REPORT NO. R-51

WATER MEASUREMENT TRAINING FOR SUBSYSTEM MANAGEMENT OF HAKRA 4-R DISTRIBUTARY BY THE WATER USERS FEDERATION

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SUMMARY

A series of six flow measurement training courses were held by the Water Users Federation (WUF) and the International Irrigation Management Institute (IIMI), Pakistan on "WATER MEASUREMENT FOR SUB-SYSTEM MANAGEMENT", completed between September 1 and October 2, 1997.

These training courses were held at the Hakra 4-R Distributary; the distributary selected by IIMI for the Water Users Organization Pilot Project. This distributary directly provides water to 75 watercourse command areas located along a 35-kilometer length, and indirectly, to another 48 watercourses through its two minors, which amounts to approximately 23 kilometers. Thus, the total length of the system is 58 km. The distributary's Gross Command Area (GCA) and the Culturable Command Area (CCA), including its two minors, is 48,649 and 43,801 acres, respectively.

The Hakra 4-R Distributary has five drop structures located along a 35- kilometer stretch. The distances between these drop structures vary between 6 and 8 kilometers. From the first to the fifth, each drop structure is located at RD 25, 46, 72, 82 and 1O7, respectively. The two minors originate from RD 23+200 and 72+100, respectively. In this regard, the Hakra 4-R Distributary could easily be divided into seven hydrological units to monitor water supplies. However, for the purpose of social organization work, the system was divided into five convenient sub-systems. The mean culturable command area per sub-system is 8,760 acres, the largest of which is 10,621 acres. The mean culturable command area per watercourse is 356 acres, the largest of which is 1,003 acres (W/C No. 16290-R).

The two major objectives to be pursued were:

1. To provide the necessary training to leaders of the Water Users Federation so that they can monitor the water supply being received from the Hakra Branch Canal, as well as regulating the distribution of this supply among the five sub-systems; and

2. To provide the necessary training to the leaders of each of the five Water Users Organizations so that they can monitor the water supply being received by every sub-system, as well as regulating the distribution of their water supply to each Water Users Association.

   Specific objectives of the course were:

   a) To train the farmers in flow measurement so that they are truly capable of monitoring the discharge rates at the flow control structures for sub-system management;

b) To strengthen the technical capability and management capacity of the WUF and WUO governing bodies to undertake the management of operational activities at the distributary level, including water distribution among the five sub-systems; and

c) To prepare the resource persons (WUO leaders) for the training at each sub-system.

The first training was provided to WUF leaders at the distributary level; monitoring the water supply received from the Hakra Branch Canal and the distribution of water among the five sub-systems. The emphasis was to measure the discharge at each of five flow control structures used to define the hydraulic boundary for each WUO. Forty farmer leaders participated in the training course; 35 from the Hakra 4-R Distributary's Water Users Federation, and 5 members of Water Users Federation of Bahaderwah Minor of the OFWM project, who were invited to attend.

In order to provide practical training under actual field conditions, five separate training courses, one within each sub-system, was conducted. Access to this training was available to every Water Users Association (WUA) representative serving on the WUO, which varies from 15 to 33 representatives. A total of 132 farmers availed this opportunity.

Thus, 160 farmers participated in the six training courses (Annex 2). The majority of farmers who attended the first session, also participated at their respective sub-system levels. Therefore, the actual amount of individuals who received training totaled 132.

The primary focus of these training courses was to monitor the distribution of water to each WUA within the sub-systems. In addition, the WUO members have learned how to monitor the water supply received by the WUO. Again, training focused on measuring the discharge at the head of each watercourse in the sub-system, as well as that of the inflow to each sub-system (and outflow for sub-systems 1 and 2), as in the training course for WUF leaders. Also, the discharge rating for most of the structures (104 out of 128) were provided by the staff of Haroonabad Field Station, IIMI-Pakistan. WUO members were, thus, trained to measure the actual total water supply received by the WUO, and the distribution of this supply among each of the WUAs. Consequently, each WUA is now capable of monitoring their water supply, and comparing it with the water supply received by each of the other WUAs. Transparency among all of the WUAs within a WUO has, thus, been achieved.

The six main aspects for the flow measurement training included:

1. reading staff gauges using white marks (a unique reference mark adopted by IIMI to reference the water levels);

2. discharge measurements in earthen watercourses using a flume;

3. discharge measurements in lined watercourses using a current meter;

4. method of converting a gauge reading to a discharge using the discharge rating table;

5. practicing to calculate the quantum of water supply, and duty of water, to each sub-system command; and

6. practicing to calculate the quantum of water supply, and duty of water, to each watercourse command.

An evaluation of the course by participants yielded that most of them could read gauges, measure watercourse discharges, convert discharges from discharge tables, and calculate water duties. Farmers now report that they intend to disseminate the knowledge gained in the training course by organizing meetings at the watercourse level. They also suggest that courses such as these should be ongoing in order to maximize the use of the exercise. In addition, they propose that the WUF should take steps aimed at reducing inequity. Participants applauded the IIMI staff for their interaction with farmers.

As far as drawbacks of the training courses are concerned, most farmers reported that none was evident, except some remarks pertaining to the difficulty in understanding certain English words and heavy technical and engineering jargon.

This report proposes future water measurement activities and related training, which include:

- Refresher courses on flow measurement;
- Periodic calibration of control structures;
- Inflow and outflow tests;
- Verification of discharges of modified and replaced outlets;
- Training on water use efficiency;
- Training on flow measurement for water users at the watercourse level;
- Workshop on important water allocation rules; and
- Training on measuring outlet sizes and maintaining a gauge register.

Training at the WUF's request, participation by leaders from all three tiers of the WUF, participation by the OFWM WUOs Pilot Project's leaders, the use of farmers as resource persons (at second stage), field-oriented training, the provision of personal transport by farmers, the formation of sub-groups to facilitate the discharge measurements, farmers training on the transfer points of their respective sub-systems, the calibration of all transfer points and outlets in advance of training, the provision of design data for the participants, the use of visual aids in *Urdu*, experience-sharing sessions at the end of each training course, the involvement of highly experienced IIMI technical staff, the participation of PID high officials, the participation of the Dutch Mid-term Evaluation Mission, and the distribution of certificates to each participant, were the main features of these training courses.

The water distribution pattern for each of the five Hakra 4-R Distributary's sub-systems was also studied, in terms of weighted averages for water duties (cusecs / 1000 acres). The calculation of water duties shows a great variation in the water duties among the sub-systems.

The calculated figure of water duty for Sub-system 2 is 9.67 cusecs / 1000 acres, the highest among the sub-systems. The water duty for Sub-system 1 is 3.22 cusecs / 1000 acres, the lowest. The current water duty for Sub-system 4 is 5.84 cusecs / 1000 acres. The water duties for Sub-system 1 and Sub-system 3, are 6.30 and 3.89 cusecs / 1000 acres, respectively. Relatively speaking, Sub-systems 3 and 4, in terms of receiving water supplies falls in the medium range.

The report draws many conclusions:

- Farmers have a high potential to receive technical training;
- Trained farmers can act as resource persons;
- Farmers are capable of implementing technical activities;
- Some farmers, without formal education, can be trained;
- Where farmers have multiple-income sources, less interest in the training was displayed, however, farmers from water-scarce areas showed a higher level of interest;
- The training program has helped to increase farmer-confidence about the system, as well as the IIMI program;
- The training courses contributed towards increased curiosity for legal recognition;
- Interaction among farmers has improved;
- Farmers' commitment towards the program has emerged more clearly;
- The high participation in such programs is inextricably linked with the presence of social organizers in the area; and

The involvement of social organizers, along with technical staff, in providing technical training, is an effective way of training farmers.

Finally, the physical and social infrastructure of the system lent effect and impact. The social infrastructure helped to maintain an appropriate amount of participants in all six training courses. The physical infrastructure provided two uses: 1) each control structure provided an interesting training and practice point for participants from respective sub-systems; and 2) farmers were very enthusiastic about knowing the quantum of water supplied to their sub-systems. Therefore, each transfer point, and reach between two transfer points, accelerated farmer-interest in the training courses.

FOREWORD

This was a carefully designed program to assist farmer leaders in moving towards equitable water distribution, which is one of the major criteria for the Water Users Federation (WUF) of Hakra 4-R Distributary to become sustainable.

The concept was to create, first of all, transparency among the WUF leaders (five members from each subsystem for a total of twenty-five) regarding the water supply to each of the five subsystems. They were taught how to read the staff gauges, or water level from a white mark (WM) elevation and then convert these readings into a discharge rate using a discharge rating table provided by IIMI. At the end of the training, all of the WUF leaders realized the differences in water supply to each of the five subsystems.

Then five additional trainings were provided, one inside each of the subsystems. Some of the WUF leaders were used as resource persons in these trainings, which proved to be quite successful. For each subsystem, the intent was to create transparency about water distribution to each Water Users Association (WUA) managing a watercourse command area.

The farmer leaders (132) were very enthusiastic during these trainings. They were intent on learning, asked lots of questions, helped one another to learn, and were amazed, themselves, that they could measure water for the first time in their life.

The field staff (9) of the IIMI Haroonabad Field Station were well organized and demonstrated a high level of performance. Their reward comes from knowing that they participated in a historic event. But the job is not finished. Some people selected by the WUF need to be trained for developing discharge ratings so that they are not dependent on IIMI.

Prof. Gaylord V. Skogerboe, Director
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ACKNOWLEDGMENTS

A series of six training courses were organized jointly by the International Irrigation Management Institute and the Water Users Federation (WUF) of the Hakra 4-R Distributary. These training courses aimed at providing the necessary training to the leaders of the Water Users Federation as well as the leaders of the five Water Users Organizations (WUOs) of the each of five subsystems so that they can monitor the water supply being received from the Hakra Branch Canal as well water supply received by every subsystem. This was the first biggest formal effort to develop the management capacity of the farmers in the history of Pakistan. The farmer leaders of all three levels of the WUF deserves special appreciation for their enthusiasm and interest shown in these training courses. Especially, the dedication and personal commitment of the executive body members of the WUF; Mian Abdul Wahid, M.Amin, A.Shakoor, Sofi Iqbal, Ali Moosa, President, General Secretary, Vice President, Secretary Information and Treasurer, respectively, is greatly appreciated..

The leaders of the WUF of Bahadarwah Minor, which is a OFWM Pilot Project, also participated in these training courses. The authors would like to thank them for providing an opportunity to do these courses collaboratively.

This series of six training courses was facilitated by the nine members of the IIMI field team based at Haroonabad. Special thanks should go to M/s Muhammad Nasir, Bilal Asghar, Muhammad Amjad, Khalid Rashid, Tipu Naveed and Muhammad Asghar for their tireless efforts in organizing the training courses, providing the technical assistance, and being the resource persons for the execution of these six training courses. The authors would like to thank Mr. Zafar Iqbal Mirza and Mr. Mehmood-ul-Hassan for their participation in the training courses from Lahore, and their valuable suggestion given to us.

Ch. Muhammad Shafi, Jafar Kabir Insari, Sheikh Nawaz, Mr Shafi-uz-Zaman, Cheif Engineer, Superintending Engineer, Executive Engineer and Assistant Commissioner, respectively, participated in the inaugural and closing ceremonies of these training courses. Their presence provided encouragement to the participants in this capacity building effort, and their gesture in attending this courses is gratefully acknowledged.

The authors wish to acknowledge the untiring work in formatting the report and incorporating changes and corrections in the final report carried out by Mr. Muhammad Manshah, Secretary, IIMI-Pakistan. His attention to detail and spending long hours to improve the format and capturing minor errors in the report is gratefully appreciated.

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1. CREATING FARMERS ORGANIZATIONS AT HAKRA 4-R DISTRIBUTARY

The Hakra 4-R Distributary WUOs Pilot Project was conceived in July 1995. Initially, the organizational work was carried out by the six-member social organization field team. The organizational process was completed on March 5, 1997. A three-tier organization was created at the distributary (the detailed structure and nomenclature will be described later in this chapter). Later, three more persons with technical background were inducted in the team, to assist WUOs with capacity-building and the implementation of technical activities. The main objectives of the project follow.

1.1. OBJECTIVES OF THE PROJECT

The main objectives of this action research were:

1. to learn how to organize water users (WUs) at the watercourse, minor and distributary levels of the irrigation system;
2. to test their viability as an effective organization, and the extent to which they could be involved in the decision-making process and management of the system; and
3. to provide policy recommendations for future replication.

1.2. SUB-SYSTEM IDENTIFICATION[1]

1.2.1. Rationale

The general objective of the institutional development component of IIMI's program of activities is to find basic ways and means to enhance the existing institutional capacity for improved irrigation management in Pakistan. Additionally, these strategies are to be developed for maximizing water users' participation in decision-making. Past experience shows that water users' participation at the tertiary level can accomplish satisfactory results in mobilizing resources and making decisions related to a short-term objective, such as watercourse improvement. However, after the completion of this task, WUAs were no longer sustainable. The main reason was the lack of a long-term purpose for organized collective action. If the organizational effort is moved upstream to a higher level, i.e. at the distributary or minor level, the assumption is that a more meaningful and longer-term purpose for organization will be attached. For instance, a water users organization at this higher level could achieve the maximum possible participation in "joint management" of the irrigation system. Logically, users' participation would contribute to improving the efficiency, equity, reliability, productivity and sustainability associated with the use of irrigation water resources.

[1] This section has been adopted from Mirza and Mehmood, 1996.

1.2.2. Identifying Sub-systems

The selected pilot site (4-R Haroonabad) is a fairly large distributary canal system, consisting of over 121 irrigation outlets / watercourses. The large size and command area of the pilot distributary were major considerations to plan the action research program. The traditional way of organizing water users associations (WUAs), i.e. one WUA at each watercourse, then federating these to form a water users organization (WUO) at the distributary level, was likely to delay the process of accomplishing project objectives. The time set aside for organizational activities was less than three years, and for optimal use of time, limited resources and manpower, it was necessary to reach the distributary level fairly quickly by way of an appropriate alternative method. Considering these project constraints, the chosen alternative approach was to define a set of **sub-systems** within the Hakra 4-R Distributary for initial organization.

Five logical sub-units, or sub-systems, based on the existence of two minors, and the possibility of dividing the main distributary into three reaches, i.e. head, middle and tail, preferably on the basis of hydraulic structures along the main distributary, was proposed. This proposal was deemed appropriate for action research on farmers' participation in irrigation system operation and maintenance, as such a division covers many relevant factors.

1. The Hakra 4-R Distributary has a number of hydraulic structures. Division on the basis of hydraulic structures would help to monitor discharges, in terms of time and space.
2. Medium-sized groups are more suitable for effective social organization in the initial stages.
3. Initial representation at this intermediary sub-system level would enable an equality of opportunity for water users to gain membership to executive committees for participation and decision-making.
4. Water user groups can be identified in terms of clusters of watercourses (in each sub-system), which helps in arranging meetings, discussing problems and resolving disputes more effectively.
5. The initial identification of these sub-systems would help to generate common interests and, possibly, common problems.

Specifically, the following division was made:

SUB-SYSTEM 1 :	RD 00 to RD 46
SUB-SYSTEM 2 :	RD 46+300 to RD 72
SUB-SYSTEM 3 :	RD 72+100 to RD 112+050
SUB-SYSTEM 4 :	MINOR 1RA/4R
SUB-SYSTEM 5 :	MINOR 1R/4R

Table 1. Important physical and social characteristics of the proposed sub-systems on the Hakra 4-R Distributary.

Sub-system	RD	No. of irrigation outlets	Lined / W/C's	Unlined W/C's	GCA acres	CCA acres	Authorized discharge cusecs	No. of T.W.	Share-holders
1	00 to <46 main 4-R	23	5	18	9806	8888	32.91	43	695
2	46 to <72 main 4-R	23	17	6	7638	7581	31.19	45	1053
3	72 to <112 main 4-R	27	16	11	12220	10636	41.95	82	1029
4	1RA minor	15	6	9	6933	6088	21.85	16	565
5	1R minor	32	21	11	11648	10217	40.24	51	1348

1.3. THE FOUR PHASES OF THE PROJECT

The four main phases of this WUO project is discussed below.

1.3.1. Support Mobilization Phase

The main purpose of activities in this phase was to secure the institutional support necessary to initiate actions for the pilot project. Support was solicited from the concerned line agencies, as well as from the farmer leaders. In this phase, the field team was mobilized and trained, initial collaborative arrangements were discussed with PID and OFWM staff, the selection of the pilot site was finalized, members for a Field Implementation Coordination Committee (FICC) were identified, and initial baseline information was collected (D. J. Bandaragoda *et.al.*, 1997).

1.3.2. Initial Organization Phase

The activities in this phase were designed to generate an interest among users to identify mutually beneficial aspects of collective action in their given situation. In this phase, some progressively advanced steps, to interact with the communities, were taken. Unlike many top-down government projects, this pilot project adopted a consciously-developed participatory approach.

1.3.3. Organization Consolidation Phase

This phase consisted of a series of activities aimed at consolidating the process, by entering into a stronger relationship with operating agencies. In this phase, WUOs were established at each of three levels; watercourse level, sub-system level and distributary level. Only then were training programs developed and implemented. Farmers were trained in different O&M-related aspects. The proposal for the Joint Management agreement was developed and sent to the Secretary of Irrigation and Power.

1.3.4. Organizational Action Phase

The project remained in this phase until writing this report. This phase was dedicated to the implementation of the agreed plan of action. The WUOs and the agency been finalized, therefore, many actions could not be taken. WUOs have, however, implemented maintenance and flow measurement activities on a self-help basis, with facilitation from IIMI.

1.4. FORMATION PROCESS AND NOMENCLATURE

The formation of a Water Users Federation (WUF) at the Hakra 4-R Distributary is a three-tier system in which 4,500 water users were organized (as first tier) into 121 Water Users Associations (WUAs). WUAs could not be formed on two watercourses, due to the unwillingness of the water users, thought to be influenced by the PID field staff propaganda.

Each WUA was composed of all the farmers along a watercourse. The number of WUA leaders varies from 5 to 7, depending on the number of factions (*baraderies*, number of potential leaders) in a watercourse, except those of one to two-member WUAs where the entire watercourse command belongs to one owner. The members of the WUAs were nominated by participating water users at the watercourse level. These 121 watercourse committees nominated 121 watercourse representatives, who, in most cases, were nominated by the WUAs. In certain other cases, however, they were selected by the general water users.

The Hakra 4-R Distributary system was grouped into five sub-systems, based on social and physical divisions. The number of watercourses among the users varies from 15 to 33, depending on the size of its hydrological unit. These WUAs were only then organized (as second tier) into five water users organizations (WUOs). The electoral body of each WUO also comprises of 15 to 33 watercourse representatives. Each WUO formed 7- to 10-member executive bodies, again, depending on the social and hydrological units (villages, *baraderies* and watercourses). Each sub-system WUO nominated 5 members to the Water Users Federation WUF general assembly (third tier). In most cases, the sub-system level's president and general secretary were also co-opted for the federation general assembly. The remaining three WUO members were watercourse representatives. Thus, the general assembly of the Water Users Federation is comprised of 25 members. These members then selected a five-member executive body for the water users federation for the entire distributary command on March 5, 1997.

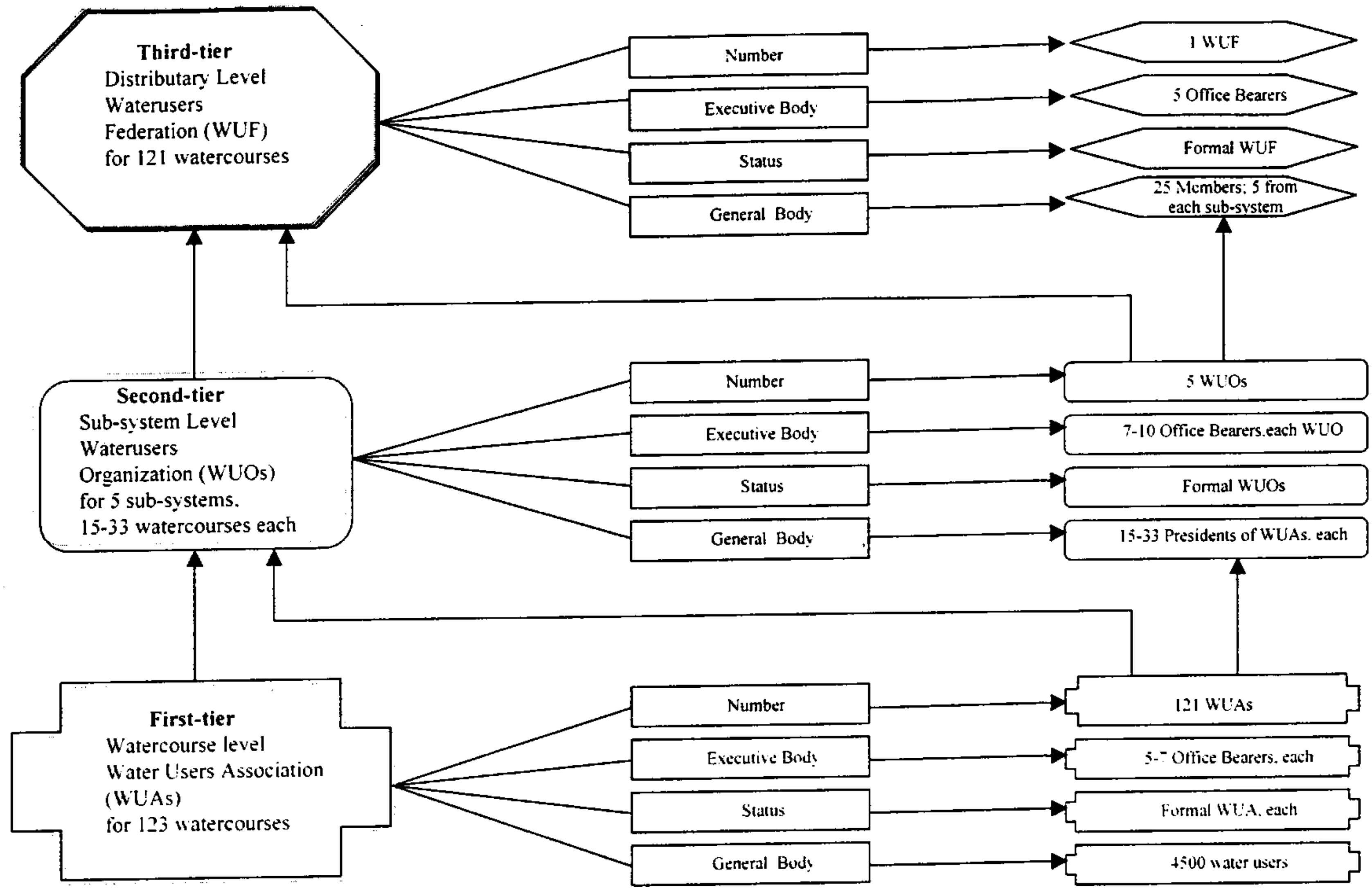


Figure 1. The organizational structure and nomenclature of the Hakra 4-R Distributary Water Users Federation.

2. GENERAL DESCRIPTION OF HAKRA 4-R DISTRIBUTARY

2.1. LOCATION OF STUDY SITE

The nexus of the irrigation system related to the study site starts with a diversion from the left bank of the Sutlej River at Sulemanki Headworks to the Eastern Sadiqia Canal. This 74 km-long stretch trifurcates into the Hakra and Malik Branch Canals, and the Sirajwah Distributary at RD 242 of the Eastern Sadiqia Canal. The Hakra Branch Canal originates from Head Jalwala, trifurcating into 1-L, 3-R and 4-R at RD 89750 (29 km) at Head Ghulab Ali, where the Hakra 4-R Distributary off-takes from the right side of the Hakra Branch.

The Hakra 4-R Distributary is part of the Fordwah Eastern Sadiqia (South) (FESS) Irrigation and Drainage Project. The FESS area stretches to 203 km in length, and is from 18 to 80 km wide along the left bank of the Sutlej River, between the Suleimanki and Islam Headworks. Encompassing the irrigable lands in the Eastern Sadiqia and Fordwah Canal commands, it is located between latitudes 29 06 25 N to 30 22 45 N, and longitudes 72 16 47 E to 73 58 30 E.

Comprising an area of 1.67 million acres in south-eastern Punjab Province, it also encompasses part of *Tehsils* Haroonabad and Bahawalnagar. The study area is encircled by the Hakra 3-R Distributary in the north-east, Hakra 5-R and the 6-R Distributaries in the south, and towards the east, by the Hakra Branch. The Hakra Branch Canal runs almost parallel with the Indian border, which is only 2.5 km east from Head Ghulab Ali.

2.2. DESCRIPTION OF STUDY SITE

The Hakra 4-R Distributary directly provides water to 75 watercourse commands located along a 35-kilometer length, and indirectly, to another 48 watercourses through its two minors, which collectively, are approximately 23 kilometers long. Thus, the total length of the system is 58 km. The Gross Command Area (GCA) and the Culturable Command Area (CCA) of the distributary, including its two minors, are 48,649 and 43,801 acres, respectively.

The Hakra 4-R Distributary has five drop structures located along a 35-kilometer stretch of the distributary. The distances between these drop structures vary between 6 and 8 kilometers. These five drop structures, from first to fifth, are located at RDs 25, 46, 72, 82 and 1O7, respectively. Each of two minors originate from RD 23+200 and 72+100, respectively. In this regard, the Hakra 4-R Distributary could easily be divided into seven hydrological units to monitor water supplies. However, for the purpose of social organization work, the system was divided into five convenient sub-systems with a mean CCA of 8,760 acres; the largest of which is 10,621 acres. The mean CCA per watercourse is 356 acres; the largest of which is 1,003 acres (W/C No. 16290-R) (Waheed-uz-Zaman, 1998).

2.3. SLOPES IN THE STUDY SITE

The average natural slope evident in the Hakra 4-R Distributary is 0.71 ft per km from north to south, with a greater elevation difference on each of four drop structures varying between 2.50 ft and 7.50 ft. The crests of the off-take head and tail outlet clusters have elevations of 525.011 ft and 500.641 ft above mean sea level, respectively. The irrigated fields (Natural Surface Level, or NSL) are situated in a range from between 526.606 ft and 498.666 ft above sea level, between the head and the tail areas.

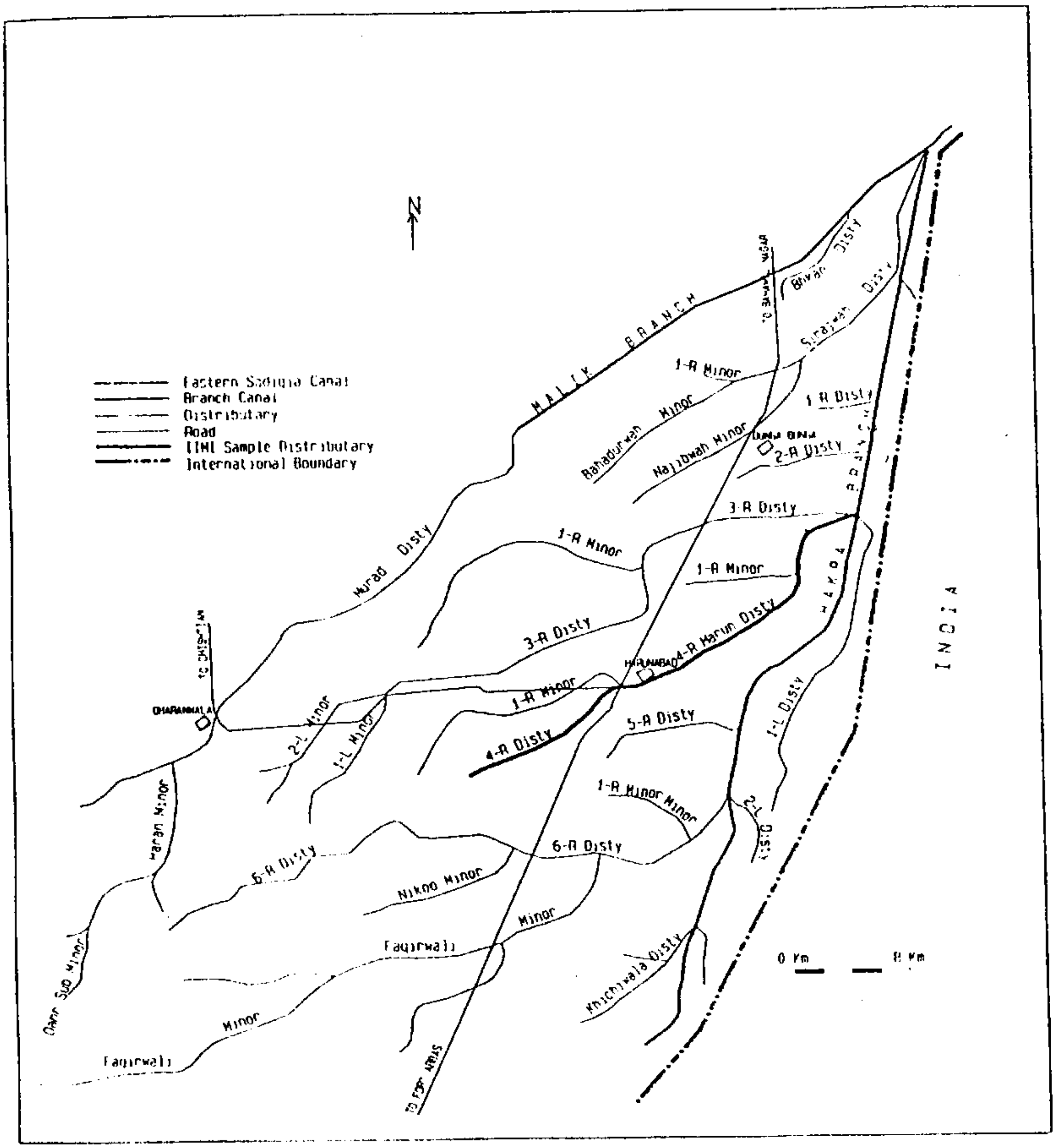


Figure 2. Location map of Hakra 4-R WUO Pilot Project

2.4. PRECIPITATION IN THE STUDY AREA

The climate in the region is hot and arid. The average rainfall ranges between 125 and 250 mm, of which maximum occurs during the months of July and August. October and November are dry months. A hot and dry climate, insufficient rainfall, brackish ground water, a demand for reliable and adequate water supplies for both, irrigation and drinking, purposes. (Mirza and Hassan 1996)

2.5. DATA AVAILABLE

IIMI-Pakistan has already conducted a baseline survey in the area. This survey covers information pertaining to characteristics of farm holdings, cropping patterns, cropping intensities, water supplies and its reliability, irrigation practices, waterlogging and salinity, use of agricultural inputs, farm machinery, and different crop yields (Cheema *et al.*, 1997). Serving as benchmark information, these data can be used to test different indicators and the impact of irrigation supplies after the application of operations and maintenance activities. In addition, the Watercourse Monitoring and Evaluation Directorate (WMED) is monitoring five watercourses in the distributary command area to assess the impact of waterlogging and salinity on crop production, considering existing management practices. These data will also be helpful for project gestation or monitoring and evaluations.

