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**PILOT PROJECT FOR FARMER-MANAGED IRRIGATED AGRICULTURE UNDER  
THE LEFT BANK OUT FALL DRAIN STAGE I PROJECT, PAKISTAN**

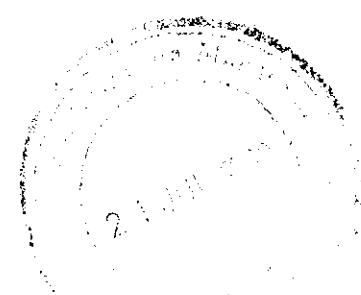
**MAINTENANCE PLANS FOR IRRIGATION FACILITIES  
OF PILOT DISTRIBUTARIES IN SINDH PROVINCE, PAKISTAN**

*Volume Three*

*Bareji Distributary, Mirpurkhas District*

by

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## FOREWORD

The Water Users Federation (WUF) for each pilot distributary was established in mid-December, 1996. Three weeks later, a walk-thru survey was conducted along each distributary channel, where farmer leaders and IIMI staff walked together discussing the many maintenance and operational problems along the way. While walking, numerous farmers were encountered and discussions were held with them. There was a great deal of enthusiasm among the participants, even though it was Ramazan.

One year later, two days were spent with each WUF. The first day was spent conducting another walk-thru survey very similar to the survey conducted a year earlier. The second day was a large meeting to discuss the maintenance program, operational situation with particular emphasis on achieving equitable water distribution among the watercourses, and the combined management of the irrigation and drainage facilities.

Bareji Distributary did not have a major maintenance problem because of the recent remodeling of Jamrao Canal. However, the WUF does contend with sediment deposition problems in the head reach. They have made a number of improvements during 1997, besides desilting. However, the WUF will have to confront some difficult operational problems in attempting to achieve equitable water distribution among watercourses.

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## 1. INTRODUCTION

### 1.1. MAINTENANE AND OPERATION

The first step of an irrigation development strategy is the correction of any maintenance deficiencies that are interfering with the proper operation of existing systems (Skogerboe and Merkley, 1996). As the most economical projects have already been taken up, the major thrust in the future will be on improving irrigation management practices on existing croplands. A common problem in many irrigation systems worldwide is the continual cycle of irrigation system construction, followed by deterioration of the system because of inadequate maintenance, then rehabilitation, followed again by deterioration. This recurring cycle of construction-deterioration-rehabilitation usually precludes the timely and equitable distribution of irrigation water supplies.

The efficient maintenance and operation of an irrigation system is primarily based on its effective management and use of technical solutions. Improved maintenance and operational practices would provide equitable, reliable and predictable irrigation water supplies at different levels in the system, particularly at the tertiary level. To undertake efficient maintenance and operation, a comprehensive maintenance plan is required. A well conceived and organized maintenance plan can help in alleviating the operational and maintenance constraints regarding unreliable and inequitable irrigation water supplies. Many problems regarding maintenance and operation which are effecting the system's performance can be resolved through active participation of water users / farmers' organizations.

Evaluating the maintenance deficiencies of a particular irrigation system is highly important. Then, all of the maintenance deficiencies that interfere with the proper operation of that irrigation system should be corrected. The proper maintenance of the water conveyance system, including irrigation flow control structures, can improve the irrigation conveyance efficiency, which leads to more equitable water distribution; however, additional efforts will be required to improve operations in order to provide more reliable water distribution, proper farm water management, and increased cropping intensity and crop yields. Generally, maintenance is the first activity to be undertaken before embarking upon a program of improving operations.

Essential Structural Maintenance (ESM) is considered to be the minimum level of investment that should be made in order to improve water deliveries. ESM is the required maintenance for the essential flow control structures that will also allow these structures to be used for discharge measurements after repair and then discharge calibration.

### 1.2. MAINTENANCE SURVEY

The first step is to gather considerable information about the irrigation system. The information may cover the water supply situation, water distribution pattern,

irrigation structures, channel reaches, channel physical conditions, existing maintenance strategies, involvement of beneficiaries, responsible agency role and possible constraints. After acquiring sufficient knowledge about maintenance needs, all of the maintenance requirements are categorized into different maintenance programs.

The first major field activity in the maintenance phase is to conduct an Operations Control Maintenance Survey of essential flow control structures that are required for improved operations of the irrigation system, which is used to identify Essential Structural Maintenance (ESM) needs.

The most important step in the maintenance phase is to conduct a detailed Diagnostic Walk-thru Maintenance Survey that lists all deferred maintenance needs along the distributary, which is used to identify Priority Deferred Maintenance Needs (PDMN). The majority of maintenance problems are easily observed in the field during these walk-thrus. After conducting the survey of all the structures and channels, the major and minor problems can be identified. A detailed Essential Structural Maintenance Plan and a Deferred Maintenance Plan can be prepared for a comprehensive maintenance program according to time and budget available.

### **1.3 MAINTENANCE PLANS**

An Essential Structural Maintenance Plan generally includes information on the following important key items:

1. Physical description of irrigation system.
2. Proposed flow measurement program for equitably distributing water supplies.
3. Proposed flow measurement program for evaluating channel losses.
4. Essential structural maintenance (ESM).
5. Cost of ESM.
6. ESM implementation plan.
7. Field notes and sketches.

To prepare a Deferred Maintenance Plan, the following sections would be added to the above outline.

7. Inventory of required deferred maintenance.
8. Deferred maintenance costs.
9. Priority Deferred Maintenance Needs (PDMN) and costs.
10. Maintenance plan.
11. Field notes and sketches.

### **1.4. MAINTENANCE PLAN OF BAREJI DISTRIBUTARY**

The preliminary Essential Structure Maintenance Survey of the Bareji pilot distributary and all of its outlet structures was conducted during the annual canal closure period of January 1996. After formation of the Water Users Associations (WUAs) and

the Water Users Federation (WUF), a comprehensive Deferred Maintenance and ESM survey along with the farmer leaders and members of WUF was carried out during the canal closure period of January 1997. Information was also collected regarding the effects of deferred maintenance in obtaining the desired flow conditions along the channels, as well as in flow control and regulation.

The maintenance plan presented hereafter is the result of the two maintenance surveys mentioned above. The maintenance plan was prepared in consultation with the members of the Water Users Federation (WUF) in order to jointly identify specific problems and to propose technical solutions in the light of the experiences by the WUF members. Walk-thru surveys are done jointly by walking along the distributary channel for observing the problems of: vegetative growth; conditions of the channel bed; banks and berms; and functioning of the head regulator and all of the control structures along the distributary. Besides, efforts are made to explore the causes of these problems and to suggest the possible remedial measures along with estimating the cost of recommended measures.

## 2. PHYSICAL DESCRIPTION OF BAREJI IRRIGATION SYSTEM

A general description of the Bareji Distributary irrigation system is given hereunder, including a location map (Figure 2.1) and a map of the irrigation system showing the distributary command area (Figure 2.2).

### 2.1. BAREJI DISTRIBUTARY

The Bareji Distributary in Mirpurkhas District off-takes from the East Jamrao Canal at RD 408 (which means 408,000 feet downstream from the Jamrao Canal Head Regulator). The head regulator of the distributary has been installed recently under the remodeling program of Jamrao Canal. The total length of the distributary channel is about 12 km (RD 0 to RD 39.31). The design discharge is 41.5 cusecs. This is a perennial channel which runs throughout the year except during the canal closure period in January. Occasionally, this distributary is closed under the rotational closure program due to shortages of irrigation water supplies in the Jamrao Canal.

The irrigation system in the command area of the distributary is canal irrigation, which is a gravitational system. The head reach command area of the distributary is being cultivated by this system, but the middle reach command area is higher than the water surface elevation of the distributary channel. Thus, the command of this reach is cultivated by canal irrigation through using lift pumps. Also, some watercourses in the tail reach have the same problem.

The distributary is irrigating 13,049 acres of land through 24 tertiary channels (watercourses) of which six are lined and eighteen are unlined. The land holding size in the distributary command area is considered to be small to medium ranging from 5 to 100 acres. There are about 254 water users. They include land owners, owner cultivators, lessees and managers.

The distributary is divided into three reaches to facilitate data collection and analysis; there are nine (9) watercourses in the head reach. They are identified as 1R, 1L, 2R, 3R, 4R, 2L, 5R, 3L and 6R. There are seven (7) watercourses in the middle reach; they are identified as 4L, 5L, 6L, 7L, 8L, 9L and 7R. The remaining eight (8) watercourses are in the tail reach; they are identified as 8R, 9R, 10L, 10R, 11L, 12L, 11R and 13L. The average water duty (cusecs per 1000 acres) at the head section is 5.27, at the middle reach it is 5.21 while at the tail reach it is 3.48 cfs/1000 acres.

At some outlets, water users had placed sand bags just near the outlet entrances for raising the water level in order to draw more water than their due share. Due to this placing of sand bags and lowering of the outlet crest level through tampering, sediment deposition has occurred near the outlet entrances.

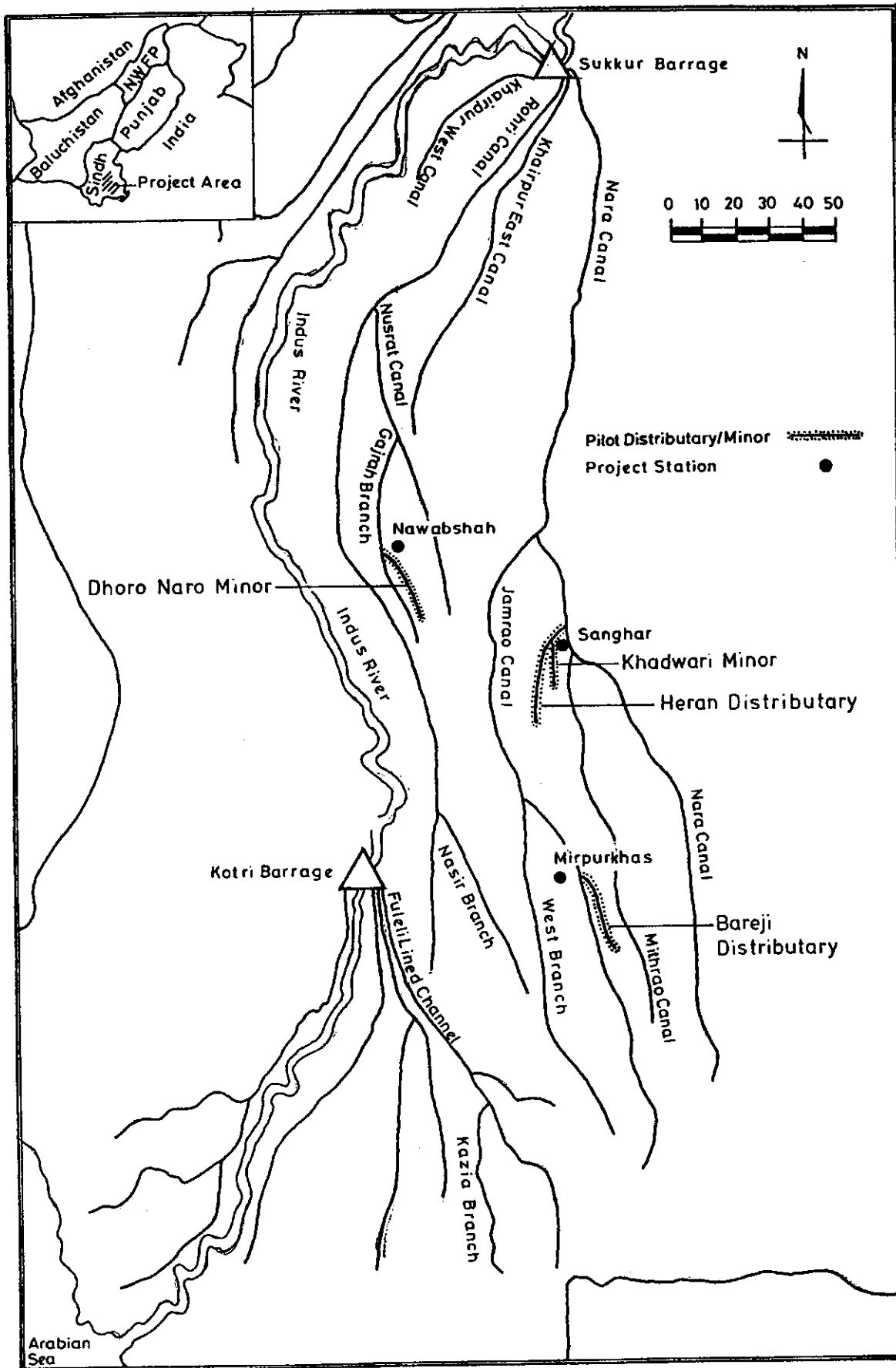


Figure 2.1. Location map of the three pilot distributaries in Sindh Province.

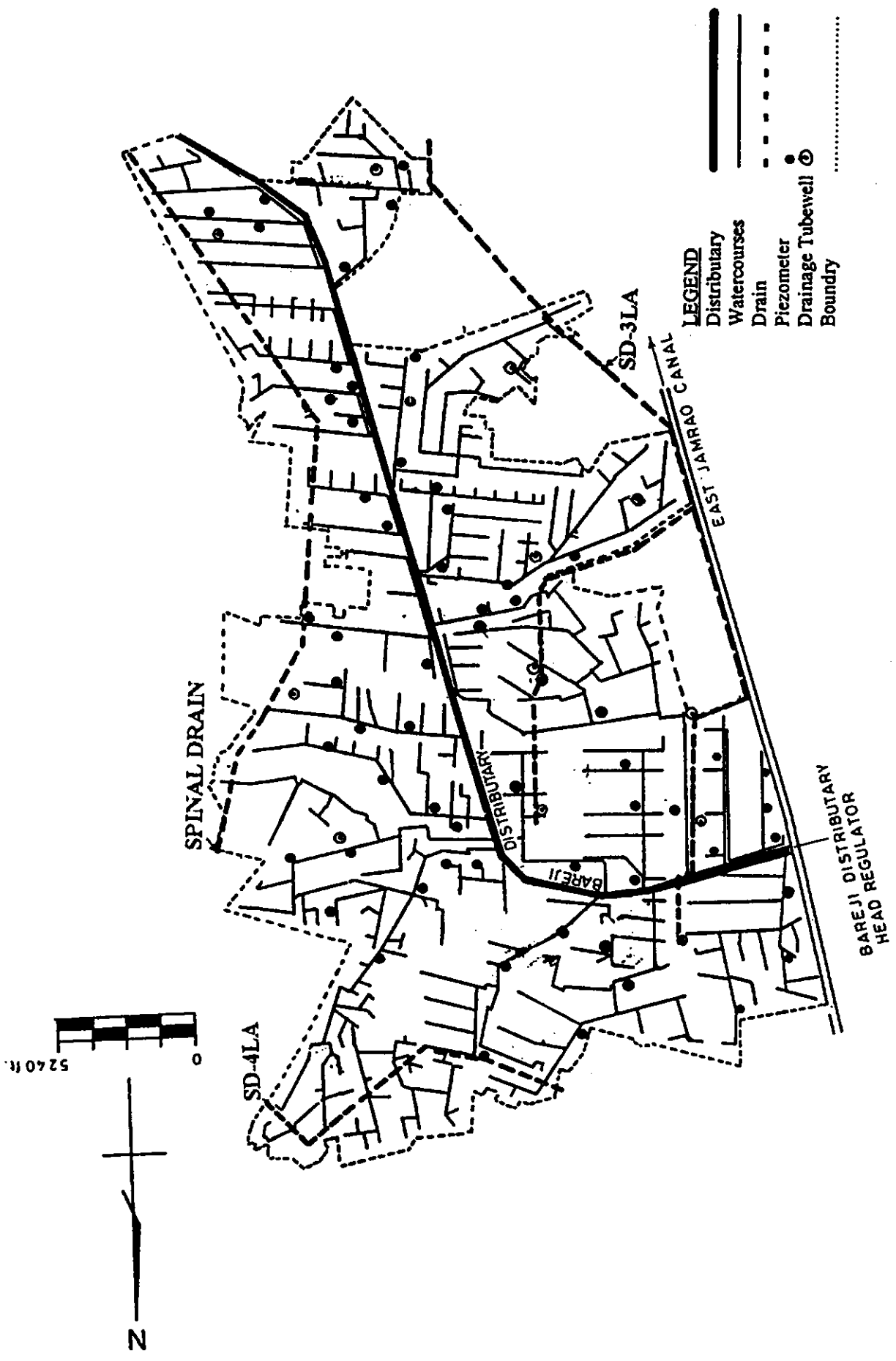


Figure 2.2-Layout Plan of the Bareji Distributary Command Area.

There are two types of drainage facilities available in the Bareji command area - surface drainage and subsurface (tile) drainage. A total of 13 sump houses for tile drainage are located in the Bareji Distributary command area, which are collecting subsurface water through collectors and lateral lines laid in the pilot command area.

The ground water in the distributary command area is mostly saline water. During the collection of data on water quality, it was observed that the water quality varies from area to area and sump house to sump house. However, the water pumped from the sump houses is saline and cannot be used for irrigation purposes.

