

WORKING PAPER 12

Pakistan Country Series No. 2

Achieving Stable Canal Conditions Following Remodeling

The Case Study of Bareji Distributary Mirpurkhas

Bakhsal Lashari,
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Working Paper 12

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The Case Study of Bareji Distributary, Mirpurkhas

Bakhshal Lashari
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and
Mashooq Talpur

International Water Management Institute

**Extended Project on Farmer Managed Irrigated Agriculture Under
The National Drainage Program (NDP)**

IWMI receives its principal funding from 58 governments, private foundations, and international and regional organizations known as the Consultative Group on International Agricultural Research (CGIAR). Support is also given by the Governments of Pakistan, South Africa, and Sri Lanka.

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Lashari, B. Murray-Rust, D. H., Memon, Y., and Talput, M. 2000. *Extended Project on Farmer Managed Irrigated Agriculture Under The National Drainage Program (NDP): Achieving Stable Canal Conditions Following Remodeling: The Case Study of Bareji Distributary, Mirpurkhas. Lahore, Pakistan: International Water Management Institute (IWMI) 19p. (IWMI working paper 12).*

farmer-managed irrigation systems / irrigation canals / distributary canals / watercourses / water distribution / design / drains / hydraulics / performance / case studies / Pakistan / Mirpurkhas / bareji

ISBN: 92-9090-203-5

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ACKNOWLEDGMENTS

The authors of this report express their profound thanks to the following members of the IWMI field team members Mr. Asghar A. Memon, Mr. Ghulam Mustafa Ujjan, Mustafa Talpur and Mr. Aftab A Khushak, who collected all kind of the data presented in this report.

We also convey our gratitude to Dr. Yameen Memon, Team Leader IWMI Hyderabad, for his encouragement and continuous discussion on completing this report.

Special thanks are due to Mr. A.N.G. Abbasi Ex. Minister for Irrigation and Power Department Government of Sindh for his constant guidance and support to finish this report.

The authors are indebted to the SIDA and NDP staff for cooperation in discussing the issues of design and actual discharges.

The study forms an additional work of the Farmer Managed Irrigation project in Sindh Province, which is funded by the Government of Sindh with assistance from the World Bank.

Finally, the authors are grateful to Miss Sofia Saeed and Mr. Tabrez Ahmad for editing and compiling this report.

SUMMARY

The Bareji Distributary was monitored by IWMI for canal and structure dimensions and levels of water distribution equity. Both indicate unsatisfactory conditions. Deviations from design are very high for canal cross-sections and long-sections. Half the outlets used are based on a 1984 design discharge of 41 cusecs, half on a 1994-design discharge of 109 cusecs. Actual average monthly discharges range from 60-70 cusecs.

These changes in design result in hydraulic conditions that do not permit regime to be established, and also result in high inequity between head and tail of the distributary. There is also no evidence of technically based maintenance; most desilting that has occurred has been eyeballed rather than measured.

Revised designs have been drawn up that are based on three different levels of discharge (41, 70 and 109 cusecs) and on two bed slopes (existing and 1994 design). However, for regime to be re-established not only is some significant reshaping of the canal required but it must be accompanied by an effective program of water measurement and monitoring. Both are lacking so that it is impossible to control hydraulic conditions properly.

A set of recommendations is presented that, if followed, should result in accomplishment of regime and the associated equity of water distribution.

1 INTRODUCTION: ACHIEVING STABLE CANALS AFTER REMODELING

Since July 1995, the International Water Management Institute (IWMI) has been implementing a pilot action research program on Farmer Managed Irrigation in the LBOD area. Initially it was in collaboration with the Department of Agriculture Engineering and Water Management, Government of Sindh (GoS), but from April 1999 the collaboration was with the Sindh Irrigation and Drainage Authority (SIDA).

The broad purpose of the pilot project is two-fold. (1) To test the viability of farmers managing distributaries, minors and watercourses so that more efficient and equitable allocation of water can be achieved. (2) To make recommendations, based on the results of the pilot projects, on future extensions in the rest of the Sindh Province.

Before this project farmers were only responsible for managing watercourses and therefore were not involved in operation and maintenance of canals above their own individual outlets. By giving Farmer Organizations (FOs) this responsibility it is important to make sure that the canal is constructed in a way that the FOs can achieve effective water allocation between watercourses and maintain them in this condition once management transfer has occurred.

Ideally distributary and minor canals are designed and constructed to be in regime, that is where there is no net silt accumulation or scouring and the canal long-section and cross-sections remain stable. To achieve this objective canals have to be designed so that there is a steady and constant water velocity along the canal, and that each outlet not only draws its fair share of water but also its fair share of silt. Standard formulae, particularly those of Kennedy and Lacey, can be used to determine the correct dimensions of the distributary or minor that will result in regime conditions.

In the design stage the discharge is calculated on the basis of the culturable command area (CCA) and then the outlet for each watercourse is sized so that it provides proportional distribution of water and silt. Normally the elevation of each outlet is above the bed of the distributary or minor to enable proportional silt load to be extracted and the height and width is then calculated so that discharges are also proportional.

This study is based on the experiences of the pilot project in Bareji Distributary which offtakes from Jamrao Canal, and which falls within the command area of the Left Bank Outfall Drain project (LBOD).

2 THE LEFT BANK OUTFALL DRAIN PROJECT (LBOD) AND CHANGES IN CANAL DESIGNS

The LBOD Project is a huge investment in irrigation and drainage infrastructure in areas commanded by canals that originate from the Indus Left Bank at Sukkur Barrage. Over a period of several decades water tables rose to a point where large areas of productive land were affected by waterlogging and salinity of groundwater reached very high levels. Millions of acres of land were affected. It was decided to raise productivity through a comprehensive and integrated drainage and irrigation program.

The core of the project is the main LBOD drain that removes excess water to the sea close to the Indian border. The main drain is fed by a combination of surface drains, tubewells (saline and scavenger) and tile drainage that is located in areas worst affected by waterlogging and salinity.

In addition to restoring the productivity of land affected by waterlogging and salinity, it was decided to improve cropping intensities by increasing design discharges in those areas that benefited from improved drainage conditions.

Before LBOD annual cropping intensities were typically around 81 percent. It was hoped that the combination of improved drainage and increased irrigation deliveries would result in annual cropping intensities of 147%.

The area selected for increased canal discharges was in the upper portion of Jamrao canal. To deliver more water a parallel main canal (Twin Jamrao) was constructed and each distributary and minor in the area was remodeled to allow for new design discharges more or less double the original design discharges.

The remodeling required complete reconstruction of canals because long-sections and cross-sections needed to be readjusted, while all outlet structures had to be completely rebuilt. For convenience pre-cast concrete outlet structures were installed rather than the traditional brick and mortar structures used in the original

design. Once the pre-cast structures had been installed the actual orifice could be built into the structure in-situ.

Physical work in all distributaries and minors was completed in the 1994/95 period. However, the Twin Jamrao Canal, which supplies additional water, was not completed and discharges have, at least in theory, been maintained at their 1984 levels for the past six years. With the anticipated commissioning of Twin Jamrao Canal in 2000 it is anticipated that the remodeled canals will be brought into use.

Bareji Distributary lies within the overall area selected for remodeling, and because it was also selected as one of the first three pilot distributaries for farmer organization at distributary level, a special investigation of the current situation for design and achievement of regime has been undertaken.

3 DESIGN AND REMODELING OF BAREJI DISTRIBUTARY

Bareji Distributary offtakes from Jamrao Canal at RD 408. It was originally designed and constructed in 1932 with a CCA of approximately 20,000 acres with 31 outlets. The design of the canal and the outlets was in accordance with standard designs and we can assume that the canal was at or close to regime in the initial years. The design discharge at the head at that time was 64.28 cusecs.

The LBOD project was not the first time that Bareji Distributary was remodeled: an earlier remodeling occurred in 1984. The reason for the first remodeling was that some 6,500 acres irrigated by seven outlets at the tail were transferred to another canal. The CCA was reduced to 14,531 acres, the length of the distributary reduced from 62,250 feet to 39,300 feet, and the number of outlets reduced to 24. As a result of these changes in CCA the design discharge at the canal head was also reduced to 41.0 cusecs and there was no change in the overall water allocation for the command area.

These changes in design required a complete remodeling of the canal from the head to meet the conditions necessary to achieve regime. With reduced demand at the head the long-section and cross-sections had to be modified. Because remodeling changes the elevation of outlets, all outlets had to be remodeled to ensure proportionality in both water and silt distribution. Cross-sections for the 1984 design are presented in Annex 1, Table 1. Design dimensions of outlets constructed in this period are presented in Annex 2, Table 1.

In 1994/95 Bareji Distributary was remodeled for the second time as part of the LBOD project. On this occasion the CCA was not changed, and the number of outlets was kept at 24. However, design discharge was increased from 41.0 cusecs to 109 cusecs, requiring that all canal dimensions had to be completely revised.

On the basis of this new discharge cross-sections have been remodeled. The details are presented in Annex 1, Table 2. However, no data are available concerning the location and new

designs for the remodeled outlets in the Nara Canal Circle office of Irrigation and Power Department (IPD), and the office of the Chief

Engineer (Development) does not have a revised outlet register, either designed or built.

4 CURRENT PHYSICAL CONDITIONS AND HYDRAULIC PERFORMANCE

Since 1995, following the inception of the project by IWMI, the physical condition of the distributary has been measured, and regular observations of discharges at the canal head and at watercourse outlets have been made.