2.6. SOCIO-ECONOMIC CHARACTERISTICS OF THE FARMERS

The International Irrigation Management Institute (IIMI) Pakistan conducted a baseline survey at the Hakra 4-R Distributary during the month of July 1995. The survey revealed (Asghar *et al.* 1995) that, overall, the mean number of family members per household at the sample watercourse, is 8.78. The mean age of respondents is 48.7 years. Farmers' irrigation experience is 28.2 years, on average. Local respondents are equivalent to about 20 %, while the rest of the sample farmers are either settlers or migrants. The Jat, Rajput and Arain farmers form about 80 % of the command area population, with the majority being illiterate (61.6%). Sample farmers who had an opportunity to education below matric, constituted about 34 %, whereas, only 5 % have post-matric education.

The mean number of males engaged in full-time agriculture is higher than that of females. The mean number of family members in full-time agriculture, in respondent households, is 1.97. Females of working age are commonly involved in agriculture on a part-time basis. The majority of the sample farmers (55%) own up to 5 acres of land, and about 83 % with landholdings below the subsistence level. About 12 % of farmers own land between 12.6 and 25 acres, while 6 % own 25.1 acres, or more.

In total, the mean area operated is about 13 acres, with the mean area owned by sample farmers, about 8.34 acres. The mean total operated area is higher at the head reach than at the tail. The number of farmers owning tractors is 17 %, and the number of tubewell owners, 11.7 %. The majority of cultivators (50.7 %) are landowners. Tenants constitute 16 %, while owner-cum-tenants is 33 %.

2.7. IRRIGATION SUPPLY CONDITIONS IN THE REGION

The baseline survey of the Hakra 4-R Distribuatry (Asghar *et al.* 1995) also provides interesting background information about water supply conditions. The majority of farmers have access to canal water as a source of irrigation supply. About 43 % of sample farmers use alternative sources, like private tubewells, or they purchase canal water from others. Farmers are of the view that canal water fulfills their crop requirements to a limited extent, total 81.1 %, whereas, 4 % point out that canal water does not fulfill their crop requirements at all, and only about 15 % report that canal water fulfills their water requirements to a large extent.

In instances of short water supply, 54 % of farmers maintain fallow land. On average, about 26 minutes are allocated for each farmer to irrigate one acre of land, but realistically, 132 minutes are required.

A water deficiency was experienced at sowing and harvesting times during the 1994 *Kharif*; about 30 % of farmers say water shortages were acute in that June; and about 22 %, that canal water was in acute shortage at the harvest, i.e. September 1994.

Around 80 % of farmers report that canal water was in acute shortage during *Rabi* 1995. Insufficient water supply was also noticed by 13.1 % of the farmers during December. About 24 % of the farmers are of the view that the present canal water distribution system is not satisfactory at all.

The majority of sample farmers (68.8 %) are of the opinion that government agencies can improve the present canal water distribution system. Around 45 % of respondents say that water is distributed inequitably along the distributary, while about 52 % hold the opposite view. About 80 % indicate inequity in water distribution within the Hakra 4-R Distributary command area, and an overall 42 % feel that PID officials are responsible for the unequal distribution of water.

3. CONCEPTUAL FRAMEWORK FOR WATER DISTRIBUTION TRAINING

3.1. GOAL

The goal is for farmers to manage their available irrigation water supply to improve water distribution in order to achieve better equity for each tertiary watercourse command area.

3.2. PURPOSE

First of all, the Water Users Federation's (WUA's) major concern pertains to the irrigation water supply they are receiving from the Hakra Branch Canal. Secondly, the WUF is concerned about the distribution of their water supply among the five sub-systems, with each one represented by a Water Users Organization (WUO). Thus, the purpose of this training program is to assist the WUF in acquiring the necessary skills to monitor the water supply received at the distributary head, and equitably distributing the available water supply among the five sub-systems.

Then, each sub-system WUO has a primary concern about, first at all, receiving their appropriate share of the total available irrigation water supply being administered by the WUF. Secondly, each sub-system WUO is concerned about the equitable distribution of their water supply to each Water Users Association (WUA) serving a tertiary watercourse command area. So, the purpose of this training program is also to assist the five WUOs in acquiring the necessary skills to monitor water distribution among the five sub-systems, and equitably distributing their water supply among the WUAs.

3.3. OBJECTIVES

The two objectives to be pursued are:

1. To provide the necessary training to leaders of the Water Users Federation so that they can monitor the water supply being received from the Hakra Branch Canal, as well as to regulate the distribution of this supply among the five sub-systems; and

2. To provide the necessary training to the leaders for each of the five Water Users Organizations so that they can each monitor the water supply being received by every sub-system, as well as to regulate the distribution of their water supply to each Water Users Association.

The specific objectives of the training course are threefold:

1. To train farmers in flow measurement so that they are capable of freely monitoring the discharge rates at the flow control structures for sub-system management.

2. To strengthen the technical capability and management capacity of the WUF and WUO governing bodies to undertake management of operational activities at the distributary level, including water distribution among the five sub-systems; and

3. To prepare resource persons (WUO leaders) to provide training at each sub-system.

3.4. APPROACH

The objectives are to be met through the provision of practical training to leaders of the WUF and WUOs. Fortunately, the WUF is a body of 25 members; five from each of the five sub-systems. In turn, each WUO member is a representative of a WUA served by the WUO. Thus, each watercourse command area has a representative on the WUO, with five of these representatives serving on the WUF. This social organization infrastructure facilitates the effectiveness of the training program.

The first training course will be used to satisfy the first objective. This course will focus on providing training to WUF leaders to monitor the water supply received from the Hakra Branch Canal, and the distribution of water among the five sub-systems. The emphasis will be to measure the discharge at each of five flow control structures used to define the hydraulic boundary for each WUO. The discharge rating for each of the structures will be provided by the Haroonabad Field Station staff, IIMI-Pakistan. Thus, *WUF leaders will be trained to measure the water supply to each sub-system by themselves*. In turn, each sub-system will be capable of monitoring their water supply for comparison with the water supply received by each of the other sub-systems, facilitating transparency among all five sub-systems.

In order to provide practical training under actual field conditions, a separate training course will have to be provided within each sub-system, totaling five courses at the sub-system level. Each WUA representative serving on the WUO will have access to this training; membership varying between 15 and 33 representatives. The primary focus of the training will be to monitor the distribution of water to each WUA in each of the five sub-systems. In addition, WUO members would learn how to monitor the water supply received by the WUA. Again, the training would focus on measuring the discharge at the head of each watercourse in the sub-system, as well as the inflow to the sub-system (and outflow for Sub-systems 1 and 2), as in the training course for WUF leaders. Also, the discharge rating for all of these structures (a total of 128) will be provided by the Haroonabad Field Station staff, IIMI-Pakistan.

Thus, the WUO member will be trained to actually measure the total water supply received by the WUA, and the distribution of this supply among each of the WUAs. In turn, each WUA will be capable of monitoring their water supply, for comparison with the water supply received by each of the other WUAs. Thus, transparency will be possible among all of the WUAs within a WUO.

4. TRAINING DESIGN FOR SUB-SYSTEM MANAGEMENT

4.1. BACKGROUND

The Hakra 4-R Distributary WUO's Pilot Project was initiated in July, 1995, and aims at testing the feasibility of organizing water users at the watercourse, minor and distributary levels, before federating these into a Water Users Federation. Another objective was to determine its viability as an effective organization. To meet these broader objectives, and to make the WUOs viable, it is essential to involve them in the implementation of technical activities.

The first effort in this regard was a one-day training workshop on flow measurement at a smaller scale for eight selected farmers, held during the last week of June 1997. After this training program, farmers had started to monitor flows at strategic points of the distributary i.e., three tails and one drop structure.

The second endeavor was a study tour of about 40 water users to *Haji* Arshad's farm at Khanpur, aimed at providing technical know-how to WUs about the use of modern techniques in the field of agronomic practices, agricultural implements and irrigation methods at the farm level. The water users regarded this exposure-training to be highly worthwhile. Although these training courses were regarded as a big success, this was only a stepping stone towards the involvement of farmers in the implementation of technical activities, such as operation and maintenance, and to provide a sense of confidence in managing the system. Upon realizing the usefulness of these training efforts, the President of the Hakra 4-R Distributary Water Users Federation (WUF) demanded, on many occasions, that training such as these should be organized on a much larger scale.

Involving water users organizations in the management of the irrigation system is very important. With growing awareness about participatory irrigation management (PIM), the technical component of an irrigation system cannot work in isolation because an irrigation system is defined as a set of physical and social elements (Rao, 1993).

4.2. TRAINING FOR WATER DISTRIBUTION AMONG SUB-SYSTEMS

In view of the importance of this training program, an initial three-day training for WUF and WUO office bearers was planned for members of the WUF between September 1 and 3, 1997, in which 40 WUs participated.

4.3. TRAINING STRATEGY

4.3.1. Trainers

This training program will be conducted by the nine-member IIMI Haroonabad Field Team, which provides an excellent blend of social and technical expertise. The training program will be actively supported by Prof. Skogerboe, the Director of IIMI-

Pakistan, who will serve as a resource person. Of the nine team members, two members (including the team leader) have experience on both the technical and social aspects, while three members have a purely technical background, and four have a social background with some exposure in flow measurements.

Out of nine team members, four have six to ten years of technical measurement experience with IIMI; the remainder have IIMI experience ranging from nine months to two years. In order to train the trainers, all team members were recently provided with 'hands-on' flow measurement training in the field, so that outlet calibrations for the Hakra 4-R Distributary could be done. The team was divided into two groups; one for current metering, and the other, for flumimg. Members were, however, rotated between the groups to train them in both fluming and current-metering techniques. They were also involved in recording water levels with staff gauges.

A list of trainers is provided in Annex. 1.

4.3.2. Trainees

The trainees will be selected from among WUF and WUO members of the Hakra 4-R Distributary. The two criteria for trainee selection are:

1. An interest to obtain training; and
2. The potential to acquire the necessary flow measurement skills to play a role in sub-system management, and a willingness to communicate the acquired skills to all water users at the watercourse level.

Keeping these two criteria in mind, trainees will be selected from the levels of the Water Users Federation described below.

First, WUF distributary level office bearers and selected farmers from the sub-system level WUOs. Since the formation of the Water Users' Federation (WUF) in March 1997, interaction with water users indicates that most of WUF and WUO office bearers possess the potential to acquire the necessary basic training. Exceptions, however, always exist. The emergence of these competent office bearers is the result of a truly participatory and democratic social organization process.

The second category of participants will be selected from eight farmers who have already received training at a one-day training workshop held at the IIMI Field Station, Haroonabad. The previous trainees may also be used as resource persons during field measurement training.

Thirdly, there is a good number of water users among the watercourse level associations, and amongst the Social Organization Volunteers (SOVs), who possess the required potential for leadership and training. For various reasons, however, they have been unable to rise to higher level WUF and WUO offices. At later stages, persons within this category will also be eligible for this training.

4.3.3. Trainee Groups

Participants will be divided into five groups, based on sub-system classifications. These sub-systems define the hydrological, as well as social boundaries, for social organizational work. Each group will be led by one technical person and one social organizer, but Sub-system 5 will have only the team leader.

4.3.4. Training Sites

The Hakra 4-R Distributary system was divided into five logical sub-systems based on technical and physical reasons to help divide operations and maintenance responsibilities of the sub-system level WUOs. Field orientation will be imparted to each group in respective sub-systems on five existing well-defined field sites, and participants will be rotated to each of the five locations.

There will be four main topics for the flow measurement training:

1. Reading staff gauges and white marks (a unique reference mark adopted by IIMI to reference water levels;
2. The concept of rating tables and the method of converting a gauge reading into a discharge using the rating table;
3. discharge measurements in earthen watercourses using a flume; and
4. discharge measurements in lined watercourses using a current meter.

"Staff gauging" and "white mark" training will be imparted on the selected watercourses. Each group will be taken to the transfer points of their respective sub-systems to provide orientation on the rating table for each of the five control structures. These five flow control structures have already been calibrated. For flumimg and current metering, farmers will be sent to watercourses already selected in their respective sub-systems. The details of the training sites are listed below.

4.3.5. Flow Control Structures

1. Hakra 4-R Distributary off-take point (RD 0+00).
2. Drop Structure RD 46+300 of the Hakra 4-R Distributary (cut-off point for Sub-systems 1 and 2).
3. Drop Structure RD 72+100 of the Hakra 4-R Distributary (cut-off point for Sub-systems 2 and 3).
4. Intake structure of the 1RA Minor (RD 23+200) of the Hakra 4-R Distributary (cut-off point for Sub-system 4).
5. Intake structure of the 1R Minor (RD 72+100) of the Hakra 4-R Distributary (cut-off point for Sub-systems 2, 3 and 5).

4.3.6. Training Materials and Equipment.

In the past, in Pakistan, farmers were trained about agricultural practices and the use of agricultural implements. This is, perhaps for the first time, that farmers of a distributary level WUF are being trained on flow measurements. Training materials and visual aids will be prepared in *Urdu*. Recently-developed discharge rating tables will be used for the orientation of flow measurement at the main control points between sub-systems. A Cutthroat Flume and a Pygmy current meter will be used to measure the discharge in earthen and lined watercourses, respectively. Portable staff gauges will be used to record the water levels from the white marks (benchmarks).

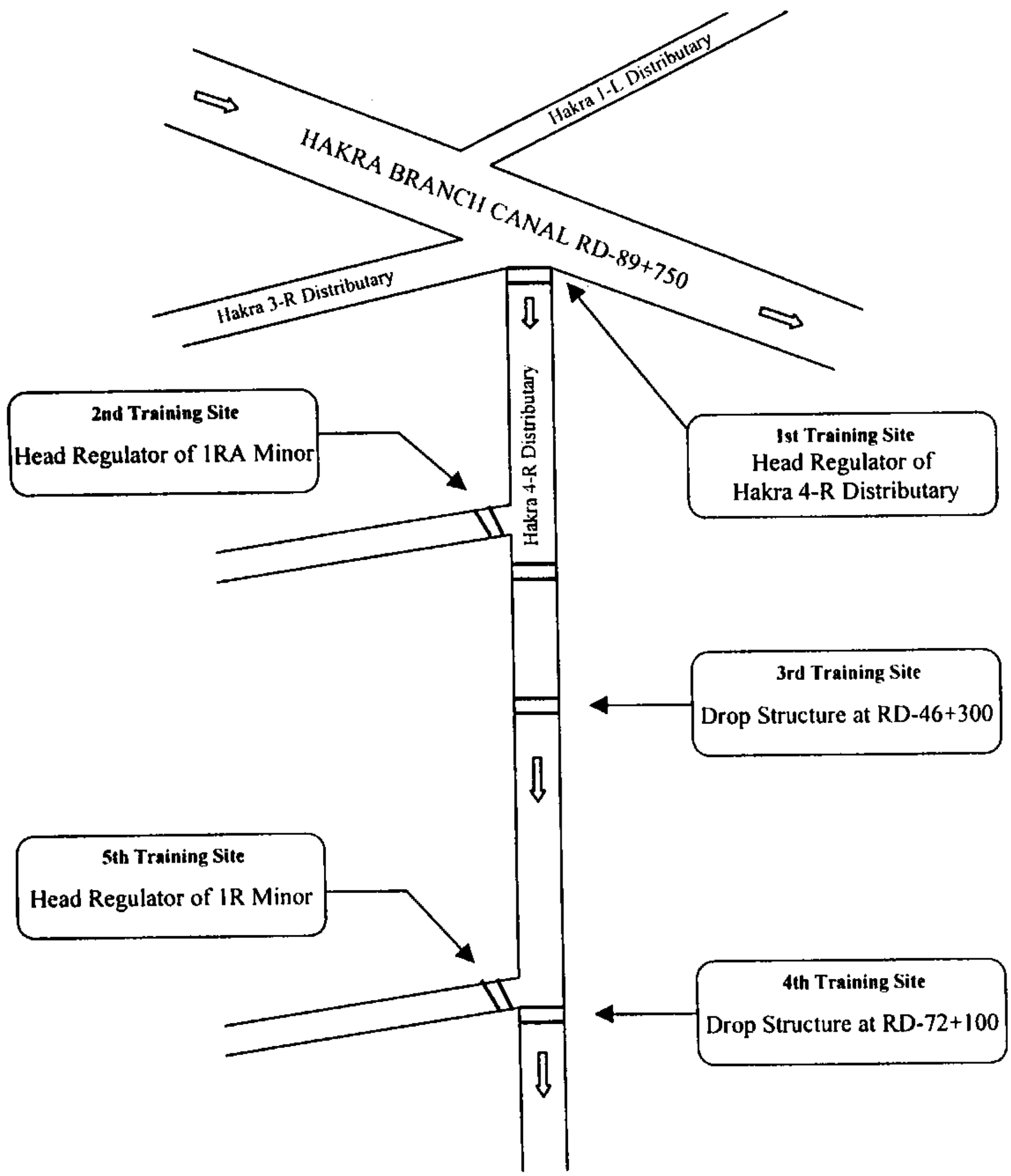


Figure 3. Training Sites.

5. MAIN FEATURES OF THE TRAINING COURSE

The general notion among professional government engineers is that farmers have no potential to be trained, and that they lack initiative. The training courses conducted on the Hakra 4-R Distributary suggest that this notion is no longer valid. Farmers have demonstrated tremendous enthusiasm and potential to be trained. Besides, these training courses were unique in many respects, as detailed below.

5.1. TRAINING AT THE REQUEST OF THE WUF

During the month of July 1997, a one-day flow measurement course was organized for eight selected farmers, after which they started monitoring daily supplies at some of the strategic locations. However, monitoring these points could not be systematized due to the of lack of incentives (absence of legal involvement, compensation for the service). Upon observing the utility of these training courses, the WUF President formally requested IIMI to organize these training courses on a larger scale. The proposal was accepted and training courses were organized for a much larger number of farmer leaders.

5.2. PARTICIPATION OF WUF LEADERS ON ALL THREE TIERS

The first three-day training was organized for 25 members of the WUF general assembly; the remaining five, at each sub-system. The focus was aimed at all leaders at the sub-system level organization, and representatives at the watercourse level association. Representatives from all three tiers of the WUF were invited. The majority participated, and in a few cases, where watercourse representatives were unable to participate, other appropriate members of the WUA were invited.

5.3. PARTICIPATION BY WUO LEADERS OF OFWM PILOT PROJECT

Members of the Water Users Federation executive body of the OFWM project, related to the Bahaderwah Minor and Bhukan Distributary, which are World Bank-funded projects, were also invited to attend.

5.4. FARMERS AS RESOURCE PERSONS

As mentioned earlier, the focus of the first training was for 25 WUF leaders, representing equal participation from all five sub-systems. Participants of the first training course were used as resource persons for sub-system level training. Some have displayed natural capabilities as resource persons. Ten farmers, approximately two from each sub-system, turned out to be effective recourse persons. These farmers also presented different technical aspects in the closing ceremony of the training courses, attended by the **PID Chief Engineer and the IIMI-Pakistan Director.**

5.5. FIELD-ORIENTED TRAINING

Relatively more time during the first training course was devoted to training hall lectures. Farmers themselves expressed their preference for both, lectures, as well as field measurements. The remaining five courses were focused on field orientations. Everyday, after introductory sessions of about half an hour, lectures and measurements were conducted in the field.

5.6. THE USE OF FARMERS' OWN TRANSPORT

IIMI provided pick-and-drop, and transport for farmers to commute from one location to another. Many farmers also participated with their own motorbikes, and some, with their cars.

5.7. THE FORMATION OF SUB-GROUPS FOR TRAINING

Participants were divided into many sub-groups in order to facilitate field discharge measurements. Usually, of two groups, one measured the earthen watercourse with flume, and the other measured the discharge in the lined watercourse with a current meter. Similarly, to record water levels, 5 to 7 groups were formed.

5.8. FARMERS' TRAINING AT SUB-SYSTEM TRANSFER POINTS

Training on how to read a gauge, and converting this reading into a discharge using the discharge rating table, were mainly conducted at respective transfer points. Another important point is that all of the groups were also rotated among transfer points.

5.9. CALIBRATION OF ALL TRANSFER POINTS AND OUTLETS

All of the main transfer points, the head regulator, each of the five sub-systems' transfer points, and all of the outlets, except a few, were calibrated in advance of these training courses. Calibration facilitated practicing and calculation at the field sites. Had no structural calibration taken place in advance, the training would have been less effective.

5.10. THE PROVISION OF DESIGN DATA FOR PARTICIPANTS

The design discharge of all the control points and outlets, CCAs and other related information, was collected from official sources and provided to the participants. These data were a big help to participants, particularly for calculations and comparisons.

5.11. THE USE OF *URDU* VISUAL AIDS

Training orientation was imparted with the use of visual aids. Charts, tables, diagrams, materials, and *Urdu* hand-outs were also prepared. Portable gauges and flow measurement devices (flume and current meter) were also used for practical impact.

5.12. EXPERIENCE-SHARING SESSIONS

At the end of each course, experience-sharing sessions were organized, which provided valuable feedback about farmers' potential to be trained, as well as to improve future training courses. These experiences have been presented in Chapters 11 and 12 of this report.

5.13. PARTICIPATION OF OFWM PILOT PROJECT WUO LEADERS

WUF office bearers from the Bahaderwah Minor and Bhukan Distributary, a World Bank-funded pilot project, also participated in the first three-day training course. This, also, was an apt opportunity for experience-sharing between office bearers from two different Water Users Federations' pilot projects, who have received technical assistance from the On-Farm Water Management (OFWM) Directorate, Punjab Department of Agriculture.

5.14. INVOLVEMENT OF IIMI TECHNICAL STAFF

The Director, IIMI-Pakistan, and three other field-based technical staff members with 8 to 10 years' experience, along with five social organizers, played active roles in implementing training courses, as well as acting as resource persons.

5.15. THE PARTICIPATION OF PID OFFICIALS

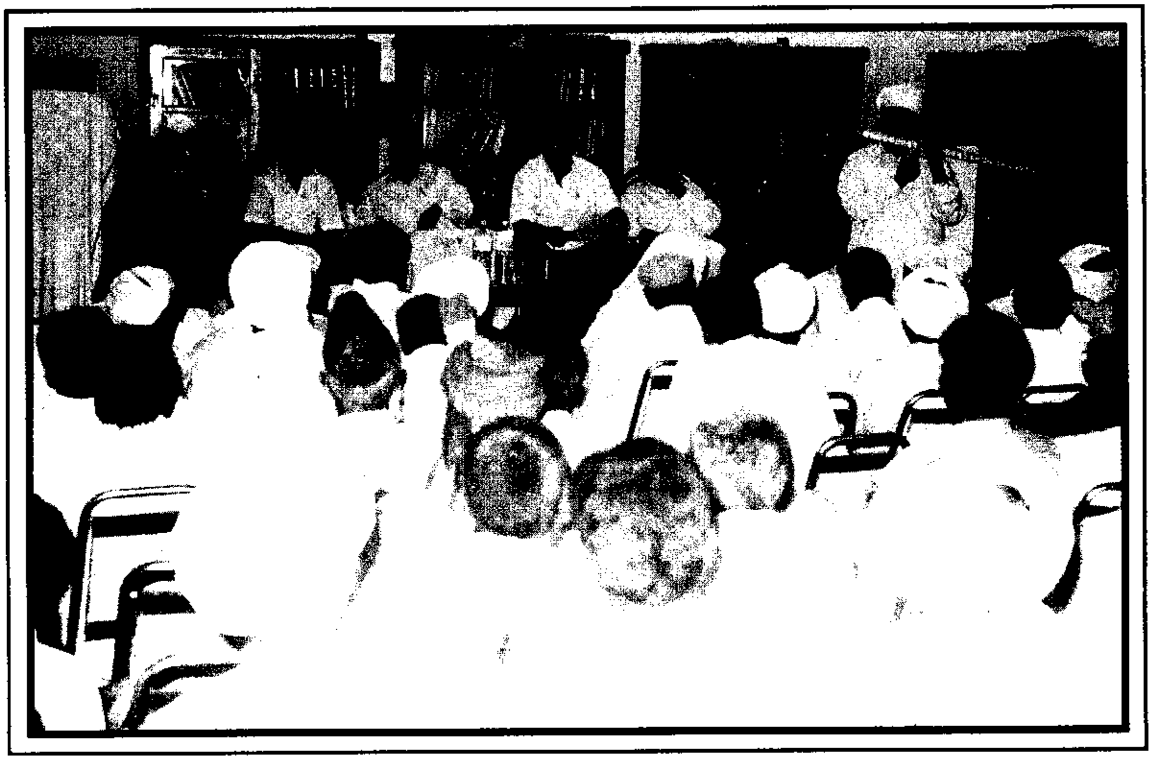
The closing ceremonies of the training courses were also attended by Ch. Muhammmd Shafi, Chief Engineer, Bahawalpur Zone, Jafar Kabir Insari, Superintending Engineer, Bahawalnagar Circle, and Sheikh Nawaz, Executive Engineer, Hakra Division and SDO Haroonabad Sub-division. Some officers from the district management also participated in the training course.

5.16. PARTICIPATION OF DUTCH MID-TERM EVALUATION MISSION

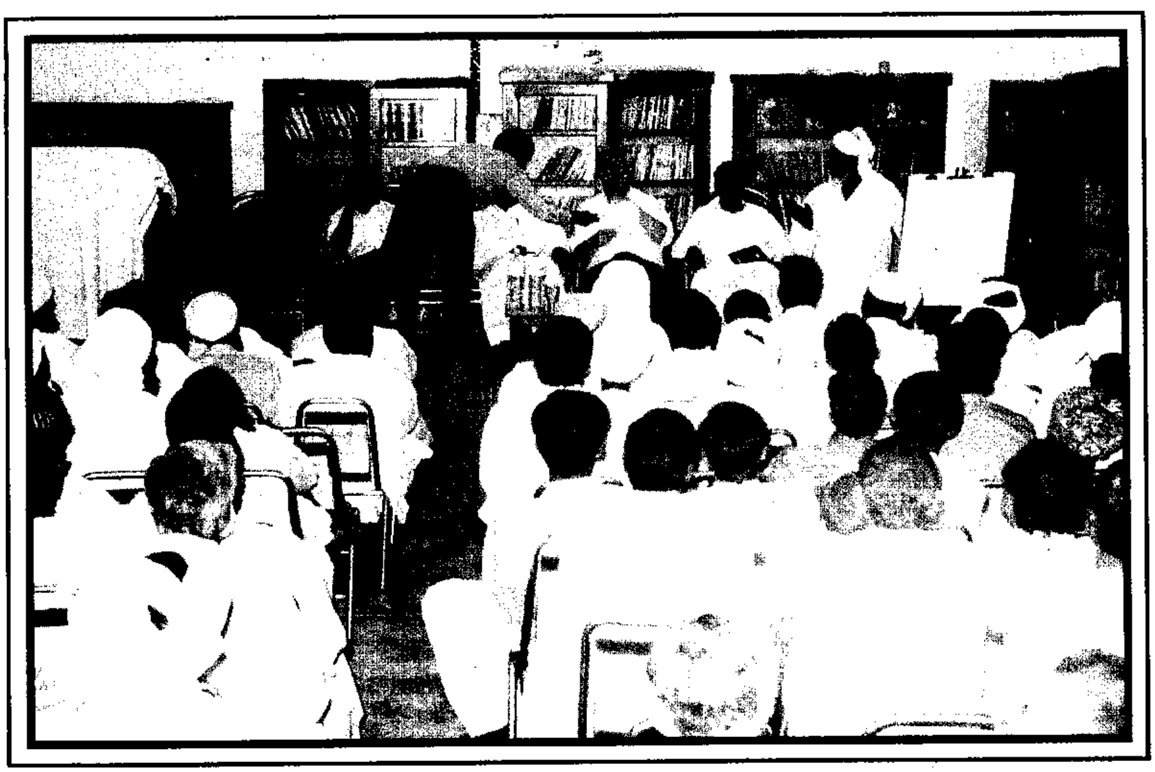
The three-member Dutch Mid-term Evaluation Mission also participated in Sub-system 3's training course. In addition to engaging in discussion with participants, the mission also witnessed farmers practicing gauge reading at the training sites during the courses.