## 2.2. WATER LIFTING MACHINES

Eight of the watercourses are equipped with 15 lift machines to lift the water as the command areas of these watercourses are at a higher elevation. Three of the eight watercourses are located in the middle reach, while five are in the tail reach. A schematic diagram showing the water passing through a lift machine is shown in Figure 2.3. The land elevations at four watercourses are higher than that of the water surface elevation in the distributary, while at four watercourses it is almost equal; thus, water could not flow without lifting. The details of the lift machines are given in Table 2.1

Table 2.1. Details of fifteen lift machines on eight watercourses along Bareji Distributary.

	WC No.	Name of owner	Land Irri. acres	Hours per week	Cost of fuel/ week (Rs)	Other costs/ season (Rs)	HP
1.	11L	Arzi Khan	75	90	1200	7000	16.5
2.	12L	Manjhi Khan	80	128	1650	6500	16
3.	8L	G.Rasool	17	2	20	6000	16.5
4.	10L	Yusif Bhanger	70	69	1900	7000	18
5.	10L	Yusif Jhulan	16	10	180	3000	12
6.	10L	Ghulam Dal	150	99	1550	8000	16
7.	9R	Ch. Saeed	35	28	650	4000	12
8.	9R	Ch. Javed	15	12	250	3000	12
9.	9R	M. Bashir	15	12	250	3000	12
10	9R	G. Shabir	33	28	650	4000	12
10	10R	Agidino	100	147	3000	8000	12
11	10R	Ch. Rashid	20	13	225	3500	16
12	9L	H. G. Hussain	130	66	2100	8000	22
13	9L	H. Peroz	32	20	700	4000	12
14	7L	Gul Mohammad	34	12	400	3000	12
15	7L	H. Imam bux	12	4	50	1000	12

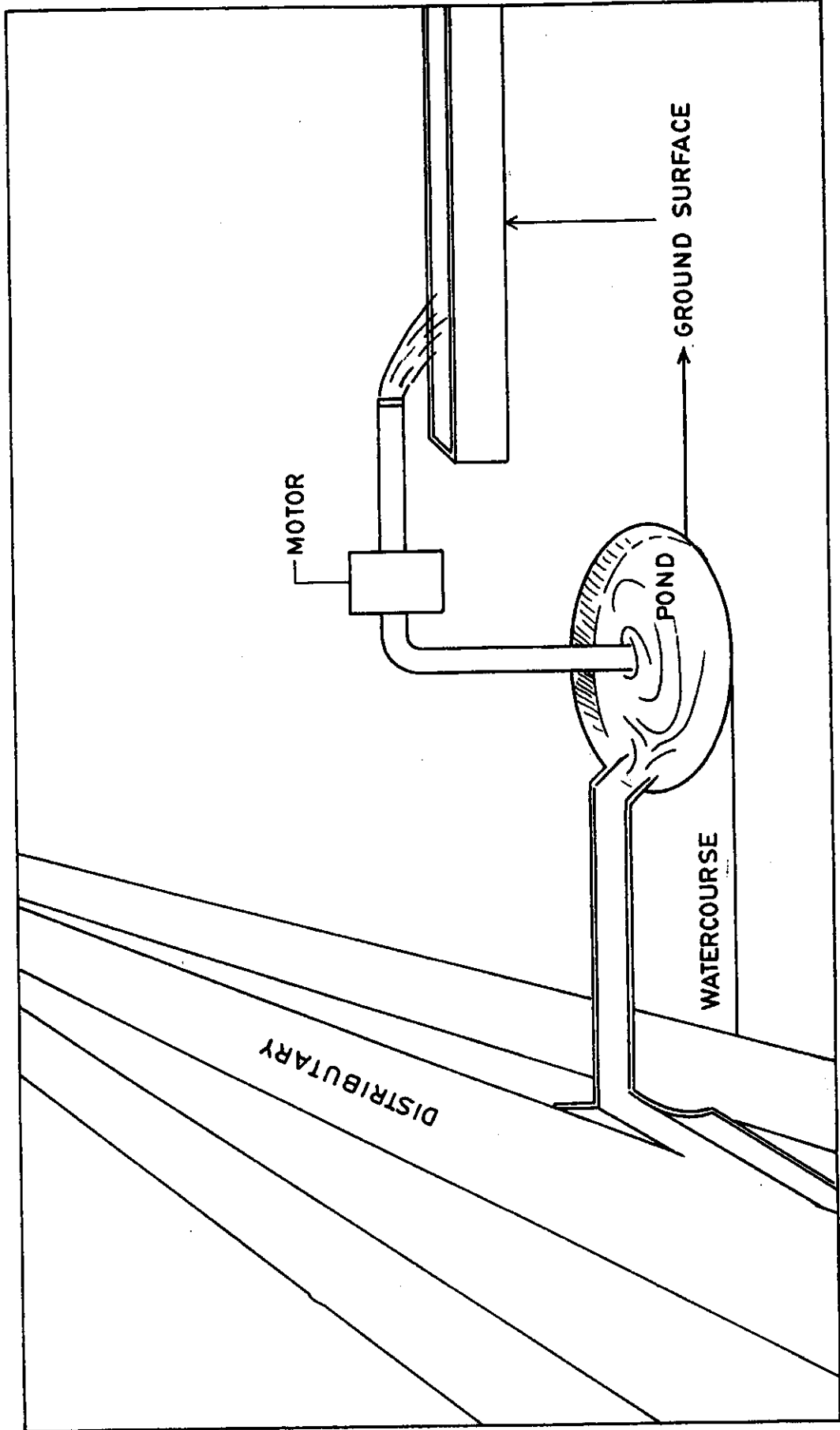


Figure 2.3. Typical schematic diagram for lifting water in eight watercourses of Bareji Distributary.

### 3. FLOW MEASUREMENT PROGRAM

Water measurement is a fundamental basis for evaluating the performance of water management practices and for quantifying the effects of various improvements on these practices. Flow rate information can be used to calculate various performance indices, such as efficiency terms, from which comparative evaluations can be made for different seasons and years, as well as comparing among different irrigation systems (Skogerboe & Merkley, 1996).

#### 3.1. FLOW MEASUREMENT FOR EQUITABLE WATER DISTRIBUTION

Every irrigation system has some irrigation structures to control, regulate and distribute irrigation supplies within the system. The role of these various structures in controlling flows in the system, and in equitably delivering water to the outlets (turnouts) serving the tertiary subsystems, needs to be clearly presented.

Flow measurements at the head regulator and each outlet provide information on the amount of water supplied to a particular area. The system providing equitable flow to tertiary units will provide the foundation for an equal distribution of water to farmers and promote their participation in operating and maintaining the tertiary system. Provision of reliable water supply to the tertiary units should be a primary operational objective of a project. This objective was sometimes neglected in the past when emphasis was placed on farmer participation and on-farm water management, without considering possible management upstream in the system (Plusquellec, 1988). The improvement of water management practices invariably hinges upon the ability to measure flow rates and volumes at key locations in an irrigation system.

##### 3.1.1. Flow Measurement at the Head Regulator

The head regulator is a gated structure, which is rectangular in shape and has adjustable gates. When the upstream water level is higher than the top of the opening of these gated structures, they are functioning hydraulically as orifices. For a rectangular gate having a gate opening,  $G_0$ , and a gate width,  $W$ , the free-flow and submerged-flow discharge can be computed by using the appropriate equations, assuming that the dimensionless velocity head coefficient is unity. The velocity head coefficient approaches unity as the approach velocity to the orifice decreases to zero. The head regulator for Bareji Distributary was calibrated for discharge measurements.

First of all, the hydraulic flow conditions at the head regulator were observed on both the upstream and downstream side of the structure. Tranquil water level locations were sought where there was a minimum of "bounce" in the water level; in other words, locations were preferred where the water surface is calm and smooth. Before calibrating the structure, it was necessary to establish benchmarks at the upstream as well as downstream of the gate structure. White marks (benchmarks) were painted on the upstream and downstream walls of the gated structure, which were referenced to the crest level using a Dumpy Level. The benchmarks were helpful in measuring upstream (u/s)

and downstream (d/s) water levels. These observations were used to obtain the upstream depth and downstream depth of flow using vertical tape measurements from the benchmarks down to the water surface levels.

Current metering was conducted downstream of the head regulator to measure the actual flow and to determine the coefficient of discharge,  $C_d$ , values for different gate openings. The  $C_d$  value was determined for future use in the equations.

After establishing the white marks and their elevations with respect to the crest level, tape readings were taken regularly. These readings were used to determine the values of the upstream and downstream flow depths. Then, knowing the flow depths and measuring the discharge rate using a current meter, and while visually establishing the flow condition (free orifice flow or submerged orifice flow), then the following equations were used to calculate the coefficient of discharge,  $C_d$ .

For free flow

$$Q_f = C_d G_o W \sqrt{2g(h_u - \frac{G_o}{2})} \quad (3.1)$$

For submerged flow

$$Q_s = C_d G_o W \sqrt{2g(h_u - h_d)} \quad (3.2)$$

$C_d$  is the coefficient of discharge,  $G_o$  is the vertical gate opening,  $W$  is the gate width,  $h_u$  is the upstream flow depth and  $h_d$  is the downstream flow depth. Values of  $h_u$ ,  $h_d$ ,  $G_o$  and  $W$  were measured in the field and discharges were calculated using the above equations where the value of  $C_d$  had been developed by calibrating each structure using a current meter. The head regulator of the Bareji Distributary was thus calibrated. The data were collected and plotted. The results achieved were found quite satisfactory for the Bareji Distributary.

The results of the measurement program are presented in Table 3.1

Table 3.1. Average monthly discharges at the head regulator of Bareji Distributary for Kharif 1997.

Sr. #	Month	Discharge in cusecs
1	April 1997	63.42
2	May 1997	62.31
3	June 1997	64.79
4	July 1997	70.95
5	August 1997	72.30
6	September 1997	69.50

### 3.1.2. Flow Measurements at the Outlets

The physical condition of the outlets was observed to see whether the outlet is functional or dysfunctional, its crest is tampered or in good condition, and the sides are damaged or in proper condition. The type of outlet was identified and the dimensions, such as width and height, were measured. The flow conditions were determined as to whether the flow is free flow or submerged flow. The discharge, using the Cutthroat Flume in unlined watercourses and a current meter in lined watercourses, was measured.

According to the flow condition and the type of outlet, the equations were used to determine the discharge coefficient,  $C_d$ . In the case of a tampered outlet, the  $K$  which is equal to the cross-sectional area multiplied by  $C_d$  was computed. By applying the appropriate equation for the determination of the discharge coefficient, the exponent was kept constant. To verify the accuracy of the discharge coefficient, a few readings were observed and the discharge coefficients were computed. Following the benchmarks, established earlier, the tape readings were recorded (see Figure 3.1). The tape readings were subtracted from the benchmark elevations for obtaining the water depths above the outlet crest.

The white mark elevations with respect to the crest is given in Table 3.2

Table 3.2. Upstream and downstream benchmarks.

W/c #	U/s BM	D/s BM	W/c #	U/s BM	D/s BM
1R	3.656	-	1L	3.836	-
2R	3.026	-	3R	4.542	2.859
4R	4.115	4.517	2L	2.936	-
5R	3.13	-	3L	3.595	1.675
6R	3.33	2.445	4L	2.415	-
5L	3.807	2.45	6L	2.89	2.215
7L	3.933	2.938	8L	2.63	2.22
9L	5.682	3.342	7R	4.43	1.315
8R	6.175	4.54	9R	5.35	4.955
10L	3.095	2.705	10R	6.4	5.64
11L	7.782	5.16	12L	8.727	8.267
11R	7.52	6.72			

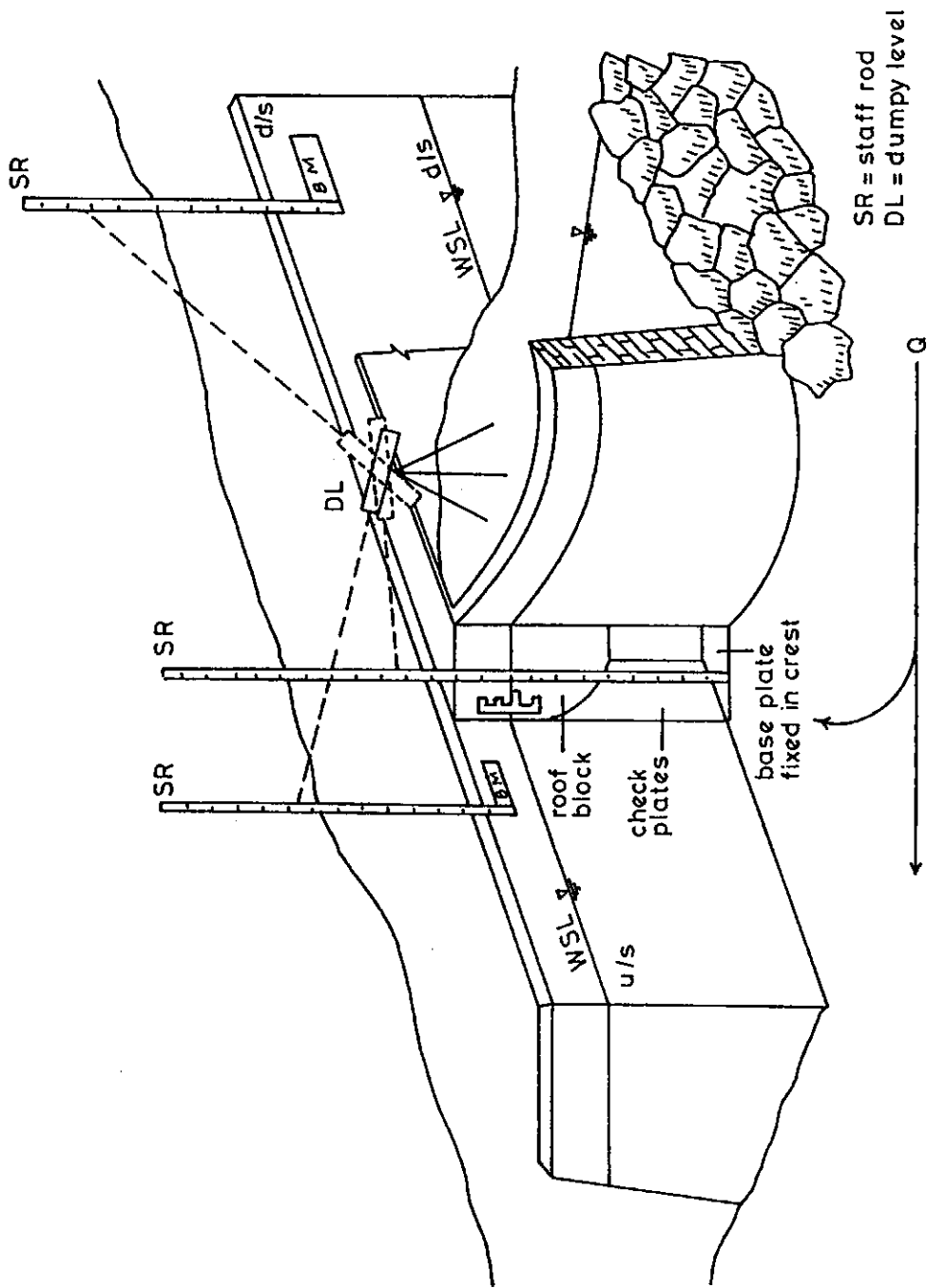


Figure 3.1 Typical fixed orifice Outlet showing benchmarks.

The average monthly discharges for the outlets are presented below in Table 3.3.

Table 3.3. Average monthly discharge (cusec) of outlets.

W/C	April	May	June	July	August	Sept.	Avg.
1-R	1.39	1.80	1.81	1.77	2.10	1.76	1.77
1-L	3.47	3.70	3.71	3.75	3.65	4.75	3.84
2-R	1.52	1.49	1.50	1.51	1.46	1.49	1.49
3-R	3.00	3.09	2.97	3.54	3.66	2.35	3.10
4-R	1.09	1.25	1.31	1.27	1.12	1.12	1.19
2-L	3.38	4.41	4.42	2.99	2.95	3.72	3.64
5-R	2.71	2.99	2.99	3.05	2.23	3.06	2.84
3-L	3.40	3.97	3.95	4.34	4.12	4.49	4.04
6-R	2.94	2.25	2.23	5.19	5.61	4.01	3.71
4-L	1.60	2.11	1.60	0.90	0.98	1.01	1.37
5-L	5.69	4.51	4.72	3.64	4.36	4.89	4.64
6-L	4.36	5.09	5.25	4.86	4.62	4.84	4.84
7-L	2.69	3.53	4.27	4.12	4.33	3.92	3.81
8-L	2.29	2.12	1.84	3.12	3.38	3.05	2.63
9-L	3.48	2.37	2.57	2.59	2.38	3.05	2.74
7-R	1.09	0.76	0.45	1.19	1.10	0.97	0.93
8-R	1.15	0.60	0.59	0.46	1.10	1.11	0.83
9-R	1.41	1.27	1.20	1.20	1.30	1.76	1.36
10-L	2.57	2.67	3.02	2.38	2.53	3.33	2.75
10-R	1.50	1.65	1.53	1.37	1.88	0.58	1.42
11-L	1.48	1.38	2.44	2.57	3.48	2.50	2.31
12-L	1.97	2.05	1.40	2.14	1.55	2.03	1.86
11-R	1.16	0.30	0.80	0.90	1.21	0.60	0.83
13-L	3.15	2.77	3.55	2.64	4.01	2.49	3.10
Total	58.50	58.13	60.11	61.48	65.12	65.88	61.04
Head	63.42	62.31	64.79	70.95	72.30	69.50	67.21
Losses	4.92	4.18	4.68	9.47	7.18	6.62	6.17

Average monthly duty for the outlets is presented in Table 3.4.