4.1 Physical Conditions of Bareji Distributary

Cross-sections of Bareji Distributary at each 5000 feet (5 RD) distance from the canal head are presented in Annex 3, Figures 1-9. From these figures it is clear that the existing canal is not in conformity with any designed cross-section.

However, it is difficult to know precisely what the design cross-section should be. There are two concurrent designs: the 1984 design based on a design discharge of 41 cusecs, and the 1994 design based on 109 cusecs. The canal was physically remodeled to enable delivery of 109 cusecs but never operated at this level because the Twin Jamrao Canal has not been commissioned. Though, there is some confusion, it is clear that all the physical structures and the banks and berms were remodeled. But there are conflicting accounts of whether the cross-sections and long-sections were actually remodeled, as built drawings are not available to verify what actually was accomplished.

Further, the canal has been permitted to operate with average monthly discharges in the 60-70 cusec range for long periods, and short periods with much higher flows, the cross-section has in effect changed to reflect reality, not design. The increased flow requires larger canal dimensions and it is likely these result in some scouring.

In terms of the long section it is clear that at all levels the bed is lower than the 1984 design (Annex 3, Figure 10). It is not exactly clear why

this is so because the 1994 design calls for more or less the same bed elevation. Perhaps scouring, or enthusiasm to desilt, either by IPD staff or by farmers in the absence of any technical supervision, has led to over-deepening of the canal. As there are no records maintained of desilting by IPD and because desilting is done by eye rather than on the basis of measured conditions, it is hardly surprising that the actual canal dimensions deviate significantly from design.

4.2 Physical Conditions of Outlets

The results of a detailed measurement survey of all outlets taken in August 1999 are presented in Annex 4, Table 1. Several observations can be made from this table.

Firstly, three outlets which are supposed to be Adjustable Proportionate Module (APM) are actually Open Flumes (OF). It is not clear if these changes have been sanctioned but it is inevitable that simply removing the roof block of an outlet will enable it to receive more discharge than intended.

Also farmers in eleven of the 24 watercourses are using the 1994 outlets, while 13 are using the original 1984 outlets. It is inconceivable that a canal can perform anywhere near design when two totally different types of outlet structure are being used simultaneously.

In the absence of any available design data for the 1994 outlets it is impossible to determine if the dimensions are as designed or reflect subsequent tampering. However, in all eleven cases the actual dimensions in the new outlets are so much larger than the 1984 design data that any comparison is meaningless.

Thirdly, almost all outlets were tampered in terms of both B (width of orifice) and Y (height of orifice). Regarding measurements of B, of the twelve 1984 structures still in use, seven are within

10% of original design, three are between 10-50% bigger than design and two are more than 50% bigger than design. Regarding measurements of Y, one outlet has been converted to an Open Flume, two are between 10-50% bigger than designed, and nine are more than 50% bigger than designed.

Given the incapacity to maintain outlet dimensions within $\pm 10\%$ of design, the maximum discrepancy permitted to meet IPD guidelines about accuracy of outlet discharges, it is hardly surprising that discharges at outlets are completely different from design.

4.3 Discharges at the Head of Bareji Distributary

The average monthly discharges at the head of Bareji Distributary are presented in Annex 5, Table 1. From these data it can be seen that the actual discharge delivered is at least 150% of design and in some periods is as high as 175% of design. This means that the canal is not operated close to design and any possibility of achieving regime is lost.

It should be noted that there has not been any official increase in design discharge above 41 cusecs so operation of the canal at higher than design levels indicates a lack of discipline among operational staff. The situation is made graver because there is no longer a program of discharge or water level reading at the distributary head: the gauge installed by LBOD is above current water levels and cannot be used in any measurement program. It is not clear that it was ever calibrated. The only functional gauge is that installed by IWMI as part of the pilot program. It should also be noted there is no tail gauge.

5 DESIGNS FOR RESTORING REGIME CONDITIONS

Restoration of regime at Bareji Distributary require four conditions: an agreed design discharge, an agreed bed slope, an agreed outlet design with correct installation, and re-establishment of proper monitoring procedures to ensure lack of

Bareji is not unique in this respect. None of the other adjacent distributaries appear to have a calibrated head gauge or a working tail gauge, meaning that there is no capacity to measure water and to manage it.

4.4 Discharges at Watercourses along Bareji Distributary

Average discharges in all watercourses along Bareji Distributary are presented in Annex 4, Tables 2 and 3. In Kharif season, when water is comparatively scarce in relation to crop water demand and equitable sharing is necessary, only four watercourses out of 24 receive less than design discharge, while twelve receive more than twice the design discharge. In Rabi there is slightly more equity insofar as there only four watercourses which fail to get design discharges while ten outlets draw more than twice their design. Therefore, there is no equity of water distribution along the distributary from head to tail.

These data imply there is no effort to measure water levels upstream of each outlet and complete the 'H' registers as required under normal operating conditions.

4.5 Tail End Lifting Devices

The tail section/reach of distributary water surface elevation is below the ground surface elevation, either due to improper design or construction in 1994, or improper maintenance. In this reach eight watercourses are using lift machines to raise water from the distributary to the watercourse. The water elevation and ground surface elevations measured are presented as Annex 6, Table 1.

tampering, correct water levels at head and tail, and correct hydraulic conditions at each outlet.

Determining design discharge is a policy decision of Irrigation and Power Department (IPD), or more recently of Sindh Irrigation and Drainage

Authority (SIDA) and the Area Water Boards (AWB). Because no clear policy exists at present, three different scenarios have been used in determining optimal design conditions: the 1984 design discharge of 41 cusecs, the actual discharge of 70 cusecs, and the 1994 design discharge of 109 cusecs.

Bed slope is a design variable that can be chosen at the time of design. Two bed slopes exist: the actual bed slope and that selected by LBOD designers for a design discharge of 109 cusecs. These are shown in annex 3, Figure 10.

The other two conditions are beyond the scope of this report but conditions, both physical and operational are such that even if the design discharge is agreed and implemented, equity of water distribution and achievement of regime cannot be guaranteed.

Based on Kennedy's formula, there are six possible alternatives for Bareji Distributary,

because there are three possible design discharges and two possible bed slopes. Annex 7, Table 1, shows different possible cross-sections at each 5000 feet along the canal for three design discharges and bed slopes, while Annex 7, Table 2 shows cross-sections using three design discharges and the LBOD slope. In almost all locations the canal is too narrow and too deep to meet the newly calculated regime conditions for 70 and 109 cusecs, but is too wide and too deep to carry 41 cusecs and still achieve regime.

Annex 8, Tables 1 and 2, use existing bed slopes and two different design discharges (41 and 70 cusecs) to calculate outlet dimensions and elevations to achieve proportional design discharge. Annex 8, Tables 3 and 4, use LBOD bed slopes and two levels of design discharge (41 and 70 cusecs) to determine required outlet dimensions to achieve proportional division.

6 CONCLUSIONS

The current conditions of Bareji Distributary reflect the processes and procedures of the past 7 years. The canal and new outlets were remodeled for a significantly larger design discharge in 1994, but as yet the upstream infrastructure to deliver new discharges is not complete. This is an unacceptable delay: if a canal is physically remodeled then water deliveries should be adjusted to the new design as soon as possible.

Under present conditions a combination of conditions make it impossible to achieve regime conditions. These conditions include:

- the new discharge has never been delivered so that there is a mismatch between design and actual conditions;
- new outlets capable of meeting new design conditions are already used in about half the watercourses, while old outlets are used in the remainder: mixing outlets with different design specifications prohibits proper hydraulic conditions to be achieved;

- actually delivered discharges are not close to either the old or new design, rendering all cross-sections and long-sections irrelevant;
- it appears that any maintenance has been ad-hoc and not undertaken following survey of desilting requirements: using an 'eyes-only' approach will not restore proper canal dimensions and may well result in over-deepening of the canal;
- outlet tampering has occurred so that current dimensions are so different from original 1984 designs that hydraulic stability has been lost;
- there has been no systematic observation of hydraulic conditions: the absence of head gauges, tail gauges or 'H' registers means IPD staff have no knowledge of what is happening along the canal.

Restoring regime requires that a set of conditions must be met: meeting only one or two conditions will lead to renewed failure. These conditions are:

- an agreed design discharge;

- an agreed bed slope;
- an agreed outlet design with correct installation;
- repair/reconstruction of physical conditions to agreed conditions
- re-establishment of proper monitoring procedures to ensure lack of tampering, correct water levels at head and tail, and correct hydraulic conditions at each outlet;
- proper discipline on behalf of both IPD/SIDA staff and FOs.

It is clear that if FOs inherit the current physical infrastructure they will be unable to achieve equity of water distribution and regime will not be reestablished.

7 RECOMMENDATIONS

To achieve regime in Bareji Distributary, and indeed in all distributaries, the following steps are recommended:

- Selection of an agreed discharge at distributary head. This requires a policy decision at SIDA or AWB level because it will affect all distributaries. In Bareji farmers probably cannot cope with 109 cusecs because they still have waterlogging and there are concerns over maintenance of some drainage facilities. A discharge of 70 cusecs would likely be acceptable to the Bareji Distributary FO.
- Selection of agreed bed slope. Current bed slope is easier to use because it requires less physical work.
- Recalculation of canal cross-sections, long-sections and outlet dimensions. The procedures used in this report are perfectly acceptable.