5.17. CERTIFICATE DISTRIBUTION

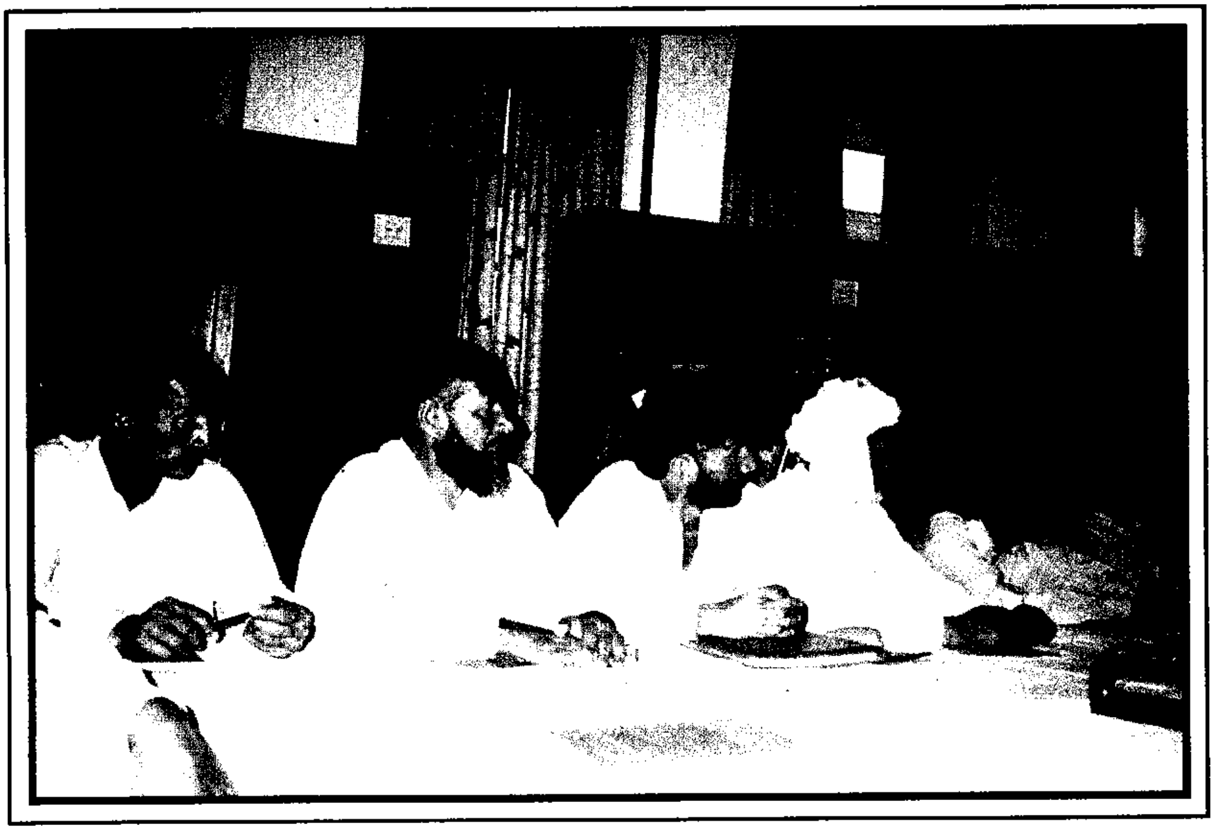
At the end of each training course, certificates were presented to farmers in recognition of their successful participation. Certificates bore joint acknowledgment from the Hakra 4-R Distributary WUF and IIMI-Pakistan, and were signed by the President of the WUF, the Director, IIMI-Pakistan and the IIMI Team Leader.



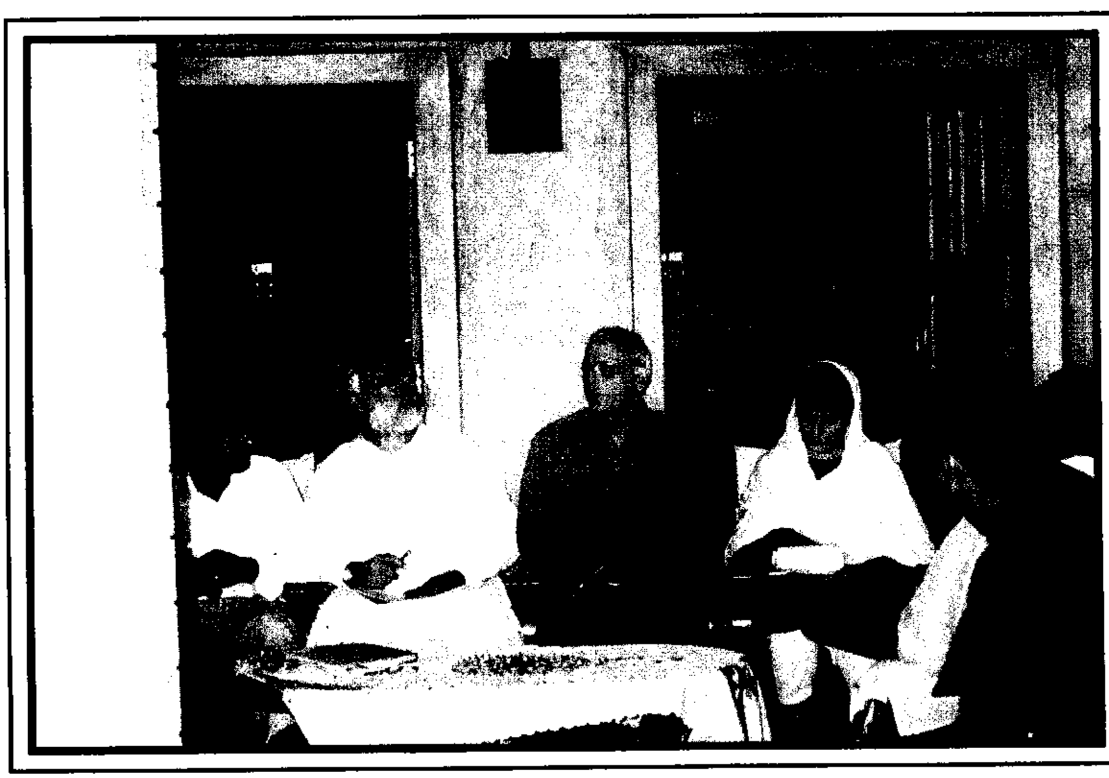
Photograph 1. How to read a gauge: farmers as resource persons.



Photograph 2. Converting discharge from a discharge table: farmers as resource persons.

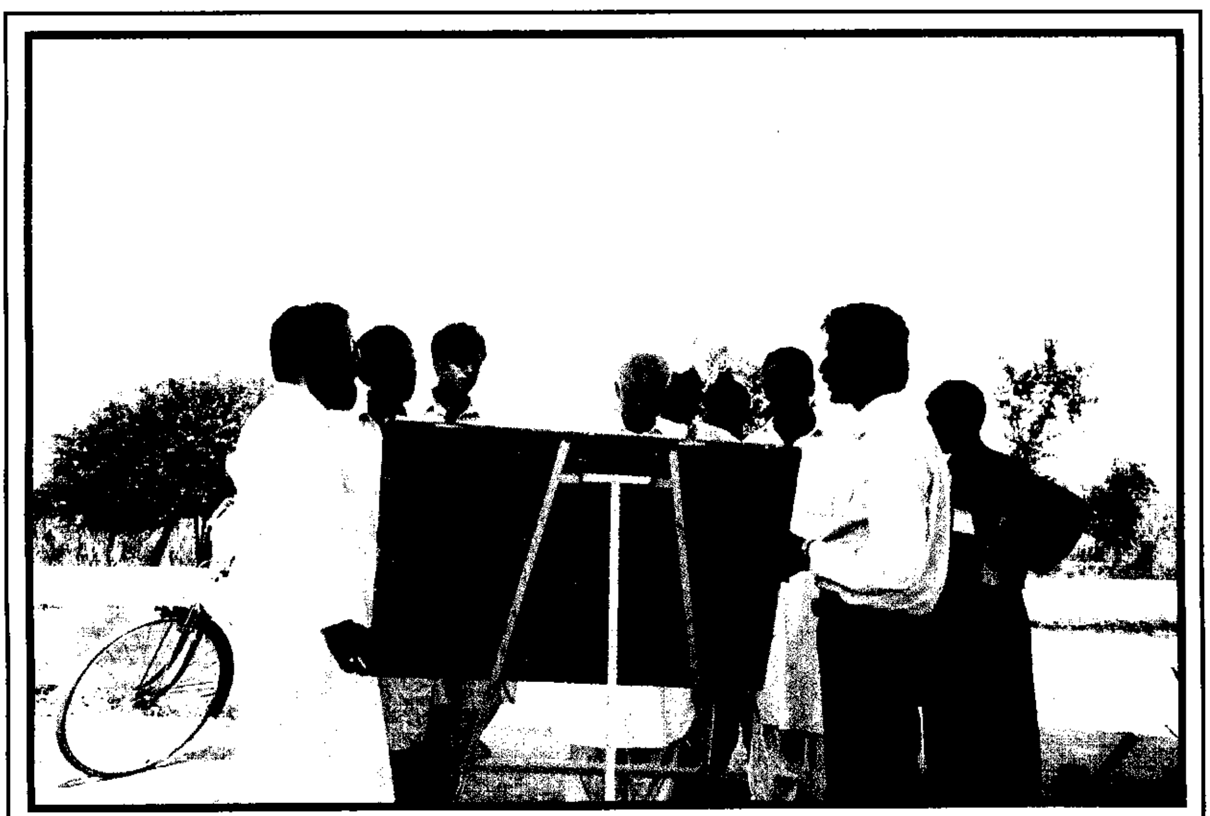


Photograph 3. The Office Bearers of the WUF of Bahaderwah Minor in the training session.



Photograph 4. Three-member Mid-term Dutch Evaluation Mission participated in the training of Sub-system 3.

Photograph 5. A sub-group of the training course measuring flow in the earthen watercourse with Cutthroat Flume.



Photograph 6. Orientation before the flow measurement at training site.

6. MAIN FEATURES OF THE FLOW CONTROL STRUCTURES FOR THE FIVE SUB-SYSTEMS

6.1. INTAKE STRUCTURES

6.1.1. The Head Regulator of the Hakra 4-R Distributary

This head regulator is one of the seven control structures of the Hakra 4-R Distributary, and is of gated-type, forming part of a cluster of three off-takes at RD 89+750 of the Hakra Branch (trifurcating structure at Head Ghulab Ali). Two other channels, 3-R Distributary and 1-L Minor, also originate from this point. The Hakra 4-R Distributary off-take is a single-gated structure.

The inflow through the gate is regulated by an operator, who raises and lowers the gate. These gates at Head Gulab Ali are operated by an L-shaped key, which remains in the custody of regulation staff, who are on duty around the clock.

The crest width of the head regulator structure for the Hakra 4-R Distributary is six feet. The design and the actual width of the head regulator is devoid of any significant differences. This structure's flow is modular (free-orifice flow) at both low and high flows. At full supply level (FSL), this control point acts as an orifice-modular. According to old PID inscriptions and artifacts, the design discharge through this structure at FSL is 189 cusecs. In conjunction with an interview with PID staff, PID records show that the discharge of 189 cusecs was valid until 1963; and was revised later. PID documents reflect that the design discharge was 193 cusecs in 1966, and PID staff reported that, although, the design discharge of the Hakra 4-R Distributary is 193 cusecs, the regulation staff is currently issuing 225 cusecs through this off-taking head regulator.

However, the measured discharge by IIMI-Pakistan ranges from 240 cusecs and above. The full supply depth at the distributary head regulator is 3.85 feet at a gate opening of 5.30 feet. At 225 cusecs, the height of the orifice is 4.95 feet. However, the maximum permissible limit of the orifice opening is 5.50 feet. An old, dilapidated 4.8 ft gauge existed in the stilling well on the upstream side of the distributary (branch canal side). In January 1997, IIMI-Pakistan installed a 5 ft gauge at this point. PID follows a decades-old rating curve for this structure.

The head structure is in relatively good condition; however, during a hydraulic survey conducted during the 1996/7 annual closure, it was discovered that the crest structure was missing a brick. Moreover, a few holes were present in the gate of the regulator.

6.1.2. The Head Regulator of the 1RA Minor

The Hakra 4-R Distributary bifurcates at two locations. The first bifurcation structure is at RD 22+300, where 1RA Minor originates. This bifurcation structure serves as the intake structure for 1RA Minor, but does not provide any structure in the Hakra 4-

R Distributary at this location. This head regulator is un-gated. Three hundred feet downstream from the head of the 1RA Minor, a drop structure exists in the distributary at RD 25+000. This minor has 15 outlets and is 22+000 feet in length.

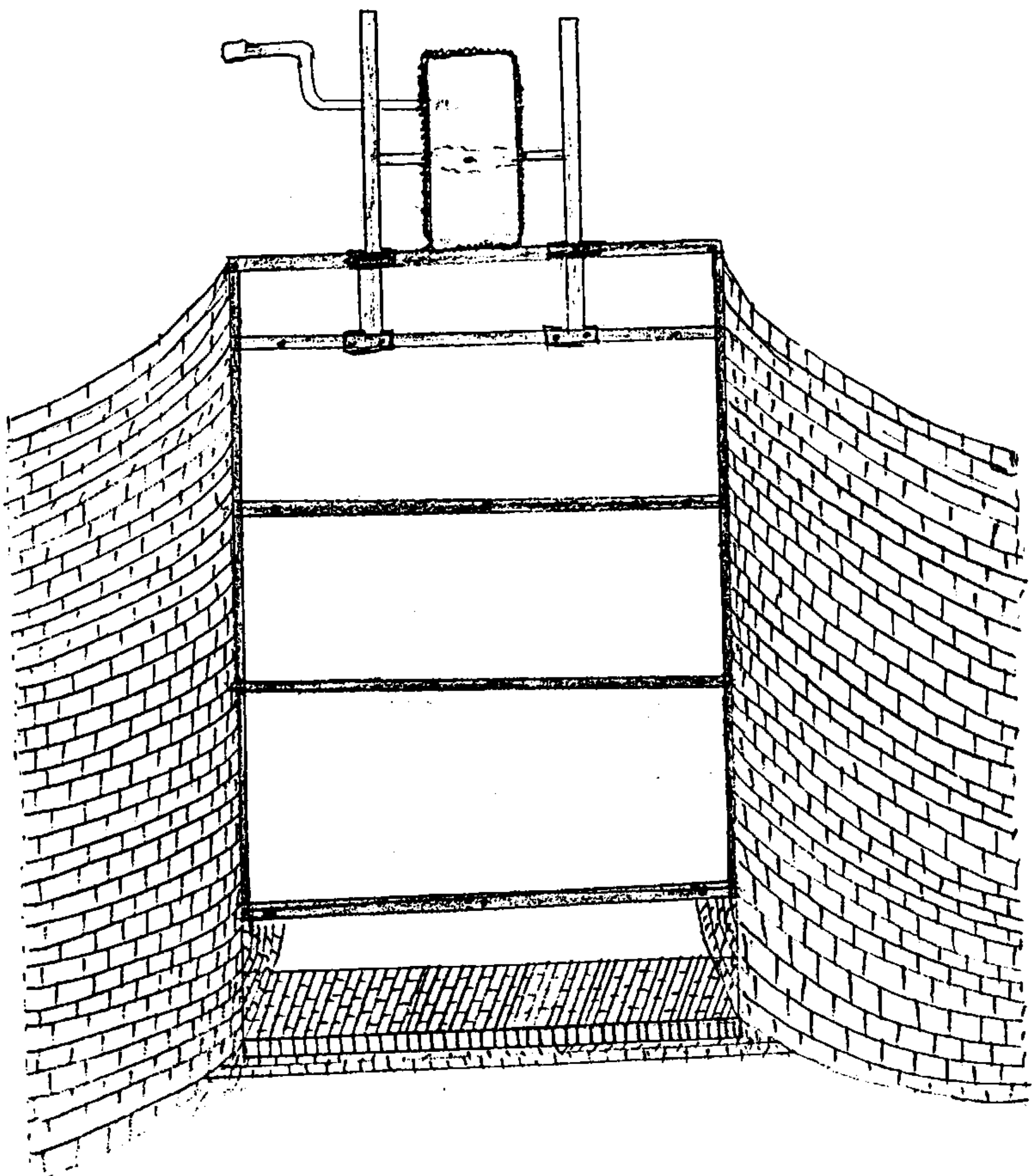


Figure 4. The Head Regulator of the Hakra 4-R Distributary.

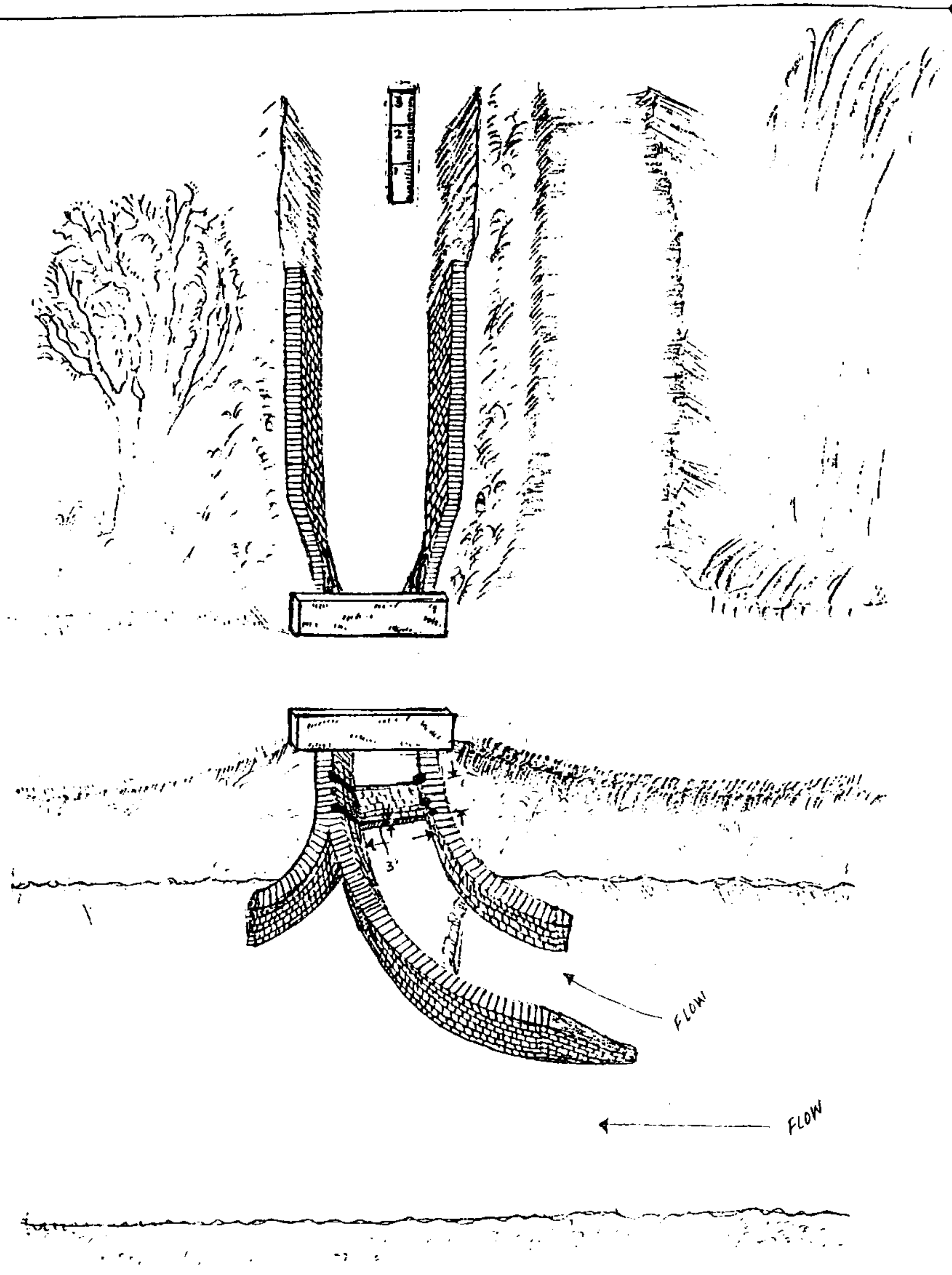


Figure 5. The Head Regulator of the 1-RA Minor (Transfer Point SS-4).

The original design of the structure is similar to that of a weir, with right and left curved piers (supporting structures) at the entrance. This structure was, however, modified in the past. Another pier was constructed, originally the first constructed tangent to the distributary, and then changed to a curve pointing opposite to the direction of flow.

There are two crests in the head regulator of the 1RA Minor; the first was originally constructed in the center of the head regulator, and the second is constructed in the extended portion of the head structure. The PID constructed this crest in 1980. In the past, both crests have been tampered with and altered. The original (first) crest was altered by the PID a few years ago. Farmers report that the crest was raised up to 4 inches higher. The objective of raising the crest structure was to feed the downstream outlets of Hakra 4-R Distributary. Farmers tampered with the second crest soon after it was constructed.

The design and existing width of the head regulator is 2.5 feet. The design Full Supply Depth FSD at the minor's head is 2 feet. This head structure's non-modular flow is submerged open channel flow both for low and high flows. The design discharge of the minor is 22 cusecs. Previously there was no gauge at the head regulator. PID neither monitored nor controlled the flow at this point. IIMI-Pakistan has recently installed a new gauge at the head. The measured discharge at FSD is 39 cusecs. There is a provision for placing *karies* in the head structure to regulate the flow.

6.1.3. The Head Regulator of 1R Minor

The Hakra 4-R Distributary bifurcates at RD 72+100 once again. Contrary to the bifurcation structure located at RD 22+300, this bifurcation structure has a proportional divider which requires a control section in both the off-take and the parent channel. To distinguish this structure from an intake structure, another structure, which diverts more than 25 % of the flow of the parent channel, is also regarded as a dividing structure (Bhutta, 1990).

This minor is approximately 15 km in length and serves 33 watercourse command areas. The off-take head structure of 1R Minor is also an ungated weir. The flow from this off-take head structure is never regulated with the use of *karies* (wooden planks). There is, however, provision for *karies* in the head structure. The crest of this structure is of a very unusual type, where modifications were made a few decades ago; a checkered wall measuring 1.33 x 0.63 x 1.16 feet (LxHxW) is evident on the rights side of the crest.

The design width of the crest of 1-R Minor is 5.30 feet. The length of the crest along the flow direction is 5.75 feet. There is no difference in the design and existing width of the intake structure, except for the alteration described above.

The crest has a broken and dilapidated 3-ft gauge. IIMI-Pakistan installed a new gauge in March 1997, in order to help assess the inflow conditions through the bifurcation structure.

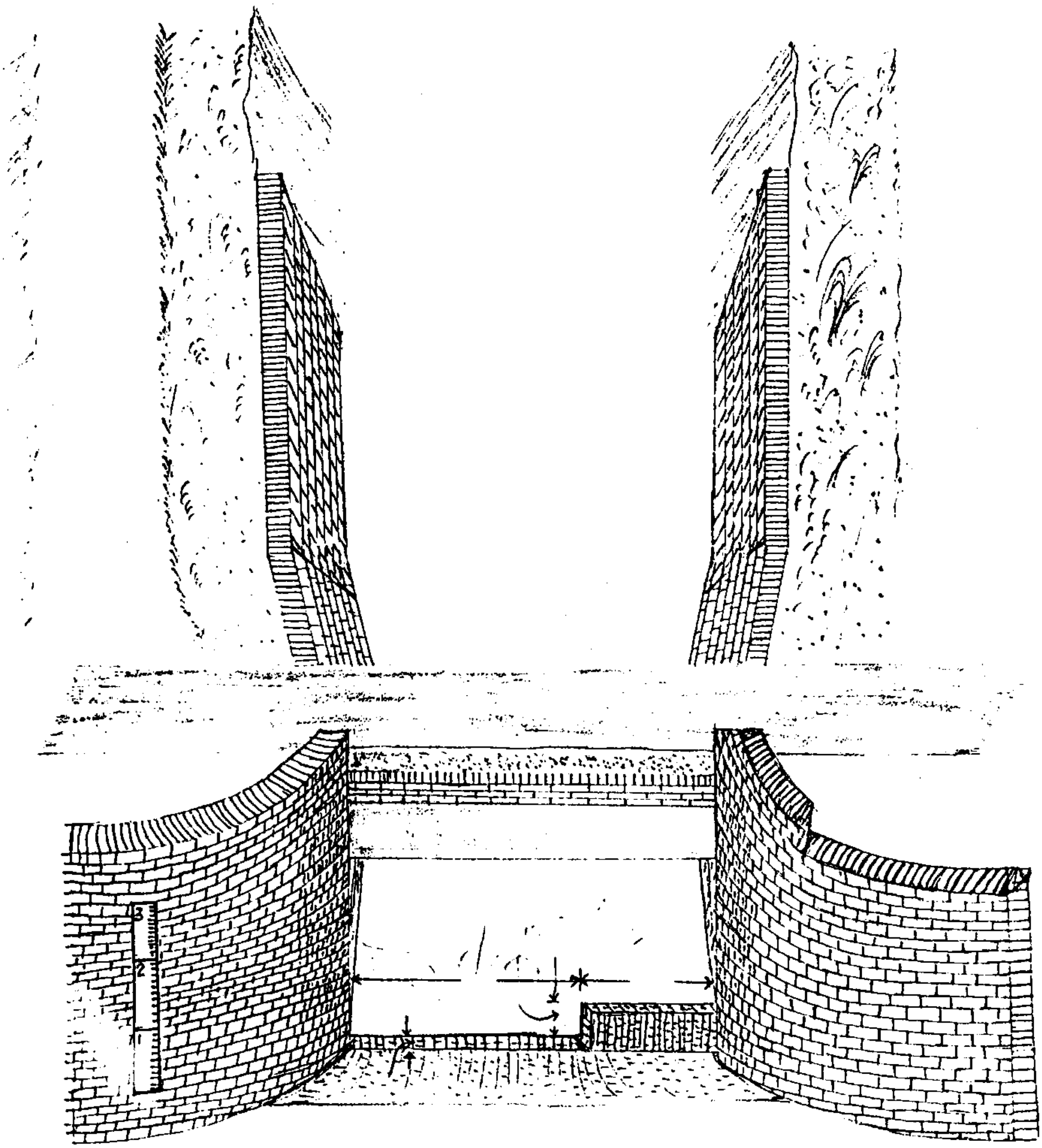


Figure 6. The Head Regulator of 1-R Minor (Transfer Point SS-5).

The design discharge of the minor at this point is 43 cusecs, at a design water depth of 1.99 feet. IIMI-Pakistan measured its discharge to be 62 cusecs at a water depth of 2.86. This structure's flow is always non-modular. The PID gauge reader keeps the rating table for this structure, which is very old.

6.2. DROP STRUCTURES

The first three drop structures along the distributary channel are located about 6 to 8 km apart. The third and fourth drop structures are situated at a distance from 4 to 5 km. All five drop structures are overflow weirs. A detailed description for the two drop structures being used as inflow-outflow points for three of the sub-systems is given in the following sections.

6.2.1. Drop Structure at RD 46+300

This drop structure is located at RD 46+300 and is also an overflow weir-type. The existing and design width of the crest is 11 feet, with the crest's length along the flow direction being 5 feet. The design discharge for this drop structure is 119 cusecs at a design water depth of 2.35 feet. At a FSD of 3.4 feet, the measured discharge at this drop structure is 182 cusecs. With regard to the bed elevation difference on the upstream and downstream sides, this drop structure is also very akin to the drop at RD 24+800. A profile survey conducted during the canal closure of 1996/7 shows that the bed elevation difference between upstream and downstream of the distributary at this drop structure is 0.58 foot. The flow condition through this drop structure is always modular.

As no gauge has ever been installed there in the past, IIMI-Pakistan installed a 4-ft gauge. Contrary to the drop structure at RD 24+800, there is no place for *karies* to regulate the flow. The upstream side of the crest floor has been damaged. Farmers who participated in the walk-through survey reported that the drop structure's crest had been tampered with for up to 6 inches to feed the downstream outlets, about two years ago (against the will of the farmers of the upstream reach). With the lowering of the crest elevation, the water level on the upstream side of the distributary has also dropped. Consequently, the water level on the upstream reach of the distributary has also been reduced, with a concomitant decrease in the discharge for outlets in this reach. Farmers, however, informed that after being tampered with, then the crest was once again altered afterwards. During this adjustment, the crest was raised to a height of two inches. The drop structure has a roof bridge for animals and vehicles to pass. The old roof had become so weak that it was replaced about two years ago. There is, however, no railing along the sides of this bridge over the drop structure.

6.2.2. Drop Structure at RD 72+100

Located at RD 72+100, this is also a weir-type drop structure, with the design and existing widths of the crest being 5.11 and 5.08 ft, respectively, an insignificant difference. The length of the crest along the flow direction is 5 ft. The design discharge at this drop structure for the Hakra 4-R Distributary is 41 cusecs, at a design water depth of

Next >>

1.92 ft. IIMI-Pakistan measured 63 cusecs at a water depth of 2.62 ft. This drop structure has a modular flow.

Contrary to the drop structures at RDs 24+800 and 46+300, there is no elevation difference between the bed elevations on the upstream and downstream sides of the drop structure. A profile survey conducted during the 1996/7 canal closure shows that the bed elevation difference between the upstream and downstream of the distributary at this drop structure is 0.58 foot.

The PID has installed a staff gauge. In February 1997, IIMI-Pakistan installed a new gauge to monitor water supply conditions, with a place for *karies* to regulate the flow. Never, however, is the flow at this drop structure regulated with the use of *karies*.

Similar to that of the IR Minor, this crest structure is also of a very unusual type. The modification was made ten years ago, but, compared to that of the 1R Minor, the crest of the Hakra 4-R Distributary is altered from both the left and right sides at this point. The check wall on the right side is 1.75 x 0.63 x 1.25 ft (LxHxW), and on the left side, the wall is 1.33 x 0.63 x 1.25 feet (LxHxW).

The drop structure has a roof bridge to enable animals and vehicles to pass. However, there is no railing along the sides of the roof over this drop structure.