Table 3.4. Average monthly water duty (cfs/1000 acres).

W/C	CCA	Avg. Discharge cfs	Avg. Water Duty cusecs/1000 acres	STD	CV
1-R	253	1.77	7.00	0.81	0.12
1-L	685	3.84	5.60	0.57	0.10
2-R	248	1.49	6.03	0.07	0.01
3-R	829	3.10	3.74	0.48	0.13
4-R	294	1.19	4.06	0.27	0.07
2-L	806	3.64	4.52	0.69	0.15
5-R	601	2.84	4.72	0.45	0.10
3-L	670	4.04	6.04	0.48	0.08
6-R	481	3.71	7.70	2.58	0.34
4-L	144	1.37	9.50	2.83	0.30
5-L	1619	4.64	2.86	0.35	0.12
6-L	661	4.84	7.32	0.41	0.06
7-L	523	3.81	7.28	1.00	0.14
8-L	583	2.63	4.52	0.91	0.20
9-L	359	2.74	7.63	1.03	0.14
7-R	136	0.93	6.83	1.73	0.25
8-R	777	0.83	1.07	0.35	0.32
9-R	458	1.36	2.96	0.39	0.13
10-L	385	2.75	7.14	0.78	0.11
10-R	807	1.42	1.76	0.47	0.27
11-L	339	2.31	6.81	1.94	0.28
12-L	388	1.86	4.78	0.67	0.14
11-R	356	0.83	2.33	0.82	0.35
13-L	647	3.10	4.80	0.77	0.16
Mean			5.29		
STD			2.10		
CVt			0.40		

A comparison of the old design and existing average duty of water for the outlets is presented below in Table 3.5.

Table 3.5. Design and average existing water duty of the outlets.

W/C	Old Design	Present Avg. Discharge	Old Design Water Duty	Present water Duty
	cfs	cfs	cusecs/1000 ac.	cusecs/1000 ac
1-R	0.69	1.77	2.73	7.00
1-L	2.01	3.84	2.93	5.60
2-R	0.69	1.49	2.78	6.03
3-R	2.32	3.10	2.80	3.74
4-R	1.89	1.19	6.43	4.06
2-L	2.26	3.64	2.80	4.52
5-R	1.74	2.84	2.90	4.72
3-L	1.88	4.04	2.81	6.04
6-R	1.29	3.71	2.68	7.70
4-L	0.39	1.37	2.71	9.50
5-L	4.36	4.64	2.69	2.86
6-L	1.83	4.84	2.77	7.32
7-L	1.44	3.81	2.75	7.28
8-L	1.63	2.63	2.80	4.52
9-L	1.54	2.74	4.29	7.63
7-R	0.38	0.93	2.79	6.83
8-R	2.25	0.83	2.90	1.07
9-R	1.28	1.36	2.79	2.96
10-L	0.94	2.75	2.44	7.14
10-R	2.26	1.42	2.80	1.76
11-L	0.52	2.31	1.53	6.81
12-L	0.56	1.86	1.44	4.78
11-R	N.A.	0.83	N.A.	2.33
13-L	1.51	3.10	2.33	4.80

### 3.2. FLOW MEASUREMENTS FOR EVALUATION OF CHANNEL LOSSES

Channel losses vary with water surface elevation in the irrigation channel, which is also affected by sedimentation, vegetation and aquatic growth, but much more by biological life in the embankments. The seepage loss rate is often expressed in cubic meters per day of water loss per square meter of wetted surface area, which can be converted to millimeters per day (mm/day).

The channel losses can be evaluated for most of the reaches in the irrigation network using the inflow-outflow method. They should be measured periodically each irrigation season to determine the effects of channel water depths and water table depths on seepage rates. Of particular importance is the rapid increase in seepage rate when the water surface elevation is raised above the normal operating level. This phenomena is primarily due to the large amount of biological life (rodents, snakes, worms, insects, etc.) that exists in an earthen embankment just above the saturated soil in the capillary fringe. The losses tend to increase with each season, sometimes resulting in failure of the embankment. This is highly important in the maintenance of earthen channels, as well as the losses that occur during the operation of the system. The results on the seepage rate measurements are presented in Table 3.6.

Table 3.6. Seepage rates in Bareji Distributary.

Reach	Inflow cfs	Outflow cfs	Losses cfs	Seepage Rate) (cfs/msf
0.295 to 11.280	84.108	83.272	0.836	3.8
11.280 to 23.744	46.422	44.137	2.385	13.9
23.744 to 40.464	-	-	-	-

The physical condition of Bareji Distributary is almost the same along its entire length. The seepage rate from the first reach is considered to be a better approximation as compared with the second reach. The reasons for a higher seepage rate in the second reach could be the frequent movements of animals and lifting of water pumps because of which water fluctuates with time and space. The results for the third reach were inconclusive.

#### **4. MAINTENANCE PLANS**

The field work required for undertaking an ESM plan is the Operations Control Maintenance Survey (OCMS). The field work consists of visiting each flow control structure and determining the maintenance needs so the structure can be used for flow measurement and regulation.

##### **4.1. OPERATIONS CONTROL MAINTENANCE SURVEY**

The intent is to fix all flow control structures required for the improved hydraulic operation of the irrigation project so they can function both as flow control and flow measurement structures. This activity is the crucial linkage between the Maintenance Phase and the Operations Phase. The operations phase will identify the essential flow control structures that need to be calibrated for discharge measurement. The maintenance phase will conduct a maintenance survey of these identified flow control structures to determine what is required to have these structures in good condition prior to developing discharge ratings. Ideally, the maintenance survey of flow control structures should be done twice: once when the channels are operating and once during canal closure.

The first step is to gather existing information about the irrigation system. This information may cover the water supply situation, water distribution pattern, irrigation structures, channel reaches, channel physical conditions, existing maintenance strategies, involvement of beneficiaries, responsible agency role and possible constraints. After acquiring a good knowledge of maintenance needs, all maintenance requirements are categorized into two different maintenance programs: (1) essential structural maintenance; and (2) deferred maintenance.

##### **4.2. MAINTENANCE INFORMATION FROM FARMERS**

Farmers involvement and participation in the maintenance of the irrigation systems is crucial for the success and sustainability of maintenance and operations of the system. Sometimes, they know the operation and the maintenance problems of the system better than the field staff. Some finer issues, which may not be discovered during the surveys, can be identified through discussion with the farmers. In this case, a large number of farmers participated in the walk-thru surveys.

##### **4.3. ESSENTIAL STRUCTURAL MAINTENANCE (ESM)**

The results from the "Operation Control Maintenance Survey" for the essential flow control structures and interaction with the farmers provide all of the field data necessary to prepare an ESM Plan. The major maintenance requirements can be identified and the estimated costs can be developed. The results of the survey are presented as Annexure A.

#### 4.4. COST OF ESSENTIAL STRUCTURAL MAINTENANCE

The individual and total maintenance costs for the Essential Structural Maintenance (ESM) are given in Table 4.1.

Table 4.1. Cost estimates of Essential Structural Maintenance.

Outlet No.	Material		Labor Charges		Total Cost (Rs.)	Remarks
	Cement (kg)	Sand (kg)	Skilled (Rs.)	Non-Skill (Rs.)		
U/s	-	-	-	100	100	Removal of silt
240/1R	-	-	-	50	50	Removal of stones
239/1L	1	2	150	50	206	Outlet repair
240/1AR	2	3	150	50	214	Outlet repair
239/2R	3	5	150	50	222	Outlet Repair
239/2AR	-	-	-	50	50	Removal of stones
228/1L	4	6	150	50	228	Outlet repair
240/2R	-	-	-	50	50	Removal of stones
228/1AL	4	6	150	50	228	Outlet repair
240/3R	8	13	150	50	258	"
228/2L	6	9	150	50	242	"
227/1AL	8	13	150	50	258	"
227/1L	4	6	150	50	228	"
226/1L	4	6	150	50	228	"
226/2L	3	5	150	50	222	"
225/1L	-	-	-	50	50	Removal of stones
239/3R	2	3	150	50	214	Outlet repair
238/1R	-	-	-	50	50	Stones removal
238/2R	-	-	-	50	50	"
225/1L	5	8	150	50	238	Outlet repair
237/1R	-	-	-	-	-	Good condition
225/2L	-	-	-	-	-	"
224/1L	-	-	-	-	-	"
236/1AR	-	-	-	-	-	"
224/2L	-	-	-	-	-	No structure
Total	54	85	1950	1050	3386	cement= Rs. 4/kg reti = Rs. 2/kg

Transportation charges (approx.)  
Therefore, total approximate cost

= Rs. 1700  
= Rs. 5086/- say Rs. 5000/-

The items listed in Table 4.1 represent the minor ESM costs. The major ESM costs will be associated with the remodeling or repair of outlet structures. The cost of remodeling can range from Rs.20,000 – 50,000. Remodeling would be associated with the eight watercourses where water is lifted, with an average estimated cost of Rs.25,000 (8 w/cs x Rs.25,000 = Rs.200,000). For the remaining sixteen watercourses, only repairs would be required with an estimated cost of Rs.5,000 per outlet (16 w/c outlets x Rs.5,000 = Rs.89,000). Thus, the total estimated ESM costs would be Rs.285,000 (Rs.5,000 + Rs.200,000 + Rs.80,000).

#### 4.5. PRIORITY DEFERRED MAINTENANCE

Participating in the actual maintenance by completing the Priority Deferred Maintenance Needs provides field personnel with extremely valuable experience in the application of remedies to maintenance problems. It is highly recommended that the IIMI field staff and WUF leaders be expected to do this activity over every meter of length of the distributary channel.

During the survey, it is important to list all of the deferred maintenance needs along the distributary. The maintenance surveys were undertaken in the pilot distributary in collaboration with members of the WUF. The results of these exercises were very interesting. Preliminary results show that farmers involvement in maintenance activities can ensure high quality works at very economical costs. This involvement also creates a sense of ownership among them.

The deferred maintenance costs are shown in Table 4.2

Table 4.2. Deferred maintenance costs for sediment removal.

RDs	Length (ft)	Width (ft)	Depth (ft)	Total Volume (ft <sup>3</sup> )	Laborers #	Tractor (hrs)	Total cost Rs.
U/s H.R	-	-	-	-	5	-	500
0.00 to 0.5	500	25	0.5	6250	42	6	5100
0.50 to 1.75	1250	20	0.5	12500	83	12	10100
1.75 to 4.9	3150	18	0.5	22680	151	16	17500
4.90 to 6.7	1800	17	0.4	12240	82	-	8200
6.70 to 11.5	4800	16	0.4	30720	205	-	20500
11.5 to 12.1	600	15	0.4	3600	24	-	2400
12.1 to 17.3	5200	12	0.4	24960	166	-	16600
17.3 to 25.1	7800	9	0.4	28080	187	-	18700
25.1 - 39.31	14210	5	0.0	0.0	-	-	000
<b>Total</b>	-	-	-	-	945	34	99600

- \* Estimated volume desilted/day/labor = 150 cubic feet
- \* Labor charges / 8 hrs (per day) = Rs. 100/- per day
- \* Tractor charges / hour = Rs. 150/-

#### **4.6. SCHEDULE OF WORK / IMPLEMENTATION WORKS**

All of the work which has been identified in Annexure B could be implemented during the canal closure period of January 1997. Two team members under the supervision of the O&M specialist, IIMI Hyderabad supervised the work along with the WUF and WUAs leaders. The work took about 10 days for its implementation.

As a consequence, all of the deferred maintenance needs were corrected during 1997. This was quite an accomplishment by the WUF.

The ESM requirements will not be undertaken until the WUF receives legal authority for managing the distributary command area. This is a lesson learned from the difficulties faced by the Dhoro Naro Minor WUF during 1997 (see Volume One).

## 5. IMPROVEMENTS

Several developments schemes were implemented in collaboration with the Water Users Federation (WUF) of Bareji Distributary. The WUF not only participated in the whole process of identification, planning and implementation, but also contributed about half of the costs of these schemes.

Table 5.1. Total costs and its sharing in Pak rupees.

Sr.#	Name of Scheme	Total Amount (Rs.)	WUF Share (Rs.)	Project (Rs.)
1	Earth work from RD 0.5 to 1.3	8650	2612	6038
2	Earth work from RD 4.20 to 4.50	5458	1567	3891
3	Culvert on W/C 2-L	11281	5595	5686
4	Culvert on W/C 5-L	9973	4818	5155
5	Culvert on W/C 6-L	11631	5608	6023
6	Culvert on W/C 8-L	11631	5608	6023
7	Culvert on W/C 5-L	12054	5928	6126
8	Culvert on W/C 5-L	12054	5928	6126
9	Culvert on W/C 6-L	11354	5464	5890
10	Culvert on W/C 6-L	11354	5464	5890
11	Culvert on W/C 7-L	10727	5307	5420
12	Culvert on W/C 7-L	10727	5307	5420
13	Culvert on W/C 9-L	11377	5619	5758
14	Culvert on W/C 10-L	11854	5963	5891
15	Culvert on W/C 10-L	11977	5835	6142
16	Culvert on W/C 11-L	11754	5864	5890
17	Culvert on W/C 12-L	11554	5664	5890
18	Culvert on W/C 13-L	11277	5519	5758
19	Culvert on W/C 10-R	14512	7302	7210
Total Expenditures		205,735	95,508	110,227

As can be seen from Table 5.1, all of the works undertaken were extremely cost-effective and most economical. These improvements would have cost several times more if they had been done by a government agency staff. Sample calculations on the estimates made are presented below in Boxes.

<i>Box 5.1. Stabilization of Inspection Path (IP) on Bareji Distributary from RD 0.5 to 1.3.</i>			
Average depth with reference to length	(D)	=	0.96 ft
Average width of Inspection Path	(W)	=	14 ft
Required length of Inspection Path	(L)	=	800 ft
Volume of fill required	(V)	=	10,752 ft <sup>3</sup>
One tractor trolley carries		=	140 ft <sup>3</sup>
No. of tractor trolleys for 10752 ft <sup>3</sup>		=	76.80 say 77
Rate per Trolley		=	Rs. 115
(A)	Total Amount	=	Rs. 8855
<i>Mandays</i>			
Two laborers with tractor for maintaining side and top level of path			
No. of trolleys per day		=	8
No. of hours		=	9.6 say 10
hours			
No. of Laborer - Days		=	20
Laborer charges per day		=	Rs. 125
(B)	Total Labor cost	=	Rs. 2500
	Total cost ( A + B )	=	Rs.11,355

*Box 5.2. Stabilization of Non- Inspection Path (NIP) on Bareji Distributary from RD 4.2 - 4.5*

Earthwork for filling embankment from surplus earth from one side

Length	=	$\frac{92 \times 3.20 + 11.72}{2} \times 2.13$
Quantity	=	$1461.86 \text{M}^3$ , say $1462 \text{M}^3$
Existing earth work is		$92 \times \frac{2.33+4}{2} \times 1.5$
Quantity	=	$437 \text{M}_3$
The proposed earthwork is	=	$1462 \text{M}^3$
Existing earth work is	=	$437 \text{M}^3$
Now remaining earth work is	=	$1025 \text{M}^3$
Mandays	=	$\frac{1025 \times 28.57}{100} = 292.84$ , say 293
Tractor hours	=	$\frac{293}{5.5} = 53.27$ hours, say 53 hours
Tractor days	=	$\frac{53}{8} = 6.63$ , say 7 days

Assume four laborers will work with the tractor for cutting of bushes and maintaining side slopes and the top level of the path

No. of Laborers	=	$7 \times 4 = 28$ Labor Days
Market Rate of Tractor hours	=	Rs. 170 per hour
Laborer rate for one day	=	Rs. 60 per day
Amount of Tractor hours	=	$53 \times 170 = \text{Rs. } 9010$
Amount for Labor	=	$28 \times 60 = \text{Rs. } 1680$
Total Estimated cost	=	Rs.10,690

Box 5.3. *Sample example of material-estimation for the construction of a culvert along a watercourse.*

S#	Description	Bill Of Quantities				Quantity
		No.	L (ft)	B (ft)	D (ft)	
1	Excavation in foundation	1	20	4.5	5	450 cft
	wing walls	4	4	1.5	4	96
	Total excavation					546 ft
2	P.C.C 1:2:4 in foundation	1	20	4.5	0.33	29.7
	wing walls	4	4	1.5	0.33	7.92
	Total P.C.C 1:2:4					37.62
3	Brick Masonry 1:2:4 C/C					
	First step	2	18	1.83	1	65.88
	Second step	2	18	1.08	1	38.88
	Third step	2	18	0.75	2	54
	Wing wall First step	4	4	1.12	1	17.92
	Wing wall Second step	4	4	0.75	2	24
	Abutment wall first step	2	5	1.5	1	15
	Abutment wall second step	2	5	1.12	3	33.6
	Total brick Masonry					249.28
4	Plaster 1:4 c/s walls outside	2	20	----	4	160 sft
	Plaster 1:4 c/s walls inside	2	20	----	4	160 sft
	Wing walls	2	4	----	3	48 sft
	Abutment walls outside	1	5	----	4	40 sft
	Abutment walls inside	1	5	----	3.5	35 sft
	Total plaster					443 sft
5	R.C.C slab 1:2:4	1	16	3	0.5	24 cft
6	Steel	16x16	159	----	----	159 ft
		21x03				

**Box 5.4. Sample example of cost-estimation for the construction of a culvert along a watercourse.**

**A: Summary of material requirements.**

S.#	Description	Quantity	Bricks#	Cement	Sand	Crush Ballart	Steel
1	Excavation	546	-	-	-	-	-
2	P.C.C.	3762	-	6.39	16.55	-	-
3	B/Masonry	249.50	3428	11.48	59.82	-	-
4	Plaster	443	-	4.25	15.94	-	-
5	R.C.C.	24	-	4.08	10.56	21.12	-
			3428	26.56	102.9	54.22	159

**B: Material cost I/C cartage**

1	Cement 27 bags @ Rs.200/Bag	=27x200	=Rs. 5400
2	Sand 103 cft @ Rs.800.00/cft	= 103x8	= Rs. 824
3	Bricks 3428 @ Rs.1/No	=3428x1	= Rs. 3428
4	Crush 54 cft @ Rs.1400/cft	=54x14	= Rs. 756
5	Steel 37.49 Kg @ Rs.25/Kg	=37.49x25	= Rs. 937
6	Binding wirel ½ KG @ Rs.30/KG	=1/2x30	= Rs. 15
			= Rs.11360

**C: Labor charges**

Skilled Labor	=10x160	= Rs. 1600
Unskilled Labor	=33x70	= Rs. 2310
Total labor charges		= Rs. 3910

**D: Summary of cost**

Total material cost	= Rs.11360
Total labor cost	= Rs. 3910
Total labor charges	= Rs.15270

## 6. CONCLUSION AND RECOMMENDATIONS

The study has led to the following general conclusions and recommendations.