The events of the past years cannot be blamed on any one group alone: both IPD and farmers must take some measure of responsibility. Past design, construction, operational and maintenance deficiencies are agency responsibilities (Water and Power Development Authority (WADPA) and its consultants, and Irrigation and Power Department (IPD)) while outlet tampering is largely but not exclusively farmers responsibility.

If the Management Transfer process is to succeed then both SIDA and FO staff must undertake their responsibilities seriously and diligently, and ensure they each undertake their share of the redefined responsibilities.

- Restoration of required physical conditions in the field. This should to be done before transfer is fully effective because FOs will have just as much difficulty in achieving equity and regime conditions as IPD if the actual water delivery infrastructure is not in conformity with design.
- Operation of distributary canal at agreed discharge by SIDA/AWB staff.
- Routine monitoring of discharges and adjustment to ensure targets are met.
- Establishment of correct desilting practices to ensure design conditions are maintained in the following years.

ANNEXURES

Annex-1

Table 1. Design cross-sections for the year 1984

Location (RD)	Bed Level [ft]	Width [ft]	Depth [ft]	Standard Specifications*				
				Berm Width [ft]	Bank Width [ft]		Side Slopes	Free Board IP
0	54.19	12	2.5	10	12	5	0.5:1	2
5	53.34	11	2.5	10	12	5	0.5:1	2
10	52.49	10.5	2.0	10	12	5	0.5:1	2
15	51.64	7.0	2.0	10	12	5	0.5:1	2
20	50.79	7.0	2.0	10	12	5	0.5:1	2
25	49.94	6.0	1.4	10	12	5	0.5:1	2
30	49.08	3.5	1.2	10	12	5	0.5:1	2
35	48.23	3.5	1.2	10	12	5	0.5:1	2

*These dimensions were not available therefore, have been taken from Irrigation Manual 1995

Table 2. Design cross- section for the year 1994/95 (LBOD)

Location (RD)	Bed level [ft]	Width [ft]	Depth [ft]	Berm Width [ft]	Bank Width [ft]		Side Slopes	Free Board [ft]
					IP	NIP		
0	54.2	23	3.3	10	12	12	0.5:1	1.5
5	53.8	21	2.9	10	12	12	0.5:1	1.5
10	53.1	19	3.1	10	12	12	0.5:1	1.5
15	52.7	17	2.5	10	12	12	0.5:1	1.5
20	52.0	14	2.3	5	12	12	0.5:1	1.5
25	51.3	13	2.1	5	12	12	0.5:1	1.5
30	50.5	10	1.8	5	12	12	0.5:1	1.5
35	49.7	6	1.4	5	12	12	0.5:1	1.5

Where: RD is reduced distance (=1000 feet), IP is inspection path and NIP is non-inspection path

Annex-2

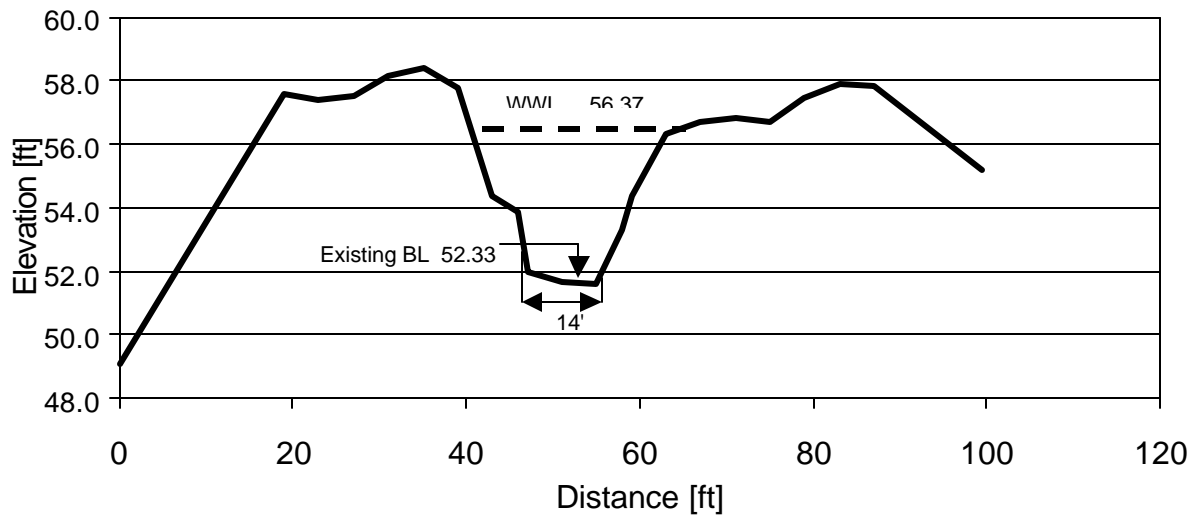
Table 1 Design dimensions of outlets (1984).

Watercourse No		RD	GCA	CCA	Kabuli	Rice	Garden	Od	H	B	Y	HL	H	MMH	Type	R.L
IWMI	IPD		acres	Acres	Acres	Acres	Acres	(cfs)	(ft)	(ft)	(ft)	(ft)	(H-Y)	(0.75*h)	of O/L	Crest
1-R	240/1	0.5	318	254	245	-	-	0.7	1.30	0.20	0.50	-	0.8	0.6	APM	53.16
1-L	229/1L	0.5	776	685	681	-	17	2.01	2.70	0.25	0.80	2.1	1.9	1.42	APM	51.72
2-R	240/1AR	1.75	250	248	248	-	-	0.72	1.20	0.32	0.40	0.3	0.8	-	APM	53.05
3-R	239/2R	4.9	918	829	828	-	-	2.32	2.20	0.40	0.66	0.6	1.5	1.15	APM	51.36
4-R	239/2A	4.9	297	294	294	67	36	1.89	2.00	0.32	1.08	0.2	0.9	0.69	APM	51.56
2-L	228/1L	5.7	873	806	806	-	-	2.26	2.00	0.32	0.92	2.3	1.1	0.81	APM	51.81
5-R	240/2R	6.7	683	601	601	-	8	1.74	2.10	0.40	0.72	-	1.4	1.04	APM	51.55
3-L	228/1A	11.5	775	670	667	-	2	1.88	2.10	0.50	0.40	2.0	1.7	1.27	APM	50.48
6-R	240/3R	11.5	504	481	462	-	-	1.29	1.30	0.32	0.75	-	0.6	0.39	APM	51.22
4-L	228/2L	12.1	165	144	140	-	-	0.4	1.50	0.20	0.25	1.1	1.3	0.93	APM	50.96
5-L	227/1AL	12.1	1657	1590	1560	-	8	4.43	2.60	0.63	0.80	-	1.8	1.35	APM	49.80
6-L	227/1L	13.1	730	661	654	-	-	1.84	1.90	0.32	0.72	1.63	1.2	0.90	APM	50.50
7-L	226/1L	14.0	560	523	515	-	-	1.44	1.90	0.25	0.72	1.40	1.2	0.90	APM	50.37
8-L	226/2L	17.3	613	583	544	-	-	1.63	2.00	0.25	0.80	0.90	1.2	0.90	APM	49.74
9-L	225/1L	20.0	565	547	538	-	5	1.54	1.20	0.35	-	1.00	1.2	0.19	OF	50.21
7-R	239/3R	22.9	147	136	136	-	-	0.39	1.60	0.20	0.24	0.90	1.4	1.02	APM	48.38
9-R	238/2R	25.1	541	451	442	-	6	1.27	1.00	0.40	-	0.20	1.0	0.14	OF	48.51
8-R	238/1R	25.1	834	777	777	-	10	2.25	1.80	0.40	0.76	0.60	1.0	0.78	APM	48.76
10-L	225/1AL	25.4	809	722	337	-	-	0.91	1.35	0.18	-	-	1.4	-	OF	-
10-R	237/1R	29.2	831	807	807	-	-	2.26	1.30	0.17	-	0.10	1.3	0.17	OF	47.49
11-L	225/2L	30.3	381	339	188	-	-	0.52	1.30	0.20	0.41	0.30	0.9	0.66	APM	48.71
12-L	224/1L	33.5	404	354	192	-	4	0.58	1.00	0.18	-	0.05	1.0	0.14	OF	47.56
11-R	236/1AR	36.0														
13-L	224/2L	39.3	719	646	540	-	-	1.53	1.00	0.48	-	-	1.0	0.14	OF	47.16

Source of data: Irrigation and Power Department, Mirpurkhas sub division.

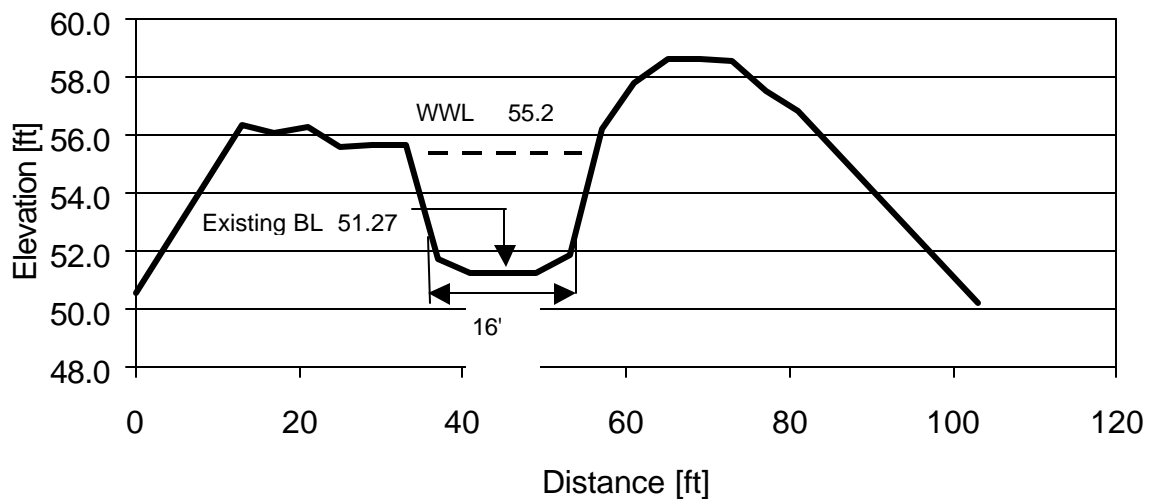
Note: Design data of 11R outlet were not available.

