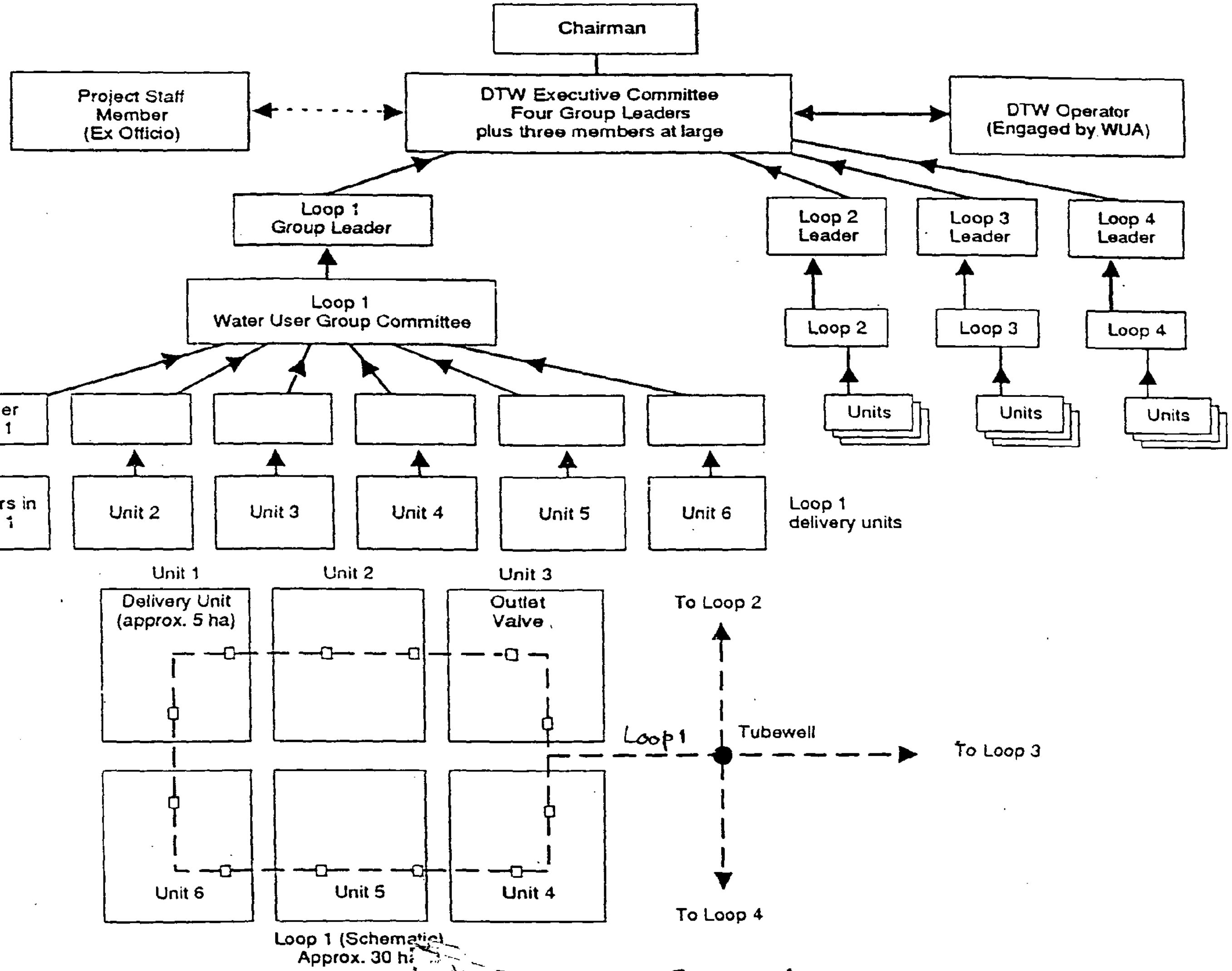