1. The deferred maintenance needs were not so great because of the remodeling of Jamrao Canal under LBOD. The fact that the deferred maintenance was completed during 1997 is a good indicator that the WUF can achieve cooperative action among the farmers.
2. Maintenance activities require considerable technical and financial resources. Considering the present level of resource availability, it would be very difficult for a government agency to undertake maintenance activities on their own. Therefore, it is necessary that the water users, who are also the beneficiaries, may be involved in this process.
3. The M&O activities undertaken on the Bareji Distributary indicates the farmers' ability to participate in the maintenance activities. This also shows, once organized, they can be very effective in undertaking the M & O activities in a very economical way.
4. Tampering of the outlets and the lack of essential structural maintenance has resulted in the problem of inequity in water distribution. Therefore, the solution of this problem is to remove or repair the outlet structures.
5. A strong recommendation is that the farmers, through their WUF, may be provided necessary training, resources and powers (legal authority) to undertake these activities in the future. Without legal authority, they will be unable to achieve equitable water distribution.

## REFERENCES

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***ANNEXURES  
ON  
MAINTENANCE SURVEYS***

**ANNEXURE A**

**FIELD NOTES AND SKETCHES**  
**ON**  
**OPERATIONS CONTROL MAINTENANCE SURVEY**  
**OF**  
**BAREJI DISTRIBUTARY**

RD 408  
 JAMRAO  
 CANAL

1. HEAD REGULATOR (DISTRIBUTARY INTAKE STRUCTURE)

1.1 *Gates of the Head Regulator*

The head regulator for the Bareji Distributary (Figure A1) has three cast iron gates of different dimensions which are manually operated. The gates were installed recently and are being well maintained. Their sizes as measured during the inspection are given below.

Left Gate

Gate height	4.75 feet
Width	5.00 feet

Middle Gate

Gate height	4.95 feet
Width	5.00 feet

Right Gate

Gate height	4.94 feet
Width	5.00 feet

1.2 Crest

The crest of the head regulator is in good condition. Full Supply Level (FSL) at the head regulator is 54.46 feet above mean sea level.

1.3 Gate Seat

The seat of the gate is made of iron, which is in good condition.

1.4 Handle and Gear

The handle and gear are used for opening and closing of the gates manually. These are in good working condition.

1.5 Wing Walls

Wing walls are constructed on the upstream side, as well as on the downstream side, of the head regulator to streamline the flow. They are in good condition.

1.6 Upstream and Downstream of the Head Regulator

There is a heavy amount of sediment (silt) deposition upstream of the left gate. The other two gates are clear. There is no silt deposition

downstream of the head regulator mainly because of free flow conditions at the head regulator. The width of the weir is 3.5 feet and it is in good condition. Stone pitching on the upstream side is also in good condition. Downstream of the weir an apron of friction blocks 10 feet in length is provided. Stone pitching follows the friction blocks and is 19.5 feet in length. About 50 feet downstream of the stone pitching, there is erosion which has resulted in increased flow depth of the distributary channel at that place.

**Causes** Heavy silt accumulation on the left gate of the Head Regulator is due to partial opening of the left gate. Because of partial opening, the velocity of water is reduced at the left gate and consequently silt is deposited.

**Remedy** Silt clearance upstream of the left gate of the Head Regulator is needed to allow the entry of more water to the distributary.  
Fill the eroded portion downstream of the friction blocks.

## 2. OUTLETS STRUCTURES (MOGHAS)

### RD 0.5 OUTLET 240/1-R (240 is Deh number)

**Situation** The module is a single orifice constructed recently. The area of the orifice opening is 0.27 square feet. Rocks have been accumulated in front of the module (see Figure A2).

**Causes** The accumulation of rocks has been done deliberately to head up the water for drawing more water and cultivating additional areas.

**Remedy** The rocks will be removed in consultation with Water Users Association and they will be persuaded to refrain from this practice in the future.

### RD 0.5 OUTLET 239/1L (1-L)

**Situation** This module is a newly constructed double orifice. The orifice on the left is tampered. The area of the right orifice is 0.231 square feet. There is some stone deposition at the face of the outlet to divert more water into the outlet. The tampering has not significantly affected the discharge rate as it was hammered with an iron instrument. The right orifice is in good condition (see Figure A3).

Causes	The practice of tampering and rock accumulation in front of the outlets is done to get extra water for cultivating more land or to get enough water during the days of shortage.
Remedy	The tampering of the orifice can be repaired using cement and fine aggregates. Rocks can be removed in consultation with the WUA.

#### RD 1.75 OUTLET 240/1AR (2R)

Situation	The module is an old single orifice structure. The orifice is made up of a cast iron frame with graduations. The orifice is tampered in the bottom and rocks have been accumulated in front of the outlet (see Figure A4). The area of the orifice is 0.313 square feet.
Causes	Rocks have been accumulated and the orifice bed is tampered to draw more water.
Remedy	Rock accumulation may be removed by the cooperation of the WUA. Tampered outlet can be repaired by ordinary masonry work.

#### RD 4.9 OUTLET 239/2R (3R)

Situation	The module is an old structure and is an open flume. There is silt deposition in the bed of the module. Concrete blocks are placed in front of the outlet. The width of the throat is 0.684 foot. A cavity has been formed at the bed of the outlet (see Figure A5).
Causes	The silt deposition is due to the elevated bed of the downstream watercourse. The presence of the concrete blocks, as well as the cavity formation in front of the outlet, is to draw additional water for increasing cultivation, especially during the periods of irrigation water shortage.
Remedy	There must be regular desilting of the watercourse. Concrete blocks will be removed through cooperation of the concerned WUA. The cavity can be removed by ordinary masonry work.

## RD 4.9 OUTLET 239/2AR (4R)

Situation	The module has a single orifice and is an old structure. The orifice is made up of a cast iron frame with graduations both upstream and downstream of the frame. There is heavy silt deposition in the bed of the outlet. Stones are placed in front of the outlet. The area of the orifice is 0.275 square feet. The outlet operates mostly as a submerged orifice.
Causes	Silt deposition is due to submerged flow and the elevated bed of the watercourse. Stones are placed in front of the outlet for drawing more water.
Remedy	Since its construction the flow condition has been submerged orifice flow. This causes the problem of silt deposition. There must be regular desilting of the watercourse. Concrete stones may be removed from the mogha manually.

## RD 5.7 OUTLET 228/1L (2L)

Situation	The module is a single orifice and is an old structure. There is silt deposition in the bed and stones have been placed in front of the outlet. The outlet has been tampered. The measured area of the orifice is 0.44 square feet.
Causes	Silt deposition is due to the lack of excavation. Stones are placed in order to divert more water into the outlet for more cultivation, especially during the periods of water shortage. The tampering is also done for obtaining more water.
Remedy	Desilting of the watercourse. Tampering can be corrected by ordinary masonry work. Remove the stones by the cooperation of the WUA.

## RD 6.7 OUTLET 240/2R (5R)

Situation	The module is an old single orifice structure. The orifice is made up of a cast iron frame graduated at both the upstream and downstream sides, which is in good condition. There is some silt deposition. Bulky stones were placed in front of the outlet. The area of the orifice is 0.443 square feet.
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Causes	Silt deposition is due to the lack of excavation of the distributary. Stones are placed in order to divert additional water into the outlet for more cultivation.
Remedy	Remove the stones by the cooperation of the concerned WUA.

#### RD 11.5 OUTLET 228/1AL (3L)

Condition	The module is an old single orifice structure. The orifice is made of cast iron frame with graduations on the upstream and downstream sides. The bed of the orifice is tampered. Bulky stones have been placed in front of the outlet (see Figure 6). The area of the orifice is 0.59 square feet.
Causes	Orifice tampering and the accumulation of rocks is done to obtain more water.
Remedy	Tampering can be corrected by ordinary masonry work. Remove the rock accumulation by the cooperation of the WUA.

#### RD 11.5 OUTLET 240/3R (6R)

Condition	The module is an old single orifice structure, which is made of a cast iron frame graduated at both the upstream and down stream sides. The orifice and its side walls are tampered from both sides. Sand bags are also placed in front of the outlet. Area of the orifice is 0.3 square feet (see Figure A7).
Causes	The main reason for tampering and placing the sand bags is to draw more water.
Remedy	Tampering can be corrected by ordinary masonry work. The sand bags can be removed by the cooperation of the concerned WUA.

#### RD 12.1 OUTLET 228/2L (4L)

Condition	The module is an old single orifice structure. The module is made of a cast iron orifice graduated at both the upstream and downstream sides. The bed of the orifice is tampered. Heavy silt deposition and concrete stones are placed in
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front of the outlet (see Figure A6). The area of the orifice is 0.194 square feet

**Causes** Tampering of the orifice bed and placing of bulky stones in front of the orifice is to draw more water during the periods of water shortage. Silt accumulation is also due to the lack of excavation.

**Remedy** Tampering can be repaired by masonry work. The bulky stones can be removed by the cooperation of the concerned WUA.

#### RD 12.1 OUTLET 227/1AL (5L)

**Condition** The module is an old single orifice structure. The orifice is made of a graduated cast iron frame. The module draws water with more pressure as the bed of the orifice is tampered and bulky stones have been placed in front of the outlet. There is heavy silt deposited at the outlet (see Figure A6). The watercourse is lined. The area of the orifice is 0.70 square feet.

**Causes** Tampering and placing of bulky stones in front of the outlet is done to get more water for cultivation. The design of the module is such that it faces directly the stream flow. Silt deposition takes place mainly due to the lack of excavation.

**Remedy** Excavation of the channel must be done regularly. Tampering may be repaired by ordinary masonry work. Bulky stones may be removed by the cooperation of the concerned WUA.

#### RD 13.1 OUTLET 227/1L (6L)

**Situation** The module is an old single orifice structure. The orifice frame is made of iron graduated on both sides. The bottom of the orifice is tampered. There is heavy silt deposition and bulky stones are placed in front of the outlet (see Figure A6). The area of the orifice is 0.53 square feet.

**Causes** Tampering and stone accumulation is done to get more water. Silt deposition is due to the lack of excavation of the distributary.

**Remedy** Excavation of the distributary must be done according to schedule.

Tampering may be repaired by ordinary masonry work.  
Stone accumulation may be removed by the cooperation of the concerned WUA.

#### RD 14 OUTLET 226/1L (7L)

- Situation** The module is an old single orifice structure with a graduated cast iron frame.<sup>43</sup> The orifice has been tampered from the side walls. There are two orifices instead of one supplying the water. There is heavy silt deposition and rock accumulation upstream of the outlet (see Figure A8). The orifice has an area of 0.249 square feet.
- Causes** Tampering and the accumulation of rocks are done to create more head for obtaining additional water.
- Remedy** Excavation may be done according to schedule.  
Tampering of outlet may be repaired.  
Rocks should be removed.

#### RD 17.3 OUTLET 226/2L (8L)

- Situation** The module is an old single orifice structure made of a cast iron frame which is graduated on both sides. The outlet is tampered in the bottom. There is heavy silt deposition and rock accumulation in front of the outlet (see Figure A6). The area of orifice is 0.31 square feet.
- Causes** Tampering and the accumulation of rocks are done in order to get more water during the periods of water shortage. The silt deposition is mainly due to the accumulation of rocks in front of the outlet.
- Remedy** Tampering may be repaired by normal masonry work.  
Rocks may be removed and stopped in the future through the cooperation of the WUA.

#### RD 20 OUTLET 225/1L (9L)

- Condition** The module is a double inlet open flume constructed recently. A great amount of silt is deposited in front of the outlet, which affects the flow of water. Stones are also placed in front of the outlet (see Figure A9). The measured throat width of each outlet is 0.307 feet.

<b>Causes</b>	Silt deposition takes place due to the low velocity of water at this section of the distributary. Stones are placed to divert more water into the outlet.
<b>Remedy</b>	Silt may be removed. Stones may be removed through the cooperation of the WUA.

#### RD 22.9 OUTLET 239/3R (7R)

<b>Condition</b>	The module is a single orifice constructed recently. The outlet is tampered. Heavy silt deposition at the outlet face affects the flow of water into the outlet (see Figure A10).
<b>Causes</b>	Tampering is done in order to get more water for cultivation. Heavy silt deposition at the face of the outlet is due to the lack of excavation and also because of the low water velocity.
<b>Remedy</b>	Desilt the outlet in a proper manner. Tampering may be repaired by masonry work.

#### RD 25.1 OUTLET 238/1R AND 238/2R (8R & 9R) AT RD 25.1

<b>Condition</b>	Both modules are single inlet open flumes constructed recently. There are heavy silt deposits in front of both outlets. Stones are also placed in front of the outlets to divert more water into them (see Figure A11). The throat widths are 0.936 and 0.502 square feet, respectively.
<b>Causes</b>	Silt deposition is due to improper maintenance of the watercourse. Stones are placed in order to divert more water for cultivation.
<b>Remedy</b>	Desilt the watercourse in a proper way. Remove the stones by the cooperation of the WUA.

#### RD 25.4 OUTLET 225/1L (1AL)

<b>Condition</b>	The module is an old single orifice structure with a cast iron frame without graduations on any side. The outlet is tampered (see Figure A12). The area of the orifice is 2.364 square feet. With full supply in the distributary, the structure becomes submerged in the water.
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Causes	The water overtops due to the physical situation of the outlet. The top edge of the structure is below the full supply level in the distributary. Tampering is done in order to get more water, especially during the periods of water shortage.
Remedy	The outlet may be reconstructed. Tampering may be corrected by masonry work.

#### RD 29.2 OUTLET 237/1R (10R)

Condition	The module is a single open flume outlet constructed recently. There is heavy silt and bushes in front of the outlet (see Figure A11). The throat width is 1.074 feet.
Causes	Heavy silt and bushes due to a lack of maintenance.
Remedy	Proper maintenance is required.

#### RD 30.3 OUTLET 225/2L (11L)

Condition	The module is a single inlet open flume newly constructed. There is little silt in the front of the outlet (see Figure A11). There is not any significant problem and the outlet is functioning properly. The throat width is 0.47 foot.
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#### RD 33.5 OUTLET 224/1L (12L)

Condition	The module is a single inlet open flume newly constructed. There is heavy silt deposition at the entrance. Bulky stones have been placed in front of the outlet to divert more water into the outlet. The throat width is 0.508 foot (see Figure A11).
Causes	Heavy silt and bushes are due to occasional maintenance. Proper attention to the watercourse must be given.
Remedy	There should be proper excavation of the watercourse channel.

#### RD 36 OUTLET 236/1AR (11R)

Condition	The module is a single inlet open flume newly constructed. Heavy silt is deposited at the face. Bulky stones have been
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placed in front of the outlet to divert more water (see Figure A11). The throat width is 0.675 foot.

**Causes** Heavy silt deposition is due to improper maintenance of the watercourse, the lands with higher elevation, and fewer excavation activities. Stones are accumulated in order to get more water, especially during the times of water shortage.

**Remedy** Proper maintenance and desiltation of the watercourse may be done. Bulky stones may be removed by the cooperation of local people.