Annex 3



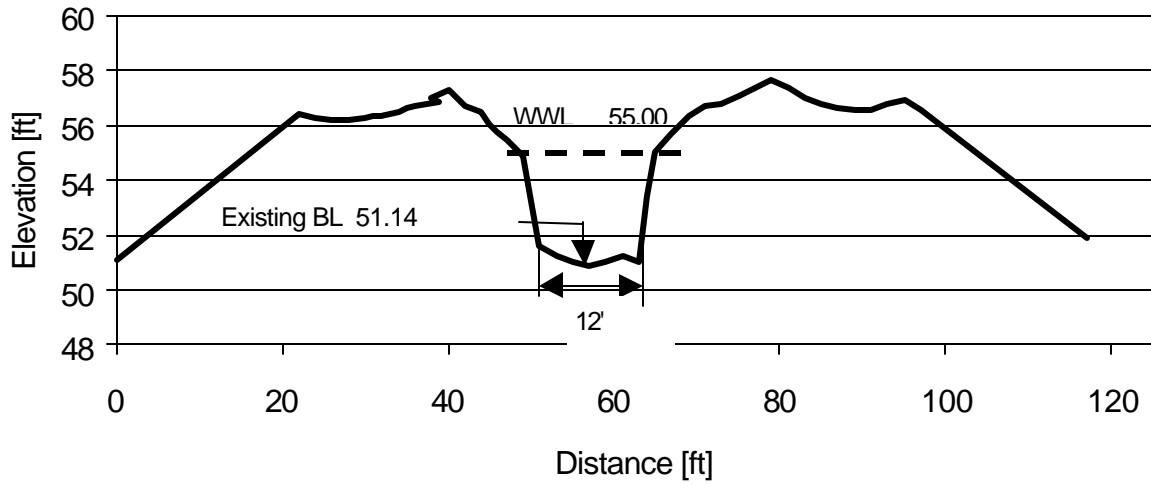
Area [ft ²]									6.44	2.13	12.1	17.24	17.6	8.01	1.62												
Base [ft]	0	19	4	4	4	4	4	4	1	3	4	4	3	1	4	4	4	4	4	4	4	4	4	4	4	12	
Mean Depth [ft]									1.61	2.13	4.04	4.31	4.41	2.67	1.62												
WWL [ft]																											
Existing B.L. [ft]	49.1	57.6	57.4	57.5	58.2	58.4	57.8	54.4	53.9	52.0	51.7	51.6	53.3	54.4	56.3	56.7	56.8	56.7	57.4	57.9	57.9	55.2					
Distance [ft]	51	32	28	24	20	16	12	8	7	4	0	4	7	8	12	16	20	24	28	32	36	48					

Figure 1. Existing X-Section of Bareji Distributary, Mirpurkhas at RD 0+200.



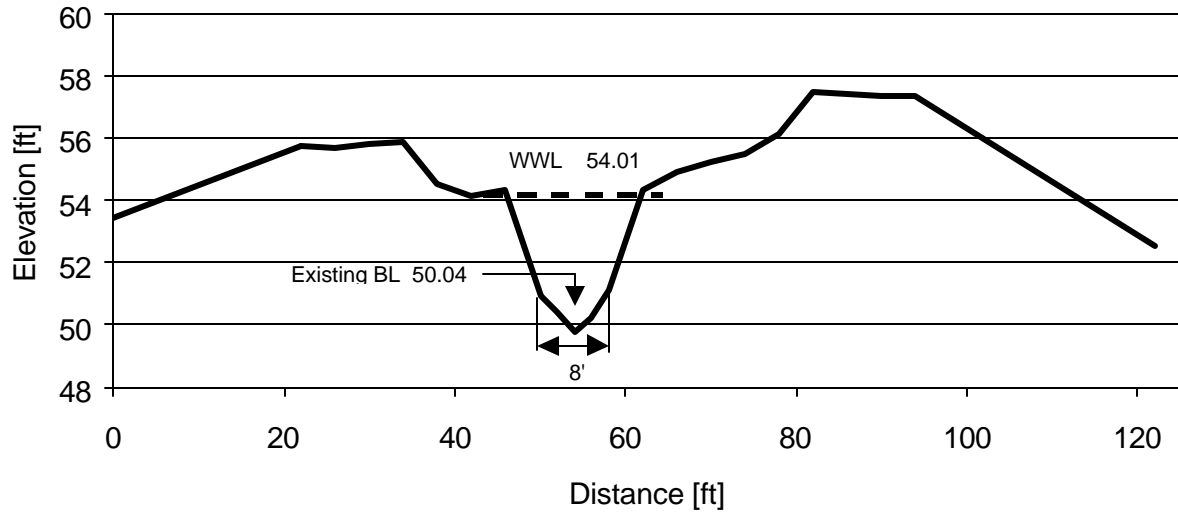
Area [ft ²]									15.6	17.3	17.4	17.4	14.8												
Base [ft]	0	13	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	22	
Mean Depth [ft]									3.9	4.32	4.35	4.36	3.71												
WWL [ft]													55.6												
Existing B.L. [ft]	50.6	56.3	56.1	56.3	55.6	55.6	55.7	51.7	51.3	51.3	51.2	51.9	56.2	57.8	58.6	58.6	58.6	57.5	56.8	50.3					
Distance [ft]	45	32	28	24	20	16	12	8	4	0	4	8	12	16	20	24	28	32	36	58					

Figure 2. Existing X-section of Bareji Distributary, Mirpurkhas at RD 5+00.



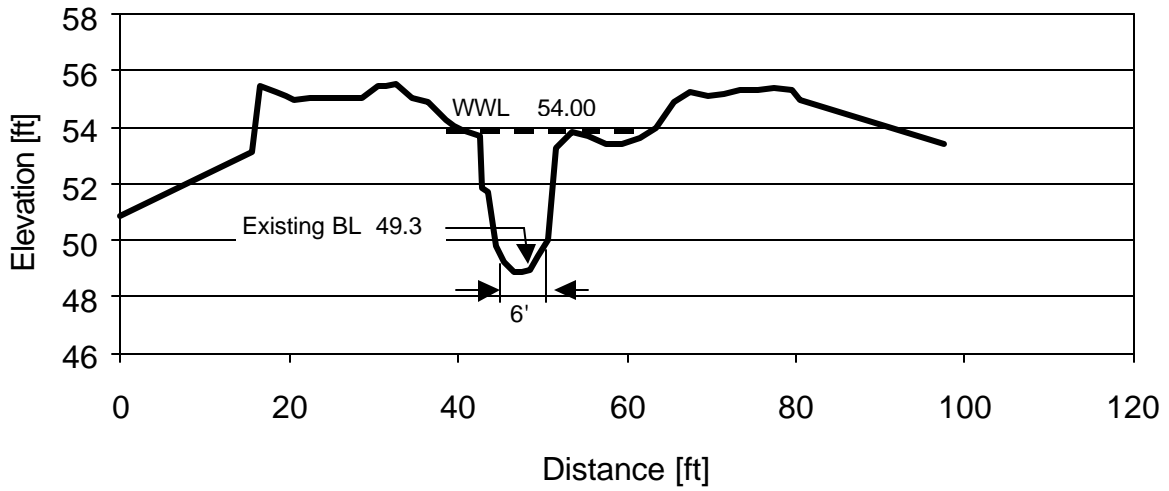
Area ft ²										0.5	6.8	15	16	15	24																						
Base [ft]	0	23	4	4	4	4	4	4	4	4	2	4	4	4	6	8	12	16	20	24	28	32	36	40	60												
Mean Depth [ft]										0.1	3.4	3.8	4.1	3.8	4.0																						
WWL [ft]														55																							
Existing B.L. [ft]	51.1	56.3	56.2	56.3	56.6	56.8	57.0	56.1	54.9	52	51.2	50.9	51.2	51.0	55.0	56.3	56.8	57.4	57.4	56.8	56.5	56.8	56.5	51.9													
Distance [ft]	59	36	32	28	24	20	16	12	8	6	4	0	4	6	8	12	16	20	24	28	32	36	40	60													

Figure 3. Existing X-section of Bareji Distributary, Mirpurkhas at RD 10+00.