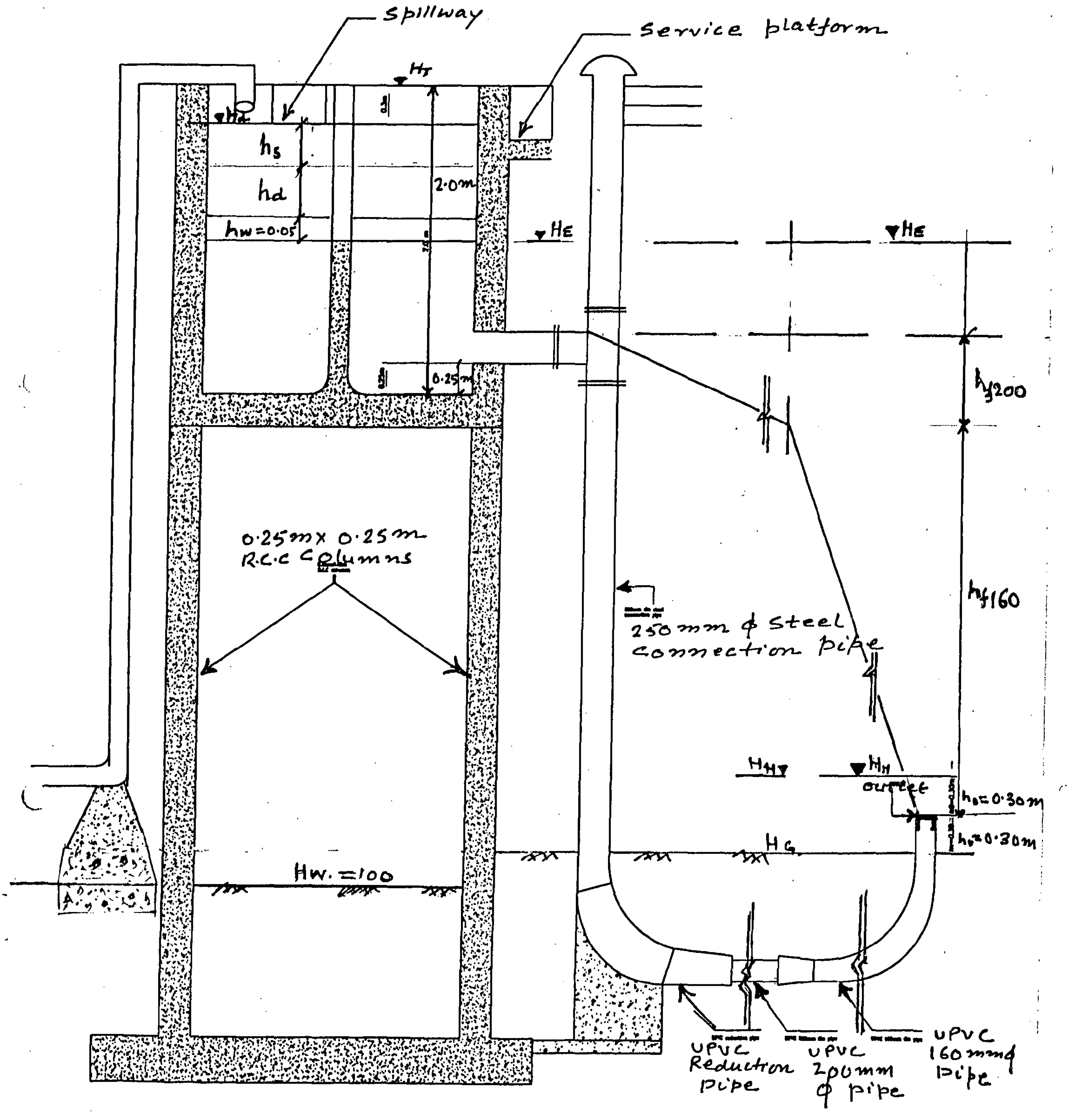