#### RD 39.31 OUTLET 224/2L (13L)

**Condition** There is no module. A newly constructed open flume structure is located adjacent to this location, but that is not functioning yet.

### 2.3. CULVERTS

There are seven culverts located at various places along the distributary. Figure A13 presents a typical diagram of these culverts. Their details are provided below.

S.No.	RD	Width (Feet)	Remarks
1.	4.85	14.00	Good condition. No maintenance required.
2.	9.77	9.83	Good condition. No maintenance required.
3.	16.65		Good condition. No maintenance required.
4.	19.61		Good condition. No maintenance required.
5.	25.40	8.00	The bed of the culvert must be cleaned. The side walls of the culvert may be re-constructed.
6.	29.82	9.20	The side walls may be re-constructed
7.	34.90	4.87	There are two sections of this culvert. One is choked by heavy silt deposition. However, there is no need for cleaning because it is being designed for a wider section to be done under remodeling in the near future. The side walls may be re-constructed.

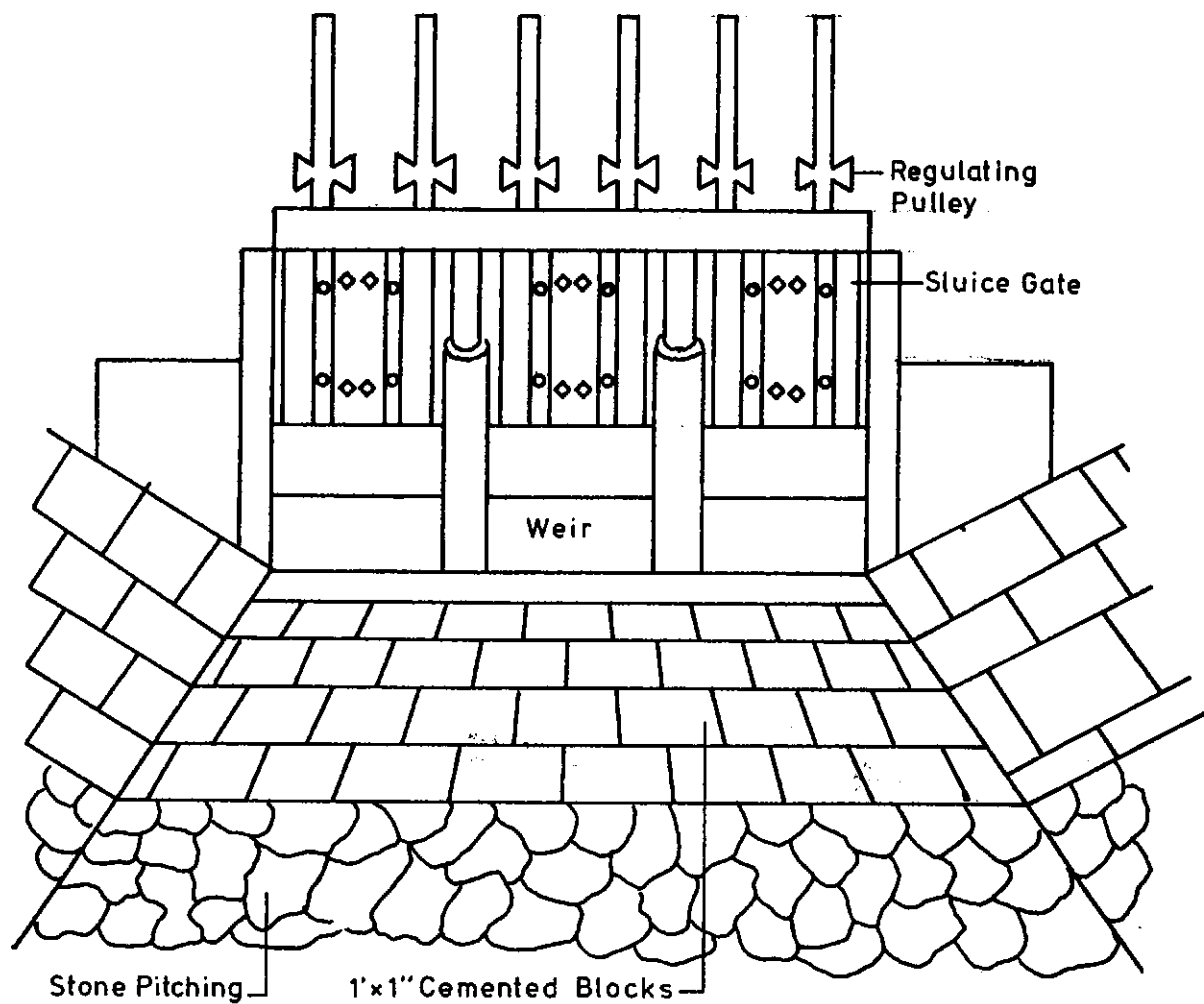


Figure A1. Head Regulator of Bareji Distributary.

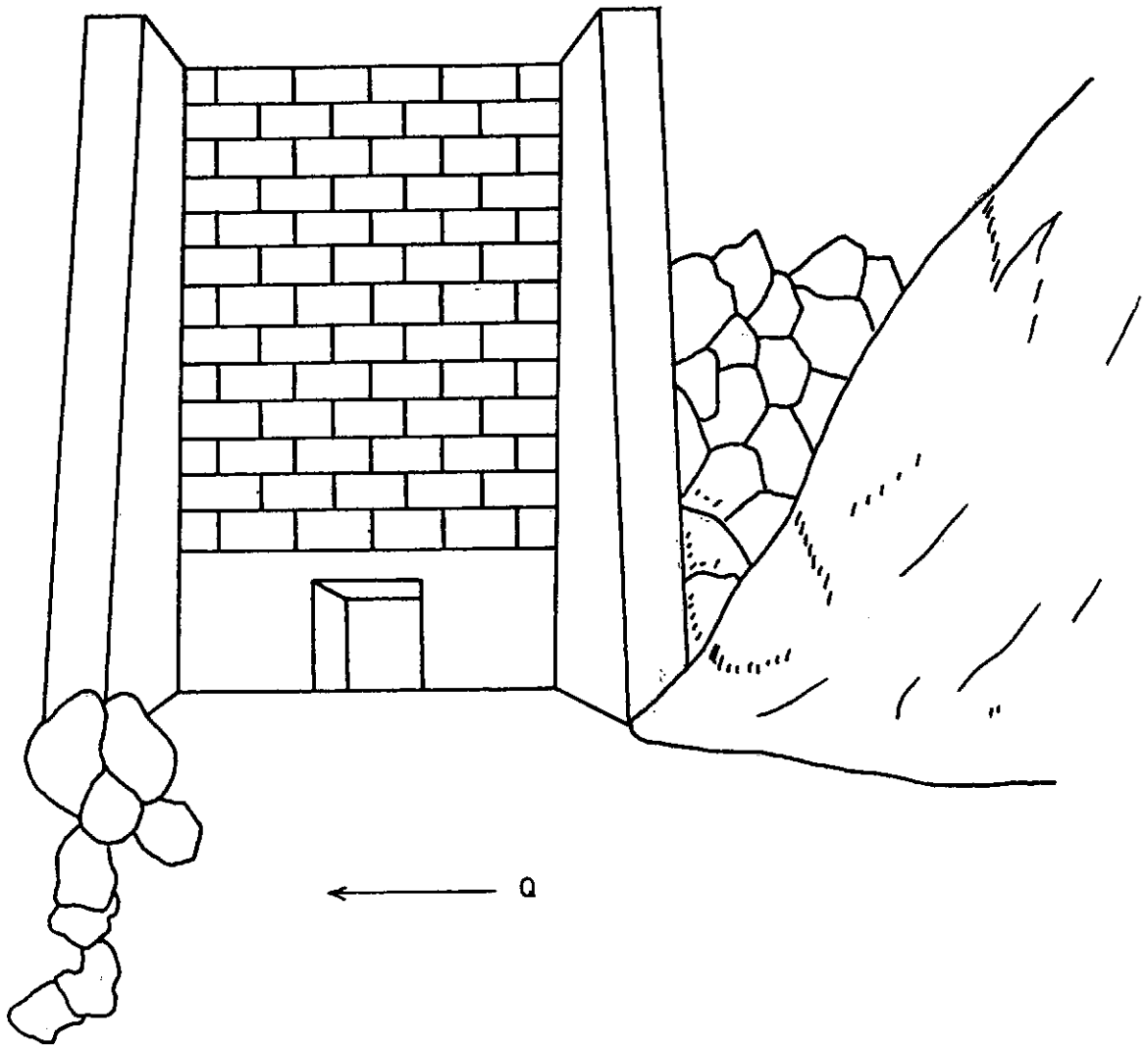


Figure A2. Single orifice structure Outlet No. 240/1R (1R).

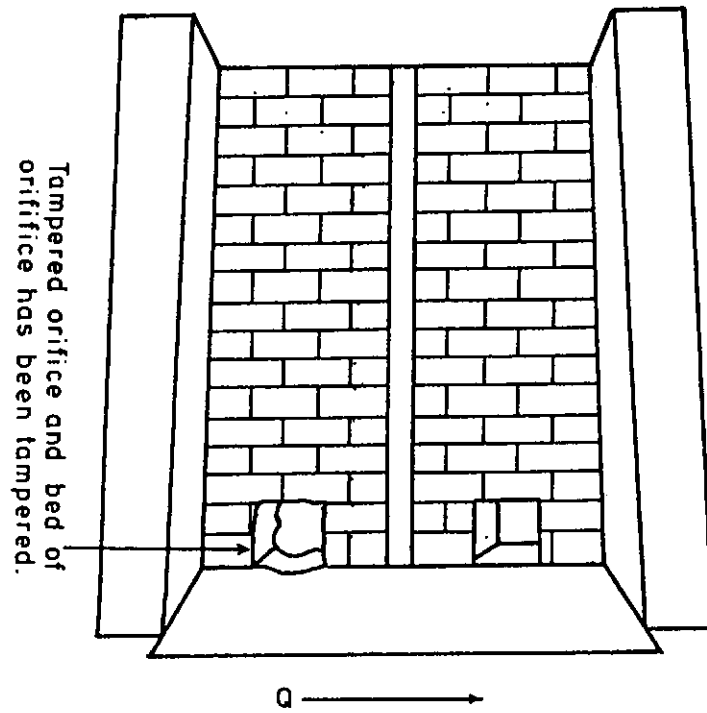


Figure A3. Double orifice newly constructed Module 239/1L (1L).

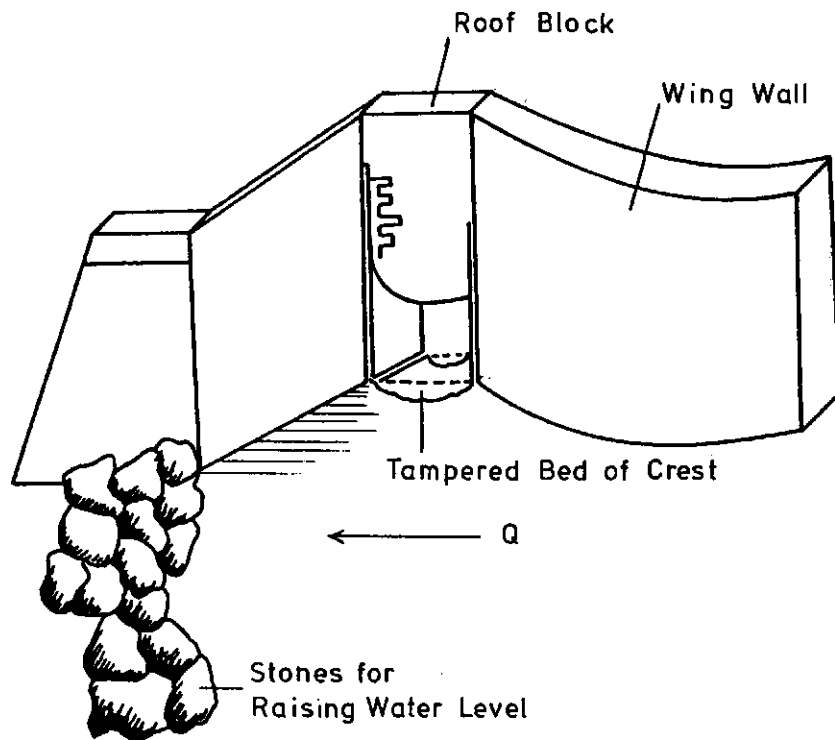


Figure A4. Outlet 240/1AR.

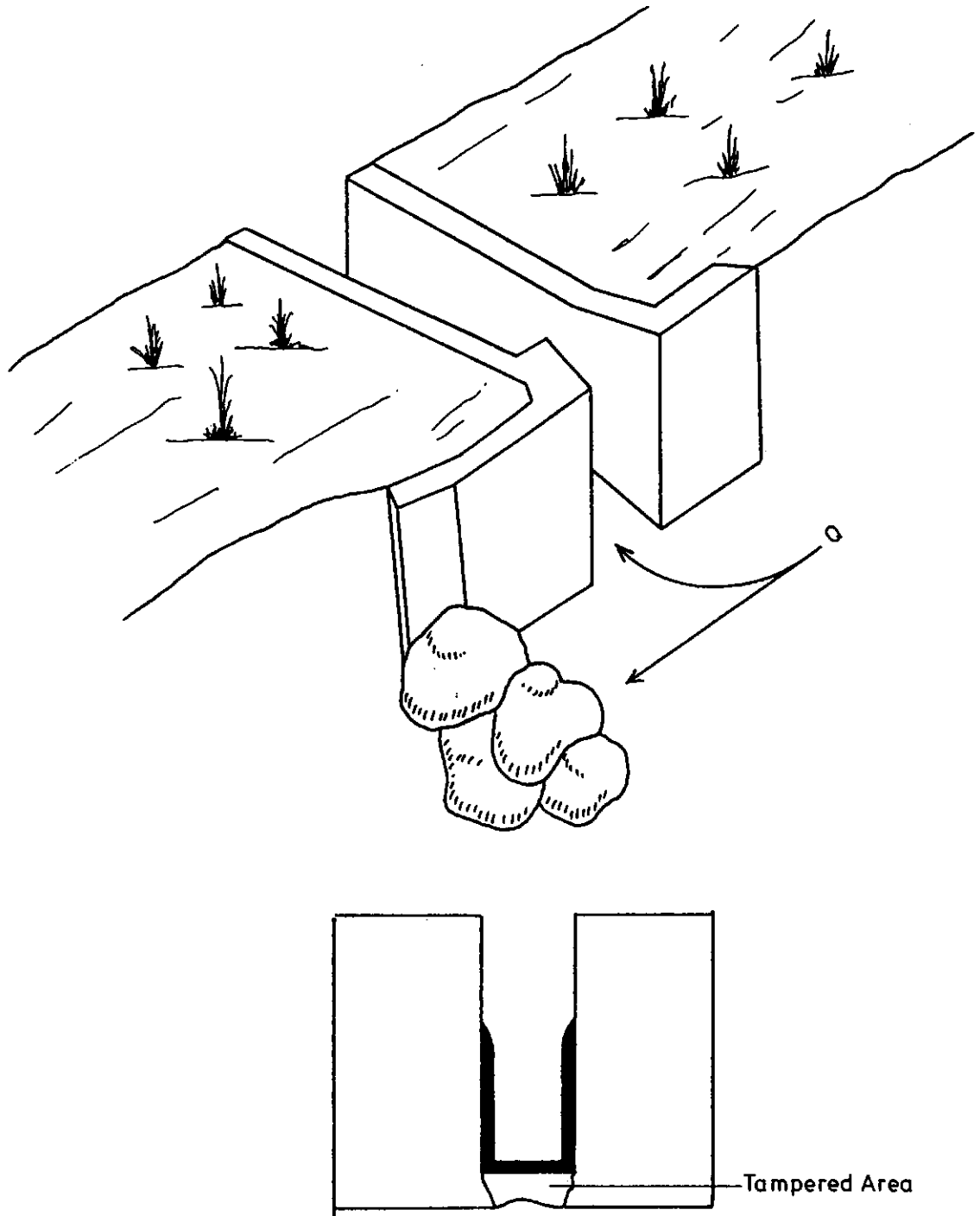


Figure A 5. Plan and elevation of Outlet 239/2R (3R).