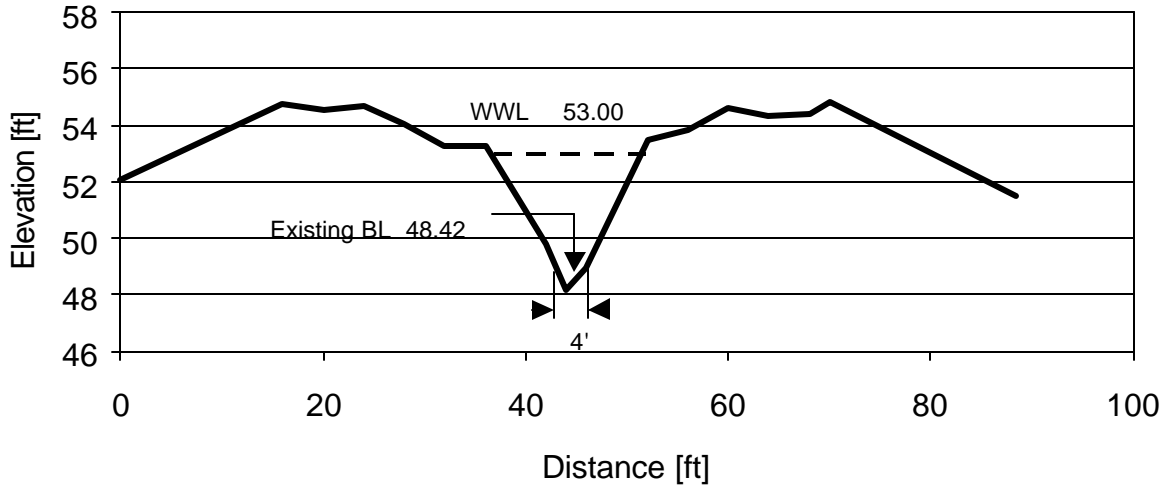
Area ft ²											12	7.2	8.5	7.6	5.8																						
Base [ft]	0.0	24.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	2.0	2.0	2.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	28.0													
Mean Depth [ft]											3.1	3.6	4.2	3.8	2.9																						
WWL [ft]															54.01																						
Existing B.L. [ft]	53.5	55.8	55.7	55.8	55.8	54.5	54.2	54.4	50.9	50.4	49.8	50.2	51.1	54.3	54.9	55.3	55.5	56.1	57.5	57.4	57.4	57.4	52.5														
Distance [ft]	56.0	32.0	28.0	24.0	20.0	16.0	12.0	8.0	4.0	2.0	0.0	2.0	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	68.0														

Figure 4. Existing X-section of Bareji Distributary, Mirpurkhas at RD 15+00.



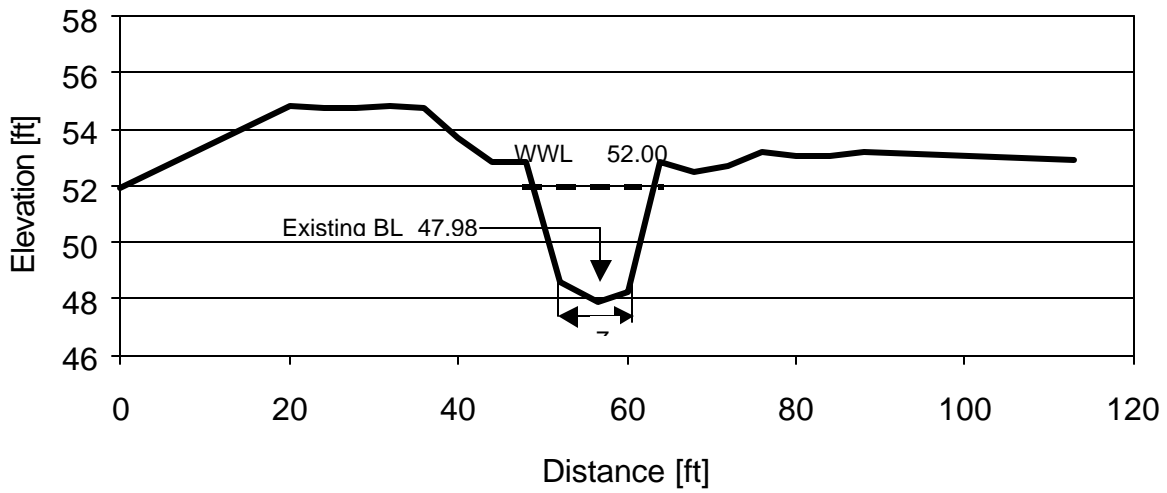
Area ft ²										20.9	15.4	12.0	1.4	2.3						
Base [ft]	0	15	4	4	4	4	4	4	4	5	3	3	5	4	4	4	4	4	4	18
Mean Depth [ft]										4.2	5.1	4.0	0.3	0.6						
WWL [ft]	54																			
Existing B.L. [ft]	50.8	53.1	55.1	55.0	55.0	55.5	55.0	54.1	49.8	48.9	50.0	53.7	53.4	54.0	55.2	55.2	55.3	55.3	53.4	
Distance [ft]	47	32	28	24	20	16	12	8	3	0	3	8	12	16	20	24	28	32	50	

Figure 5. Existing X-section of Bareji Distributary, Mirpurkhas at RD 20+00.



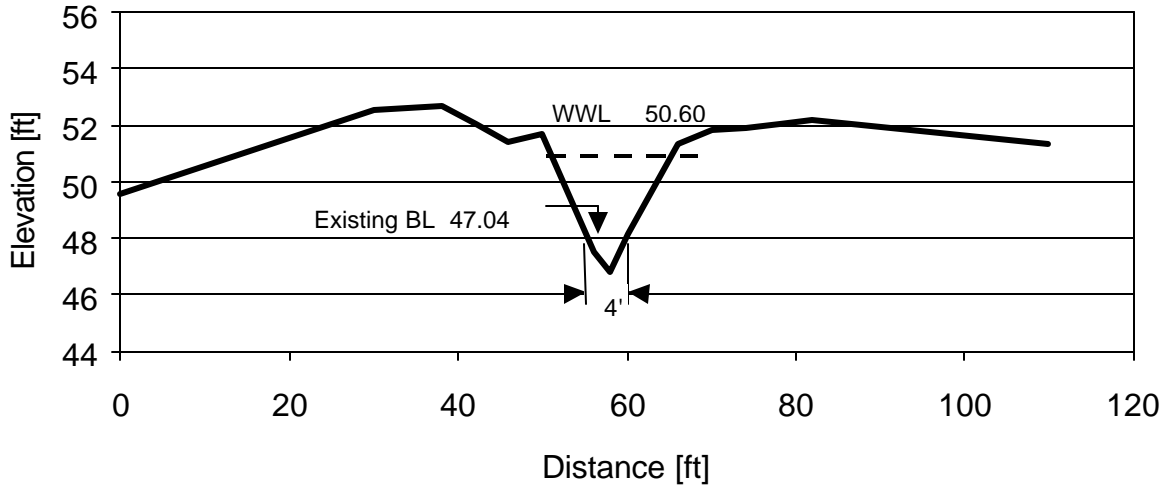
Area ft ²										19.02	9.68	8.18								
Base [ft]	0	16	4	4	4	4	4	4	4	6	2	2	6	4	4	4	4	4	4	18
Mean Depth [ft]										3.17	4.84	4.09								
WWL [ft]	53																			
Existing B.L. [ft]	52.09	54.72	54.53	54.69	54.01	53.24	53.26	49.83	48.16	48.91	53.51	53.86	54.64	54.34	54.38	54.86	54.86	51.5		
Distance [ft]	44	28	24	20	16	12	8	2	0	2	8	12	16	20	24	28	46			

Figure 6. Existing X-section of Bareji Distributary, Mirpurkhas at RD 25+00.



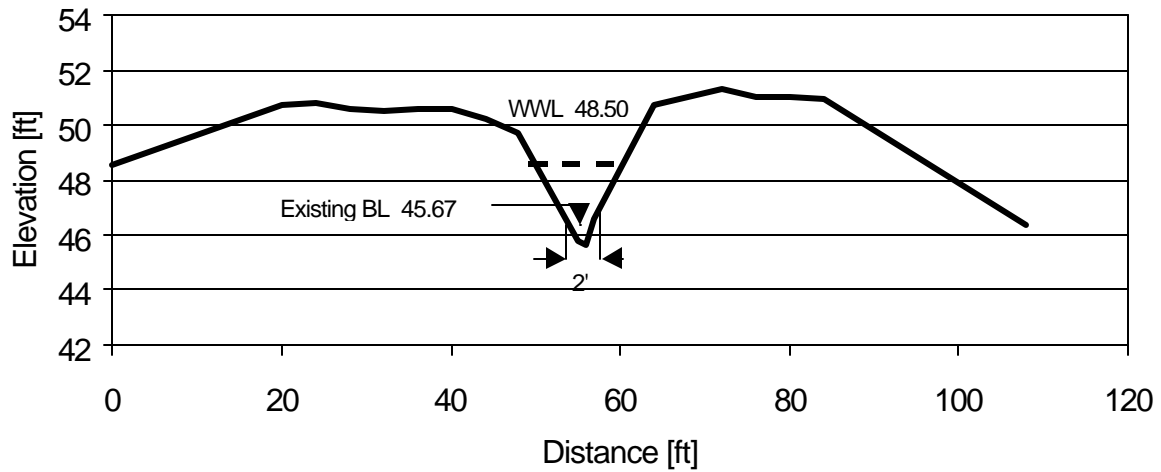
Area ft ²										13.6	16.5	15								
Base [ft]	0	20	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	25	
Mean Depth [ft]										3.41	4.12	3.75								
WWL [ft]	52																			
Existing B.L. [ft]	51.9	54.8	54.7	54.8	54.8	54.8	53.7	52.8	52.8	48.6	47.9	48.3	52.8	52.5	52.7	53.2	53	53.1	53.2	52.9
Distance [ft]	56	36	32	28	24	20	16	12	8	4	0	4	8	12	16	20	24	28	32	57

Figure 7. Existing X-section of Bareji Distributary, Mirpurkhas at RD 30+00.