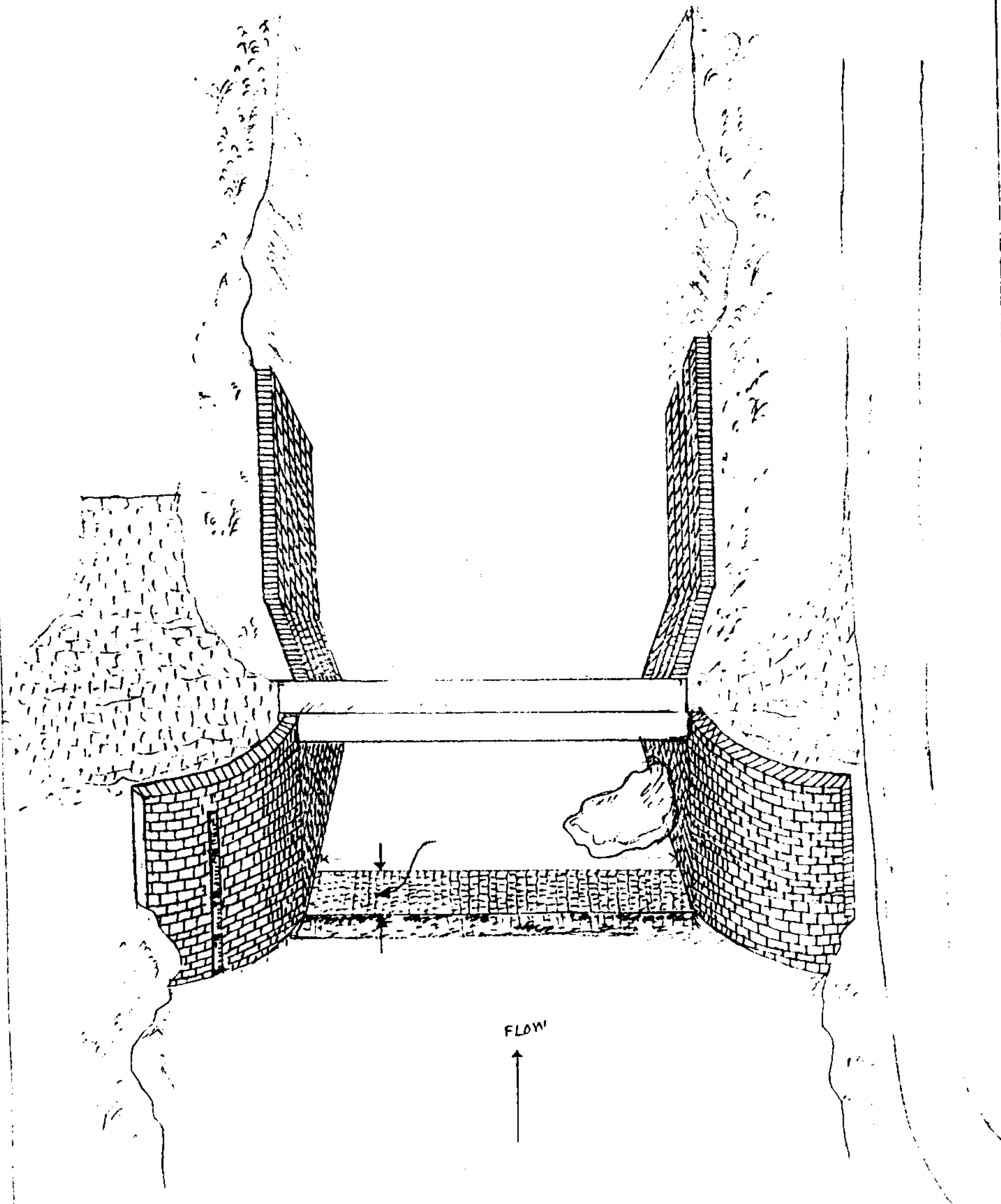


Figure 7. Drop Structure RD 46+300 (Transfer Point of SS-2).

7. READING A GAUGE

In order to establish the discharge rate at any irrigation flow control structure, the first requirement is the ability to read a gauge. In this section, the gauge will be introduced, the importance of using a gauge will be discussed, and then the procedure, differences among gauges, and precautions will be presented.

7.1. INTRODUCTION TO A GAUGE

7.1.1. Description

An instrument used to measure distance, weight, volume, etc., is called a gauge. Gauges may be for different uses, e.g. a thermometer is a temperature gauge, weight is gauged in kg's, volume is measured in *pawa* (pot) and, in the same way, a scale is the gauge used for length. Scales in daily use have different units. For example, meters are used to measure cloth, km for distance, wheat in maunds, gold in grams, while liter is used for liquids, drinking water, Pepsi (soft drink), etc..

Liquids also require different measurement units. For example, volume is used for still water, and cusec (rate of flow, in cubic feet per second) for running water. Naturally, liquids maintain a certain level before adjusting from an upper to a lower level. The canal system demonstrates this phenomenon. To estimate the amount of canal water in cusecs, a gauge was introduced.

7.1.2. Definition

For purposes of measuring hydraulic depth, which is related to discharge rate at an irrigation flow control structure, a gauge may be defined as a *"water-level measuring device which may be an elaborate recording instrument, or merely a stick with meters, or feet, painted on it"* (Penguin Dictionary of Civil Engineering).

7.1.3. The Importance of Using a Gauge

The importance of using a gauge will be explained below in two ways.

7.1.3.1. The Importance of using a Foot Gauge

The foot-pound-second (FPS) system of measurement was introduced in the Indian Sub-continent by the British. Today, in Pakistan, both the FPS and metric systems of measurement are used. However, the Irrigation Department uses the FPS units, which will also be used in this flow measurement training program. If a gauge is marked in inches, then the inch will be sub-divided into 1/4, 1/8, 1/16 and 1/32, which presents a slight difficulty when making calculations. Therefore, this foot system is sub-divided into hundredths-of-a-foot, and can be used in calculations directly.

7.1.3.2. The Value of using a Three-Foot Portable Gauge

Listed below, are a few reasons why three-foot portable gauges are useful.

- This size is neither short, nor long.
- This size is comfortably and easily handled, even when on a bicycle or motorcycle, as well as when walking.
- Most importantly, a length of three feet is sufficient for almost every flow control structure along the Hakra 4-R Distributary.

7.1.4. The Use of Portable Gauges

A portable gauge is usually used to measure the white mark reading. The white mark is also a gauge, as it is installed with the reference being the crest, while the crest elevation could be known by using an engineering level set. Only purpose to install the white mark is that it is easy to manage, as a gauge can be more easily damaged. The white mark is also not too costly like a gauge.

7.2. PROCEDURE

7.2.1. Graduation

A gauge may be graduated in two forms:

1. One foot is sub-divided into tenths of a foot (1/10), or hundredths of a foot (1/100); and
2. A foot may be classified into twelve inches, where each inch is further split into fourths, eighths, sixteenths or thirty-twos.

7.2.2 Gauge Reference

The gauge is usually installed on both the inflow and outflow sides of most flow control structures (i.e., upstream (U/S) and downstream (D/S) sides). The upstream gauge is installed with reference to the crest of the control structure, while the downstream gauge is mostly installed with reference to the downstream design bed level. The gauge's zero constant is according to the crest elevation of the flow control structure, or the design bed elevation immediately downstream of the flow control structure of the channel.

7.2.3. Gauges on Different Structures

Gauges vary in length, according to the particular structure and the associated hydraulic depth. Gauge lengths are listed in the accompanying table, according to different flow control structures.

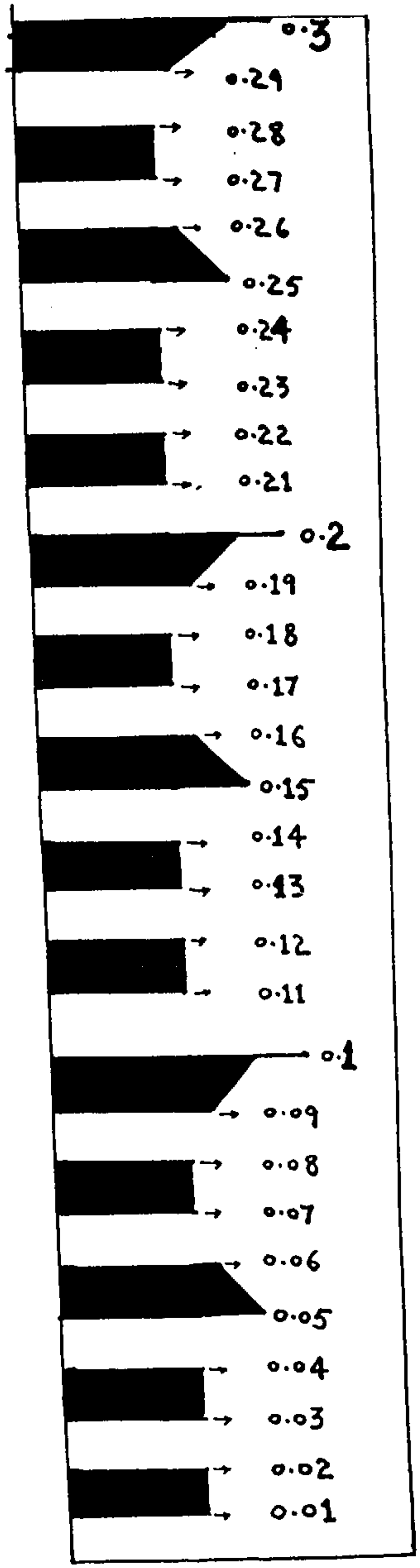


Figure 8. Sketch of a Typical Staff Gauge Used to Record Water Levels.

Table 2. Gauge lengths of different structures in Haroonabad Subdivision.

S.No.	Structures	Gauge Length (in feet)
1	Hakra Canal (Head Ghulab Ali)	10
2	Hakra 1-L Distributary	4
3	Hakra 3-R Distributary	6
4	Hakra 4-R Distributary Head Regulator	4
5	Minor 1RA Head Regulator	3
6	Drop Structure (RD-46) upstream (u/s) gauge	4
7	Minor 1R Head Regulator	3
8	Drop Structure (RD-72) down stream (d/s) gauge	3

For sub-system water management, water distribution for structures 4 to 8, among the five sub-systems of the Hakra 4-R Distributary, needs to be monitored. However, monitoring the discharge at structures 1, 2 and 3 is also important, particularly with regard to the water being received at the Hakra 4-R Head Regulator which is important for the Water Users Federation.

7.3. DIFFERENCES AMONG GAUGES

There is no big difference between various gauges, except for a minor difference that could confuse anyone. The difference in the painting of markers and numbers distinguishes gauges from each other. Also, one gauge has zero (0) painted on it, while for another, the gauge starts from 0.01 ft. For example, the PID gauge is devoid of one-tenth foot graduations, but small boxes are painted to represent the tenth graduations.

7.4. PRECAUTIONS IN USING A GAUGE (BY DRAWING SKETCH)

Make sure that the gauge being used is not damaged; otherwise, an error is likely to occur in the reading.

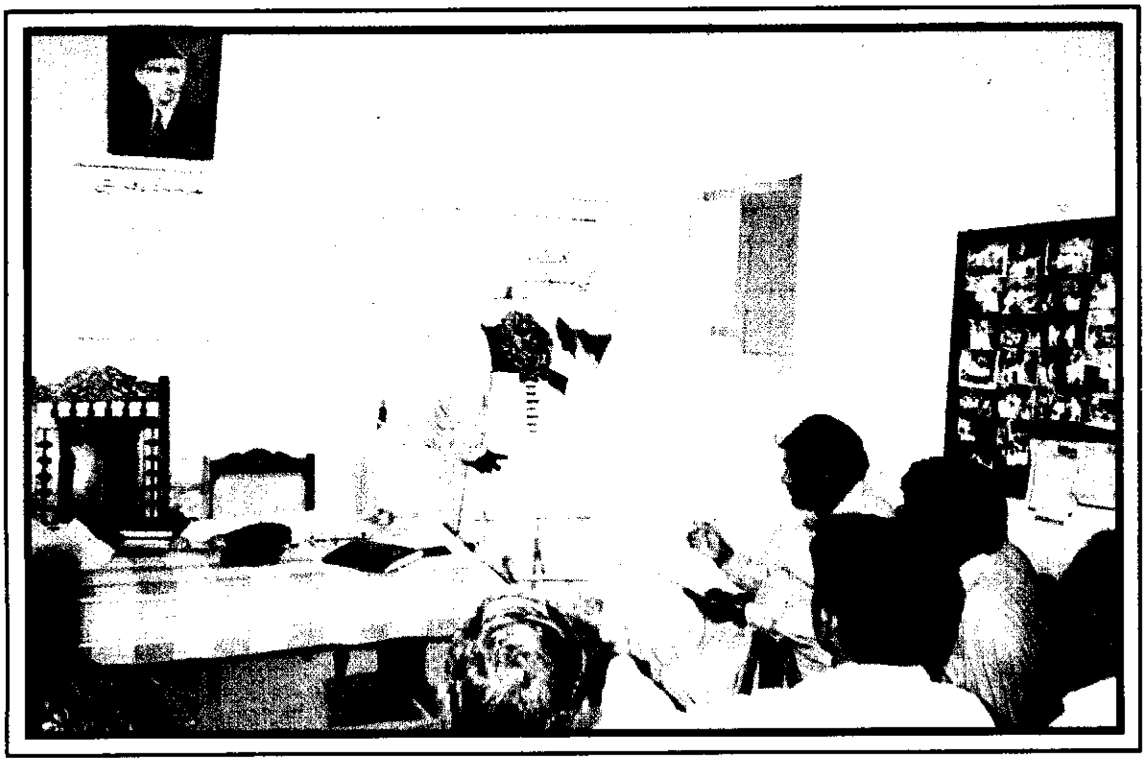
Make sure that the gauge is held firmly in a straight position throughout the reading, otherwise inaccuracies may occur.

Placing the left side (painting) of the gauge against the wall, when taking readings, improves accuracy.

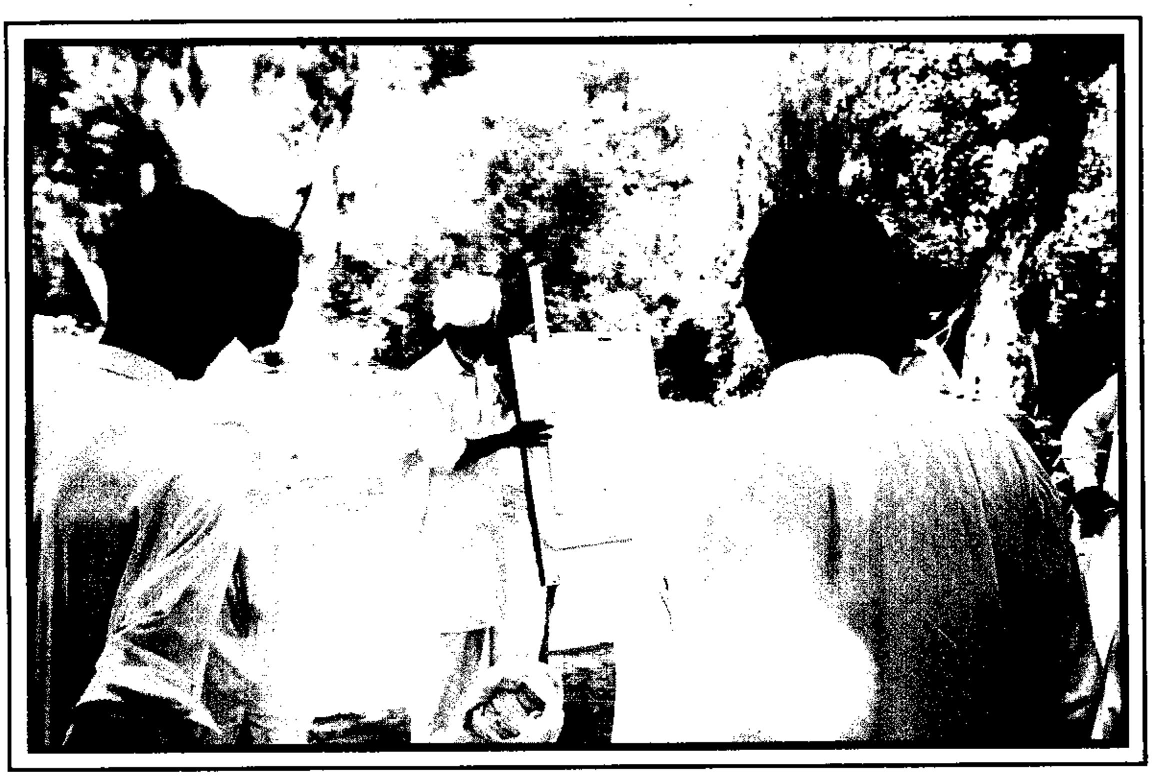
If there is a slope in the structure wall, using a small stick will help to hold the gauge firmly in a vertical position; otherwise, the bend in the structure will result in an error in the gauge reading.

Place the gauge on the water surface to take the reading, then merely touch the water with the bottom of the gauge.

Install the gauge where the flow is stable and free from turbulence, so that the gauge is easy to read. Care for the gauge by maintaining it in a cloth, or leather, cover so that the paint will not be readily tarnished.



Photograph 7. Reading a gauge: farmers training.



Photograph 8. Reading gauge: farmer as a resource person.

8. DEVELOPING DISCHARGE RATINGS FOR FLOW CONTROL STRUCTURES

8.1. MEASURING THE HYDRAULIC DEPTH OF WATER

First of all, the gauge needs to be installed at the downstream side of the flow control structure. To ensure that the gauge shows an accurate depth of water, measure the surface width of the gauging station, or current metering point. Record the water depth at different intervals and measure the average depth without including the end segments near the banks, where the hydraulic depths are much less. Another method is to obtain the cross-sectional area of flow from the current meter measurement, then divide it by the water surface width, to obtain the mean hydraulic depth.

According to Figure 9 (a), the actual bed is above the design bed, due to sedimentation. The procedure adopted to measure the average depth of water is described below.

1) First, select a current metering cross-section near the downstream gauge.

2) Record the water level on the downstream gauge (2.40 ft).

3) The total width of the channel (11.50 ft) is measured by installing a measuring tape just above the water surface.

4) The depth of the water is recorded at intervals of 1.0 ft across the full width of the cross-section.

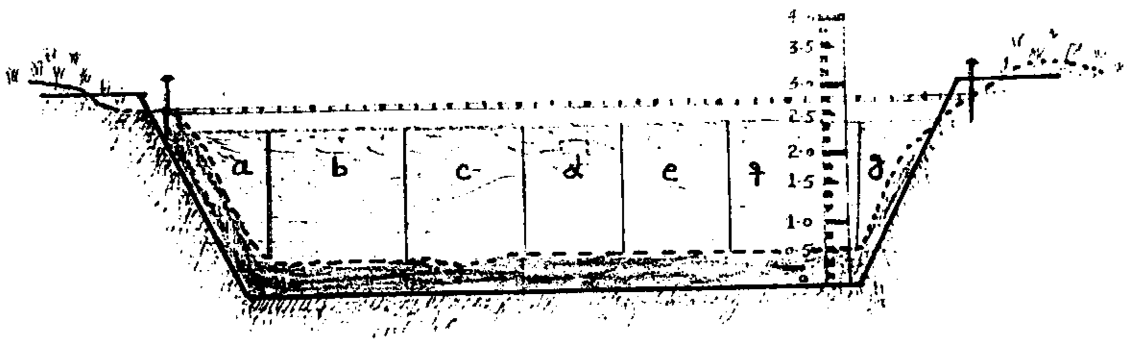
5) The sum of these depths (without including the end segments due to side slopes, i.e. sections 'a' and 'g') is divided by the total number of depth measurements. For this example, the calculated values is 1.90 ft to attain the mean hydraulic depth.

6) To obtain the gauge correction, the formula used is:
D (depth of water) = 1.90 ft (gauge reading - gauge correction) = 2.40 ft - gauge correction
gauge correction = 2.40 ft - 1.90 ft = 0.50 ft.

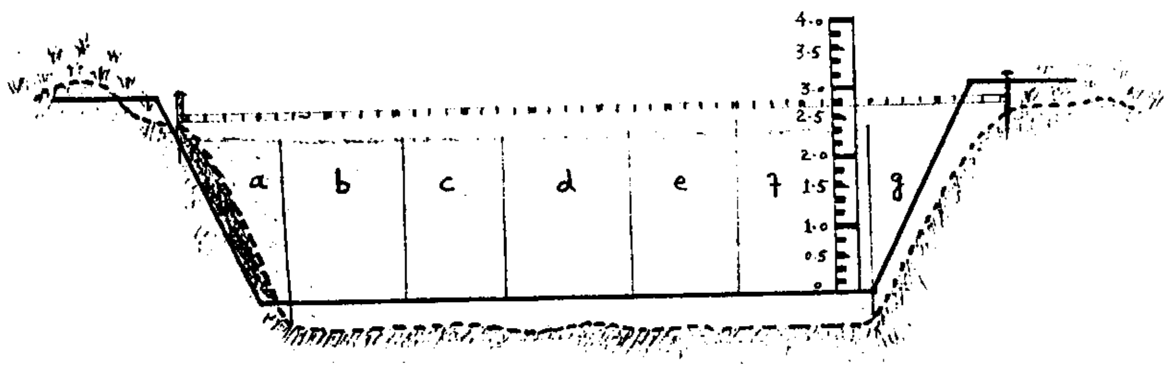
A different situation is illustrated in Figure 9 (b), where the actual bed is below the design bed, due to scouring. Also, the zero constant of the gauge is about 0.50 ft above the actual bed level. The procedure adopted to measure the average depth of the water is listed below.

1) First select a current metering cross-section near the downstream gauge.

2) Record the water level on the downstream gauge (2.40 ft).



(a) Channel width sediment deposition where zero gauge reading is below the actual bed level.



(b) Second channel where zero gauge reading is above the actual bed.

Figure 9. Location of Downstream Gauge in relation to bed of irrigation channel.

3) The total width of the channel (11.0 ft) is measured by installing a measuring tape just above the water surface.

4) The depth of the water is recorded at an interval of every 1.0 ft along the tape.

5) The sum of these depths (without including the end segments, due to side slopes, i.e. sections 'a' and 'g') is divided by the total number of water depth measurements. For this example, the calculated value is 2.90 ft.

6) To obtain the gauge correction, the formula used is:
D (depth of water) = (gauge reading - gauge correction) 2.90 feet = 2.40 feet - gauge correction
gauge correction = 2.40 feet - 2.90 feet = - 0.50 foot

The negative sign means that the zero level for hydraulic depth is 0.50 ft below the zero level on the downstream gauge.

8.2. DEVELOPING DOWNSTREAM (D/S) GAUGE RATINGS

The general formula for developing a downstream (D/S) gauge rating is:

$$Q = K * D^n$$

where,

Q = discharge in cusecs;
K = coefficient of discharge;
D = depth of water; and
n = exponent.

As described in the above section, the downstream gauge reading does not usually correspond with the water depth. Consequently, the downstream gauge needs to be corrected, using the following relationship:

Depth of water = downstream gauge reading minus a gauge correction,

or, $D = G - \Delta G$

where,

G = gauge reading
ΔG = gauge correction

so that,

$$Q = K (G - \Delta G)^n$$

8.3. THE PROCEDURE FOR ACQUIRING FIELD DATA

The following procedure can be used to acquire the necessary field data prior to developing a downstream gauge rating.

(a) Select a flow control structure where a downstream gauge rating is needed.

(b) Measure the discharge downstream of the selected flow control structure using a current meter.

(c) While measuring the discharge, record the downstream (D/S) gauge reading.

(d) After completing steps (b) and (c), the data set contains discharge, Q, in cusecs, and corresponding downstream gauge reading, G, in ft.

(e) Now, to complete one data set, the average depth of water must be calculated (without including the end segments near the channel banks) by taking the values of water depth recorded during the current metering procedure.

(f) Now, one complete data set exists, containing the actual average depth of water, D, gauge reading, G, and calculated total discharge, Q.

(g) Now that one complete data set is available, then additional data sets must be acquired by repeating steps (b), (c), (d) and (e) at different gauge readings until three, four or five complete data sets are available.

(h) As an example, after completing three measurements, suppose the following data is available:

From the first measurement,

Total discharge, Q = 35.21 cusecs;

Downstream (D/S) gauge reading, G = 1.89 ft; and

Average depth of water, D = 2.59 ft.

Then, from the second measurement,

Total discharge, Q = 39.3 cusecs;

Downstream (D/S) gauge reading, G = 2.15 ft; and

Average depth of water, D = 2.85 ft.

And, from the third measurement,

Total discharge, Q = 28.14 cusecs;

Downstream (D/S) gauge reading, G = 1.50 ft; and

Average depth of water, D = 2.20 ft.

The difference between each set of gauge readings and depths of water is 0.70 ft, so that the gauge correction, ΔG = 0.70 ft.

8.4. THE METHOD TO DEVELOP D/S GAUGE RATINGS

(a) Now, logarithmic paper can be used to plot the discharge along the vertical scale and calculated average depth of water, D, along the horizontal scale.

(b) Calculate the value of the gauge correction, ΔG. If the calculated depth of water is greater than the gauge reading, then the difference between the two, ΔG, will be added to the gauge reading, G; and, if the calculated depth of water is less than the gauge reading, then the difference, ΔG, will be deducted from the gauge reading, G.

(c) Now, plot the discharge on the vertical scale and the depth of water (downstream (D/S) gauge reading - gauge correction) on the horizontal axis, and mark the appropriate point on the logarithmic paper. Repeat this procedure for each data set.

(d) Draw a 'best fit' line which passes through the plotted data points.

(e) Now calculate the value of K according to the scale where this line intercepts the vertical axis for D = 1. Then, measure the angle of the slope and calculate the value of the exponent, n, using the tangent of the measured angle.

(f) Develop the downstream (D/S) gauge rating table for this structure by using the formula:

$$Q \text{ (discharge in cusecs)} = K (G - \Delta G)^n$$

The values of K and n were obtained from step (e). The values of the gauge correction, ΔG, was obtained in step (b). So, the only unknowns are G and Q. The rating table is prepared by calculating the discharge, Q, by inserting incremental values of G. The gauge reading on the downstream gauge is observed in the field. This value of G can be entered into the rating table to obtain the corresponding value of the discharge, Q.

An example is shown in Annex 5 form for the head regulator of 1RA Minor / Hakra 4-R Distributary.

8.5. DISADVANTAGES OF DOWNSTREAM GAUGE RATINGS

In case there is sedimentation and scouring, the rating tables developed from the downstream gauge needs periodic adjustment. Typically, this would require additional current meter measurements.

However, if the flow control structure has also been calibrated, then periodic adjustments (such as after each *kharif* and *rabi* season) of the downstream gauge rating is quite simple, and a current meter measurement is not required.

8.6. CALIBRATION OF FLOW CONTROL STRUCTURES

The primary advantage in developing a discharge calibration for a flow control structure is that changing conditions upstream and downstream from the structure may affect the discharge rate passing through the structure, but does not change the discharge calibration (rating) for the structure. In other words, if sediment deposition or scouring is occurring downstream from the flow control structure, which would affect the discharge rate passing through the structure, this change in discharge would be precisely measured by the calibration for the flow control structure.

If the flow control structure is calibrated at the same time that current meter measurements are being taken to acquire the field data for developing a downstream gauge rating, then very little extra work is required. While doing a current meter measurement, besides reading the water level on the downstream gauge, the gate opening and a flow depth upstream, and another downstream of the gate would be required in order to calibrate the flow control structure.

Now, instead of having to take a current meter water measurement towards the end of an irrigation season in order to properly adjust the gauge correction, ΔG, the discharge through the flow control structure can be obtained from a rating table by knowing the gate opening and upstream and downstream flow depths. By recording the water level on the downstream gauge, the gauge correction can be easily calculated. In fact, each adjustment of the downstream gauge rating would only require one or two hours.

9. WATER DISTRIBUTION AMONG SUB-SYSTEMS

9.1. WATER DUTIES

Pakistan's canal system has been designed to facilitate a maximum area under cultivation by spreading the irrigation water thinly. Water duty varies from 2.55 to 3.33 cusecs / 1000 acres, except for new projects (Latif and Waheed, 1996). This allocation was not based on scientific theory, but to avert famine conditions and to satisfy many settlers. The water duty was based on a 75 % cropping intensity; 25 % in the summer, and 50 % in the winter season.

The Punjab Province's irrigation systems were designed to maintain equity. The water is allocated in the canal commands in terms of water duty, which is defined as the "water allowance in cusecs per thousand acres", yet the duties for all channels, and for all *chaks* along a particular canal, were not the same (Bhutta, 1990). The Punjab Irrigation Department follows certain rules to operate the channels, one of which is that the channels should be run close to the design discharge if adequate supplies are available, and if, on the other hand, water deliveries are insufficient, rotational irrigation should be practiced.

9.2. THE FIVE SUB-SYSTEMS

Before discussing the water distribution pattern, the hydrological boundaries of each of the five sub-systems of the Hakra 4-R Distributary system is relevant. The following table indicates the extent, and size, of each sub-system.

Table 3. The extent, and size, of each of the five sub-systems.

Name of the Sub-system	RD	No. of outlets
Sub-system 1	0+00 to 46+300	25
Sub-system 2	46+300 to 72+100	23
Sub-system 3	72+100 to 112+050	27
Sub-system 4	1RA Minor (Tail RD 22+000)	15
Sub-system 5	1R Minor (Tail RD 50+623)	33

9.3. DESIGN DISCHARGES

One basis to calculate water duties could be the design discharges of different sub-systems. But these discharges are so old that their validation is questionable. Therefore, it is inappropriate to consider the design figures for such calculations. Moreover, much confusion exists among design discharge figures. For example, the following table indicates the progression in the design discharges of the Hakra 4-R Distributary, taken from the ID record, and as reported by their field staff.

Table 4. The history of design discharge at the head of the Hakra 4-R Distributary.

Reference Year	Discharge (Cusecs)	Source
1963	189	ID Record
1966	193	ID Record
1996	225	Reported by SDO

Sub-system-wise design discharges are also given in the following table, considering 193 cusecs at a water depth of 3.25 ft at the head of the distributary.

Table 5. Design discharges for each sub-system in Hakra 4-R Distributary.

Name of the Subsystem	Design Discharge	Source
Sub-system 1	52	ID record
Sub-system 2	35	ID record
Sub-system 3	41	ID record
Sub-system 4	22	ID record
Sub-system 5	43	ID record

9.4. MEASURED DISCHARGES

During the first training course, on September 2, 1997, the discharges at all the transfer points were measured, and the quantum of water for each of the five sub-systems was calculated. Measuring 240.7 cusecs at a water depth of 2.52 ft at the head of the distributary, the calculated quantum for each of the five sub-system is presented in Table 6.

Table 6. Measured discharges on 2 September 1997 for each sub-system in Hakra 4-R Distributary.

Name of the Subsystem	Measured Discharge	Source
Sub-system 1	30	WUF+IIMI
Sub-system 2	68	WUF+IIMI
Sub-system 3	67	WUF+IIMI
Sub-system 4	35.64	WUF+IIMI
Sub-system 5	39.7	WUF+IIMI

Tables 5 and 6 display great variation in the design and measured discharges. This comparison indicates that placing emphasis on the design discharges is futile. Therefore, for the purpose of calculating the water duties above, measured discharges were used. An important point is that CCAs used in the calculation were taken from official sources. A survey to record CCAs has never actually been conducted. The following section describes the water duty calculated in each sub-system.