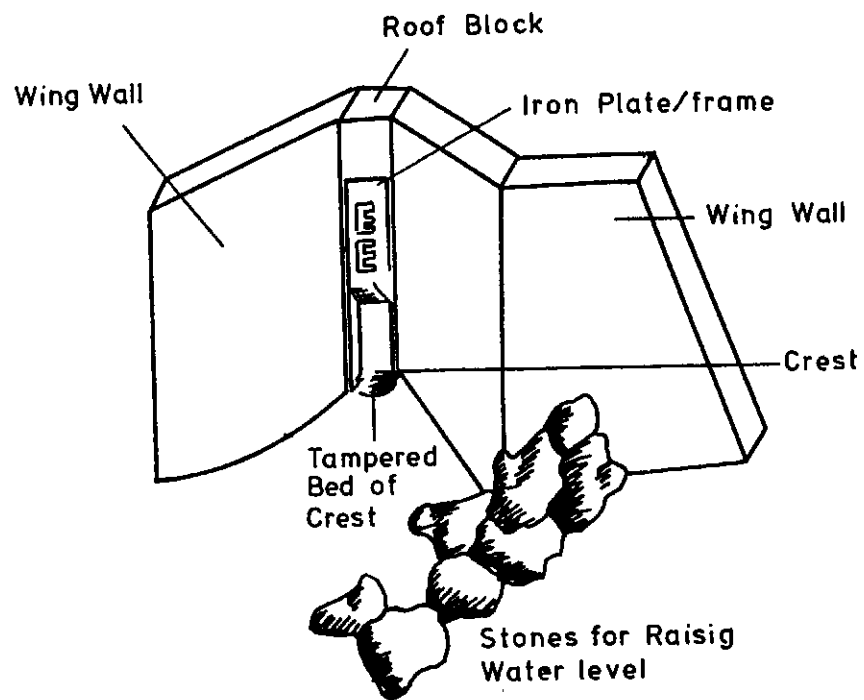


Figure: A6. Typical view of tampered crest of the outlet numbers 3L, 4L, 5L, 6L and 8L.

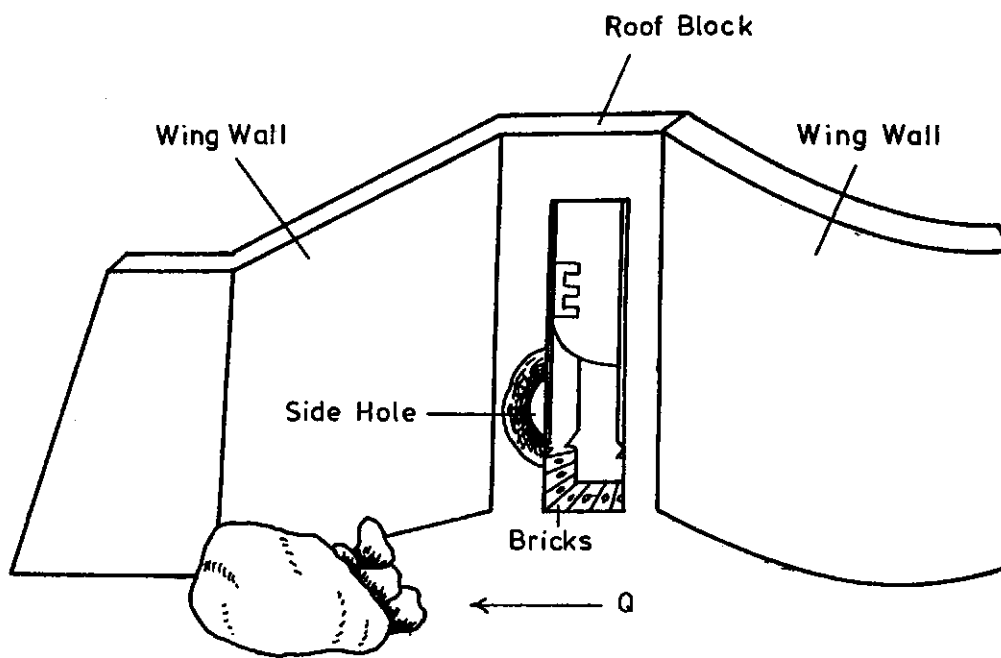


Figure A7. Elevation of Outlet 6R.

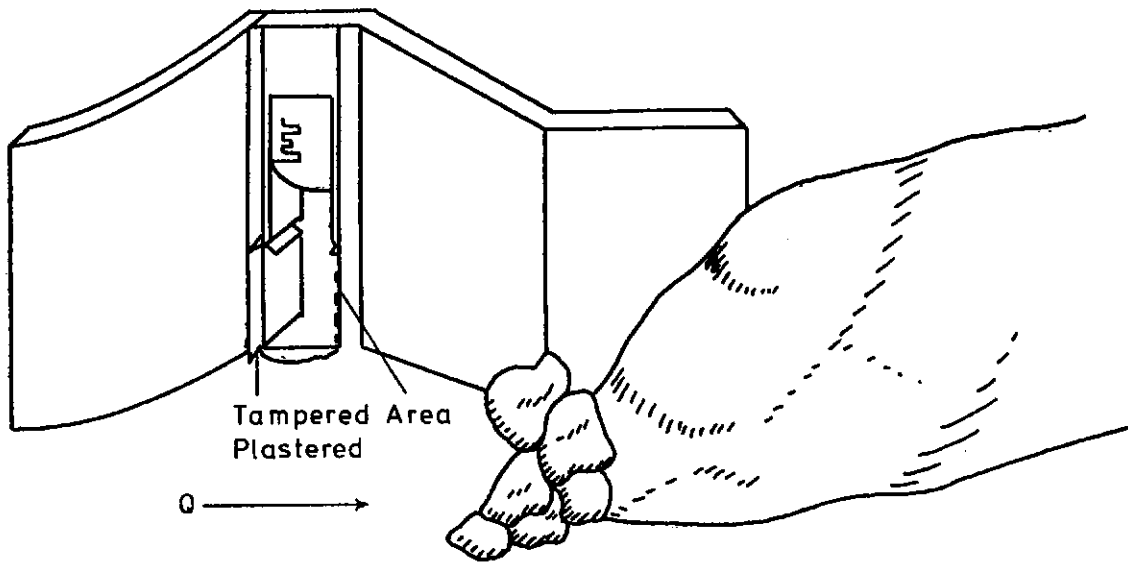


Figure A8. Outlet 7L tampered deeply and from sides.

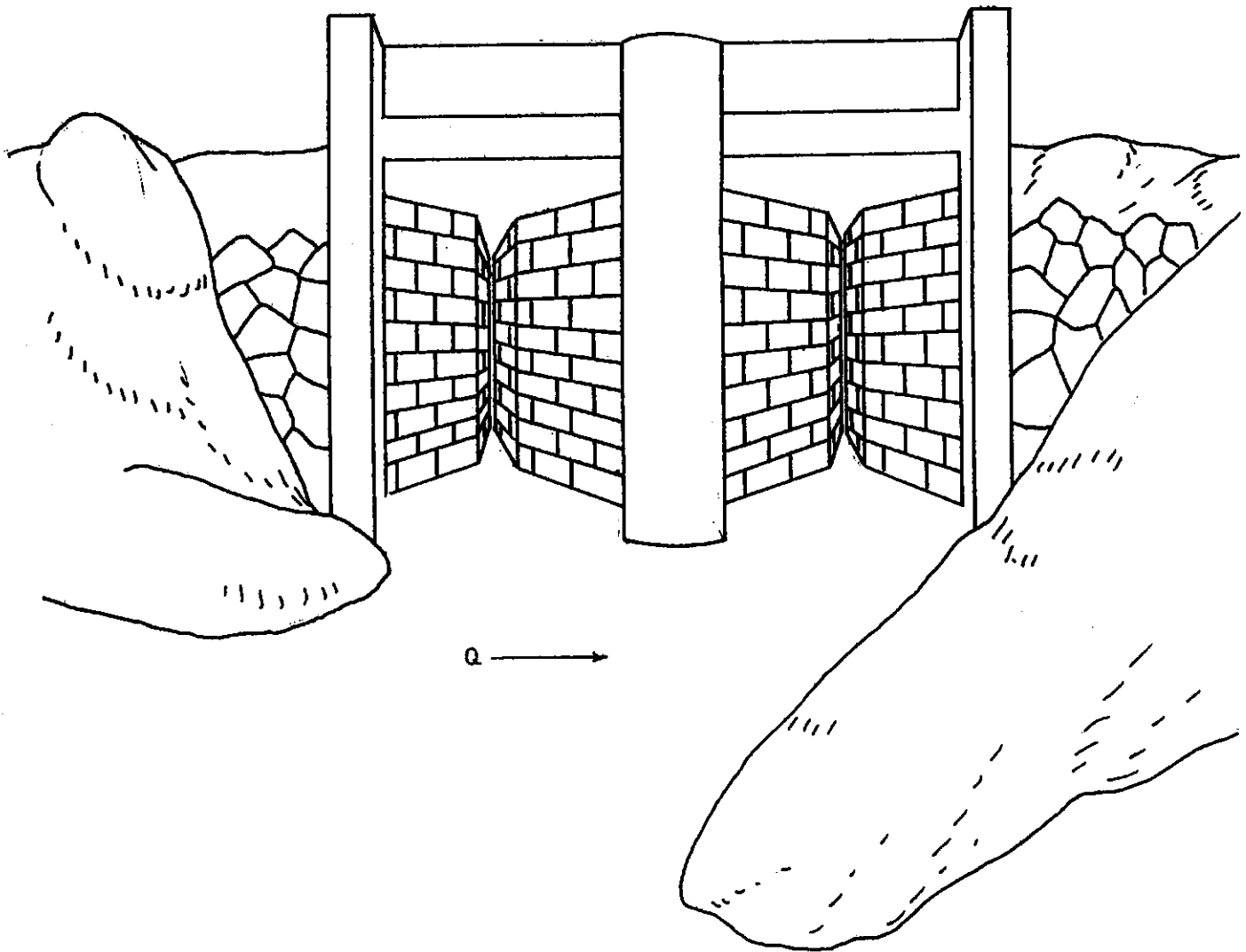


Figure A9. Two venturi flume china-made structures as  
Outlet numbers 9L.

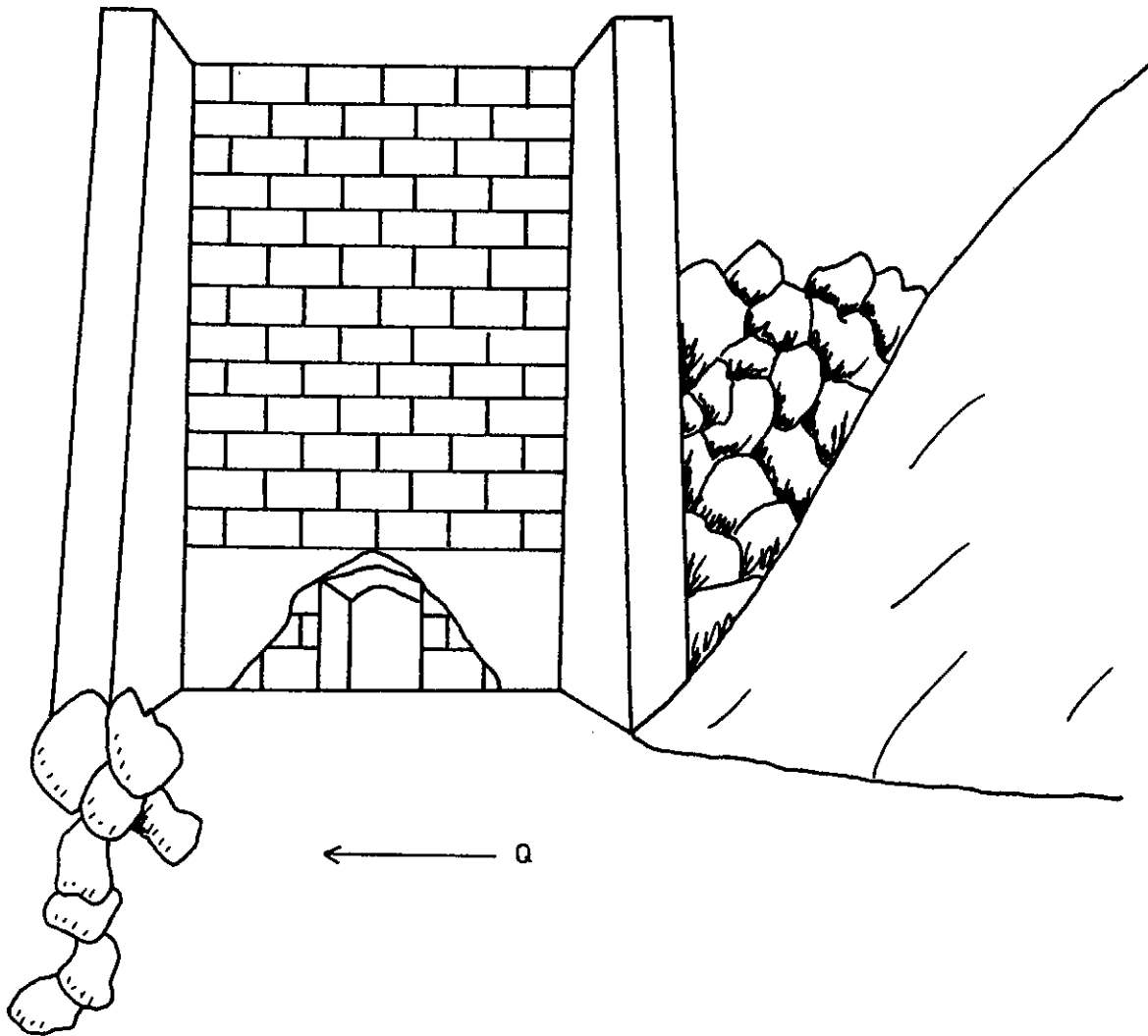


Figure A10. Single orifice structure Outlet 7R.

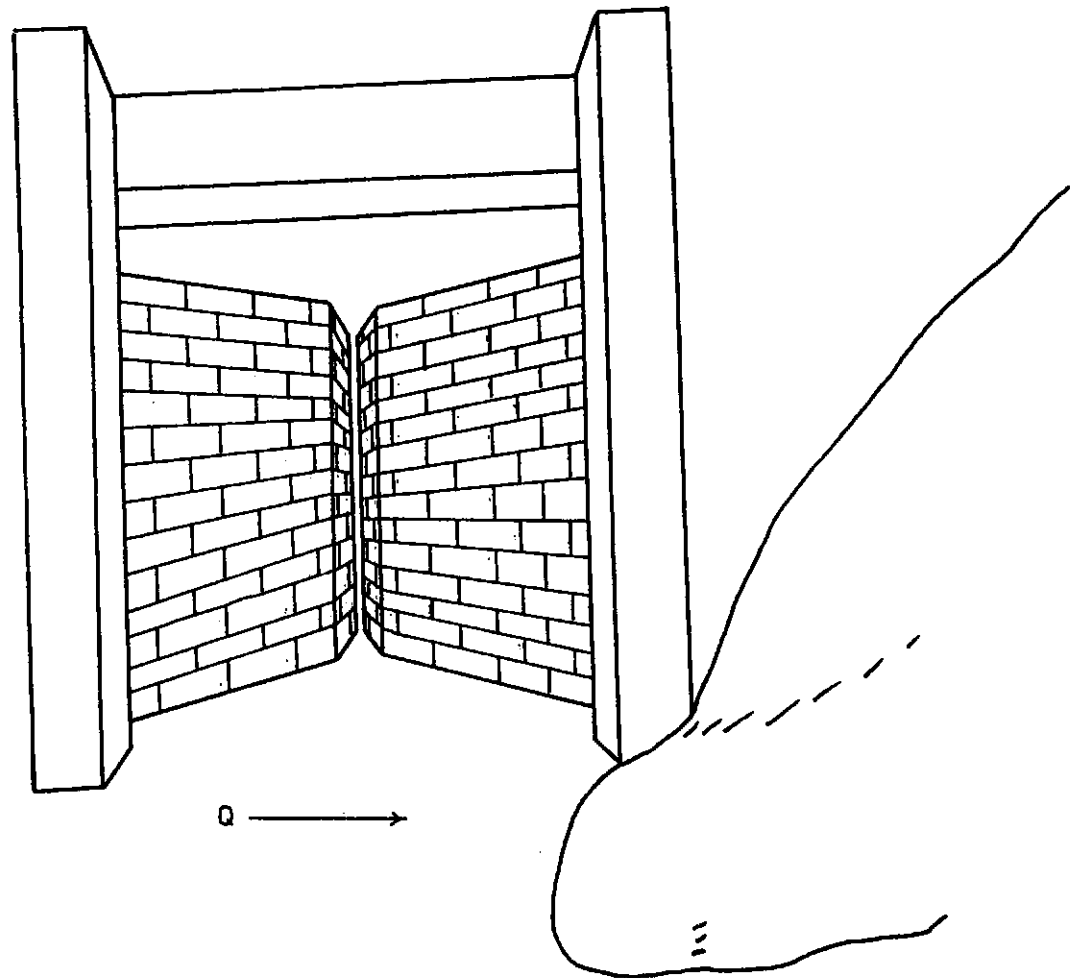


Figure A11. Single venturi flume structures as  
Outlet numbers 8R, 9R, 10R, 11L, 12L and 11 R.