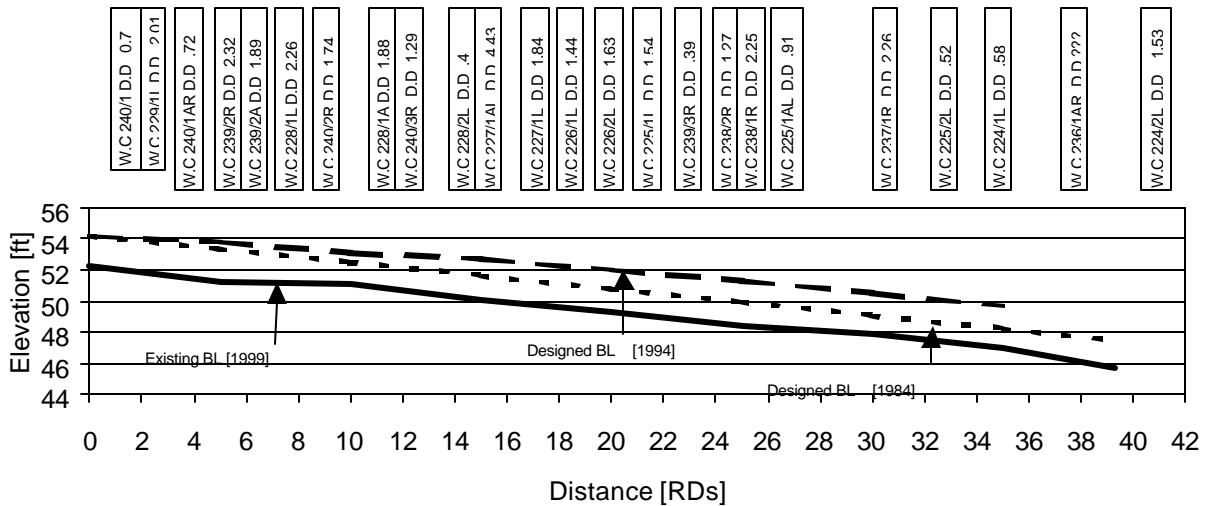
Area ft ²										18.67	7.56	4.88							
Base [ft]	0	30	4	4	4	4	4	4	6	2	2	6	4	4	4	4	4	4	28
Mean Depth [ft]										3.111	3.781	2.441							
WWL [ft]	50.6																		
Existing B.L. [ft]	49.55	52.56	52.64	52.68	52.05	51.38	51.7	47.49	46.82	48.16	51.32	51.81	51.91	52.06	52.2	51.32			
Distance [ft]	58	28	24	20	16	12	8	2	0	2	8	12	16	20	24	52			

Figure 8. Existing X-section of Bareji Distributary, Mirpurkhas at RD 35+00.



Area ft ²										19.32	2.9	1.93							
Base [ft]	0	20	4	4	4	4	4	4	4	7	1	1	7	4	4	4	4	24	
Mean Depth [ft]										2.76	2.9	1.93							
WWL [ft]											48.5								
Existing B.L. [ft]	48.54	50.74	50.78	50.57	50.52	50.6	50.61	50.2	49.67	45.74	45.6	46.57	50.7	51	51.27	51.01	51.01	50.93	46.35
Distance [ft]	56	36	32	28	24	20	16	12	8	1	0	1	8	12	16	20	24	28	52

Figure 9. Existing X-section of Bareji Distributary, Mirpurkhas at RD 39+00.



Designed Discharge [cfs]	41.5									
Existing Av. Discharge [cfs]	70									
Designed Hyd. Gradient	1/5876									
Existing Hyd. Gradient	1/7500					1/4800				
Designed F.S.Level [ft]	56.69	56.5	55.55	54.31	52.38	52.38	51	50.95	50	
Designed Bed Width [ft]	12	11	10.5	7	7	6	3.5	3.5		
Existing Bed Width [ft]	14	16	12	8	6	4	7	4	2	
Designed F.S.Depth [ft]	2.5	2.5	2	2	2	1.4	1.2	1.15	1.15	
Existing F.S.Depth [ft]	4.04	3.96	3.86	3.76	4.67	4.6	4.02	3.53	2.84	
Designed BL [ft] 1994	54.2	53.8	53.1	52.7	52	51.3	50.5	49.7		
Designed BL [ft] 1984	54.19	53.34	52.49	51.64	50.79	49.94	49.08	48.23	47.50	
Existing B.L [ft]	52.33	51.27	51.14	50.04	49.3	48.42	47.92	47.04	45.67	
Distance in RDs	0	5	10	15	20	25	30	35	39.3	

Figure 10. L-Section of Bareji Distributary, Mirpurkhas.

Annex-4

Table 1 Design (1984) and existing dimensions of outlet (August 1999).¹

Outlet Number		Distance, RD	Type of Outlet		Design Dimension of Outlet (1984)		Existing Dimension of Outlet (August 1999)			
IWMI	IPD		Design	Existing	B [ft]	Y[ft]	Old Structure		New Structure	
							B[ft]	Y[ft]	B[ft]	Y[ft]
1-R	240/1	0.5	APM	APM	0.20	0.50			0.58	0.95
1-L	229/1L	0.5	APM	APM	0.25	0.80			1.20	1.03
2-R	240/1AR	1.75	APM	APM	0.32	0.40	0.34	0.65		
3-R	239/2R	4.9	APM	OF	0.40	0.66	0.68	-		
4-R	239/2A	4.9	APM	APM	0.32	1.08	0.35	1.32		
2-L	228/1L	5.7	APM	APM	0.32	0.92	0.34	1.78		
5-R	240/2R	6.7	APM	APM	0.40	0.72	0.44	1.36		
3-L	228/1A	11.5	APM	APM	0.50	0.40	0.58	1.76		
6-R	240/3R	11.5	APM	APM	0.32	0.75	0.67	1.13		
4-L	228/2L	12.1	APM	APM	0.20	0.25	0.25	0.60		
5-L	227/1AL	12.1	APM	APM	0.63	0.80	0.66	1.96		
6-L	227/1L	13.1	APM	APM	0.32	0.72	0.43	1.41		
7-L	226/1L	14.0	APM	APM	0.25	0.72	0.28	0.91		
8-L	226/2L	17.3	APM	APM	0.25	0.80	0.28	2.21		
9-L	225/1L	20.0	OF	OF	0.35	-			0.60	
7-R	239/3R	22.9	APM	APM	0.20	0.24			0.55	0.75
9-R	238/2R	25.1	OF	OF	0.40	-			0.50	-
8-R	238/1R	25.1	APM	OF	0.40	0.76			0.94	-
10-L	225/1AL	25.4	OF	OF	0.18	-			0.91	-
10-R	237/1R	29.2	OF	OF	0.17	-			1.07	-
11-L	225/2L	30.3	APM	OF	0.20	0.41			0.47	-
12-L	224/1L	33.5	OF	OF	0.18	-			0.51	-
11-R	236/1AR	36.0		OF					0.68	-
13-L	224/2L	39.3	OF	OF	0.48	-				

¹ The dimensions of outlets have been physically measured. These can be varying with time because of tampering.

Annex. 5

Table. 1. Actual discharge at head regulator of Bareji Distributary.

Month	Average (Q), Cusecs	Average DPR	Month	Average (Q), Cusecs	Average DPR
April 97	63.5	1.55	October 97	68.59	1.67
May 97	62.2	1.52	November 97	59.52	1.45
June 97	64.8	1.58	December 97	62.26	1.52
July 97	71.0	1.73	January 98	52.37	1.28
August 97	72.2	1.76	February 98	67.93	1.66
Sept 97	69.5	1.70	March 98	67.65	1.65

Table 2. Discharges at each outlet of Bareji Distributary.