9.5. DISTRIBUTION OF WATER DUTIES AMONG SUB-SYSTEMS

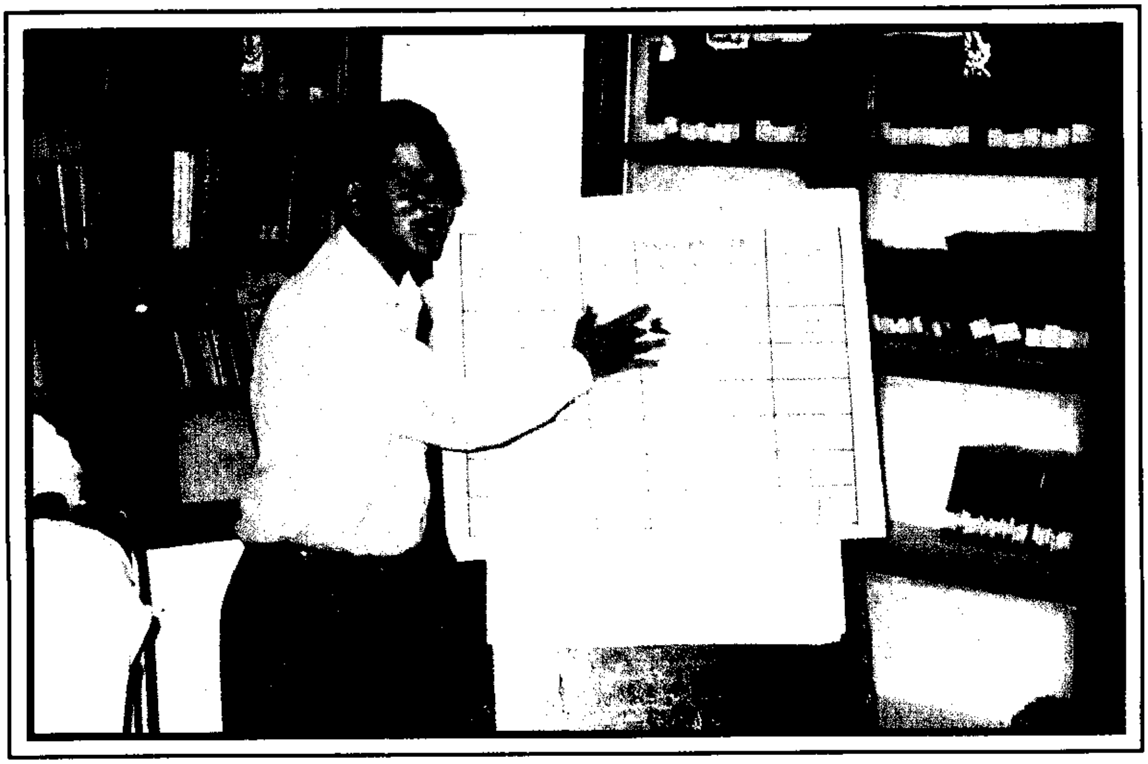
The water distribution pattern for each of the five sub-systems of the Hakra 4-R Distributary was studied in terms of water allowances, in cusecs / 1000 acres. The calculation of water duties present very interesting results. The water duty for Sub-system 1 is calculated to be 3.22 cusecs / 1000 acres, the lowest among the five sub-systems. The calculated figure of water duty for Sub-system 2 is 9.67 cusecs / 1000 acres, the highest among the sub-systems. The current water allowance for Sub-system 3 is 6.3 cusecs / 1000 acres. After Sub-system 2, Sub-system 3 draws a maximum quantum of water. The water allowance of Sub-system 4 is calculated as 5.84 cusecs / 1000 acres. Relatively speaking, this sub-system is in the middle in terms of receiving water supplies, as it draws neither less, nor more. In terms of water duties, Sub-systems 1 and 4 are at the bottom, the water duty figures of which are close to each other. The distribution of water duties among the sub-systems based on the measurement of transfer points of each sub-system is presented in Table 7.

Table 7. The distribution of water duties among the sub-systems in Hakra 4-R Distributary.

Name of the Subsystem	CCAs (in acres)	Measured Discharge	Water Duties	Source
Sub-system 1	9435	30	3.22*	WUF+IIMI
Sub-system 2	7580	68	9.67	WUF+IIMI
Sub-system 3	10635	67	6.3	WUF+IIMI
Sub-system 4	6100	35.64	5.84	WUF+IIMI
Sub-system 5	10200	39.7	3.89	WUF+IIMI

* *Few outlets were closed on that day.*

The above flow measurement results were presented to farmer leaders on the third day of the first training course. Farmers discussed the results, and a few raised the point that the sub-system discharges present unusual water duty figures, and that these should be measured again. To remove the farmers' doubts, the accuracy of these measurements were determined by double-checking the discharge at the transfer point (RD 46+300). There was no difference between the first and second discharge measurement readings. Before the training, on August 1, 1997, for the purpose of the calibration, the discharge at RD 46+300 was measured as 182 cusecs at a water depth of 3.10 ft, and later, on September 28, 1997, the reading reflected 188 cusecs at a water level of 3.14 ft. These measurements authenticate the accuracy of the IIMI field staff measurements. Thus, the variations observed in the water duties are quite accurate.



Photograph 9. Presentation of Flow measurement results by Field Team Leader.

Photograph 10. Participants listening the results of the flow measurements.

9.6. WATER DUTIES

The water distribution pattern of each of the five sub-systems of the Hakra 4-R Distributary was also studied, in terms of average of water duties (cusecs / 1000 acres). The calculation of water duties, again, shows great variation in the water duties among the sub-systems.

The calculated figure of water duty for Subsystem 2 is 7.09 cusecs / 1000 acres, the highest among the sub-systems. The of water duty for Sub-system 3 is calculated as 6.85 cusecs / 1000 acres, the lowest. The current water duty for Sub-system 4 is 4.84 cusecs / 1000 acres. The water duty for Sub-system 1 and Sub-system 5 is 5.40 and 5.89 cusecs / 1000 acres, respectively. Relatively speaking, Sub-systems 1 and 5 are in the middle, in terms of receiving water supplies.

The distribution of water duties among the sub-systems is presented in Table 8. In this table, water duties of each sub-system based on the average of water duties of all the watercourses of respective sub-system.

Table 8. Water duties of the 5 sub-systems of the Hakra 4-R Distributary.

Name of the Sub-system	CCA (in acres)	Water Duty (q / 1000)	Remarks
Sub-system 1	8808.00	5.40	Excluding 2 watercourses
Sub-system 2	5822.00	7.09	Excluding 5 watercourses
Sub-system 3	10734.00	6.85	
Sub-system 4	6107.00	4.84	
Sub-system 5	8817.00	5.89	Excluding 8 watercourses

9.7. WEIGHTED AVERAGE WATER DUTY

The weighted average water duty for the entire Hakra 4-R Distributary has been calculated as:

$$\text{Weighted Avg. Water Duty} = \sum_{WC=1}^{WC=n} \frac{CCA * WD}{\sum_{1}^{N} CCA}$$

$$= \frac{244540}{41736} = 5.86\,\text{cfs} / 1000\,\text{acres}$$

comparing weighted average water duty of the Hakra 4-R Distributary with the water duty of each sub-system reveals that out of 5 sub-systems, 3 sub-systems have less water duty whereas other two sub-systems have higher water. The weighted average water duty has been used in calculating relative water duty, and is presented in Chapter 10.

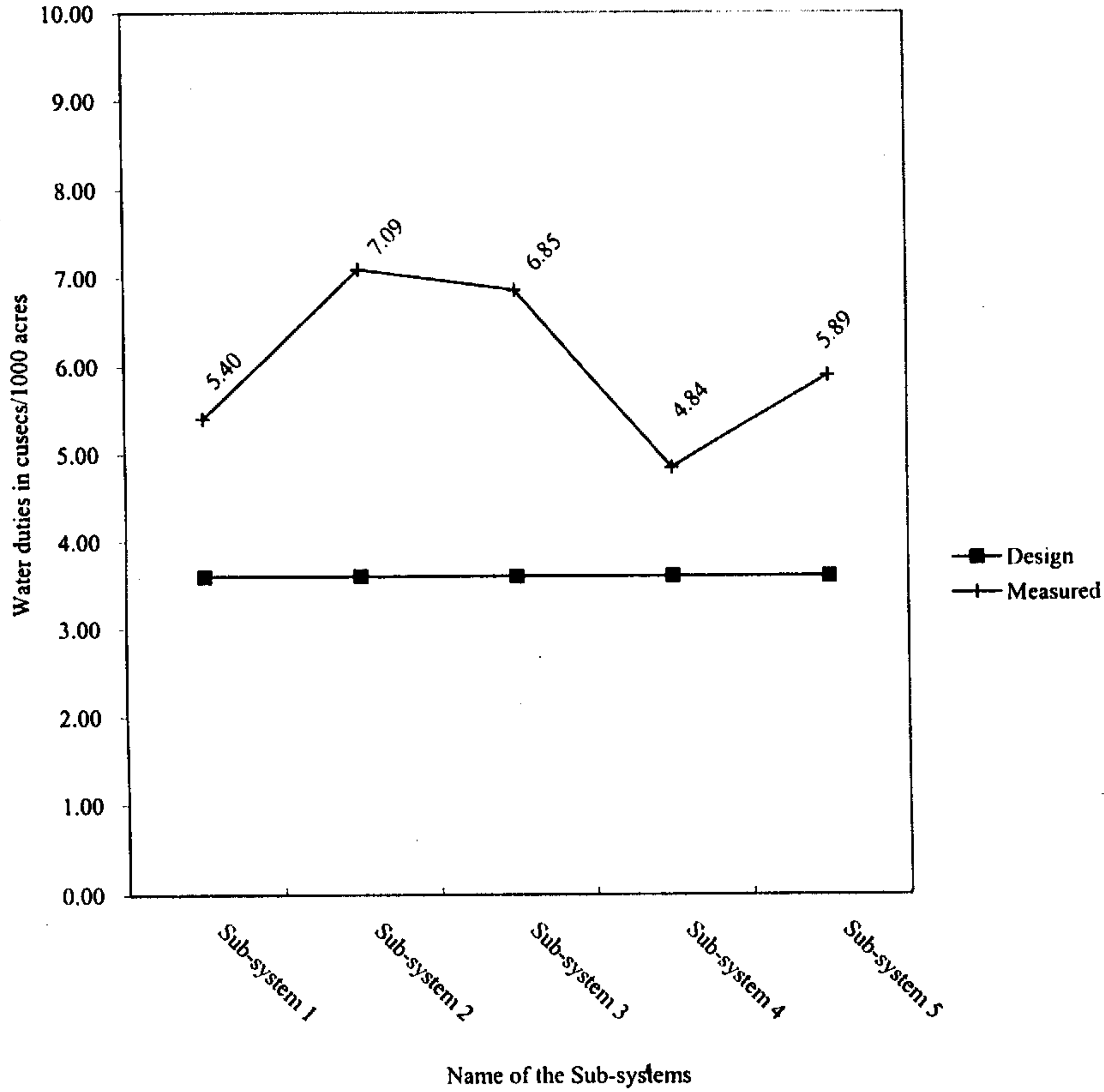


Figure 10. Comparison of design and measured water duties among five sub-systems of the Hakra 4-R Distibutary.

10. WATER DISTRIBUTION WITHIN SUB-SYSTEMS

The results presented in Chapter 5 are outcomes of the water measurement conducted during the first training course, for leaders of the Water Users Federation. In this training course, the focus of the flow measurement was to measure the discharge entering at each transfer point. Based on these measurements, the quantum of water of each sub-system was calculated, which was then used to calculate the water duties for each sub-system.

This chapter presents the results of flow measurement conducted in five training courses at sub-system level. In these training courses, the flows were measured at each transfer point, as well as at all the outlets serving each sub-system. For practice, to calculate the water duties of each outlet, these measurements were then used in the training sessions. Next, these data were used to calculate the water duties, and the findings were presented before all the farmer representatives of the Hakra 4-R Distributary. These results present an interesting water distribution pattern, in terms of duties within each sub-system.

The variations in water duties among the outlets of the Hakra 4-R Distributary is given in Figure 11. The majority of the watercourses have water duties ranging from 4.51 to 7.50 cusecs / 1000 acres. 18 % of the watercourses fall in the range of 3.51 to 4.50 cusecs / 1000 acres, 14 % in the range of 7.51 to 9.50 cusecs /1000 acres. There is one outlet that has water duty above 11.51 cusecs / 1000 acres.

10.1. WATER DISTRIBUTION WITHIN SUB-SYSTEM 1

The calculated water duties for the watercourses for Sub-system 1 are presented in Table 9, which indicates a great variation in water duties between the watercourses in this sub-system. The majority of the watercourses have water duties ranging from 5.51 to 7.5 cusecs / 1000 acres. Approximately 13 % of the watercourses have water duties ranging between 2.51 and 3.5 cusecs / 1000 acres. The water duties of about 30 % of the watercourses range between 3.51 and 5.50 cusecs / 1000 acres. For about 9 % of the watercourses, this range is from 7.51 to 9.50 cusecs / 1000 acres. The water duties of each watercourse is presented in Table 9. Categorized water duties are shown in Figure 12.

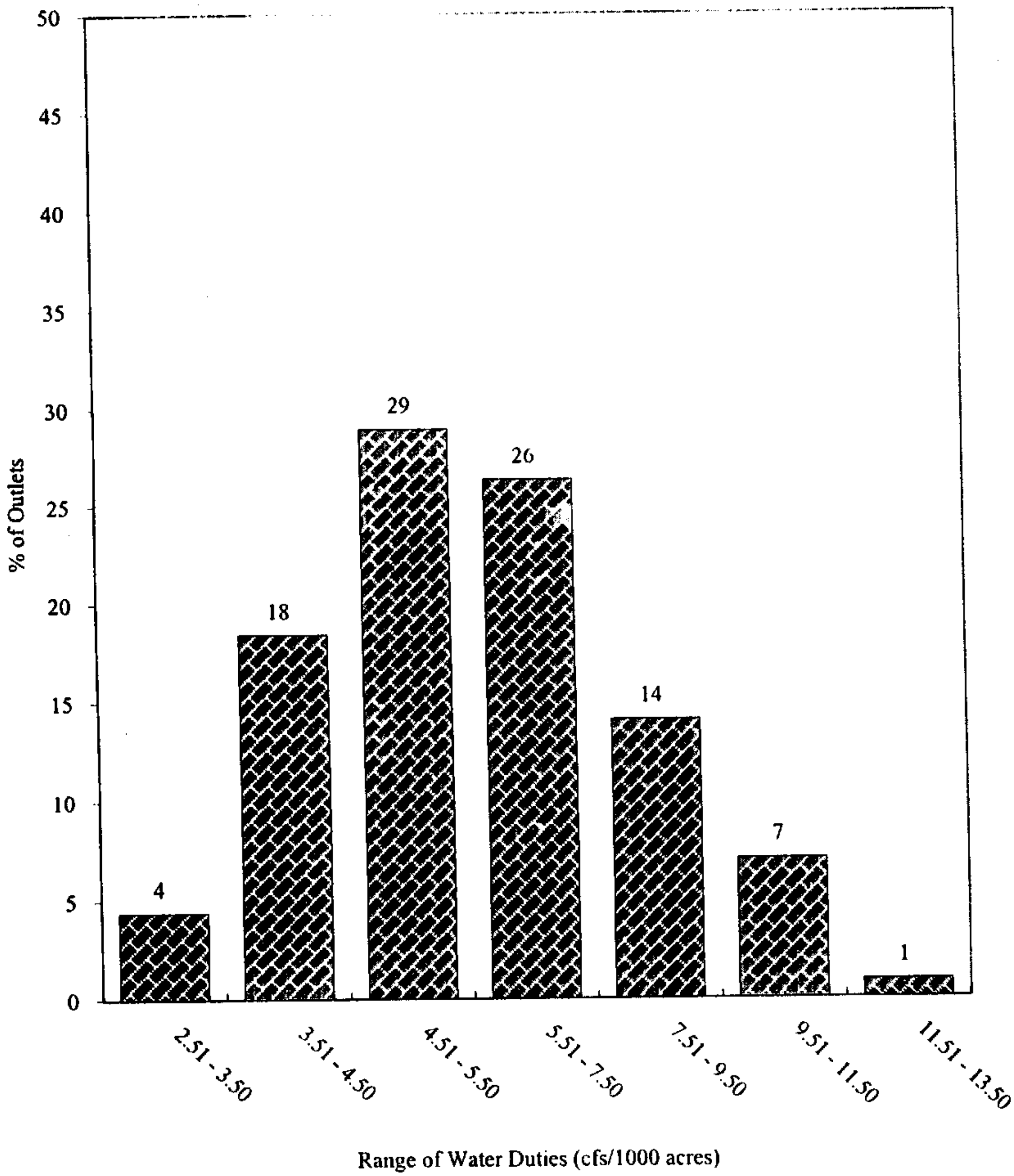


Figure 11. Variations in water duties among the outlets of the Hakra 4-R Distributary.

Table 9. Water duties for Sub-system 1 of the Hakra 4-R Distributary.

Outlets Location	Q (cusecs)	CCA (acres)	Water duty (Q / 1000)	Relative water duty (WD/Wtd.Avg.WD)
1240/L	1.70	223	7.62	1.30
4162/L	4.18	697	6.00	1.02
6431/L	1.55	355	4.37	0.75
14670/R	1.10	266	4.14	0.71
14865/L	NR	NR	NR	NR
16290/R	6.08	1003	6.06	1.03
17100/L	2.95	408	7.23	1.23
21798/L	3.36	463	7.26	1.24
21812/R	1.50	235	6.38	1.09
22818/L	1.46	467	3.12	0.53
24474/L	1.61	465	3.46	0.59
24582/R	0.65	182	3.57	0.61
28208/L	2.00	416	4.81	0.82
31980/L	1.33	392	3.39	0.58
33130/L	0.91	228	3.99	0.68
34630/R	1.10	307	3.58	0.61
35730/L	1.13	282	4.01	0.68
39610/R	1.62	416	3.89	0.66
40400/R	2.07	404	5.12	0.87
43320/L	NR	289	NR	NR
44580/R	2.38	500	4.76	0.81
45810/R	2.63	386	6.81	1.16
45850/R	2.27	283	8.02	1.37
46237/R	1.21	115	10.52	1.80
46240/L	2.71	447	6.06	1.03

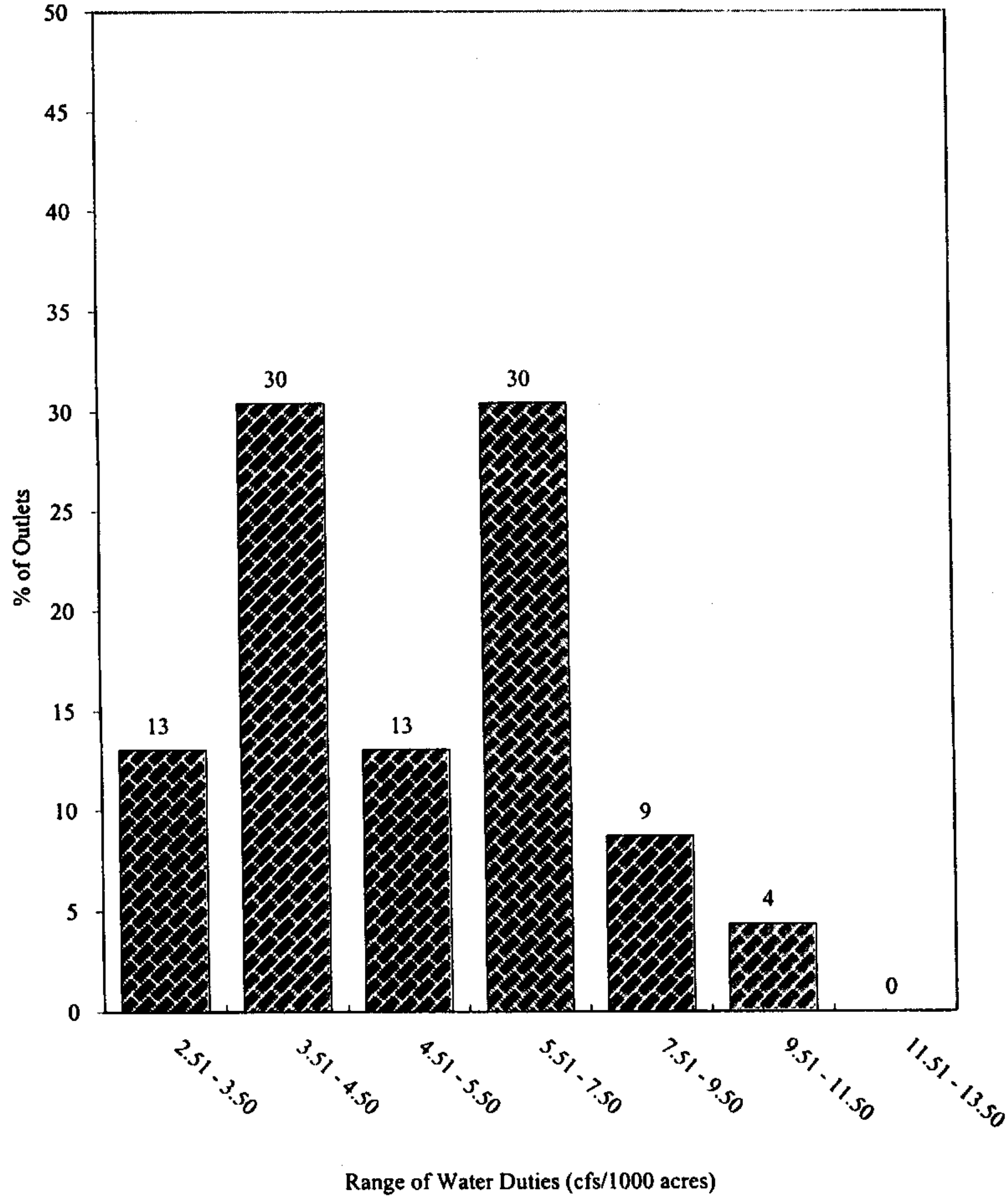


Figure 12. Distribution of water duty among the outlets of Subsystem 1 of Hakra 4-R Distributary.

10.2. WATER DISTRIBUTION WITHIN SUB-SYSTEM 2

The calculated water duties for the watercourses of Sub-system 2 are presented in Table 10, which indicates that there is also a great variation in the water duties between the watercourses in this sub-system. The majority (28 %) of watercourses have water duties ranging from 7.51 to 9.50 cusecs / 1000 acres. Approximately 0 % of watercourses have water duties ranging between 2.50 and 3.5 cusecs / 1000 acres. Water duties for about 11 % of watercourses range between 5.51 and 7.50 cusecs / 1000 acres. For about 17 % of watercourses, this ranges between 9.51 and 11.50 cusecs / 1000 acres. These water duties for each watercourse of sub-system 2 is presented in Table 10. Categorized water duties are shown in Figure 13.

Table 10. Water duties for Sub-system 2 of the Hakra 4-R Distributary.

Outlets Location	Q (cusecs)	CCA (acres)	Water Duty (Q / 1000)	Relative water duty (WD/Wtd.Avg.WD)
50310/R	1.46	274	5.33	0.91
50950/L	2.47	312	7.92	1.35
52050/L	2.83	383	7.39	1.26
52050/R	NR	310	NR	NR
54700/L	1.49	363	4.10	0.70
55715/L	0.71	130	5.46	0.93
56730/L	3.47	302	11.50	1.96
57860/R	NR	138	NR	NR
57870/R	2.98	283	10.53	1.80
57890/L	3.01	567	5.31	0.91
59100/R	2.33	395	5.90	1.01
59130/R	3.03	370	8.19	1.40
60490/L	1.66	371	4.47	0.76
62670/R	1.85	208	8.89	1.52
63910/L	1.73	186	9.30	1.59
63910/R	NR	NR	NR	Water supply outlet
65080/L	3.44	365	9.42	1.61
65080/R	NR	NR	NR	Water supply outlet
66050/L	3.36	338	9.94	1.70
69100/R	NR	NR	NR	Water supply outlet
69310/R	NR	NR	NR	NR
69482/L	---	---	---	Watercourse of the outlet 69490/L is supplemented by U/S pipe 69482/L
69490/L	NR	415	NR	
70640/L	NR	473	NR	NR
71270/R	1.30	270	4.81	0.82
71735/L	1.56	362	4.31	0.74
71750/R	1.73	348	4.97	0.85

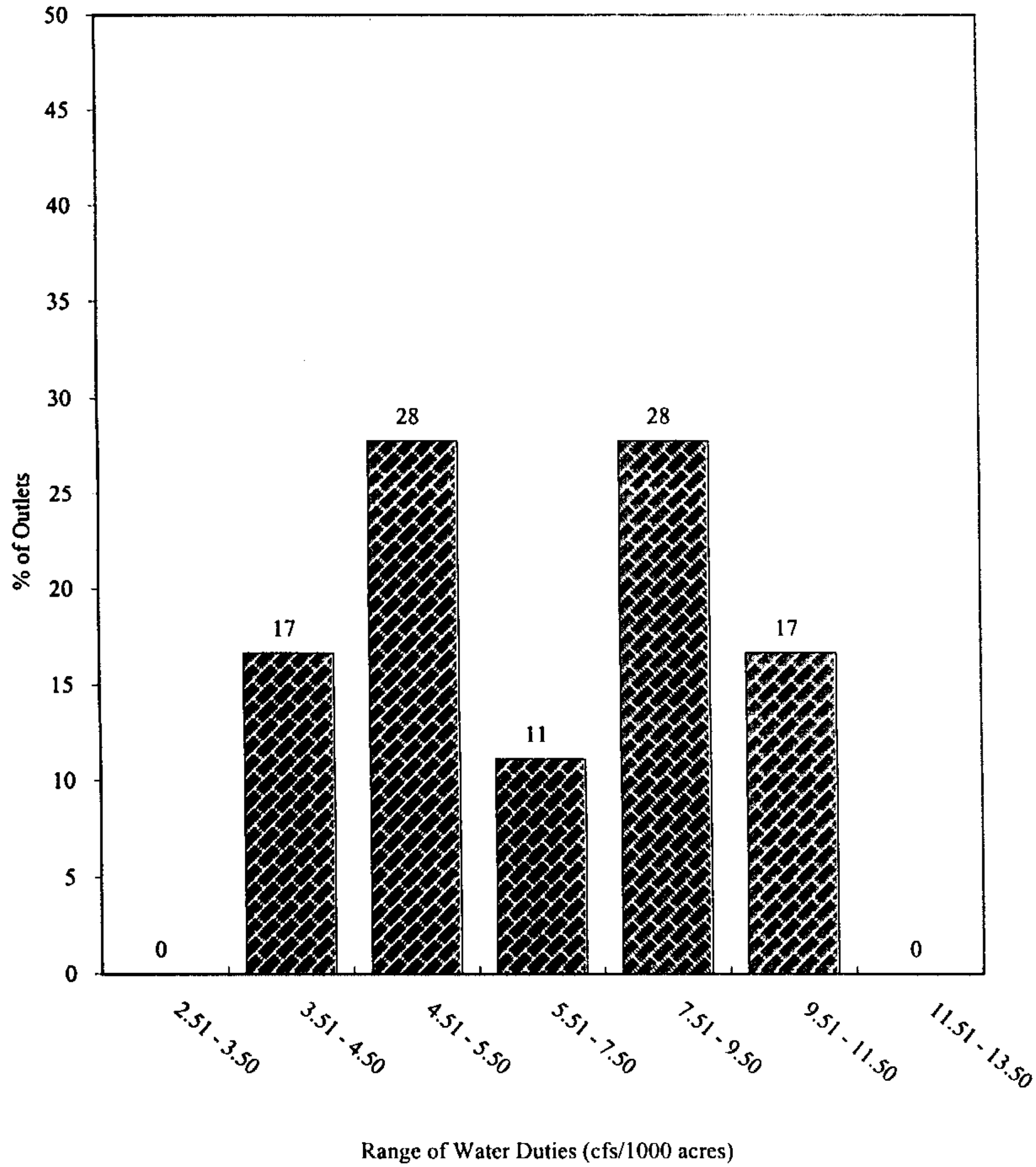


Figure 13. Distribution of water duty among the outlets of Subsystem 2 of Hakra 4-R Distributary.

10.3. WATER DISTRIBUTION WITHIN SUB-SYSTEM 3

The calculated water duties for the watercourses of Sub-system 3 are presented in Table 11, which indicates that there is also a great variation in the water duties among the watercourses in this sub-system. The majority (44 %) of watercourses have water duties ranging from 5.51 to 7.5 cusecs / 1000 acres. Approximately 7 % of watercourses have water duties ranging between 3.51 and 4.50 cusecs / 1000 acres. The water duties of about 11 % of watercourses ranges between 9.51 and 11.50 cusecs / 1000 acres. For about 19 % of the watercourses, this range is from 7.51 to 9.51 cusecs / 1000 acres. The water duties of another 19 % of watercourses are in the range of 4.51 to 5.50 cusecs / 1000 acres. The water duties for each watercourse of Sub-system 3 is presented in Table 11 Categorized water duties are shown in Figure 14.

Table 11. Water duties for Sub-system 3 of the Hakra 4-R Distributary.