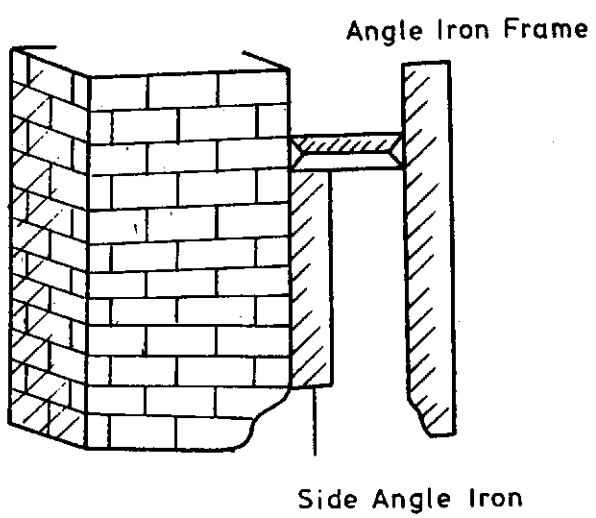
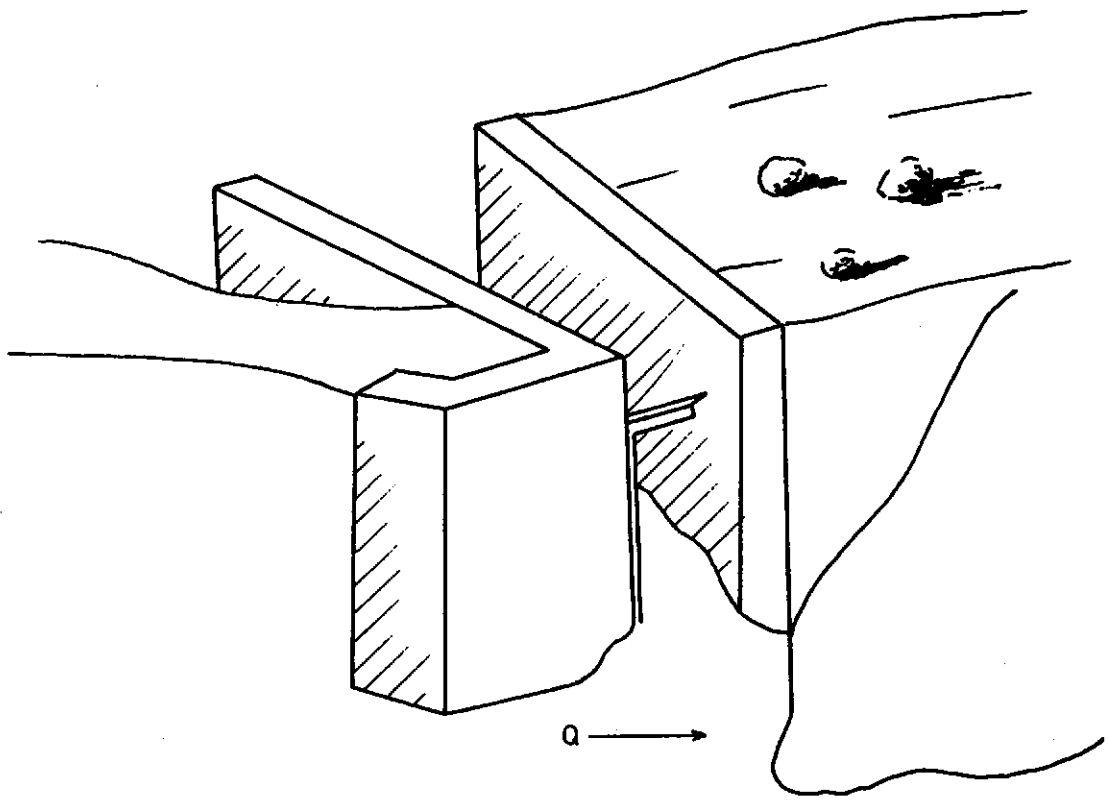


Figure A12. Outlet - 225/1AL.

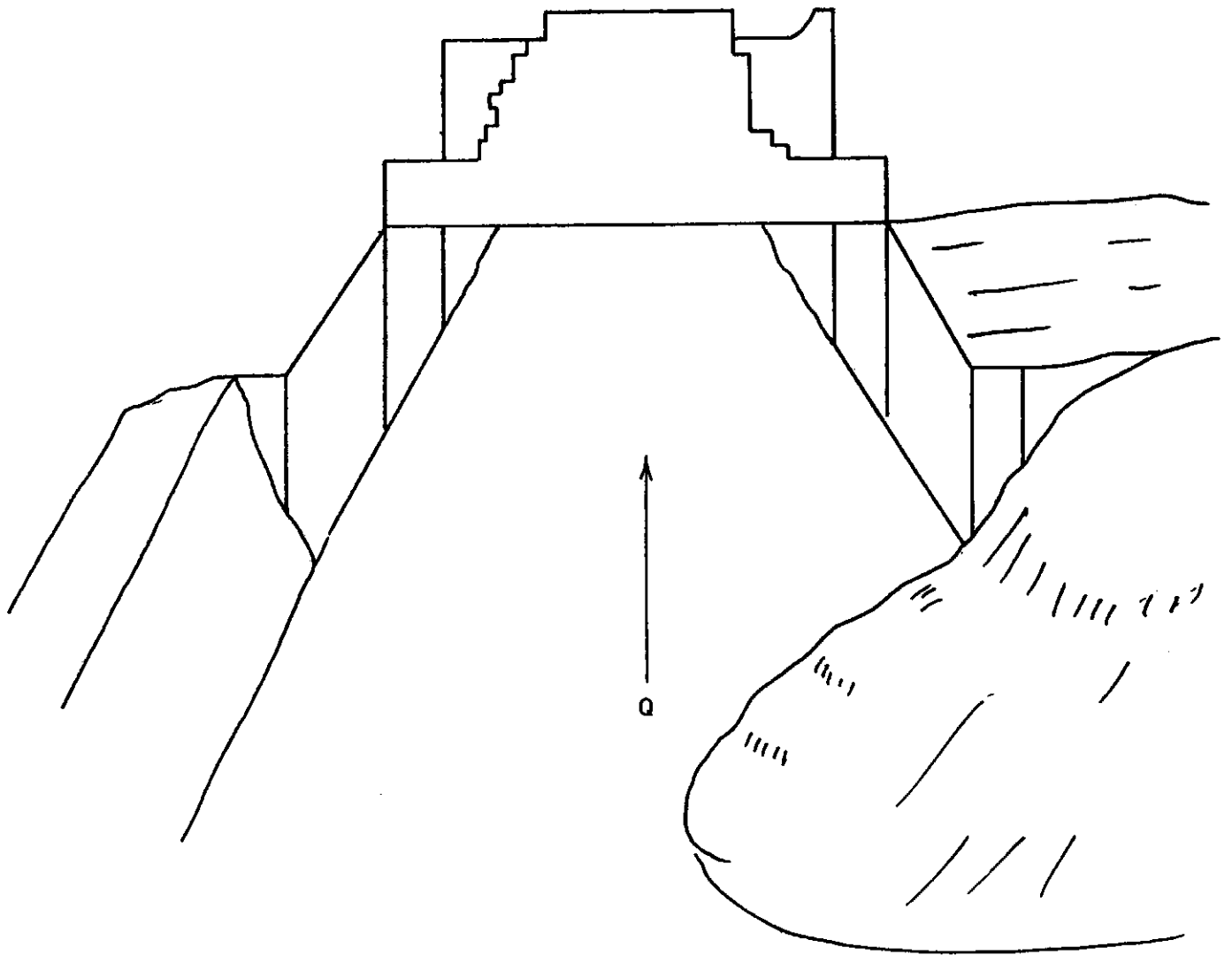


Figure A13. Typical structure of a culvert at Bareji Distributary, Mirpurkhas District.

**ANNEXURE B**

**FIELD NOTES AND SKETCHES**  
**ON**  
**DIAGNOSTIC "WALK-THRU" MAINTENANCE SURVEY**  
**OF**  
**BAREJI DISTRIBUTARY**

Field notes and sketches resulting from the Diagnostic Walk-thru Maintenance survey are presented below. All the distances are given in RD (multiples of 1000 feet beginning with zero at the distributary head regulator).

0 to 0.5	Condition	Considerable amount of silt deposition is observed in this section. The berms and banks are in good condition. The small vegetative growth is also seen on both of the berms. Even the inspection path is in good condition.
	Causes	The silt deposition in this section is mainly due to the cross-section of the distributary, which is much wider than its original design width. Due to this undesired section width, the flow velocity decreases and silt deposition increases. The width of the cross-section of the distributary is measured to be from 25 to 30 feet.
	Solution	Desilting may be done either mechanically or manually to: <ul style="list-style-type: none"> <li>- reduce the cross-section of the distributary; and</li> <li>- to align the channel sides properly so that they follow the line of the flank walls of the Head Regulator.</li> </ul> This may be done through putting the wooden logs along the banks and allowing the silt to be deposited over time.
0.5 to 1.75	Condition	This section is found to be free of silt deposition. There is some silt accumulated at places but it is not creating any problem for the flow of water. The width of the cross-section of the distributary varies slightly due to the irregular shape of the banks and berms. The inspection paths are not in good condition. There are two outlet structures in this section offtaking at RD 0.5 (Outlet 1-R on the right side and outlet 1-L on the left side of the distributary). The width of the cross-section of the distributary at this section is 20 feet approximately (see Figure B1).

	<b>Causes</b>	The small quantity of silt deposited at various places in this section is found to be eroded from the inspection path, berms and banks of the distributary. This can happen especially during the monsoon period. Also, the banks are destroyed due to frequent bathing of animals and local people.
	<b>Remedy</b>	The banks, berms and inspection path need to be maintained / rehabilitated either mechanically or manually. Bathing of local people and especially animals needs to be controlled to preserve the banks of the distributary. This can be achieved through obtaining the cooperation of the local people in the vicinity.
1.75 to 4.9	<b>Condition</b>	This portion of the distributary is relatively in good condition except for about 200 feet on the right bank which is observed to be too weak. There are two culverts for crossing the distributary in this section. One is for the aqueduct of a surface drain, whereas the other is for transportation and the crossing of the animals from one side to the other side of the distributary. The banks and berms are slightly disturbed. The width of the distributary varies slightly from one point to the other. The average cross-section width observed was 17 feet in this section (see Figure B2).
	<b>Causes</b>	The banks and the berms are found disturbed in this section of the distributary. This was mainly due to the crossing of animals and their bathing, as well as washing of clothes by the local people living in the vicinity. Due to irregular banks, the width of the distributary varies from point to point. The wider cross-section of the distributary causes silt deposition in the bed of the distributary and ultimately creates problems in the smooth flow of water.
	<b>Remedy</b>	The banks and the berms may be properly leveled. Movement of the animals across the distributary can be restricted through continuous dialogue with water users and the neighbouring population. The silt deposited in the bed of the distributary may be removed. However, most viable approach would be to have the cattle owners and the local people to maintain those distributary reaches affected by their activities.
4.9 to 6.7	<b>Condition</b>	This portion of the distributary is in good condition. There is very little silt deposition in the bed of the distributary.

There is no vegetation observed on either side of the channel. Two outlets (2L and 5R) take-off from this portion. The berms, the banks and the inspection path are in good condition. The average width is found to be 16.8 feet in this section.

	Remedy	Routine maintenance is required.
6.7 to 11.5	Condition	This part of the distributary is found generally in good condition except for some silt deposited in the bed. The banks and the berms of the distributary are irregular in their alignment and are also found damaged at several places. Two watercourses (3L and 6R )off-take from this section. Average width of the channel in this section is 16 feet (see Figure B3).
	Causes	The major cause of silt deposition in the bed of the distributary is the crossing of animals and their bathing. Also, the alignment of the banks and berms is destroyed due to the crossing and bathing of animals.
	Remedy	Efforts may be made through the WUAs and WUF of the Bareji Distributary to restrict the movement of the animals across the distributary, or to have the cattle owners to maintain those sections of the distributary damaged by their cattle.
11.5 to 12.1	Condition	This section of the distributary is in good condition. However, the banks and the berms are destroyed at some places in this section. A culvert has been constructed for crossing the distributary. There is thin vegetation on the berms. The average width of the channel is 14 feet (see Figure B4).
	Causes	The berms and the banks are disturbed mainly due to the crossing of animals and the washing of clothes by the local people living in the vicinity. Siltation is due to low water velocity. The banks and berms are damaged due to the crossing and bathing of animals and also local people washing clothes.
	Remedy	Desilt this section of the distributary. Stop animal bathing, cloth washing and other similar practices which disturb the banks and berms of the distributary would be a direct solution, but not very satisfactory. A better remedy would be to work with cattle

owners and local people and encourage them to periodically repair those sections of the distributary damaged by their activities.  
Remove vegetation.

12.10 to 17.3	Condition	This portion of the distributary is in good condition. However, at some places, the banks as well as the berms are irregular and due to this the width of the channel varies from one point to the other. Average width is 10 ft. The distributary turns to the right at this section after Watercourse 5L. A heavy log has been placed over the distributary for people to cross. An overhead bridge is situated after Watercourse 7L. Three watercourses are located in this reach, which are 6L, 7L and 8L (see Figure B5).
	Causes	Irregular alignment of the channel is mainly due to the washing of clothes and the bathing of animals.
	Remedy	Avoid animal bathing, while clothes washing on the banks and the berms may be avoided.
17.3 to 25.1	Condition	This portion of the distributary is in good condition but some amount of silt is deposited in the bed of the distributary. The banks and the berms are not in good condition. There is some vegetation on the banks and the berms, which does not create any problem for the flow of water. The main bridge has been constructed by the Highway Department for the Mirpurkhas-Umerkot Road. The bridge is in good condition. The width of the bridge is 40 ft. Average width of the distributary channel varies from 9 to 10 ft. There are four watercourses (9L, 7R, 8R and 9R) which offtake in this section (see Figure B5).
	Causes	Siltation in the bed of the distributary is due to the low velocity of water. The banks and the berms are disturbed due to the crossing and bathing of animals in the distributary and the washing of clothes by local people.
	Remedy	Desilt the distributary regularly in this section. Arrange with cattle owners and local people for periodic maintenance of those sections of the distributary affected by their activities.
25.1 to	Condition	This portion of the distributary is in good condition. But, in fact, the bed of the channel has been excavated too deep.

The width has decreased while the depth has increased. This has resulted in increased flow depth. The banks are stable. The berms are not well maintained. Six watercourses offtake from this reach of the distributary. Besides these six legal outlets, one illegal watercourse is being fed from the distributary without an outlet structure. There are two overhead bridges for crossing the channel in this section (see Figure B5).

- Causes** The main reason for deep desilting of the distributary was to get more water at the tail portion because they use lift machines at some watercourses. The tail of the distributary has no outlet structure. The lack of the berm width and adequate freeboard is due to improper maintenance. The banks and the berms are disturbed due to the crossing of animals and the washing of clothes.
- Remedy** Appropriate maintenance practices may be followed in the future to overcome many of the problems being faced presently.

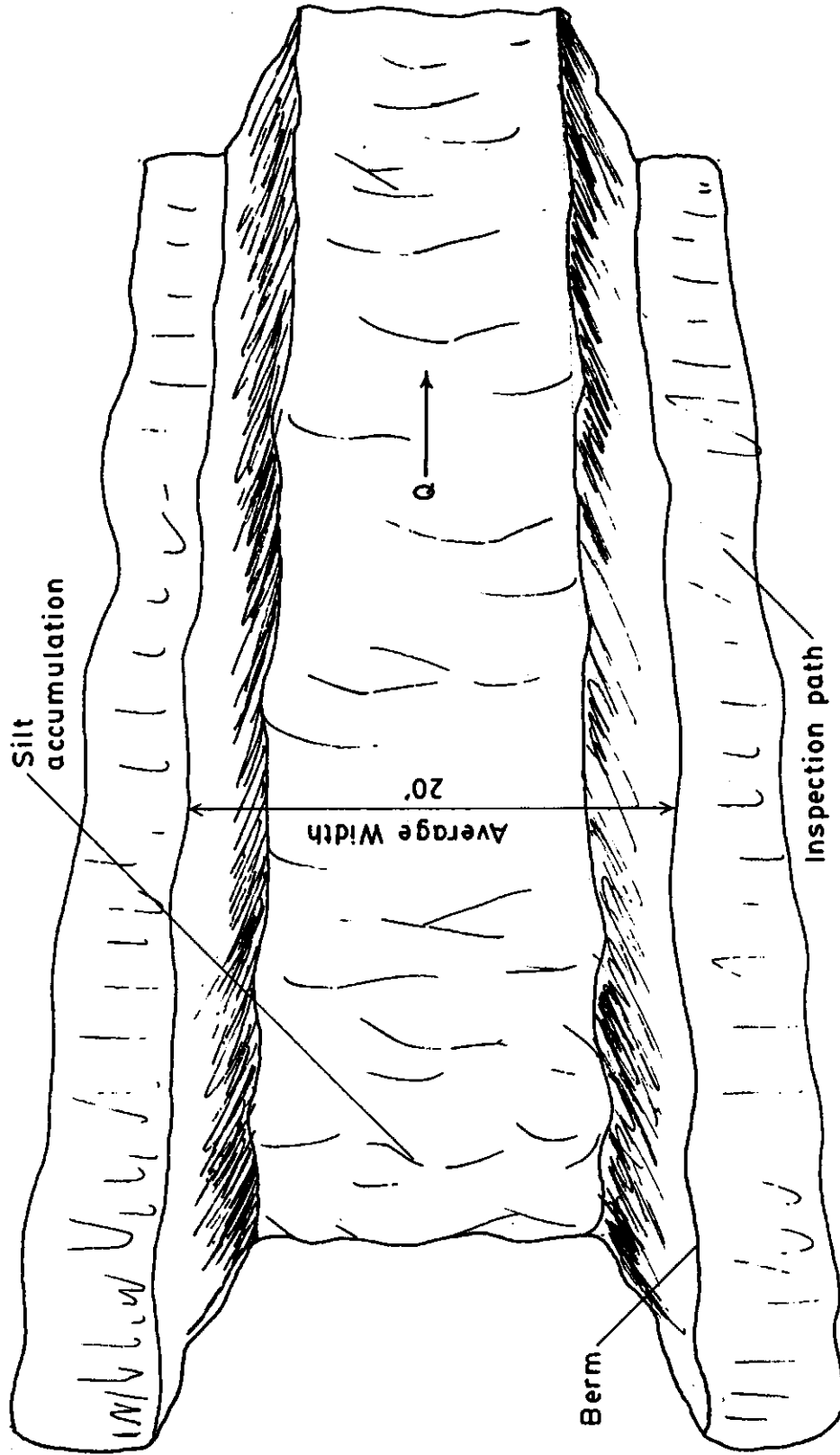


Figure B1. Sketch of Bareji Distributary from RDs 0.5 to 1.75.