WC. No.		Average discharge for the months of Kharif 97 (cusec)							Season Average	
WMI	IPD	Design Q	April	May	June	July	Aug	Sept	Q (cusec)	DPR
1-R	240/1	0.7	1.39	1.80	1.81	1.77	2.10	1.76	1.77	2.53
1-L	229/1L	2.01	3.47	3.70	3.71	3.75	3.65	4.75	3.84	1.91
2-R	240/1AR	0.72	1.52	1.49	1.50	1.51	1.46	1.49	1.49	2.07
3-R	239/2R	2.32	3.00	3.09	2.97	3.54	3.66	2.35	3.10	1.34
4-R	239/2A	1.89	1.09	1.25	1.31	1.27	1.12	1.12	1.19	0.63
2-L	228/1L	2.26	3.38	4.41	4.42	2.99	2.95	3.72	3.64	1.61
5-R	240/2R	1.74	2.71	2.99	2.99	3.05	2.23	3.06	2.84	1.63
3-L	228/1A	1.88	3.40	3.97	3.95	4.34	4.12	4.49	4.04	2.15
6-R	240/3R	1.29	2.94	2.25	2.23	5.19	5.61	4.01	3.71	2.88
4-L	228/2L	0.4	1.60	2.11	1.60	0.90	0.98	1.01	1.37	3.43
5-L	227/1AL	4.43	5.69	4.51	4.72	3.64	4.36	4.89	4.64	1.05
6-L	227/1L	1.84	4.36	5.09	5.25	4.86	4.62	4.84	4.84	2.63
7-L	226/1L	1.44	2.69	3.53	4.27	4.12	4.33	3.92	3.81	2.65
8-L	226/2L	1.63	2.29	2.12	1.84	3.12	3.38	3.05	2.63	1.61
9-L	225/1L	1.54	3.48	2.37	2.57	2.59	2.38	3.05	2.74	1.78
7-R	239/3R	0.39	1.10	0.76	0.45	1.19	1.10	0.97	0.93	2.38
8-R	238/2R	1.27	1.15	0.60	0.59	0.46	1.10	1.11	0.83	0.65
9-R	238/1R	2.25	1.41	1.27	1.20	1.20	1.30	1.76	1.36	0.60
10-L	225/1AL	0.91	2.57	2.67	3.02	2.38	2.53	3.33	2.75	3.02
10-R	237/1R	2.26	1.50	1.65	1.53	1.37	1.88	0.58	1.42	0.63
11-L	225/2L	0.52	1.48	1.38	2.44	2.57	3.48	2.50	2.31	4.44
12-L	224/1L	0.58	1.97	2.05	1.40	2.14	1.55	2.03	1.86	3.21
11-R	236/1AR		1.16	0.30	0.80	0.90	1.21	0.60	0.83	
13-L	224/2L	1.53	3.15	2.77	3.55	2.64	4.01	2.49	3.10	2.03

Table 3. Discharges at each outlet of the Bareji Distributary.

WC.No.		Average discharge for the months of Rabi 97/98 (cusec)							Season Average	
IWMI	IPD	Design Q	Oct	Nov	Dec	Jan	Feb	Mar	Q (cusec)	DPR
1-R	240/1	0.7	1.45	1.58	2.11	1.64	1.72	1.31	1.64	2.34
1-L	229/1L	2.01	5.06	2.84	2.20	2.07	2.74	2.31	2.87	1.43
2-R	240/1AR	0.72	1.49	1.23	1.42	1.34	1.14	0.94	1.26	1.75
3-R	239/2R	2.32	1.99	1.65	1.04	0.59	2.51	2.86	1.77	0.76
4-R	239/2A	1.89	1.04	0.55	0.76	0.37	2.16	2.31	1.20	0.63
2-L	228/1L	2.26	3.98	3.42	3.28	3.10	3.91	3.39	3.51	1.55
5-R	240/2R	1.74	3.08	2.91	2.92	2.77	4.01	3.23	3.15	1.81
3-L	228/1A	1.88	4.78	3.89	3.79	3.43	4.72	4.36	4.16	2.21
6-R	240/3R	1.29	3.66	4.60	3.83	3.99	3.51	3.13	3.79	2.94
4-L	228/2L	0.4	0.83	0.93	0.66	0.56	1.41	1.29	0.95	2.38
5-L	227/1AL	4.43	4.05	2.62	6.54	5.73	7.80	6.50	5.54	1.25
6-L	227/1L	1.84	4.93	3.12	3.08	2.80	4.91	4.71	3.93	2.14
7-L	226/1L	1.44	4.37	1.90	2.38	2.48	2.24	2.11	2.58	1.79
8-L	226/2L	1.63	2.46	2.69	2.54	2.12	1.70	1.78	2.21	1.36
9-L	225/1L	1.54	3.34	2.37	2.09	1.98	4.83	3.38	3.00	1.95
7-R	239/3R	0.39	1.07	0.99	0.75	0.50	0.68	0.99	0.83	2.13
8-R	238/2R	1.27	1.02	1.61	1.69	1.65	1.66	1.43	1.51	1.19
9-R	238/1R	2.25	2.04	2.29	2.11	1.60	1.23	1.64	1.82	0.81
10-L	225/1AL	0.91	2.96	3.19	1.62	2.98	2.32	1.32	2.40	2.64
10-R	237/1R	2.26	0.78	1.84	1.97	1.57	1.87	2.84	1.81	0.80
11-L	225/2L	0.52	3.04	2.20	2.13	1.70	2.11	2.13	2.22	4.27
12-L	224/1L	0.58	1.12	1.25	2.73	2.54	1.23	1.75	1.77	3.05
11-R	236/1AR		0.86	1.60	1.32	1.14	1.64	3.08	1.61	
13-L	224/2L	1.53	2.45	3.90	4.24	2.50	3.15	6.68	3.82	2.50

Annex-6

Table 1. Field ground elevation at watercourses of Bareji Distributary.

W/C. No. [IWMI]	W/C.No. IPD	Field Ground Elevation	Water Surface Elevation
7-L	226/1L	49.59	50.35
8-L	226/2L	50.01	50.25
9-L	225/1L	51.15	51.64
8-R	238/2R	50.19	50.54
10-L	225/1AL	51.68	50.29
10-R	237/1R	50.51	50.05
11-L	225/2L	50.9	48.71
12-L	224/1L	49.05	48.33
11-R	236/1AR	48.28	48.89

Annex-7

Table 1. Design cross sections at different discharges for Bareji Distributary (existing bed slope).

Distance	Q=41 cusecs		Q=70 cusecs		Q=109 cusecs		Existing	
	Width (B), ft	Depth (D), ft	Width (B), ft	Depth (D), ft	Width (B), ft	Depth (D), ft	Width (B), ft	Depth (D), ft
0.00	11.59	2.60	16.19	2.95	19.90	3.30	14.00	4.63
5.00	11.40	2.30	15.45	2.65	18.56	3.00	16.00	4.23
10.00	10.0	2.10	13.25	2.45	17.95	2.60	12.00	3.66
15.00	9.74	1.65	10.02	2.20	14.00	2.30	8.00	3.79
20.00	8.48	1.63	8.82	2.15	12.87	2.20	6.00	4.00
25.00	7.05	1.60	8.18	2.00	12.47	2.00	4.00	4.37
30.00	4.72	1.10	4.93	1.45	9.26	1.30	7.00	4.46
35.00	4.14	0.90	4.61	1.15	6.48	1.20	4.00	4.46
39.31								

Table 2. Design cross sections at different discharges for Bareji Distributary (Slope LBOD).

Distance	Q=41 cusecs		Q=70 cusecs		Q=109 cusecs		Existing	
	Width (B), ft	Depth (D), ft	Width (B), ft	Depth (D), ft	Width (B), ft	Depth (D), ft	Width (B), ft	Depth (D), ft
0.00	14.61	2.30	18.45	2.75	22.32	3.10	14.00	4.63
5.00	12.94	2.15	17.21	2.50	21.76	2.75	16.00	4.23
10.00	11.51	1.95	14.91	2.30	19.28	2.50	12.00	3.66
15.00	10.31	1.60	12.00	2.00	14.00	2.30	8.00	3.79
20.00	9.84	1.50	11.74	1.85	12.78	2.20	6.00	4.00
25.00	9.08	1.40	11.15	1.70	12.47	2.00	4.00	4.37
30.00	3.97	1.20	5.29	1.40	9.26	1.30	7.00	4.46
35.00	3.36	1.00	4.23	1.20	6.48	1.20	4.00	4.46
39.31								

Annex-8

Table 1. Design of outlets on the basis of 41 cusecs discharge at head of the Bareji Distributary, Mirpurkhas (existing bed slope).

W/C	Q [cusec]	RD	Bed Level	Hu [ft]	Hs [ft]	Y [ft]	B [ft]	MMH	HL	Crest Level [ft]	Type
1L	2.01	0.50	52.33	1.54	0.77	0.77	0.41	0.58	1.54	53.25	APM
1R	0.70	0.50	52.22	1.54	0.77	0.77	0.14	0.58	1.54	53.25	APM
2R	0.72	1.75	52.22	1.50	0.75	0.75	0.15	0.56	1.50	52.96	APM
3R	2.32	4.90	51.96	1.38	0.69	0.69	0.55	0.52	1.38	52.21	APM
4R	1.89	4.90	51.29	1.38	0.69	0.69	0.45	0.52	1.38	52.21	APM
2L	2.26	5.70	51.25	1.37	0.69	0.69	0.55	0.51	1.37	52.17	APM
5R	1.74	6.70	51.23	1.36	0.68	0.68	0.43	0.51	1.36	52.13	APM
3L	1.88	11.50	50.81	1.18	0.59	0.59	0.57	0.44	1.18	51.60	APM
6R	1.29	11.50	50.81	1.18	0.59	0.59	0.39	0.44	1.18	51.60	APM
4L	0.40	12.10	50.68	1.15	0.57	0.57	0.13	0.43	1.15	51.44	APM
5L	4.43	12.10	50.68	1.15	0.57	0.57	1.40	0.43	1.15	51.44	APM
6L	1.84	13.10	50.46	1.09	0.55	0.55	0.62	0.41	1.09	51.19	APM
7L	1.44	14.00	50.26	1.04	0.52	0.52	0.52	0.39	1.04	50.96	APM
8L	1.63	17.30	49.70	0.98	0.49	0.49	0.65	0.37	0.98	50.36	APM
9L	1.54	20.00	49.30	0.98	0.49	0.49	0.62	0.37	0.98	49.95	APM
7R	0.39	22.90	48.79	0.97	0.48	0.48	0.16	0.36	0.97	49.43	APM
8R	1.27	25.10	48.41	0.95	0.48	0.48	0.53	0.36	0.95	49.05	APM
9R	2.25	25.10	48.41	0.95	0.48	0.48	0.94	0.36	0.95	49.05	APM
10L	0.91	25.40	48.38	1.40			0.19	0.28	1.40	48.54	OF
10R	2.26	29.20	48.00	1.06			0.71	0.21	1.06	48.12	OF
11L	0.52	30.30	47.87	0.98			0.19	0.20	0.98	47.98	OF
12L	0.58	33.50	47.30	0.86			0.25	0.17	0.86	47.40	OF
11R	0.70	36.00	46.77	0.81			0.33	0.16	0.81	46.86	OF
13L	1.53	39.31	45.86	0.81			0.72	0.16	0.81	45.95	OF

Table 2. Design of outlets on the basis of 70 cusecs discharge at head of the Bareji Distributary, Mirpurkhas (existing bed slope).