Outlets Location	Q (cusecs)	CCA (acres)	Water Duty (Q / 1000)	Relative water duty (WD/Wtd.Avg.WD)
72382/L	NR	NR	NR	Factory pipe
73900/R	NR	NR	NR	Forest pipe
75366/R	2.35	364	6.46	1.10
78400/R	2.39	343	6.97	1.19
79924/L	2.07	297	6.97	1.19
79930/L	NR	NR	NR	Water supply pipe
81350/R	2.21	343	6.44	1.10
86376/L	3.32	612	5.42	0.93
87640/R	4.29	376	11.41	1.95
88920/L	1.90	330	5.76	0.98
89179/L	2.51	355	7.07	1.21
91706/R	0.86	83	10.36	1.77
92631/L	3.09	374	8.26	1.41
93870/L	2.36	377	6.26	1.07
94300/L	2.46	506	4.86	0.83
95102/L	1.50	152	9.87	1.68
95920/R	2.85	329	8.66	1.48
96362/L	3.99	610	6.54	1.12
98729/L	3.01	478	6.30	1.07
101069/L	2.65	491	5.40	0.92
102214/R	4.15	439	9.45	1.61
102234/L	2.70	411	6.57	1.12
104520/L	2.93	564	5.20	0.89
105634/R	2.37	265	8.94	1.53
107020/R	2.38	312	7.63	1.30
107022/L	2.26	485	4.66	0.80
107055/R	1.95	349	5.59	0.95
109980/R	1.96	354	5.54	0.94
112050/TL	1.50	358	4.19	0.72
112050/TR	2.73	646	4.23	0.72

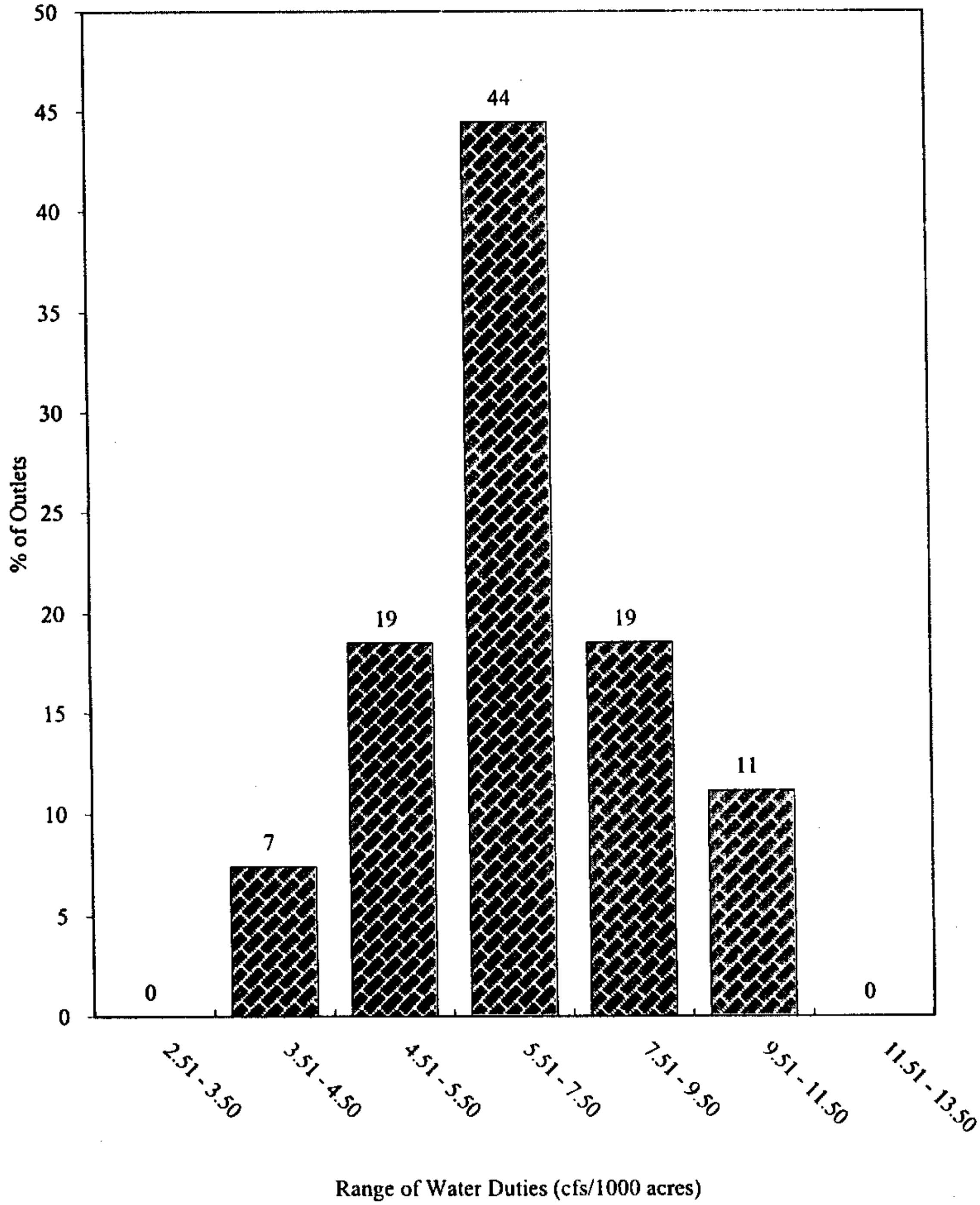


Figure 14. Distribution of water duty among the outlets of Subsystem 3 of Hakra 4-R Distributary.

10.4. WATER DISTRIBUTION WITHIN SUB-SYSTEM 4

The calculated water duties for the watercourses of Sub-system 4 are presented in Table 12, which indicates that there is also a great variation in the water duties among the watercourses of this sub-system. The majority of watercourses (47 %) have water duties ranging from 4.51 to 5.50 cusecs / 1000 acres. Approximately 33 % of watercourses have water duties in the range of 3.51 to 4.50 cusecs / 1000 acres. The water duties of about 13 % of watercourses falls in the range of 2.51 to 3.50 cusecs / 1000 acres. In this sub-system, none of the watercourses fall within the water duty range of 5.51 to 11.50 cusecs / 1000 acres. The water duties for each watercourse of Sub-system 4 are presented in Table 12. Categorized water duties are shown in Figure 15.

Table 12. Water duties for Sub-system 4 of the 1-RA Minor/Hakra 4-R Distributary.

Outlets Location	Q (cusecs)	CCA (acres)	Water Duty (Q / 1000)	Relative water duty (WD/Wtd.Avg.WD)
674/L	0.95	188	5.05	0.86
4000/R	2.86	548	5.22	0.89
4700/L	3.00	249	12.05	2.06
8565/L	2.22	584	3.80	0.65
9661/L	1.68	418	4.02	0.69
10291/R	2.22	524	4.24	0.72
11785/L	2.69	502	5.36	0.91
14080/L	1.32	273	4.84	0.83
16280/R	1.85	369	5.01	0.86
18480/L	1.33	275	4.84	0.83
19580/R	0.95	252	3.77	0.64
22000/TL1	1.83	481	3.80	0.65
22000/TL2	1.77	608	2.91	0.50
22000/TF	1.53	539	2.84	0.48
22000/TR	1.76	361	4.88	0.83

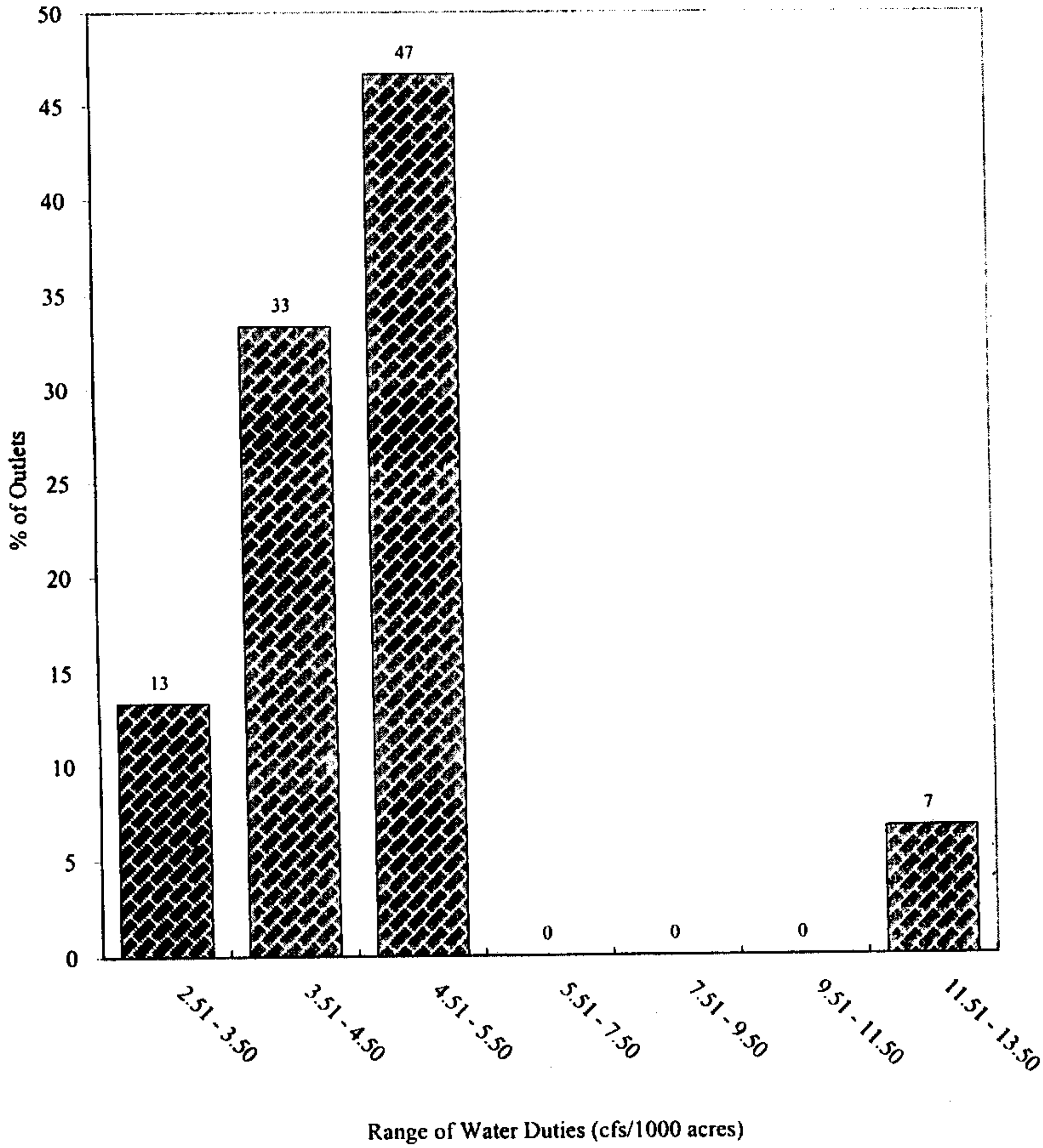


Figure 15. Distribution of water duty among the outlets of Subsystem 4 of Hakra 4-R Distributary.

10.5. WATER DISTRIBUTION WITHIN SUB-SYSTEM 5

The calculated water duties for the watercourses of Sub-system 5 are presented in Table 13, which indicates that there is also a great variation in the water duties among the watercourses of this sub-system. The majority (42 %) of watercourses have water duties ranging from 4.51 to 5.50 cusecs / 1000 acres. Approximately 13 % of watercourses have water duties ranging between 3.51 and 4.50 cusecs / 1000 acres.

The water duties for about 13 % of watercourses fall in the range of 7.51 to 9.50 cusecs / 1000 acres. For about 29 % of watercourses, this range is from 5.51 to 7.50 cusecs / 1000 acres. The water duties of another 3 % of watercourses range between 9.51 and 11.50 cusecs / 1000 acres. The water duties for each watercourse of Sub-system 5 are presented in Table 13. Categorized water duties are shown in Figure 16.

Table 13. Water duties for Sub-system 5 of the 1-R Minor/Hakra 4-R Distributary.

Outlets Location	Q (cusecs)	CCA (acres)	Water Duty (Q / 1000)	Relative water duty (WD/Wtd.Avg.WD)
1215/L	1.79	251	7.13	1.22
3420/R	1.22	296	4.12	0.70
3750/L	NR	264	NR	NR
4803/R	1.73	306	5.65	0.96
7140/R	1.75	355	4.93	0.84
7641/R	NR	405	NR	NR
8043/R	1.68	406	4.14	0.71
11792/L	1.24	240	5.17	0.88
12515/R	3.29	423	7.78	1.33
17619/R	1.93	355	5.44	0.93
17679/L	0.87	182	4.78	0.82
19116/R	3.06	308	9.94	1.70
20419/R	2.10	307	6.84	1.17
20630/L	1.64	300	5.47	0.93
22600/R	3.10	463	6.70	1.14
23738/L	2.37	274	8.65	1.48
25883/L	2.13	355	6.00	1.02
27061/R	2.07	329	6.29	1.07
27514/R	1.25	310	4.03	0.69
29418/L	3.19	414	7.70	1.31
33200/L	2.10	261	8.05	1.37
33674/L	1.65	333	4.95	0.85
33730/L	1.61	302	5.33	0.91
33813/R	2.43	456	5.33	0.91
33940/L	1.94	320	6.06	1.03
40030/R	2.27	447	5.08	0.87
43648/L	1.88	351	5.36	0.91
46500/L	1.50	243	6.17	1.05
47520/L	1.60	312	5.13	0.88
47529/R	1.49	265	5.62	0.96
50623/TL	1.67	332	5.03	0.86
50623/TF	1.54	353	4.36	0.74
50623/TR	1.84	346	5.32	0.91

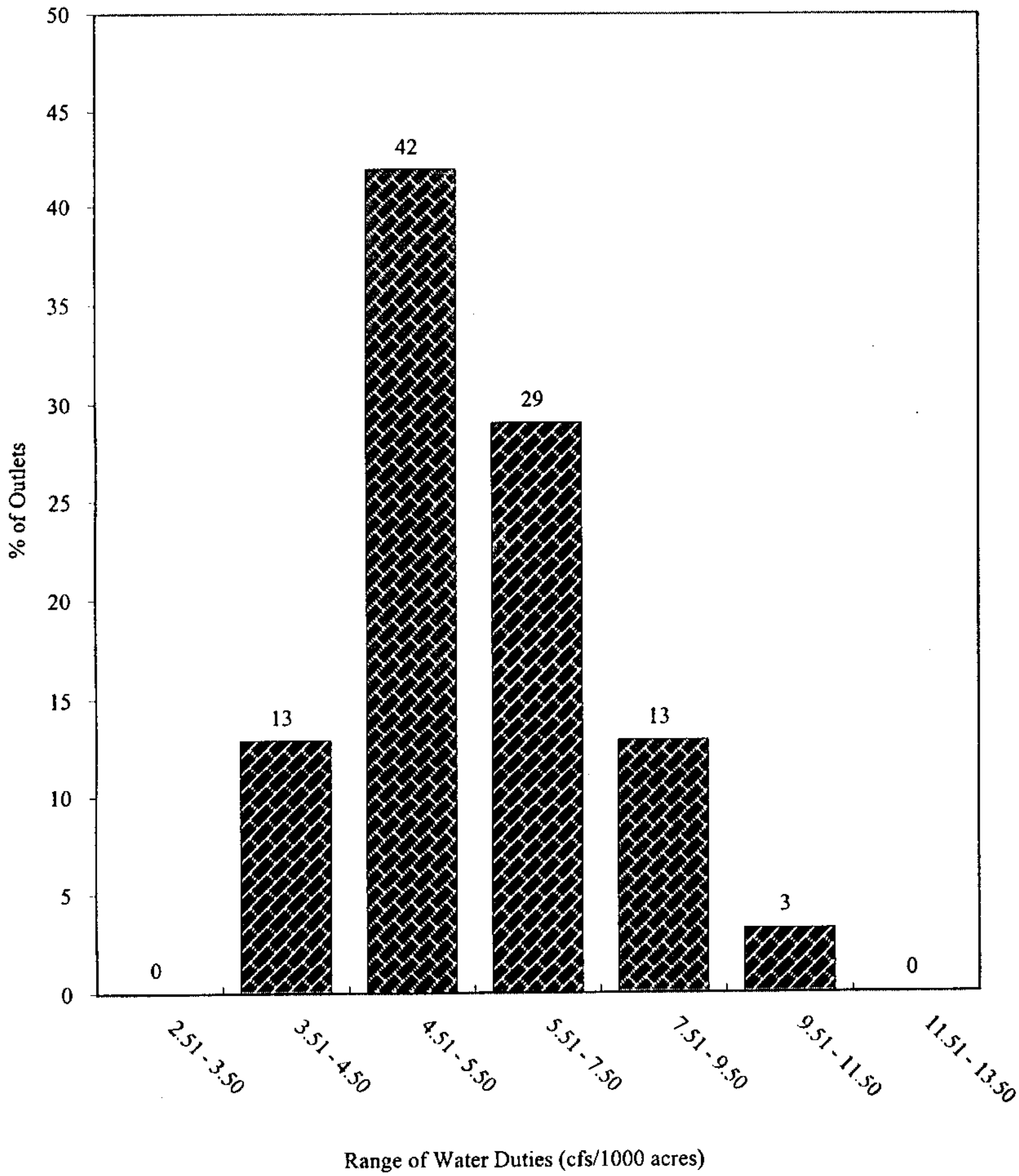


Figure 16. Distribution of water duty among the outlets of Subsystem 5 of Hakra 4-R Distributary.

11. FARMERS COMMENTS

11.1. WHAT FARMERS LEARNED

All of the farmers reported that after attending the training courses, they had acquired the ability to read the water level with staff gauges, and were capable of converting this reading into a discharge using the discharge table.

In response to a questionnaire, farmers made a few interesting remarks, as quoted in the following sections.

1) I gained technical expertise on the following aspects:

- Water measurement;
- How to read a gauge;
- Correcting the gauge according to its position;
- Reading a discharge table;
- Measuring water allocation to each sub-system;
- Discharge measurement in the watercourse with flume and current meter;
- Irrigation terminology;
- Weaknesses in the method of measurements adopted by the PID;
- Status of water supplies in the Hakra 4-R Distributary; and, moreover,
- Awareness about farmers' enthusiasm to undertake irrigation management activities **(Naeem, Sub-system 5).**

2) Interrelationships among farmers, working with discipline, and the interest shown by farmers in this training course, was a new experience for me. Practicing to read gauges, and converting discharges from discharge tables, have increased my knowledge **Abaidullah Joia).**

3) I have learned a lot from this training, e.g. measuring flow and its fluctuations. This training has enabled transparency in water shares **(Jan Muhammad, Sub-system 4).**

4) The training course was very good. Seventy-five percent has been absorbed in the mind. The training course has catalyzed our interest **(M. Anwar, Sub-system 3).**

5) I have learned from the training course

- how to read a gauge;
- discharge measurement with flume and current meter; and
- converting discharge from the discharge table **(Rao Javaid, Sub-system 5).**

6) I have learned much from this training course. Firstly, I got an opportunity to meet, and have discussions, with other WUO members. Training to read gauges was imparted to farmers. The secret of success for all farmers is in this training course **(Muhammad Azim).**

7) I have learned to measure water levels by using a gauge. As a federation member, it was necessary for me, because I should know what the inflow through the Hakra 4-R Distributary is, and what our due share is **(Muhammad Mumtaz, Sub-system 3).**

7) I have acquired the following information from this training course:

- reading a gauge correctly;
- convert the discharge from the discharge table; and
- sources of errors in the gauge reading.

8) I also came to know that:

- a current meter is used in a lined watercourse;
- a Cut-throat Flume is used in an earthen watercourse;
- the difference between command and non-command area; and
- the quantum of water reaching to each sub-system **(Fiaz Ahmad Qamar, Sub-system 4).**

9) I have learned many things from this training course. Firstly, I have come to know that our irrigation record was last updated in 1966. After that, nobody cared about maintaining the record. For every important project, planning is important, which is impossible without detailed information. Besides, I have also learned how to use a current meter, flume and gauge **(Asghar Ali, Sub-system 1).**

10) I have learned many things from this training program; first, I now know what the distributary's actual discharge is, as well as what it currently runs, and secondly, with the method of discharge measurement, an ordinary farmer can now measure the amount of cusecs running in the distributary **(Mian Hafeez Watoo, Bahaderwah Minor).**

11) The things I have learned are:

- what a cusec is;
- discharge measurement with flume;
- gauge reading; and
- how to use white marks to measure the discharge **(Muhammad Shafi, Sub-system 3).**

12) Examples of what I have learned are:

- how to read a gauge;
- how to measure velocity; and
- what a cusec is **(Muhammad Iqbal, Sub-system 4).**

13) From this training course, I have learned:

- how to read a gauge;
- measurement of discharge using downstream gauge; and
- I would like to know whether IIMI will provide us with the rating table
- for each outlet in future, as we cannot measure the discharge without the discharge table **(Abdul Hamid, Sub-system 3).**

14) Until now, we did not have knowledge about the amount of water being provided to us by the PID, and whether the given quantum of water is according to our due shares. Now, we can measure water by ourselves, and know our due shares. Agency staff have become so unfair that they refrain from entertaining farmers without charging money. With the success of this program, we will be rid of them **(Muhammad Subho Sadiq, Sub-system 5).**

15) With this training, I have learned the quantum of water being diverted from the Hakra Branch. This knowledge will be useful to monitor the flow at sub-system and watercourse levels. The measurement of quantum of water to each sub-system was also new knowledge for me **(Muhammad Jamil Gil, Sub-system 3).**

16) We have learned flow measurement. Now, we can pose certain questions to PID staff **(Muhammad Anwar, Sub-system 3).**

17) We have not witnessed this kind of program before. This is a good approach. I pray for the prosperity of this program **(Rashid Gill, Sub-system 5).**

18) From this training course I have learned how to read gauges and discharge tables. I could not, however, understand the conversion of discharge through interpolation **(Nazar Muhammad Aakooka).**

19) I have learned a lot because the information I obtained had been unknown to me before. Although we were using the water before, I did not know what the drawbacks and benefits of the system are. This training program was informative and interesting for me **(Hafiz Sanaullah, Sub-system 5).**

20) We have learned a lot from this training, such as:

- how to read a gauge;
- water duty;
- discharge measurement;
- information about the participatory approaches in different countries;
- I also obtained information about our irrigation system **(Muhammad Aataf Anjum, Bahaderwah Minor).**

11.2. DISSEMINATION OF KNOWLEDGE (FARMERS' COMMENTS)

1) We will disseminate this knowledge:

- by practical demonstration at watercourse level, for the benefit of our friends; and
- by sharing our knowledge of various technical terminology, as well as specialist equipment used during this training **(Muhammad Naeem Akhtar, Sub-system 2).**

2) We are obligated to disseminate our newly-acquired knowledge to those fallow farmers who could not attend this training. We intend for WUO representatives to disseminate this knowledge to watercourse committees. **(Abaidullah Anwar Joia, Bahaderwah Minor).**

3) Every participant should disseminate the knowledge gained in their respective areas, and tell others what due water shares we acquire at present. Any deficiencies detected should be presented to PID collectively in order to generate an amicable solution **(Jan Muhammad, Sub-system 4).**

4) The training course should be discussed in sub-system, watercourse and individual meetings that would encourage others to take an interest in training of this nature **(Muhammad Akram Wattoo, Sub-system 1).**

5) Our sub-system and watercourse committees will be called together in meetings for the purpose of teaching other farmers what we have learned **(Muhammad Anwar, Sub-system 3).**

6) What I have learned from this training program is very admirable and is worth disseminating. As a member of the WUF, I shall share all my knowledge with my farmer brothers. This is where out own success, and that of IIMI-Pakistan, lies **(Muhammad Azim, Bahaderwah Minor).**

7) The knowledge gained on flow measurement will be disseminated to all 27 watercourse presidents by calling meetings, which the IIMI-Pakistan team should help us with. What I have learned should be disseminated to all

farmers so that they should know how much water is available at the watercourse level **(Muhammad Mumtaz, Sub-system 3).**

8) To realize the dissemination of this program, we will organize similar three-day training courses, which farmers belonging to the sub-systems and watercourses will be invited to **(Muhammad Ashraf, Sub-system 5).**

9) The knowledge gained through this training will be disseminated through:

- corner meetings;
- measuring water at watercourse level;
- practicing gauge readings at site; and
- individual meetings **(Asghar Ali Sub-system 4).**

10) The knowledge will be disseminated in meetings organized for watercourse committees **(Muhammad Shafi, Sub-system 3).**

11) Organizing meetings for watercourse representatives will also enable dissemination of our knowledge **(Abdul Khaliq).**

12) We will disseminate this knowledge to absentees and regular water users, which can easily be achieved **(Mian Muhammad Hafeez Wattoo).**

13) We will inform watercourse representatives about how the Irrigation Department deprives farmers of their rights **(Muhammad Subhah Sadiq, Sub-system 5).**

14) I will organize meetings for watercourse committee office bearers to train them how to read gauges and install flume **(Jamshaid Ali Rao).**

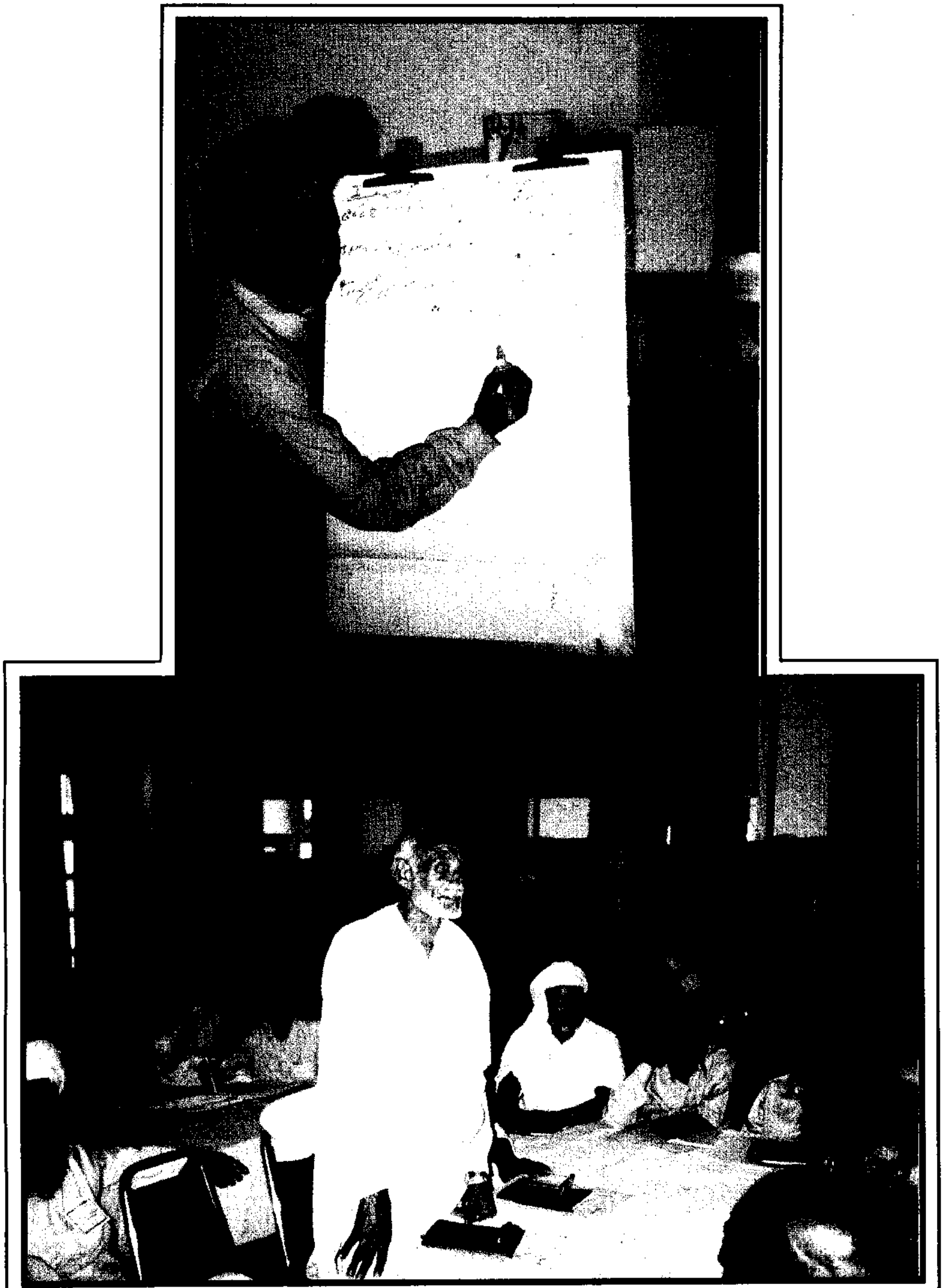
15) I will do my best to disseminate this knowledge. I pray that Allah will give me capability to do so **(Rashid Gill).**

16) I will disseminate this knowledge to those farmers who support us.

11.3. TRAINING COURSE USEFULNESS FOR IRRIGATION MANAGEMENT

1) The knowledge will only be useful if we are provided with design and current discharge tables for each watercourse. Thus, we will know how much water is being drawn and what our actual rights are **(Abdul Hamid, Sub-system 3).**

2) We can use this knowledge to manage irrigation by ensuring that are others' rights are honored, and eliminate water theft **(Muhammad Iqbal, Sub-system 4).**



Photograph 11. Experience sharing sessiom with the training participants.