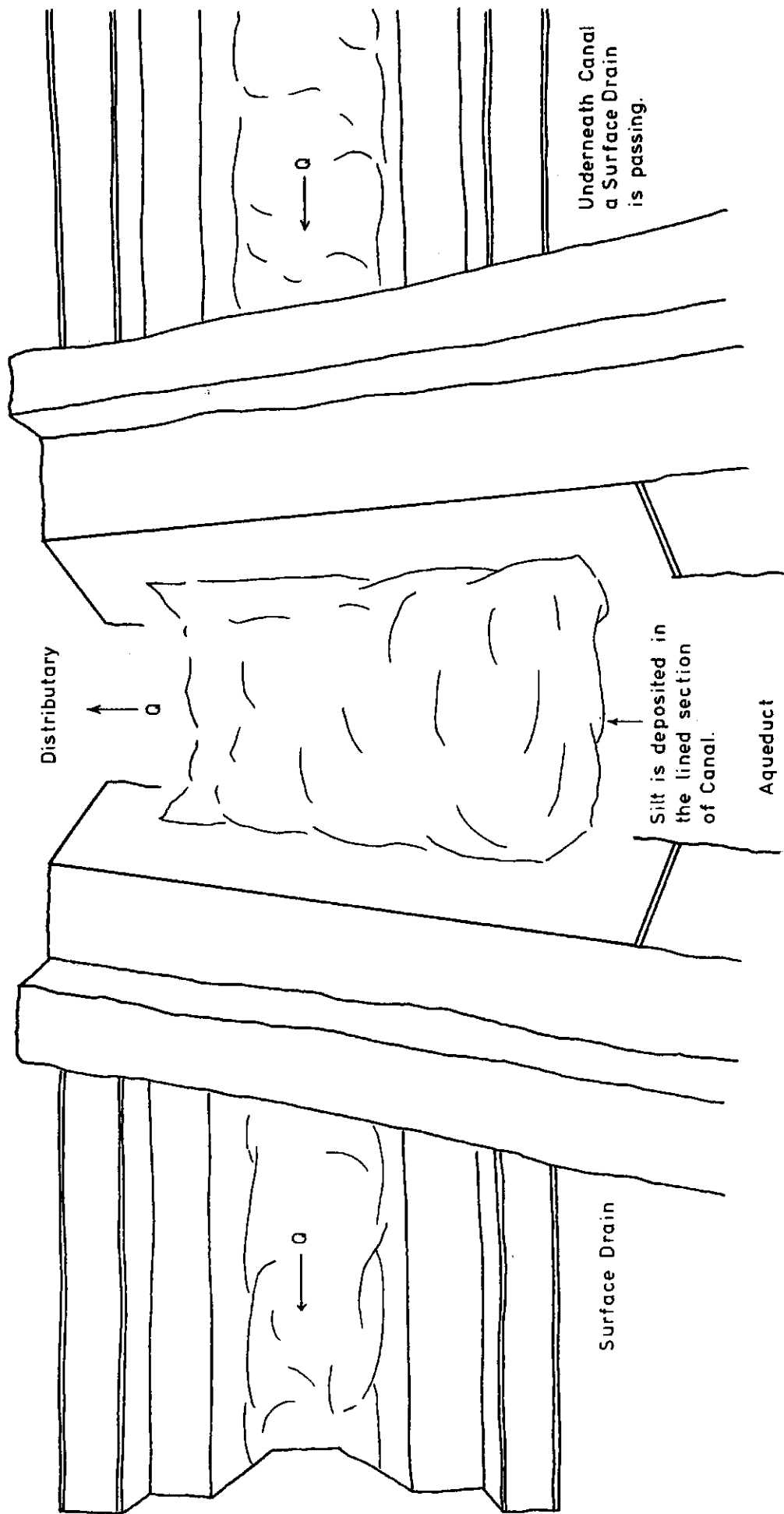


Figure B2. Sketch of Bareji Distributary from RDs 1.75 to 6.7.

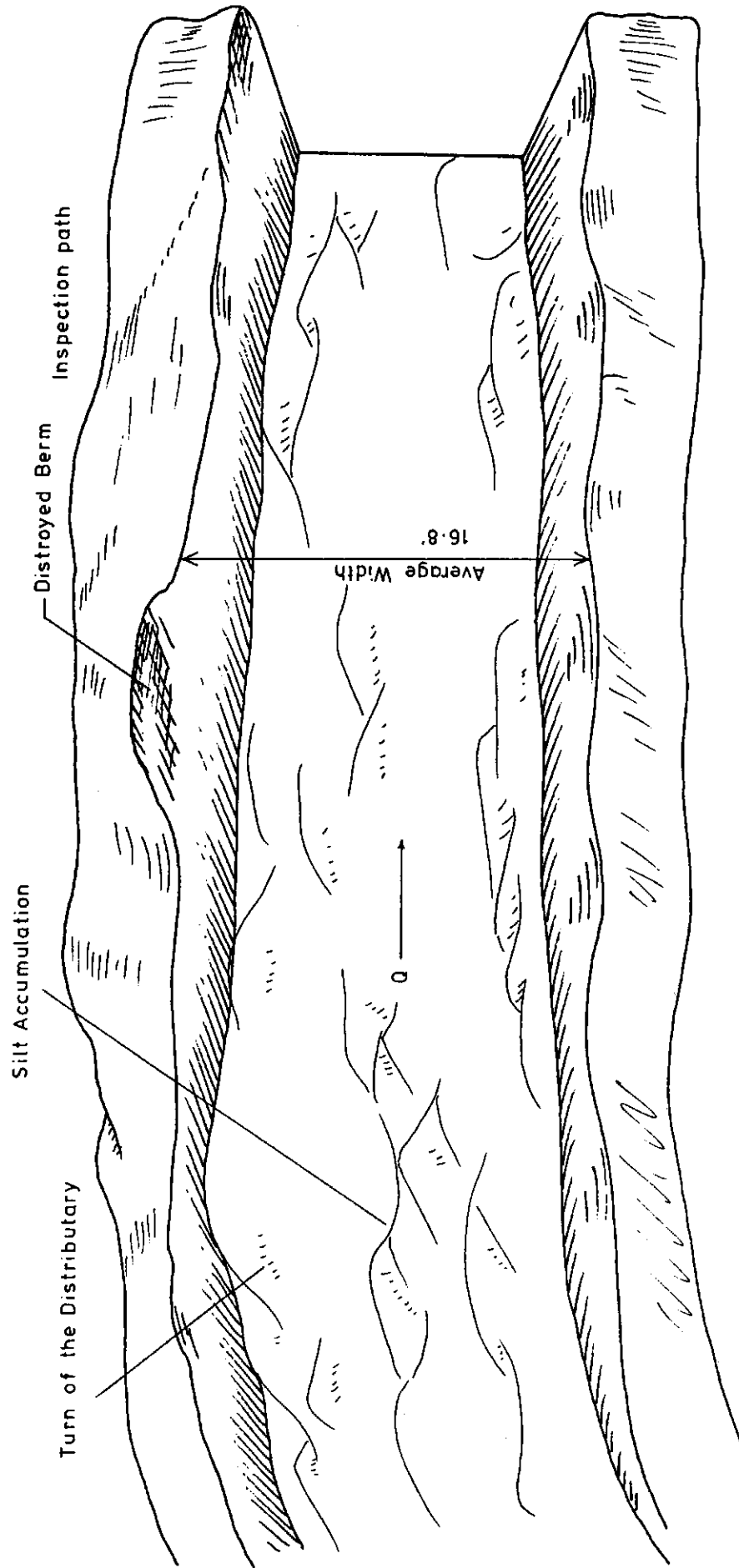


Figure B3. Sketch of Bareji Distributary from RDs 6.7 to 11.5.

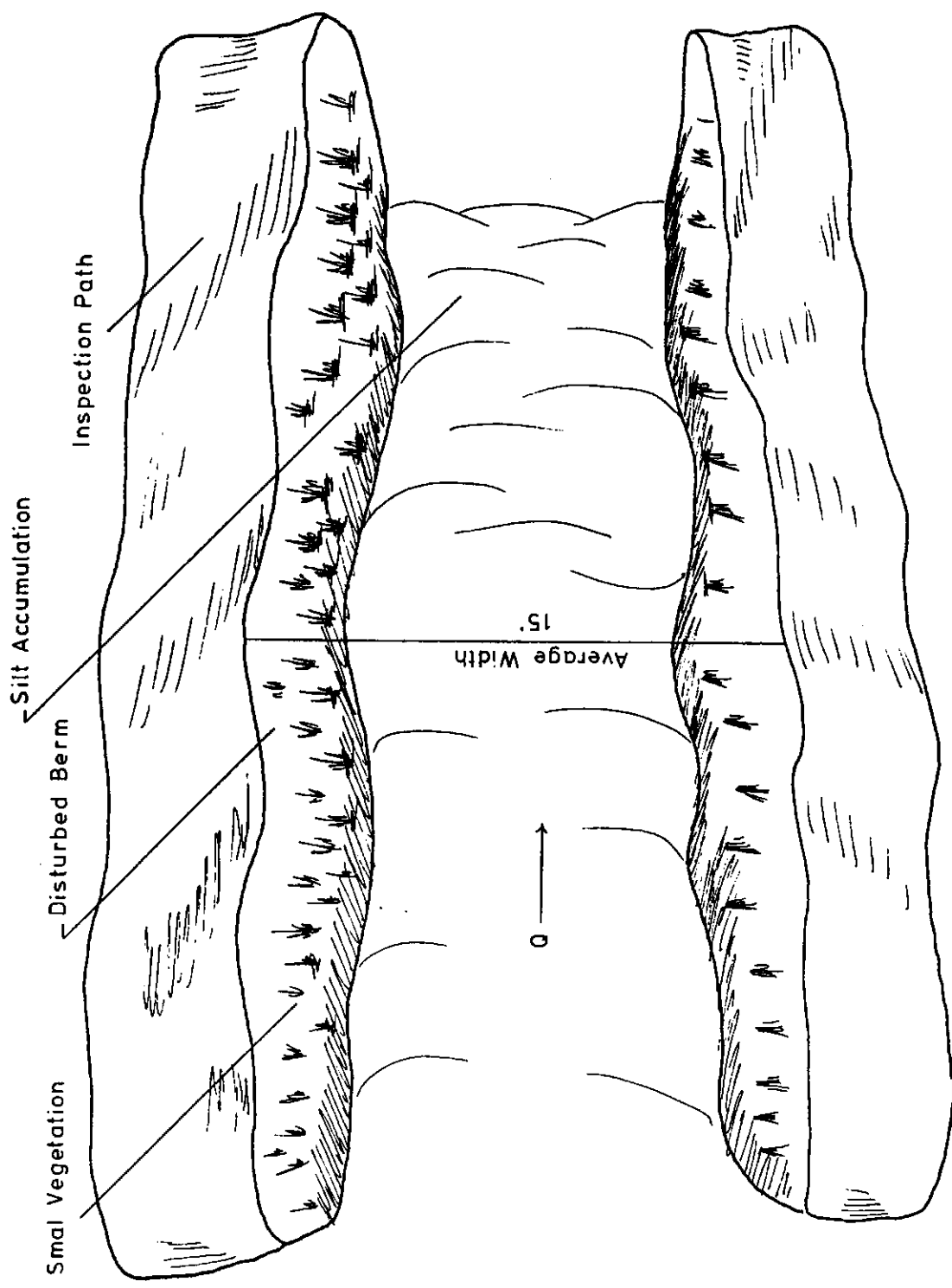


Figure B 4. Sketch of Bareji Distributary from RDs 11.5 to 12.1.

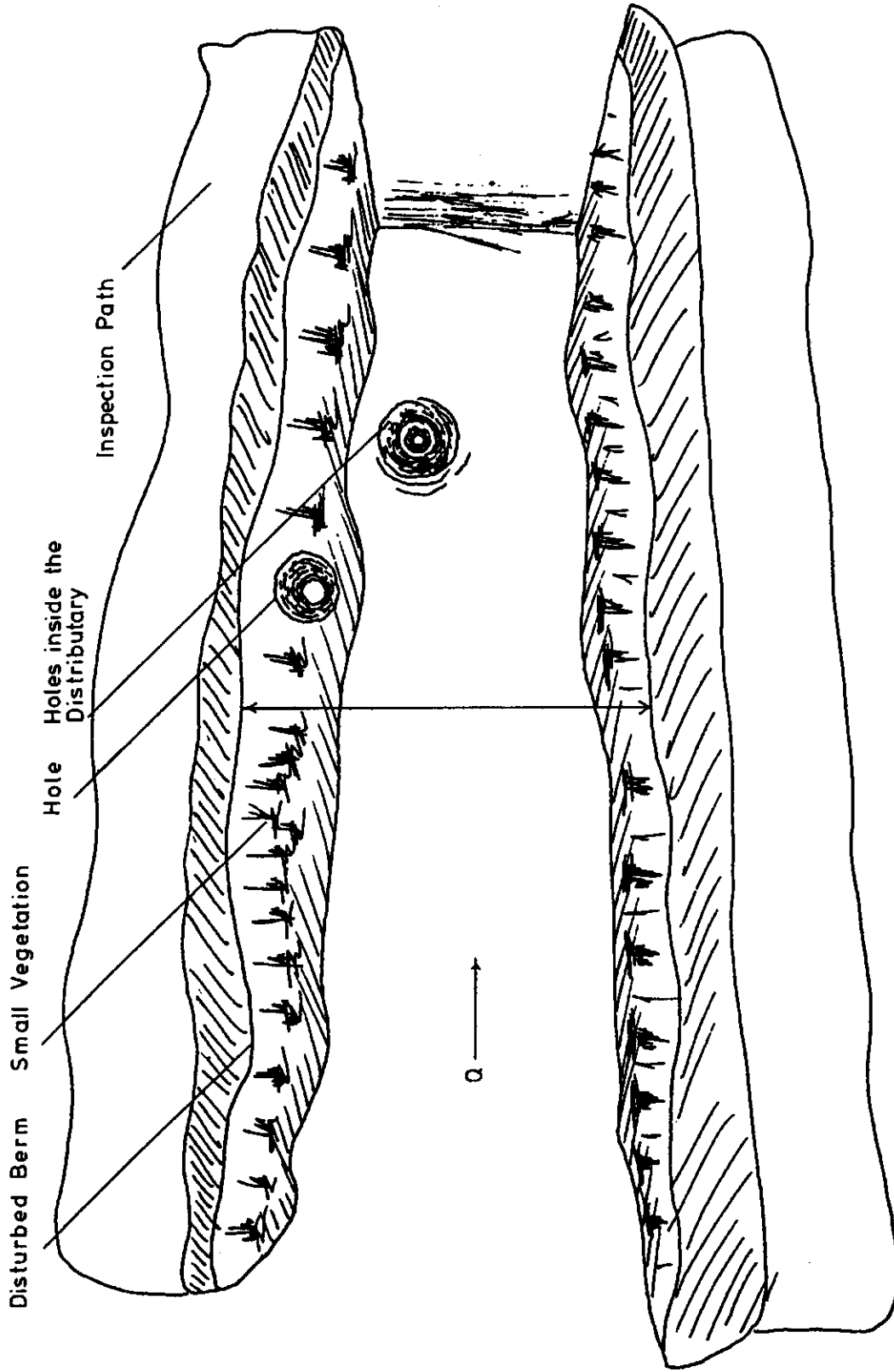


Figure B 5. Sketch of Bareji Distributary from RDs 12.1 to 39.31.

# IIMI-PAKISTAN PUBLICATIONS

## RESEARCH REPORTS

Report No.	Title	Author	Year
R-1	<b>Crop-Based Irrigation Operations Study in the North West Frontier Province of Pakistan</b> 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
R-6	Farmers Ability to Cope with Salinity and Sodicity: Farmers' perceptions, strategies and practices for dealing with salinity and sodicity in their farming systems	Neeltje Kielen	Aug 1996
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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Report No.	Title	Author	Year
R-12	Modeling of Sediment Transport in Irrigation Canals of Pakistan: Examples of Application (M.Sc Thesis published as Research Report)	Gilles Belaud	Oct 1996
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