W/C	Q [cusec]	RD	Bed Level	Hu [ft]	Hs [ft]	Y [ft]	B [ft]	MMH	HL	Crest Level [ft]	Type
1L	3.47	0.50	52.22	1.75	0.88	0.88	0.58	0.66	1.75	53.39	APM
1R	1.21	0.50	52.22	1.75	0.88	0.88	0.20	0.66	1.75	53.39	APM
2R	1.24	1.75	51.96	1.71	0.85	0.85	0.22	0.64	1.71	53.10	APM
3R	4.00	4.90	51.29	1.59	0.80	0.80	0.77	0.60	1.59	52.35	APM
4R	3.26	4.90	51.29	1.59	0.80	0.80	0.63	0.60	1.59	52.35	APM
2L	3.90	5.70	51.25	1.58	0.79	0.79	0.76	0.59	1.58	52.31	APM
5R	3.00	6.70	51.23	1.57	0.78	0.78	0.59	0.59	1.57	52.27	APM
3L	3.24	11.50	50.81	1.43	0.71	0.71	0.74	0.53	1.43	51.76	APM
6R	2.23	11.50	50.81	1.43	0.71	0.71	0.51	0.53	1.43	51.76	APM
4L	0.69	12.10	50.68	1.41	0.70	0.70	0.16	0.53	1.41	51.62	APM
5L	7.65	12.10	50.68	1.41	0.70	0.70	1.78	0.53	1.41	51.62	APM
6L	3.18	13.10	50.46	1.38	0.69	0.69	0.76	0.52	1.38	51.38	APM
7L	2.49	14.00	50.26	1.35	0.68	0.68	0.61	0.51	1.35	51.16	APM
8L	2.81	17.30	49.70	1.31	0.65	0.65	0.73	0.49	1.31	50.57	APM
9L	2.66	20.00	49.30	1.29	0.65	0.65	0.70	0.48	1.29	50.16	APM
7R	0.67	22.90	48.79	1.24	0.62	0.62	0.19	0.46	1.24	49.61	APM
8R	2.19	25.10	48.41	1.19	0.60	0.60	0.65	0.45	1.19	49.21	APM
9R	3.88	25.10	48.41	1.19	0.60	0.60	1.15	0.45	1.19	49.21	OF
10L	1.57	25.40	48.38	1.76			0.23	0.35	1.76	48.58	OF
10R	3.90	29.20	48.00	1.38			0.83	0.28	1.38	48.15	OF
11L	0.90	30.30	47.87	1.29			0.21	0.26	1.29	48.01	OF
12L	1.00	33.50	47.30	1.12			0.29	0.22	1.12	47.43	OF
11R	1.21	36.00	46.77	0.99			0.42	0.20	0.99	46.88	OF
13L	2.64	39.31	45.86	0.90			1.07	0.18	0.90	45.96	OF

Table 3. Design of outlets on the basis of 41 cusecs discharge at head of the Bareji Distributary, Mirpurkhas (LBOD bed slope).

W/C	Q [cusec]	RD	Bed Level	Hu [ft]	Hs [ft]	Y [ft]	B [ft]	MMH	HL	Crest Level [ft]	Type
1L	2.01	0.50	54.11	1.37	0.69	0.69	0.49	0.51	1.37	55.02	APM
1R	0.70	0.50	54.11	1.37	0.69	0.69	0.17	0.51	1.37	55.02	APM
2R	0.72	1.75	53.89	1.35	0.67	0.67	0.18	0.51	1.35	54.79	APM
3R	2.32	4.90	53.36	1.29	0.65	0.65	0.61	0.48	1.29	54.22	APM
4R	1.89	4.90	53.36	1.29	0.65	0.65	0.50	0.48	1.29	54.22	APM
2L	2.26	5.70	53.22	1.28	0.64	0.64	0.60	0.48	1.28	54.08	APM
5R	1.74	6.70	53.05	1.27	0.63	0.63	0.47	0.48	1.27	53.90	APM
3L	1.88	11.50	51.76	1.11	0.55	0.55	0.63	0.42	1.11	52.49	APM
6R	1.29	11.50	51.76	1.11	0.55	0.55	0.43	0.42	1.11	52.49	APM
4L	0.40	12.10	51.46	1.08	0.54	0.54	0.14	0.41	1.08	52.18	APM
5L	4.43	12.10	51.46	1.08	0.54	0.54	1.53	0.41	1.08	52.18	APM
6L	1.84	13.10	50.97	1.04	0.52	0.52	0.67	0.39	1.04	51.66	APM
7L	1.44	14.00	50.53	1.00	0.50	0.50	0.56	0.38	1.00	51.20	APM
8L	1.63	17.30	49.70	0.93	0.47	0.47	0.70	0.35	0.93	50.32	APM
9L	1.54	20.00	49.30	0.90	0.45	0.45	0.70	0.34	0.90	49.90	APM
7R	0.39	22.90	48.79	0.87	0.43	0.43	0.19	0.32	0.87	49.37	APM
8R	1.27	25.10	48.41	0.84	0.42	0.42	0.64	0.31	0.84	48.79	APM
9R	2.25	25.10	48.41	0.84	0.42	0.42	1.14	0.31	0.84	48.79	APM
10L	0.91	25.40	48.38	1.25			0.23	0.25	1.25	48.52	OF
10R	2.26	29.20	48.00	1.11			0.67	0.22	1.11	48.12	OF
11L	0.52	30.30	47.87	1.07			0.16	0.21	1.07	47.99	OF
12L	0.58	33.50	47.30	0.95			0.21	0.19	0.95	47.41	OF
11R	0.70	36.00	46.77	0.90			0.28	0.18	0.90	46.87	OF
13L	1.53	39.31	45.86	0.90			0.62	0.18	0.90	45.96	OF

Table 4. Design of outlets on the basis of 70 cusecs discharge at head of the Bareji Distributary, Mirpurkhas (LBOD bed slope).

W/C	Q [cusec]	RD	Bed Level	Hu [ft]	Hs [ft]	Y [ft]	B [ft]	MMH	HL	Crest Level [ft]	Type
1L	3.47	0.50	54.11	1.64	0.82	0.82	0.64	0.61	1.64	55.20	APM
1R	1.21	0.50	54.11	1.64	0.82	0.82	0.22	0.61	1.64	55.20	APM
2R	1.24	1.75	53.89	1.60	0.80	0.80	0.24	0.60	1.60	54.96	APM
3R	4.00	4.90	53.36	1.50	0.75	0.75	0.84	0.56	1.50	54.36	APM
4R	3.26	4.90	53.36	1.50	0.75	0.75	0.69	0.56	1.50	54.36	APM
2L	3.90	5.70	53.22	1.49	0.75	0.75	0.83	0.56	1.49	54.22	APM
5R	3.00	6.70	53.05	1.48	0.74	0.74	0.65	0.55	1.48	54.04	APM
3L	3.24	11.50	51.76	1.33	0.66	0.66	0.82	0.50	1.33	52.64	APM
6R	2.23	11.50	51.76	1.33	0.66	0.66	0.56	0.50	1.33	52.64	APM
4L	0.69	12.10	51.46	1.30	0.65	0.65	0.18	0.49	1.30	52.33	APM
5L	7.65	12.10	51.46	1.30	0.65	0.65	1.99	0.49	1.30	52.33	APM
6L	3.18	13.10	50.97	1.27	0.63	0.63	0.86	0.48	1.27	51.82	APM
7L	2.49	14.00	50.53	1.24	0.62	0.62	0.70	0.46	1.24	51.35	APM
8L	2.81	17.30	49.70	1.16	0.58	0.58	0.87	0.43	1.16	50.47	APM
9L	2.66	20.00	49.30	1.11	0.56	0.56	0.88	0.42	1.11	50.04	APM
7R	0.67	22.90	48.79	1.06	0.53	0.53	0.24	0.40	1.06	49.49	APM
8R	2.19	25.10	48.41	1.02	0.51	0.51	0.83	0.38	1.02	49.09	APM
9R	3.88	25.10	48.41	1.02	0.51	0.51	1.47	0.38	1.02	49.09	APM
10L	1.57	25.40	48.38	1.51			0.29	0.30	1.51	48.55	OF
10R	3.90	29.20	48.00	1.30			0.90	0.26	1.30	48.14	OF
11L	0.90	30.30	47.87	1.25			0.22	0.25	1.25	48.01	OF
12L	1.00	33.50	47.30	1.13			0.29	0.23	1.13	47.43	OF
11R	1.21	36.00	46.77	0.99			0.42	0.20	0.99	46.88	OF
13L	2.64	39.31	45.86	0.90			1.07	0.18	0.90	45.96	OF

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