3) This training course can be used for irrigation management, as we can now determine our watercourse discharges and that of other watercourses **(Mian Muhammad Hanif, Bahaderwah Minor).**

4) If we disseminate this training program to other farmers:

- our production will increase; and
- we will save water ***(Haji* Ata Muhammad, Sub-system 5).**

5) We will brief farmers along our own watercourse what "fair distribution of water" is. We should also inform them that the success of this program will enable realization of our rights without having to pay special charges **(Subho Saqiq, Sub-system 5).**

6) Gauges will now be installed at every watercourse, and actual shares will be introduced at every watercourse **(Muhammad Jamil Gil, Sub-system 3).**

7) We will now be able to plan our crops according to the available water supply **(Muhammad Anwar, Sub-system 3).**

8) We have learned how to acquire our rights. This training has provided us with the capability to demand our rights from the Irrigation Department **(Jamshaid Ali Rao, Sub-system 1).**

9) We are now able to assess our problems, thus we can protect our rights. This training program has given us the capability to demand our rights from the Irrigation Department and from big landlords **(Abdul Shakoor Aakooka, Sub-system 1).**

10) This knowledge will be implemented with religious fervor and honesty for the betterment of the nation and the country **(Rashid Gill, Sub-system 5).**

11) We have understood the division of irrigation water shares, thus, are able to use it more effectively for the betterment of the irrigation system **(Nazar Muhammad Aakooka, Sub-system 1).**

12) This training course is beneficial for me in two ways: first, I can use my water turn more effectively; and second, I can understand the drawbacks of my water turn **(Hafiz Sanaullah Subsystem 5).**

13) After this training we will be measuring the discharge of the outlets and the distributary. When supplies will be less than required, we can demand from the PID **(Muhammad Khan Sukhera Subsystem 4).**

14) Knowledge about the methods of discharge measurement enables us to record fluctuations for future reference to irrigation high ups, the Water Users Federation, and to common water users, in order to overcome the problem so that water can be correctly and equitably distributed **(Muhammad Akram Wattoo, Sub-system 1).**

15) We can use the knowledge to ensure that every reach of the distributary gets its due share. If any reach genuinely needs more water, it should be granted. Special concentration, however, should be given to check that nobody gets more than their due share. Perhaps a pond should be constructed near the Hakra Branch in which surplus rain water can be stored for use during peak demand in the *kharif* season **(Abdul Ghafoor, Sub-system 1).**

16) We should use this knowledge collectively to improve the system and for equitable water distribution, and teach others to avoid taking or stealing water **(Jan Muhammad, Sub-system 4).**

17) The benefits of this training has been manifold. We can now get our due share, thus, overcoming water deficiencies. Our needs can be met more effectively, as lack of information in the past contributed to deficiencies **(Muhammad Mumtaz, Sub-system 3).**

18) This knowledge can be used to improve irrigation practices in many ways:

- to determine the quantum of water entering into the distributary; and
- to plan our crops to obtain better results **(Muhammad Asghar, Sub-system 1).**

19) Our knowledge equips us to take special care of the distributary and watercourses, in terms of the maintenance **(Falik Sher, Sub-system 4).**

20) We can now measure outlet discharges, and will try to cope with fluctuations in water supplies **(Riaz Ahmad Qamar, Sub-system 4).**

21) We are extremely impressed with this training course. Although we were using water, we held no knowledge about how to use irrigation water properly. Now, for proper irrigation, plans will be prepared systematically, and even crops will be irrigated according to need. The distributary, the minors and the watercourses should be given their due share so that we can avail our rights **(Muhammad Shafi, Sub-system 3).**

22) Earlier, we were ignorant about the amount of water being issued from the distributary head regulator, how much is issued from the head to the drop structures, and how much is distributed among the watercourses. In the

past, when somebody stole water, we had no way of ascertaining the quantity. Now, we will not allow water stealing, because now we know how much water is given at different locations **(Saeed Ahmad, Bahaderwah Minor).**

23) Formerly, we were unable to measure outlet discharges, now we can. Now, we can determine whether we have received our right, or not **(Muhammad Azam, Bahaderwah Minor).**

24) We can use this knowledge to improve irrigation management by:

- ensuring equitable water distribution; and
- by increasing our agriculture yield **(Naeem, Sub-system 5).**

25) This training program will support us under new irrigation reforms. My understanding is that awareness about water measurement plays a key role in the management of irrigation water. After this training, farmers have become experts in water measurement. With this basic training, they now understand their rights, and whether they are being deprived their rights, or not. In cases of improper water distribution, they can demand their rights with the foundation of some technical information. Moreover, when they start owning the system, they would be able to manage it more amicably **(Abaidullah Anwar Joia, Bahaderwah Minor).**

11.4. STEPS WUF SHOULD TAKE AFTER TRAINING

1) The WUF can use this knowledge to:

- measure the discharge of branch canals, and the distributary, and demand their rights from PID;
- the WUF should move ahead for their rights in the light of this information;
- the WUF should call a special meeting to solicit binding all federation members to disseminate the knowledge to common farmers; and
- the WUF should monitor whether members are disseminating this knowledge to common farmers, or not **(M. Anwar, Sub-system 3).**

2) After this training,

- the WUF should disseminate the information at watercourse levels;
- the WUF should acquire the power to operate the distributary;
- the distributary should be looked after; and
- every sub-system should get its due share **(Muhammad Aataf Anjam, Bahaderwah Minor).**

3) The WUF should prepare a time-table for each member to read gauges, starting from the distributary, and all members should perform their duties to ensure that farmers get their due share **(Muhammad Mumtaz, Sub-system 3).**

4) The WUF should take the following steps:

- weaknesses in distributary management should be eliminated; and
- the WUF should take measures to protect the gauges and white marks installed by IIMI-Pakistan **(Muhammad Ashraf, Sub-system 5).**

5) The WUF now has information about:

- total quantum of water in the Hakra 4-R Distributary;
- total outlets;
- total area; and
- total quantum of water for each subsystem.

Now, as a result, the WUF can manage the system better **(Asghar Ali, Sub-system 1).**

6) The WUF should now take the following steps to improve the distributary:

- the distributary should be brought to its original design; and
- information about the distributary should be gathered for sub-system level WUOs, and used to solve problems **(Fiaz Ahmad Qamar, Sub-system 4).**

7) After this training, the WUF should:

- install gates at the distributary and minor heads;
- repair banks by earth work;
- the WUF should contribute funds towards the system management after acquiring powers from PID; and
- wherever gauges are broken, the WUF should take responsibility for repair **(Muhammad Shafi, Sub-system 3).**

8) The WUF should take the following steps:

- increasing water supplies in the distributary by improving its physical conditions;
- ensuring the equitable distribution of water among the subsystems;
- ensuring a true water demand for each outlet; and
- getting actual shares from PID **(Naeem, Sub-system 5).**

Next >>

Photograph 12. Orientation session before field practice.

Photograph 13. How to send a gauge: field practice.

9) The WUF should now bear the following in mind:

- organizing meetings regularly;
- ensuring the equitable distribution of water; and
- protecting the rights of all farmers when deprived of it by PID **(Abaidullah Joia).**

10) The WUF should maintain the distributary on a self-help basis, as well as conferring with PID when any drawbacks are identified **(Jan Muhammad, Sub-system 4).**

11) The WUF should now be firm with water users about unauthorized irrigation. Also, the distributary should be maintained on a self-help basis **(Muhammad Subho Sadiq, Sub-system 5).**

12) If proper representation is awarded to the WUF at the watercourse and distributary levels, then all the water users can play a management role **(*Haji* Ata Muhammad, Sub-system 5).**

13) The WUF should now look after the distributary in an organized way, by undertaking desiltation operations, for example, and take steps to prevent water theft **(Mian Hafeez Watoo, Bahaderwah Minor).**

14) The WUF should look after the distributary in order to maintain actual structure sizes so that extra water cannot be siphoned **(Abdul Hamid, Sub-system 3).**

15) The WUF should improve the distributary for self-help management, and should contact water users if any help is needed **(Muhammad Iqbal, Sub-system 4).**

16) The WUF should ensure the equitable distribution of water, both at watercourse and distributary levels, and also attempt to run the channel at design level **(Muhammad Jamil Gil, Sub-system 3).**

17) The WUF should strengthen the banks of the distributary, which are weak, on a self-help basis. For this, PID should also cooperate with the WUF **(Jamshaid Ali Rao).**

18) The WUF should strengthen the banks and service road, and ensure water supplies according to actual discharge rights **(M. Anwar, Sub-system 3).**

19) We should maintain the distributary at subsystem level by undertaking desiltation and repair work. We should also ensure the rights of farmers through gauge readings **(Nazar Muhammad Aakooka).**

20) The WUF can run the system better, which will improve conditions for farmers. The old system, which poses many difficulties, can be improved with farmer-involvement, that every sub-system receives their due shares of discharge **(Hafiz Sanaullah, Sub-system 5).**

21) The WUF should look after the distributary in order to assess the drawbacks. If, for example, banks and the service road is weak, we should inform PID, and if livestock causes damages, we should try to protect them **(Muhammad Khan Sukhera, Sub-system 4).**

22) After improving the berm and weak points, each outlet should be allocated its actual share so that water users can benefit according to the actual gauge settings **(Muhammad Akram Wattoo, Sub-system 1).**

23) The WUF now has no excuse to leave any stones unturned. The training provided by IIMI-Pakistan should be understood by all of us:

- we should be able to maintain the distributary; and
- prevent water theft **(Muhammad Azim).**

12. FARMERS' EVALUATION OF THE TRAINING COURSES

The training courses were evaluated by the participants. At the end of each training course, a questionnaire, comprising of seven questions, was provided to participants. The following are the questions farmers were asked to comment on:

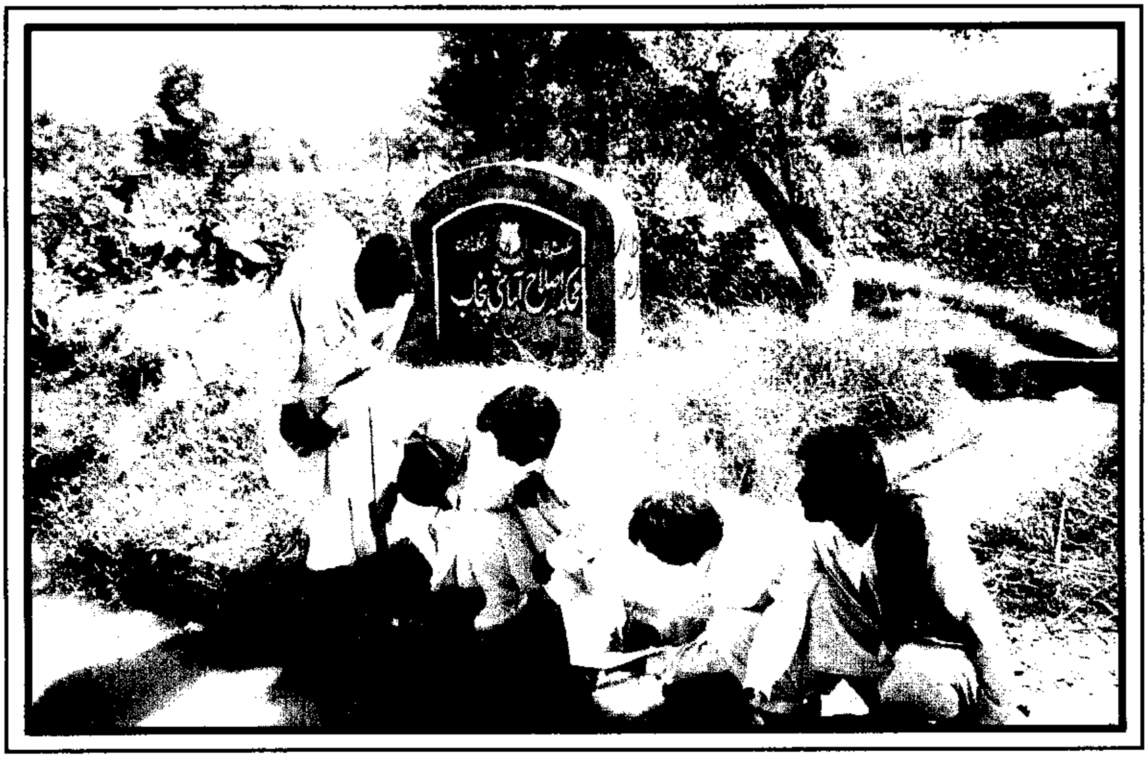
- What have you learned from this training course?
- How will you disseminate what you have learned from this training course at the sub-system and watercourse levels?
- How will this training course be useful to improve the irrigation system?
- After this training course, what steps should the WUF take to improve the management of the distributary?
- Which aspects of the training course did you like most?
- Point out any drawbacks you experienced during the training course.
- Other comments.

12.1. WHAT HAVE YOU LEARNED?

The participants commented they are now able to read gauges, measure discharges, read discharge tables, calculate water duties, understand actual versus design discharges and cusecs, etc. Farmers' responses on **What they learned from this training course,** are presented in Table 14, according to their own order of occurrence.

Table 14. Summary of responses: what farmers gained from the training courses.

S. No.	Respondent's Statement	No. of Responses
1	Learned how to read a gauge	50
2	Learned how to measure the discharge	51
3	Learned how to read discharge tables	26
4	Learned how to calculate the water duty	14
5	Learned about actual vs. design discharge	8
6	Learned many things from the good behavior of the IIMI staff	7
7	Learned about cusecs	6
8	Learned about our own due shares of irrigation water	6
9	Learned about irregularities among the watercourses	5
11	Learned about the structure of the outlet	
12	Learned about the upstream and downstream of the channel	4
13	Learned how the equitable distribution of water among channels is conducted	4
14	After training, we can negotiate our due shares with PID	2
15	Learned about the flow conditions	2
16	Learned many things from the discipline performed by trainees	1
17	Learned the reforms of irrigation management	1
18	Learned about farmers' enthusiasm to take over system responsibilities	1
19	The program was very informative and interesting, so learned many things	1
20	Learned the difference between GCA and CCA	1
21	Got the chance to meet farmers from other sub-systems	1
22	Obtained irrigation knowledge about others countries	1



Photograph 14. A sub-group of the training participants practicing: reading water level using reference mark (white mark)

Photograph 15. Fluming by a sub-group.

12.2. DISSEMINATING WHAT YOU HAVE LEARNED

Participants commented that they would disseminate the knowledge gained from this training course by organizing WUA meetings at watercourses, arranging lectures at sub-system level meetings, interacting with villagers in routine sittings, through individual contacts, and by calling special meetings, announced from the village mosque loudspeakers. The farmers responses are provided in Table 15.

Table 15 Summary of suggestions for disseminating the program at watercourse and sub-system levels.

S. No.	Respondent's Statement	No. of Responses
1	Disseminating knowledge by organizing WUA meetings	60
3	By delivering lectures in sub-system meetings	15
4	In routine village sittings	4
5	Word of mouth	2
6	Announcing specially-organized meetings from village mosque loudspeaker	1
7	By utilizing IIMI's assistance	1
8	The knowledge gained from the training course will be disseminated to others on request.	1
9	I will try my best to disseminate the knowledge of the training	1
10	By transferring the experience to others in the village in person	1
12	Occasionally disseminating the program	1

12.3. USEFULNESS OF TRAINING FOR IMPROVING IRRIGATION SYSTEM

Participants have suggested that this training course could be made useful by disseminating knowledge at every watercourse and subsystem level, maintaining equity in irrigation supplies, repeating these training courses, lining watercourses, providing discharge tables for each watercourse, etc.. Farmers' responses are given in Table 16, according to their order of occurrence.

Table 16. Summary of responses: suggestions to improve the irrigation systems.

S. No.	Respondent's Statement	No. of Responses
1	By disseminating this knowledge at watercourse and sub-system levels with IIMI's assistance	12
2	The federation should maintain equity among the watercourses	12
3	Activities such as these should be ongoing	10
4	Watercourses should be lined	5
5	The discharge table for each watercourse should be developed	3
6	The training course should be launched at watercourse level, so that all the farmers could know what their due shares are	3
7	The federation should be authorized to improve the condition of IRA Minor	3
8	The federation should take steps to reduce inequity	2
10	The distributary should be lined	2
11	The federation should formulate by-laws	2
12	The federation should be granted powers	3
13	The number of trainees should be reduced, and only sensible persons should be included	2
14	WUFs should protect farmers from PID injustices	1
15	Training timings should be reduced	1
16	All the aspects of water measurement should be covered	1
17	IIMI should support the WUF until powers are granted	1
18	Flume should be fixed at every watercourse to know the discharge	1
19	Propaganda against IIMI should be stopped	1
20	Regular fortnightly meeting between IIMI and water users should be arranged, to discuss problems	1
21	Training should be launched at one place, somewhere in the center of sub-systems, to ensure the attendance	1
22	The federation should use educated persons as resource persons to extend the training course	1
23	Trainers should evaluate trainees after the training	1
24	The water duty of each watercourse should be exposed to maintain equity	1
25	The training should also be given on agronomic and agricultural aspects	1
26	The WUF should take steps to stop water theft	1
27	Water duties should be recalculated	1
28	Trainers should be well-prepared	1
29	There must be accountability for everybody	1
30	The federation should step forwarded after the training course	1
31	No suggestions	13

12.4. STEPS BY WUF TO IMPROVE MANAGEMENT OF DISTRIBUTARY

Participants suggested that the WUF improve the distributary by taking steps to reduce inequity, protect the distributary from damages, undertake maintenance operations, and control water theft. The farmers responses are given in Table 17, according to their order of occurrence.

Table 17. Summary of responses: steps the WUF should take to manage the system.

S. No.	Respondents' Statements	No. of Responses
1	The federation should take steps to reduce inequity	21
2	The federation should take steps to prevent the distributary from all kinds of damages	14
3	The federation should strengthen the banks of the distributary	9
4	With the consultation of watercourse representatives, the allocation of water should be made according to design	9
5	The WUF should organize desilting of the distributary	9
6	The federation should be able to negotiate due shares with the department	7
7	The federation should stop water theft	6
8	The federation should instruct farmers about watercourse cleaning activities in monthly meetings	3
9	Each zone should be responsible for maintenance in the distributary's respective areas	4
10	The federation should launch further training programs	3
11	The federation should monitor daily gauges itself	3
12	Federation members should avoid all kinds of corruption	2
13	The federation should know due shares of channels, in terms of water duty	2
14	The WUF should take steps to release water according to demand	2
15	The WUF should implement the distributary's closure schedule as prescribed	2
16	The federation should introduce educated persons to manage the distributary	1
17	All farmers should maintain their watercourses	1
18	The federation should try to increase the authorized discharge	1
19	Plantation activity should be launched	1
20	The federation should arrange the dissemination of this training program	1

12.5. WHICH ASPECTS OF TRAINING DID YOU LIKE MOST?

Participants mentioned various aspects of the training that they liked most, *viz.*, the positive attitudes of IIMI staff, the arrangements and orientation by IIMI resource persons, practical involvement in the field for discharge measurement training, etc.. Farmers' responses are given in Table 18, according to their order of occurrence.

Table 18. Summary of responses: positive aspects of the training courses.

S. No.	Respondents' Statements	No. of Responses
1	Attitudes of IIMI staff was good	24
2	Every aspect was properly arranged	19
3	Orientation was impressive	17
4	The discharge measurement in the watercourse was very interesting	15
5	Good lunch and entertainment	9
6	The physical involvement for flow measurement in the field	8
7	It was good to have information about other areas within 4-R	3
8	IIMI providing a pick-and-drop service for farmers	3
9	Farmers from the area gathered together for the first time	3
10	Knowledge about how to read a gauge was interesting	3
11	Well-planned training sessions	3
12	IIMI staff performed its duty very well	2
13	Farmers demonstrated discipline	2
14	Fluming knowledge is useful	2
15	Orientation in the local language was appreciable	2
16	Knowledge about the CCA and due shares of discharge	2
17	Awareness about irrigation management.	2
18	The fruits were equitably distributed by IIMI, and now we pray for equal water distribution	1
19	Patience of farmers was appreciable	1
20	Knowledge about cusecs	1
21	Farmers now have the skill to manage the canal system	1
22	Knowledge about the upstream and downstream water levels and flow conditions	1
23	Determined efforts of the IIMI staff, and impressive organization training sessions	1
24	Khalid transporting four persons by motorbike	1
25	Quranic recitation, and translation	1
26	Formation of sub-groups	1
27	Effective training material	1
28	Experience-sharing among farmers	1

12.6. DRAWBACK OF TRAINING COURSES

Although the majority of participants applauded the training courses, they were, however, specifically asked to point out any drawbacks. Some farmers pointed out drawbacks, such as the use of English words, the use of heavy technical jargon, the absence of important watercourse representatives, the disinterest displayed by PID staff, exposing the results of water duties, IIMI's heavy expenditures, the repetition of training items, the limited number of participants, etc. The farmers responses are given in Table 19, according to their order of occurrence.

Table 19. Summary of the responses: drawbacks of the training courses.

S. No.	Respondents' Statement	No. of Responses
1	No drawbacks	47
2	The use of English words	6
3	More than one participant raising questions simultaneously, resulting in too much noise.	6
4	The use of heavy technical jargon	3
5	The absence of important w/c representatives	3
6	Exposing the result of water duties for each outlet	2
7	The disinterest of PID officials	2
8	Heavy expenditures by IIMI	1
9	Repetition of training items	1
10	Farmers were not punctual	1
20	The aspects of water measurement training were few	1
21	Farmers themselves presented drawbacks	1
22	Training took place in the hot sun, and an arrangement for cool water was lacking	1
23	The absence of a vehicle in Sub-system 4	1
24	Participants were limited	1
25	Rating tables for each watercourse was not available	1
26	Trainees should have been evaluated on the knowledge gained from training courses	1
27	I do not wish to displease the IIMI by pointing out drawbacks	1

12.7. OTHER SUGGESTIONS

Participants were also asked to make any additional suggestions, but almost all were similar to those given in Questions 3 and 4. A few prominent suggestions were related to advising the WUF, maintaining equity, implementing what has been learned, controlling water theft, measuring discharges of watercourses from time to time, conducting maintenance work, protecting live-stock entry in the distributary, and creating awareness among farmers about irrigation management. Responses are presented in Table 20, according to their order of occurrence.

Table 20. Summary of responses about participants' suggestions.

S. No.	Respondents' Statements	No. of Responses
1	WUOs should ensure the equitable distribution of water	21
2	The WUF should ensure that everyone gets their due shares	19
3	The watercourse should be improved and desilted	11
4	Irrigation improvement is possible if what has been learned is implemented	6
5	Bring more area under crop, according to the available water supply	7
6	Stop water theft	3
7	Watch irregularities on the canal	3
8	Make efficient use of water	5
9	Undertaking maintenance work on the distributary	2
	Measuring channel discharges from time to time, so that farmers can approach the Irrigation Department in case of any irregularities	5
	Creating the water-saving awareness among farmers	2
	Farmers should point out the weaknesses of the department	2
10	The WUF should monitor daily gauges	2
11	The WUF should desilt the channel properly, so that the gauge cannot be disturbed	1
12	Everybody should have knowledge about water duty	1
13	Measuring watercourse discharges periodically	1
14	Calibrating the distributary at the head, and obtaining due shares	1
	The WUF should maintain honesty	1
15	The WUF should protect cattle entry points	1
16	The WUF disseminate the training program to others	1

13. FUTURE MEASUREMENT ACTIVITIES

Irrigation systems have two components; social and technical. The social components cannot be operated in isolation of the technical ones. Although the Water Users Federation of the Hakra 4-R Distributary is a voluntary organization, it is left no choice but to undertake operations and maintenance activities; therefore, has to develop its management capacity. These six training courses acted as stepping stones towards its capacity-building endeavors, proving that farmers do have the potential to be trained in technical aspects of irrigation management. In order to train farmers in all necessary areas of water-related measurements, eight different activities and related courses have been proposed. The WUF leadership has already committed to participate.

13.1. REFRESHER COURSE ON FLOW MEASUREMENTS

Importance:

This refresher course will be conducted to reinforce earlier training. Since responsibilities have not been transferred to the WUF yet, implementation of their knowledge gained has still not been effected. Thus, a need to fortify the previous measurement training does not exist.

Potential Participants:

Refresher courses will be open to **all 132 leaders** of the WUF, WUOs and WUAs of the Hakra 4-R Distributary. As before, five members from each of the executive bodies of Bahaderwah Minor and Bhukan Distributary, will again be invited. Thus, the total number of participants will be about 140.

13.2. DEVELOPING DISCHARGE RATINGS FOR THE DISTRIBUTARY

Importance:

The session, "How to Develop Rating Curves for the Distributary", for both, downstream gauge and free flow drop structures, will be imparted to selected farmer leaders, and will help them to calibrate structures with their own skill and resources. This training will also assist in monitoring control structures.

Potential Participants:

As already discussed with WUF leaders, who will nominate **5 to 6 farmers** for training in the development of rating curves. This step is aimed at making the WUF self-reliant in implementing technical activities.

13.3. FLOW MEASUREMENT TRAINING FOR WATERCOURSE WATER USERS

Importance:

The purpose will be to train general water users to measure the discharge of the watercourses, which will enable them to measure daily water supplies entering their watercourses. This training will actively involve farmers as resource persons, with IIMI staff providing facilitation only.

Potential Participants:

This training will be held at the watercourse level. All of the water users from particular watercourses will be invited, which means that 121 sessions will be conducted in the entire distributary command area. Thus, a **total of 4300 invitees** are anticipated to attend these trainings, which may be conducted simultaneously in each sub-system at watercourse levels.

13.4. TRAINING OF DISCHARGE MEASUREMENT AT *NAKKA* POINTS (FIELD INLETS)

Importance:

This training is very crucial for farmers along the five watercourses selected for bed-and-furrow experiments of the cotton crop, helping water users to monitor the flow at their *nakka* points, and ascertaining the quantum of water going to individual sample fields.

Potential Participants:

Preferably, this session is intended for water users from all of the sample watercourses, and will be conducted at the watercourse level in each of the five sub-systems. Thus, there will be approximately **100 initial invitees,** but later, extended to sample farmers of 41 villages selected for the bed-and-furrow experiments, adding **41 sample farmers** as beneficiaries.

13.5. TRAINING ABOUT WATER USE EFFICIENCY

Importance:

This training will be very essential for those farmers participating in the bed-and-furrow experiments, which focuses on:

- When to apply irrigation water;
- How to apply irrigation water; and
- How much irrigation water to apply;

Potential Participants:

This training will also, preferably, be imparted to water users of all the sample watercourses, and will be conducted at the watercourse level in each of the five sub-systems. As for *nakka*-measurement training, about **100 invitees,** and an additional **41 sample farmers** from as many villages, will be selected for the extended bed-and-furrow experiments.

13.6. CREATING AWARENESS ABOUT IMPORTANT WATER ALLOCATION RULES

Importance:

Farmers in the region are frequently involved in getting additional water supplies through:

- Modification of outlets;
- Seasonal pipes;
- Annexing new areas to watercourse commands;
- Orchards and fish farms; and
- The exclusion of abandoned areas within the watercourse.

The majority of farmers are unaware of the official process to acquire additional supplies by employing the means mentioned above, as they are often blackmailed, and pay hefty "special charges" for what agency staff deem is "a favor". Awareness about general procedural rules will be extremely helpful for the Hakra 4-R Distributary's water users to solicit the official approval for additional supplies.

Potential Participants:

This training will be conducted as "open sessions" in one-day workshops for WUAs, WUOs and the WUF office bearers, meaning that **approximately 600 farmer leaders** will be invited for this discussion-mode session.

13.7. VERIFICATION OF DISCHARGES

Importance:

This information will be useful for WUOs to maintain transparency about water supplies distributed among and within the sub-systems. This activity will be conducted for:

-Head regulator of Hakra 4-R Distributary;
-All the transfer points; and
-All the 123 watercourses.

This measurement activity for all of the watercourses will serve three important purposes:

- The verification of discharges of previous results;
- The verification of discharges for 22 outlets modified in the 1997/8 annual closure; and
- The verification of discharges pertaining to 75 recently-altered outlets of Sub-systems 3, 4 and 5.

Potential Participants:

This measurement activity will collectively be undertaken by the IIMI and PID staff, along with WUO and WUF representatives, but more specifically, WUO and WUF leaders from the sub-systems will be expected to conduct this measurement activity. Thus, in addition to the IIMI technical team, **3 to 5 WUO leaders** will be resource persons for this measurement program.

13.8. INFLOW-OUTFLOW TEST

Importance:

The quantum of seepage losses in irrigation channels have always been a major issue. Earlier tests conducted at the Hakra 4-R Distributary show that seepage losses are almost insignificant. An inflow-outflow test along the channel will provide a good check against earlier results.

Potential Participants:

This test can be jointly conducted by the IIMI and PID, accompanied by selected farmer leaders. Preferably, also some members of the **executive body of the WUF.**

13.9. TRAINING ON MEASUREMENT OF OUTLET SIZES

Importance:

An outlet structure is of primary importance to farmers, who should have the ability to measure outlet sizes, which is particularly importance for outlets which have been recently-modified. A session on the opening and closing of gates of the head regulator may also be imparted to selected farmers. This training will be useful for monitoring inflow, especially for when the system is handed over to the WUF.

Potential Participants:

This training will be conducted for WUA office bearers, and held on a sub-system basis. As each WUA is comprised of 5 to 7 office bearers, and as the number of watercourses varies between 15 and 33, the **maximum invitees will be between 100 and 200.**

13.10. TRAINING ON MAINTAINING GAUGE REGISTERS FOR DAILY SUPPLIES

Importance:

The lack of reliable data pertaining to daily supplies is usually considered as one of the main causes for the system's declining performance. Recording daily gauges and maintaining these in a register will help WUOs to plan and make effective decisions.

Potential Participants:

There are at least eight very strategic monitoring points, which include: the head regulator of the Hakra 4-R Distributary; the head regulator of the 1R-A Minor; the bifurcation structure at RD 72; three tails; and two drop structures. Therefore, at least 16 farmers, two from each location, may be trained. These farmers will likely be nominated by respective sub-system WUOs.

14. CLOSING CEREMONIES

14.1 THE CLOSING CEREMONY FOR TRAINEES

Two closing ceremonies were held after these training courses: the first after the three-day WUF training course; and the second after the five sub-system level courses. These were jointly organized by the Water Users Federation and IIMI-Pakistan September 3 and October 12, 1997, respectively, at Haroonabad.

The chief guest at the first ceremony was Mr. Sheikh Nawaz, XEN, Hakra Division, who also distributed certificates to participants. His closing speech highlighted areas where WUOs could help PID to reduce its burdens, such as the resolution of disputes at the WUF level and canal maintenance, especially by restricting the entry of livestock. In conclusion, the WUF President announced the schedule for the five sub-system level sessions.

After the successful completion of the five training courses on water measurement for farmers of the Hakra 4-R Distributary, this closing ceremony took place on October 12, 1997, and also encompassed certificate distribution for participants. Another objective of the ceremony was to present the results of flow measurements ascertained during the training courses.

Over 170 participants from the Hakra 4-R Distributary, as well as farmers from other distributaries, attended the second ceremony. Chaudhry Muhammad Shafi, Chief Engineer, Irrigation Zone, Bahawalpur, was the chief guest, and Jafar Kabir Ansari, Superintendent Engineer, and Prof. Skogerboe, Director, IIMI-Pakistan, also participated in the ceremony.

After reciting passages from the Holy Quran, Mr. Khalid Mehmood, a local teacher, delivered a lecture on "Organization and Discipline", which highlighted the importance of mutual consultation in collective decision-making, and quoted an example from Islamic history. The lecture was followed by six farmer-presentations on different technical aspects of flow measurement, the objective of which was to test farmers' ability as resource persons. Farmers were applauded for their excellent presentations.