Fig. 7, Annex 1



CONTROL CHAMBER AND PIPE CONNECTION.

Fig .6 Annex 1

BHAIRAWA LUMBINI GROUNDWATER IRRIGATION III PROJECT
DTW Water User Association Organizational Structure

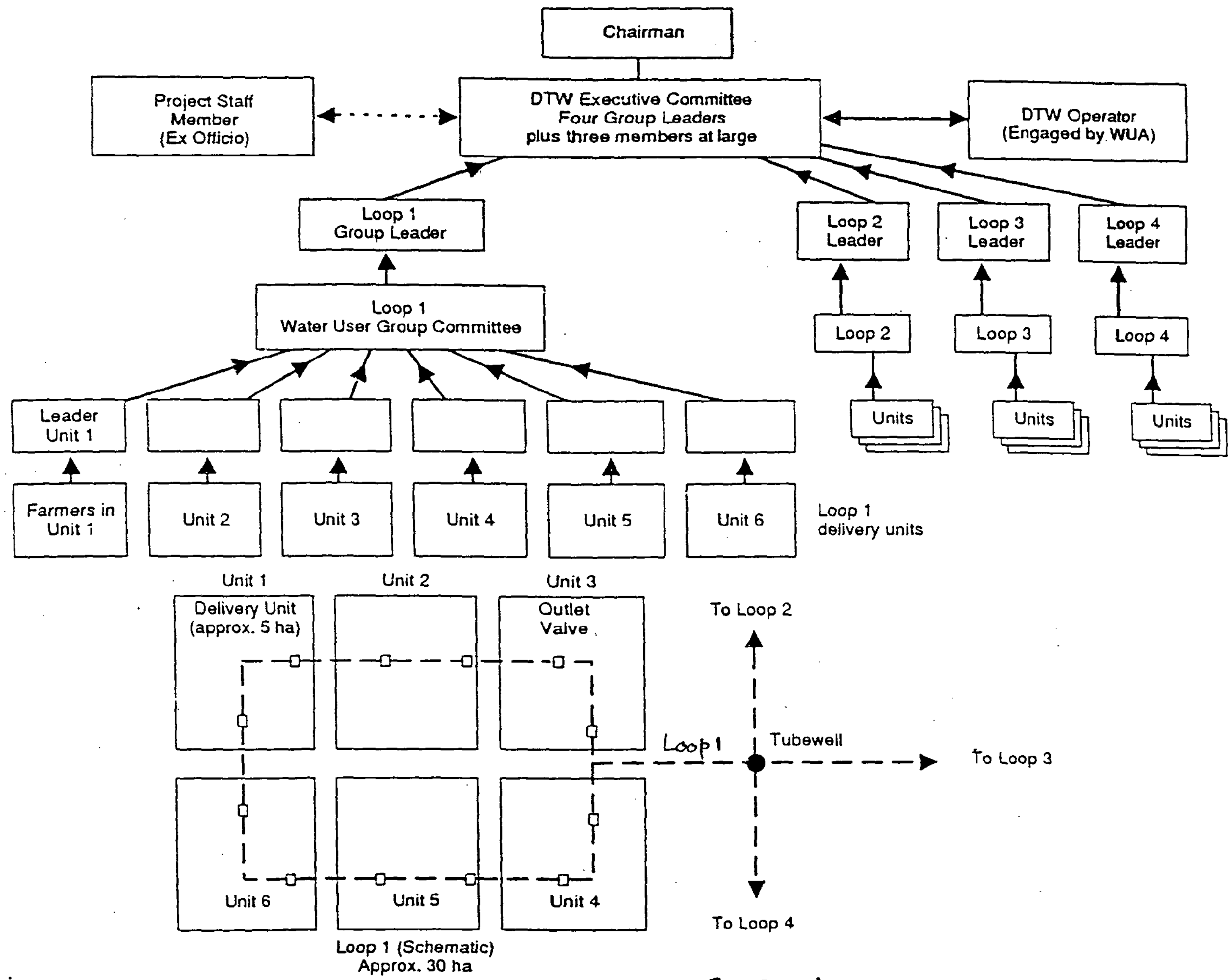


FIG. 7, Annex 1

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