Later, three farmers delivered speeches pertaining to irrigation issues, legal powers required by the WUF, and organizational process. Then, the results of the flow measurements were presented, which showed a high level of water inequity among, and within, the sub-systems. Prof. Skogerboe, during his address, briefed the audience about the government's recent recognition of WUO projects, informing them that a Joint Management Agreement between farmers and PID had been signed in Sindh (that was later rescinded by the Chief Minister of Sindh Province).

Photograph 16. President of the WUF receiving training certificate from Prof. Gaylord V. Skogerboe, Director IIMI (1st ceremony).

Photograph 17. Participants receiving training certificates from Ch. M. Shafi, Chief Engineer, PID (2nd ceremony).

Before distributing certificates to participants, the Chief Engineer delivered a good speech about his vast experiences on participatory projects. He suggested that IIMI-Pakistan and the WUF study farmer-managed canals in District Sargodha, which had been provincialized in the early '50s. He also highlighted different areas where farmer-participation is already existent. He did, however, render an assurance that he is personally ready to advocate handing over the Hakra 4-R Distributary to farmers.

14.2. FARMER-PRESENTATIONS

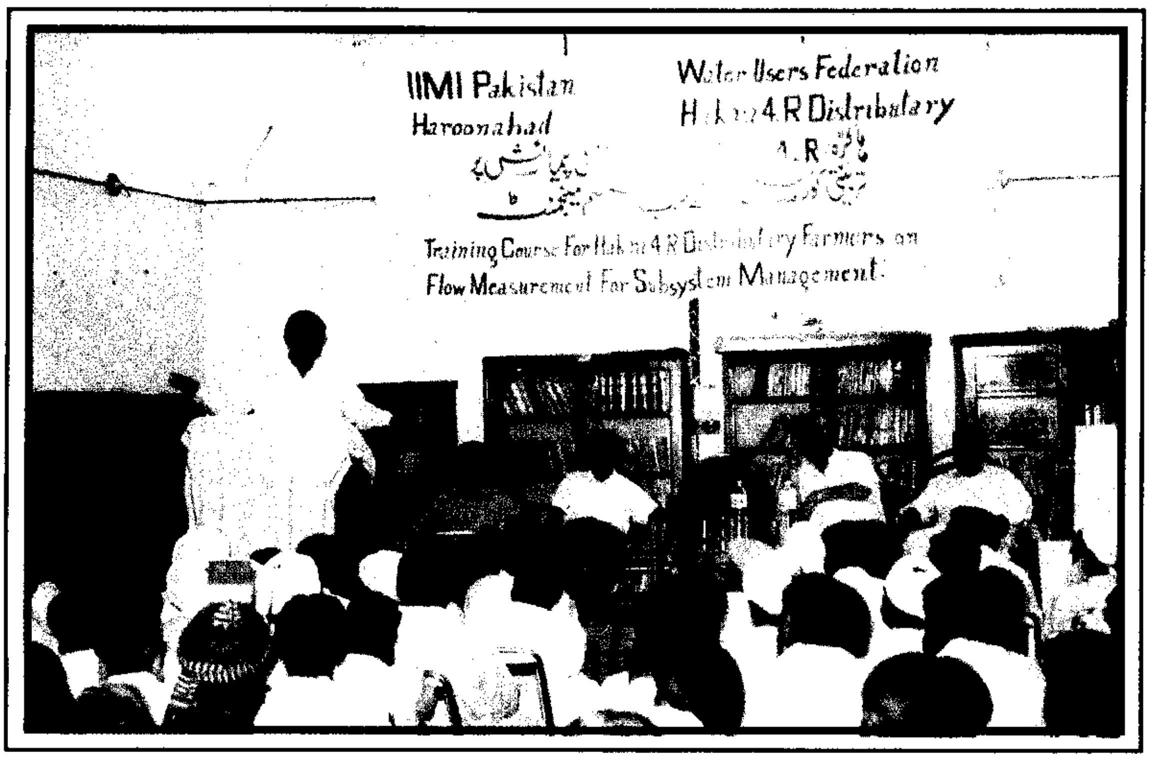
Farmer-presentations, as part of the Water Measurement Training Courses' closing ceremony, was a test to evaluate their ability to act as resource persons. "Reading a Gauge" was presented by Sofi Ashraf, a farmer from Sub-system 5. Other presentations were as follows:

- How to Measure Discharge with a Flume, by M. Anwar;
- How to Measure Discharge with a Current Meter in a W/C, by Akram Wattoo;
- How to Measure Discharge in a Distributary with a Current Meter, by Naeem Akhtar.
- Converting Discharge from the Discharge Table, by Khair Din; and
- Calculating Water Duty, by Fiaz Ahmad.

Farmer leaders also delivered speeches pertaining to general irrigation and organization issues:

- The Organization Process and the Performance of the WUF, by Mian Wahid (President, WUF);
- Legal Powers required by the WUF, by Muhammad Amin (General Secretary, WUF);
- Irrigation Problems, by Mian Muneer (General Secretary, WUO, Sub-system 5); and
- Organizational Process, by Hafiz Sanaullah (President, WUO, Sub-system 5).

All of the farmer-presentations were deemed to be so good that these reflected their potential for technical training.



Photograph 18. Ch. M. Shafi, Chief Engineer, PID, addressing the closing ceremony.

Photograph 19. Distribution of training certificates to participants.

15. CONCLUSIONS

This report is one of several other process documents about WUO pilot projects along the Hakra 4-R Distributary. Between September 1 and October 2, 1997, the International Irrigation Management Institute (IIMI) and the Water Users Federation (WUF) of the Hakra 4-R Distributary jointly organized a series of "WATER MEASUREMENT TRAINING COURSES FOR SUB-SYSTEM MANAGEMENT" for farmer leaders. The aim of the sessions was to provide the necessary training to leaders at the distributary level, leaders from each of the five sub-system level Water Users Organizations (WUOS), and leaders of the 121 watercourse level Water Users Associations (WUAs). The objective was to make these associations capable of monitoring the water supply received from the Hakra Branch Canal, as well as to regulate the distribution of this supply among the five sub-systems, and to each watercourse.

In Pakistan, this has been the first time that such a large-scale series of technical training courses was conducted for farmers. Providing technical training to farmers was a unique experience, which has led to several conclusions pertaining to linkages between training and farmer-participation, the role of SOs, the physical and social infrastructure, as well as covering organizational aspects.

First, farmers do possess a high potential to acquire technical training. Government department dogmatists firmly believe that farmers are incapable of being trained about the technical aspects of irrigation management. Of the participants, 95 % proved this belief to be contrary, and were able to measure water levels with staff gauges, and convert these readings into a discharge using the discharge tables accurately.

Second, trained farmers can act as resource persons. The level of understanding cannot be equated among participants. After this training, the majority of farmers were able to measure the flow without assistance. Only 2 % experienced difficulties to do so independently. There were, however, other farmers intelligent enough to deliver lectures at the sessions conducted at the sub-system levels. When the need arises in the future, these farmers can be used as resource persons.

Third, farmers are capable of implementing technical activities. The level of understanding and the interest shown by farmers in the different training aspects indicated that they are not only capable of acquiring technical training to measure water, but also of implementing technical activities, such as developing discharge tables and conducting technical surveys, if trained for the purpose.

Fourth, some, but not all, farmers without formal education have the ability to be trained. For example, one farmer from Sub-system 3, with no formal education, accurately read the water level with a staff gauge. Therefore, illiterate people who do not have formal schooling cannot be neglected in availing training such as these.

Fifth, less interest was shown by farmers who have multiple incomes. Participation from all of the sub-systems was high. Relatively speaking, however, participation from Sub-system 2, located close to Haroonabad City, generated a participation level of only 70 %. The majority of farmers there are involved in other non-agricultural business activities. Farmers' multiple economic interests did not encourage active participation. Another reason for this low interest is that flow measurements yielded that Sub-system 2 is a water-abundant area. The third reason attributed is that of personality clashes among the leadership of this sub-system, and as a consequence, some leaders refrain from attending meetings.

Sixth, participants from water-scarce areas showed more interest in the training. Participation related to tail sub-systems was highest; 100 %. Farmers from these sub-systems see hope in organized action, and resultantly, they are more enthusiastic about collective behavior. However, had water scarcity been considered one of the factors affecting the participation rate, then participation in the head sub-system should have been less. There again, it was high; 100 %. The reason is that although this sub-system has an advantage over other sub-systems in terms of reliable water supplies, in terms of quantum of water, it is not drawing the normally-perceived water at the head reaches. Moreover, this sub-system has other problems related to irrigated agriculture, which is more severe than in other sub-systems, e.g. waterlogging and salinity. Farmers, therefore, realize the benefits of addressing these problems through collective efforts.

Seventh, This training program has helped to increase farmer-confidence in the system, as well as on the IIMI program. After measuring discharge in the watercourse, one farmer remarked "Earlier, we thought that IIMI staff just wanders along the canal aimlessly. After this participation, we feel that they are doing some real work."

Eighth, the training courses contributed towards increased curiosity about legal recognition. These training courses have increased farmer-awareness about the objectives of this pilot experiment, as it provided ample opportunity to discuss details of the project with fellow colleagues, project, and agency staff.

Ninth, interaction among farmers has improved. After this Water Users Federation was formed on March 05, 1997, it had been the first occasion when a maximum number of leaders gathered for a three-day training course. One farmer commented, "with this training program, we have introduced ourselves to our fellow farmers in detail."

Tenth, farmers' commitment towards the program emerged more clearly. These courses provided an opportunity for farmers to interact with IIMI staff and federation leaders for several days. Informal discussions served as "concept strengthening" for many farmers, perceived to go a long way in organizational development.

Eleventh, this high participation is inextricably linked with the presence of social organizers in the area. The rapport developed between farmers and social organizers during the process of the formation of the WUF served as a valuable means to achieve a high participation rate. The lack of social organizers would invariably have affected the success of the training courses, suggesting that humanistic projects such as these require the continuous presence of social organizers.

Twelfth, the involvement of social organizers providing technical training to farmers proved to be effective in training farmers. Social organizers were equipped with 'hands-on' training on flow measurement, as well as background technical knowledge, before undertaking this series of training courses.

Thirteenth, the balance between lectures and field demonstrations lent interest and liveliness to the sessions. Farmers expressed that the first course, consisting of lengthy lectures, had been boring and least interesting. Farmers showed more enthusiasm for the other five, as lectures had been mixed with field demonstrations.

Finally, the physical and social infrastructure of the system facilitated the effectiveness of the training program. The social infrastructure helped to maintain appropriate participation volumes in all six training courses. The physical infrastructure provided assistance in two useful ways:

- each control structure provided interesting training and practice points for participants from respective sub-systems; and
- farmers were very eager to know what the quantum of water being supplied to their sub-systems.

Therefore, each transfer point, and reach between two transfer points, accelerated the interest of the farmers.

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ANNEXES

ANNEX 1. LIST OF TRAINERS

Serial No	Name of the resource person	Designation
1	Anwar Iqbal	Senior Field Assistant
2	Tipu Naweed	Field Assistant
3	Abdul Hamid	Social Organizer
4	Bilal Asghar	Social Organizer
5	Nasir Sultan	Social Organizer
6	Amjad	Social Organizer
7	Khalid Rashid	Social Organizer
8	Muhammad Asgar	Field Assistant
9	Waheed-uz-Zaman	Field Team Leader
10	Zafar Iqbal Mirza	Irrigation Agronomist
11	Professor G.V. Skogerboe	Director, IIMI-Pakistan

ANNEX 2. LIST OF RESOURCE PERSONS AMONG FARMERS

Serial Number	Name of the Sub-system	Name of the farmer	Designation
1	Sub-system 1	Akram Wattoo	WUF member
2	//	Manzoor Shah	General Secretary, WUO
3	Sub-system 2	Rizwan	President, WUA
4	//	Riaz	SOV
5	Sub-system 3	Siddique	President, WUA
6	//	Anwar	President, WUA
7	Sub-system 4	Fiaz	Joint Secretary of WUO 5
8	//	Khair Muhammad	WUF member
		Mian Muhammad Khan Sukhaira	
9	Sub-system 5	Ashraf	SOV
10	//	Naeem	WUF member

ANNEX 3. LIST OF TRAINEES

S. No.	Name of Trainees	Designation
1	Abdul Shakoor Akooka	President, WUO
2	Nazar Khan Akooka	Joint Secretary, WUO
3	Abdul Khaliq	Advisor
4	Muhammad Akram Wattoo	Federation Member
5	Rao Jumshid Ali	Federation Member
6	Mian Abdul Wahid	President, WUF
7	Raja Ghuzanfar	Vice President
8	Haji Hanif	Advisor
9	Master Riaz Hussain	SOV
10	Muhammad Javed	Previous Trainee
11	Abdul Shakoor	Previous Trainee
12	Muhammad Shafi	W/C Nominee
13	Mumtaz Ahmad Joia	Federation Member
14	Muhammad Anwar Bajwa	Secretary Information, WUO
15	Muhammad Anwar	W/C Nominee
16	Master Hamid	W/C Nominee
17	Master Muhammad Jamil	W/C Nominee
18	Haji Atta Muhammad	Federation Member
19	Fiaz Ahmad	Joint Secretary and Secretary Information, WUO
20	Khair Muhammad	Treasurer, WUO
21	Falik Sher	WUA Member
22	Muhammad Ismail Wattoo	W/C Nominee
23	Muhammad Asghar Joia	General Secretary
24	Muhammad Iqbal	Previous Trainee
25	John Muhammad	Previous Trainee
26	Hafiz Sana-Ullah	President, WUO
27	Mian Munir Ahmad	General Secretary, WUO
28	Master Subah Sadiq	Treasurer, WUO
29	Naeem Akhtar	Joint Secretary, WUO
30	Rashid Ahmad Gill	Federation Member
31	Ch. Muhammad Amin	General Secretary
32	Ashfaq Ahmad Gugger	WUA Member
33	Muhammad Ashraf	WUA Member
34	Muhammad Atif	do
35	Abaid-Ullah	do
36	Anwar Joia	do
37	Muhammad Azim	do
38	Mian Muhammad Hanif	do
39	Haji Atta Muhammad	Federation Member
40	Muhammad Anwar Bajwa	Secretary Information
41	Muhammad Rafique	Federation Member

S. No.	Name of Trainees	Designation
42	Muhammad Shafi	W/C Nominee
43	Muhammad Akram	W/C Nominee
44	Muhammad Anwar	W/C Nominee
45	Master Abdul Hamid	W/C Nominee
46	Muhammad Aslam	W/C Nominee
47	Hashmat Ali	W/C Nominee
48	Haji Muhammad Siddique	W/C Nominee
49	Muhammad Mujhaid	WUA Member
50	Ghulam Mustafa	WUA Member
51	Haq Nawaz	Common Farmer
52	Abdul Ghafoor	W/C Nominee
53	Master Muhammad Jamil	W/C Nominee
54	Abdur-ur-Rzzaq	W/C Nominee
55	Master Muhammad Talib	General Secretary
56	Mian Mumtaz Joiya	Federation Member
57	Muhammad Akram	WUA Member
58	Abdul Ghafoor	W/C Nominee
59	Muhammad Iftikhar	W/C Nominee
60	Muhammad Ashraf	W/C Nominee
61	Ch. Bashir Ahmad	W/C Nominee
62	Rao Abdul Majeed	W/C Nominee
63	Muhammad Arif	W/C Nominee
64	Liaquat Ali	W/C Nominee
65	Muhammad Asghar Joia	General Secretary
66	Muhammad Zafar	WUA Member
67	Sofi Muhammad Siddique	W/C Nominee
68	Khair Muhammad	Treasurer
69	Muhammad Hafeez	W/C Nominee
70	Ali Muhammad	Treasurer, WUF
71	Abdul Shakoor	Previous Trainee
72	Hidayatullah	W/C Nominee
73	Muhammad Ismail	W/C Nominee
74	Muhammad Shafi	W/C Nominee
75	Mian Muhammad Khan Sukeria	President
76	Fiaz Ahmad	Secretary Information
77	Haji Amin Sukeria	W/C Nominee
78	Master Riaz Ahmad	SOV
79	Rao Muhammad Ayub	W/C Nominee
80	Rao Abdul Jabbar	W/C Nominee
81	Abdul Ghafoor	Previous Trainee
82	Abdul Rauf	W/C Nominee
83	Talib Hussain	Treasurer
84	Muhammad Akram	WUA Member
85	Muhammad Javed	Previous Trainee
86	Raja Ghazanfer Ali	Vice President

S. No.	Name of Trainees	Designation
87	Kishwar Manawar	Common Farmer
88	Raja Muhammad Akram (late)	
89	Rao Ghulam Muhammad	Secretary Information
90	Bashir Ahmad Jat	W/C Nominee
91	Sian Muhammad	Federation Member
92	Ghulam Sarwar Warraich	W/C Nominee
93	Ch. Abdul Ghafoor	W/C Nominee
94	Ashiq Hussain Jat	Federation Member
95	Muhammad Tayyab	WUA Member
96	Raja Muhammad Yasin	Common Farmer
97	Naeem Akhtar	Joint Secretary
98	Mian Sher Muhammad Wattoo	W/C Nominee
99	Ch. Akbar Ali	W/C Nominee
100	Shah Muhammad	WUA Member
101	Jan Muhammad	WUA Member
102	Bao Akram	WUA Member
103	Rashid Ahmad Gill	Federation Member
104	Javed Iqbal Jugger	Federation Member
105	Akhtar Ali	WUA Member
106	Muhammad Asghar Kahlu	W/C Nominee
107	Ch. Muhammad Amin	General Secretary, WUF
108	Humayun Akhtar	W/C Nominee
109	Mazhar Hussain Chattah	W/C Nominee
110	Muhammad Akram Chattah	W/C Nominee
111	Hafiz Sna-Ullah	President
112	Qurban Ali	W/C Nominee
113	Master Subah Sadiq	Treasurer
114	Zulifqar Ali	WUA Member
115	Haji Pir Muhammad	W/C Nominee
116	Sofi Muhammad Ashraf	SOV
117	Haji Iftikhar Ahmad	W/C Nominee
118	Arfan Ali	WUA Member
119	Abdul Qayum	WUA Member
120	Mian Munir Ahmad	General Secretary
121	Ashfaq Ahmad Jugger	WUA Member
122	Ch. Maqsood Ahmad	Secretary Information
123	Mubarkh Ali	W/C Nominee
124	Ch. Muhammad Aslam	W/C Nominee
125	azir Ahmad Goria	W/C Nominee
126	Ghulam Rasool	WUA Member
127	Muhammad Azim	W/C Nominee
128	Nazir Ahmad	W/C Nominee
129	Allah Ditta Bhatti	Vice President
130	Ashiq Hussain	W/C Nominee
131	Muhammad Mallah	W/C Nominee

S. No.	Name of Trainees	Designation
132	Haji Muhammad Ali	W/C Nominee
133	Ghulam Muhammad	WUA Member
134	Muhammad Akram Wattoo	Federation Member
135	Syed Manzoor Hussain Shah	General Secretary
136	Muzammil Wattoo	W/C Nominee
137	Mian Muhammad Zubair Wattoo	Secretary Information
138	Rao Jamshed Ali	W/C Nominee
139	Qasim Ali	Common Farmer
140	Said Muhammad	Common Farmer
141	Aish Muhammad	Secretary Information
142	Ghulam Qadir	W/C Nominee
143	Shahbaz Khan	W/C Nominee
144	Riaz Ahmad	W/C Nominee
145	Nazar Muhammad	Federation Member
146	Mumtaz Ahmad	W/C Nominee
147	Gauhar Ali	W/C Nominee
148	Abdul Shakoor	Vice President
149	Muhammad Altaf Javed	W/C Nominee
150	Balia Bhatti	W/C Nominee
151	Rao Muhammad Iqbal	W/C Nominee
152	Rizwan Hameed	Federation Member
153	Ijaz Ahmad	WUA Member
154	Muhammad Ramzan	WUA Member
155	Abdul Khaliq	W/C Nominee
156	Khalid Mehmood	Common Farmer
157	Muhammad Akram	Federation Member
158	Ghulam Hussain	WUA Member
159	Mian Talib	Common Farmer
160	Ghulam Hussain	Common Farmer

ANNEX 4. TRAINERS FOR THE FIVE SUBSYSTEM COURSES

Sub-system 1

Trainers:

1. Muhammad Asghar (Field man)
2. Nasir Sultan (SO)

List of Trainees

S.No.	Name of Trainee	Status
1	Abdul Shakoor Akooka	Vice President, WUF, and President, WUO
2	Muhammad Akram Wattoo	Federation Member
3	Rao Jumshid Ali	Federation Member
4	Nazar Khan Akooka	Joint Secretary, WUO
5	Abdul Khaliq	Advisor, WUO

Sub-system 2

Trainers:

1. Anwar Iqbal (SFA)
2. Bilal Asghar (SO)

List of Trainees

S. No	Name of Trainee	Status
1	Mian Abdul Wahid	President, WUF
2	Raja Ghuzanfar	Vice President, WUO
3	Rao Ghulam Muhammad	Secretary Information, WUO
4	Haji Hanif	Advisor, WUO
5	Master Riaz Hussain	SOV
6	Javed	Already Trained
7	Shakoor	Already Trained

Sub-system 3

Trainers:

1. Abdul Hamid (SO)
2. Muhammad Amjad (SO)

List of Trainees

S. No.	Name of Trainee	Status
1	Rafiq Fouji	Federation member
2	Mumtaz Ahmad Joia	Federation Member
3	Muhammad Anwar Bajwa	Secretary Information, WUO
4	Muhammad Anwar	W/C Nominee
5	Master Hamid	W/C Nominee
6	Muhammad Shafi	W/C Nominee

Sub-system 4

Trainers:

1. Tipu Naveed (FA)
2. Khalid Rashid (SO)

List of Trainees

S. No	Name of Trainee	Status
1	Fiaz Ahmad	Joint Secretary and Secretary Information, WUO
2	Khair Muhammad	Treasurer, WUO
3	Mian Mustafa	WUA Member
4	Muhammad Arif	Advisor, WUO
5	Muhammad Asghar Joia	General Secretary
6	Muhammad Iqbal	Already Trained
7	John Muhammad	Already Trained

Sub-system 5

Trainer:

1. Waheed-uz-Zaman

List of Trainees

S. No	Name of Trainee	Status
1	Ch. Muhammad Amin	General Secretary, WUF
2	Hafiz Sna-Ullah	President, WUO, and Federation Member
3	Mian Munir Ahmad	General Secretary, WUO and Federation Member
4	Rashid Ahmad Gill	Federation Member
5	Naeem Akhtar	Joint Secretary, WUO
6	Master Subah Sadiq	Treasurer, WUO
7	Faqir Hussain	Already Trained

ANNEX 5. SAMPLE OF DISCHARGE TABLES USED DURING THE FLOW MEASUREMENT TRAINING

Discharge Table for Orifice Non-Modular (ON) Outlet RD-1240/ L along Hakra 4-R Distributary

Formula:

Q = Cd x B x Y x (2 g x (Hu-Hd))^0.5

where,

Q	=	Discharge in cusecs
B	=	Width of orifice in feet = 0.27
Y	=	Height of orifice in feet = 0.67
g	=	Acceleration due to gravity ft/sec sq = 32.2
Hu	=	Upstream water depth in feet
Hd	=	Downstream water depth in feet
Cd	=	Coefficient of discharge, Dimensionless = 1.12

Hu-Hd (feet)	Q (cusecs)
0.40	1.03
0.42	1.05
0.44	1.08
0.46	1.10
0.48	1.13
0.50	1.15
0.52	1.17
0.54	1.19
0.56	1.22
0.58	1.24
0.60	1.26
0.62	1.28
0.64	1.30
0.66	1.32
0.68	1.34
0.70	1.36
0.72	1.38
0.74	1.40
0.76	1.42
0.78	1.44
0.80	1.45
0.82	1.47
0.84	1.49

Hu-Hd (feet)	Q (cusecs)
0.86	1.51
0.88	1.53
0.90	1.54
0.92	1.56
0.94	1.58
0.96	1.59
0.98	1.61
1.00	1.63
1.02	1.64
1.04	1.66
1.06	1.67
1.08	1.69
1.10	1.71
1.12	1.72
1.14	1.74
1.16	1.75
1.18	1.77
1.20	1.78
1.22	1.80
1.24	1.81
1.26	1.83
1.28	1.84
1.30	1.85

Discharge Table for Orifice Modular (OM) Outlet RD-35730/L along Hakra 4-R Distributary

Formula;

$$Q = Cd \times B \times Y \times (2\,g \times Hu)^{0.5}$$

where,

Q	=	Discharge in cusecs
B	=	Width of orifice in feet = 0.25
Y	=	Height of orifice in feet = 0.45
g	=	Acceleration due to gravity ft/sec sq = 32.2
Hu	=	Upstream water depth in feet
Cd	=	Coefficient of discharge, Dimensionless = 0.73

Hu (feet)	Q (cusecs)	Hu (feet)	Q (cusecs)
0.70	0.55	2.00	0.93
0.75	0.57	2.05	0.94
0.80	0.59	2.10	0.96
0.85	0.61	2.15	0.97
0.90	0.63	2.20	0.98
0.95	0.64	2.25	0.99
1.00	0.66	2.30	1.00
1.05	0.68	2.35	1.01
1.10	0.69	2.40	1.02
1.15	0.71	2.45	1.03
1.20	0.72	2.50	1.04
1.25	0.74	2.55	1.05
1.30	0.75	2.60	1.06
1.35	0.77	2.65	1.07
1.40	0.78	2.70	1.08
1.45	0.79	2.75	1.09
1.50	0.81	2.80	1.10
1.55	0.82	2.85	1.11
1.60	0.83	2.90	1.12
1.65	0.85	2.95	1.13
1.70	0.86	3.00	1.14
1.75	0.87	3.05	1.15
1.80	0.88	3.10	1.16
1.85	0.90	3.15	1.17
1.90	0.91	3.20	1.18
1.95	0.92	3.25	1.19

Discharge Table for Flume Free (FF) Outlet RD-62670/R along Hakra 4-R Distributary

Formula;

$$Q = Cd \times B \times (2\,g)^{0.5} \times (Hu)^{1.5}$$

where;

Q	=	Discharge in cusecs
B	=	Width of orifice in feet = 0.29
g	=	Acceleration due to gravity ft/sec sq = 32.2
Hu	=	Upstream water depth in feet
Cd	=	Coefficient of discharge, Dimensionless = 0.39

Hu (feet)	Q (cusecs)
0.40	0.23
0.45	0.27
0.50	0.32
0.55	0.37
0.60	0.42
0.65	0.48
0.70	0.53
0.75	0.59
0.80	0.65
0.85	0.71
0.90	0.77
0.95	0.84
1.00	0.91
1.05	0.98
1.10	1.05
1.15	1.12
1.20	1.19
1.25	1.27
1.30	1.35
1.35	1.42
1.40	1.50
1.45	1.58
1.50	1.67
1.60	1.84

Hu (feet)	Q (cusecs)
1.65	1.92
1.70	2.01
1.75	2.10
1.80	2.19
1.85	2.28
1.90	2.38
1.95	2.47
2.00	2.57
2.05	2.66
2.10	2.76
2.15	2.86
2.20	2.96
2.25	3.06
2.30	3.17
2.35	3.27
2.40	3.37
2.45	3.48
2.50	3.59
2.55	3.70
2.60	3.81
2.65	3.92
2.70	4.03
2.75	4.14
2.80	4.25

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RESEARCH REPORTS

Report No.	Title	Author	Year
R-1	**Crop-Based Irrigation Operations Study in the North West Frontier Province of Pakistan** Volume I: Synthesis of Findings and Recommendations	Carlos Garces-R D.J. Bandaragoda Pierre Strosser	June 1994
	Volume II: Research Approach and Interpretation	Carlos Garces-R Ms. Zaigham Habib Pierre Strosser Tissa Bandaragoda Rana M. Afaq Saeed ur Rehman Abdul Hakim Khan	June 1994
	Volume III: Data Collection Procedures and Data Sets	Rana M. Afaq Pierre Strosser Saeed ur Rehman Abdul Hakim Khan Carlos Garces-R	June 1994
R-2	Salinity and Sodicity Research in Pakistan - Proceedings of a one-day Workshop	J.W. Kijne Marcel Kuper Muhammad Aslam	Mar 1995
R-3	Farmers' Perceptions on Salinity and Sodicity: A case study into farmers' knowledge of salinity and sodicity, and their strategies and practices to deal with salinity and sodicity in their farming systems	Neeltje Kielen	May 1996
R-4	Modelling the Effects of Irrigation Management on Soil Salinity and Crop Transpiration at the Field Level (M.Sc Thesis - published as Research Report)	S.M.P. Smets	June 1996
R-5	Water Distribution at the Secondary Level in the Chishtian Sub-division	M. Amin K. Tareen Khalid Mahmood Anwar Iqbal Mushtaq Khan Marcel Kuper	July 1996
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R-7	Salinity and Sodicity Effects on Soils and Crops in the Chishtian Sub-Division: Documentation of a Restitution Process	Neeltje Kielen Muhammad Aslam Rafique Khan Marcel Kuper	Sept 1996
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R-11	Development of Sediment Transport Technology in Pakistan: An Annotated Bibliography	M. Hasnain Khan	Oct 1996

Report No.	Title	Author	Year
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R-13	Methodologies for Design, Operation and Maintenance of Irrigation Canals subject to Sediment Problems: Application to Pakistan (M.Sc Thesis published as Research Report)	Alexandre Vabre	Oct 1996
R-14	Government Interventions in Social Organization for Water Resource Management: Experience of a Command Water Management Project in the Punjab, Pakistan	Waheed uz Zaman D.J.Bandaragoda	Oct 1996
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R-17	Hydraulic Characteristics of Irrigation Channels in the Malik Sub-Division, Sadiqia Division, Fordwah Eastern Sadiqia Irrigation and Drainage Project	Khalid Mahmood	Nov 1996
R-18	**Proceedings of National Conference on Managing Irrigation for Environmentally Sustainable Agriculture in Pakistan**	M. Badruddin Gaylord V. Skogerboe M.S. Shafique (Editors for all volumes)	Nov 1996
R-18.1	Volume-I: Inauguration and Deliberations		
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