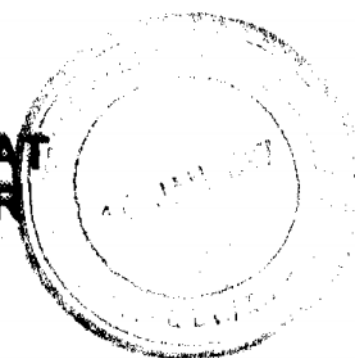


**MANAGING IRRIGATION FOR
ENVIRONMENTALLY SUSTAINABLE AGRICULTURE
IN PAKISTAN**

DECISION SUPPORT SYSTEMS - SINDH

**OPERATIONAL MANAGEMENT AT
THE MAIN SYSTEM LEVEL FOR
MIRPURKHAS SUB-DIVISION
JAMRAO CANAL DIVISION
MIRPURKHAS, SINDH**



INCEPTION REPORT

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INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE**

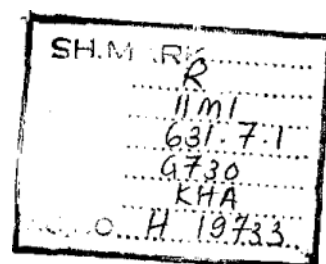


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INTRODUCTION

BACKGROUND

Pakistan is basically an agricultural country where about 80 percent of the population depends on agriculture. Irrigation has been practiced for centuries in this part of the world, either by constructing inundation canals which drew water during the flood season in the rivers, artisan wells or shallow wells. With the advent of modern technology, perennial canals were constructed to ensure irrigation water supplies. These canals are now supplemented by tubewells as well. These tubewells have either been installed by the government as a part of the Salinity Control and Reclamation Project (SCARP) or by the farming community itself in order to increase agricultural production. About 40 percent of the total irrigation water is estimated to be provided by tubewells in the Punjab which in several cases lift marginal quality water.

In order to assess and to suggest measures for minimizing the environmental impacts associated with irrigation operations, a five year research project was undertaken by the International Irrigation Management Institute (IIMI), Pakistan in Punjab. The same project was initiated in Sindh as well but could not be continued due to law and order problems. The findings of the project have enhanced awareness among the responsible institutions and have defined a number of management interventions to mitigate the problems of waterlogging and salinity. To see whether irrigated agriculture can be sustained without any further damage to the environment, another research project (phase II of the previous project) has been undertaken with financial support from the Government of The Netherlands. The project is entitled "Managing Irrigation for Environmentally Sustainable Agriculture in Pakistan".

The overall objectives of the project are:

- to expand the institutional capacity to effectively manage the solutions;
- * to maximize the role of farmers and rural communities in irrigation management for increasing agricultural production; and
- to develop and implement a set of improved management strategies and techniques which can reduce the aggravating effects of irrigation on waterlogging and salinity

This project has been divided into the following three broad components

1. Operational Management;
2. Institutional Development; and
3. Salinity Management

This report is concerned with the first component (i.e. Operational Management) of the project. This component is divided into two subcomponents:

- (i) operational management at the main system level; and
- (ii) operational ,management at the watercourse level.

Operational management at the main system level is being implemented in the Fordwah Eastern Sadiqia Irrigation System in Punjab and the Jamrao Irrigation System in Sind in collaboration with the respective Provincial Department of Irrigation and Power. The location of the Fordwah Eastern Sadiqia Irrigation System and the Jamrao Irrigation System is shown in Figure 1.

The focus of activities to be undertaken during this study in Sind will be management issues at the main system level in Mirpurkhas Sub-division of the Jamrao Irrigation Division, later, this research will be extended to other subdivisions in the Jamrao Irrigation Division. The research activities under this subcomponent will try to bring about improvements in main system management through the introduction of Decision Support Systems (DSS) developed by the collaborative efforts of CEMAGREF (French national research organization for agriculture, water and forests) and IIMI.

DECISION SUPPORT SYSTEMS

Decision Support Systems (DSS) can be defined as a "set of tools and procedures which, if properly used by the management of a particular system, would enhance the quality of decision-making processes in that system." These tools and procedures facilitate the decision-making of irrigation managers so that they can accomplish the water management tasks that are required to be achieved. CEMAGREF and IIMI have developed, adapted and demonstrated practical application of decision support technology. This provides a more comprehensive understanding of overall conditions and provide support in making management decisions in a more systematic and coordinated way. This computer-based tool, if properly used, with appropriate, reliable and timely data allows an accurate assessment of existing operational conditions of the irrigation system. This also allows managers to make an accurate prediction of the likely consequences of different alternatives.

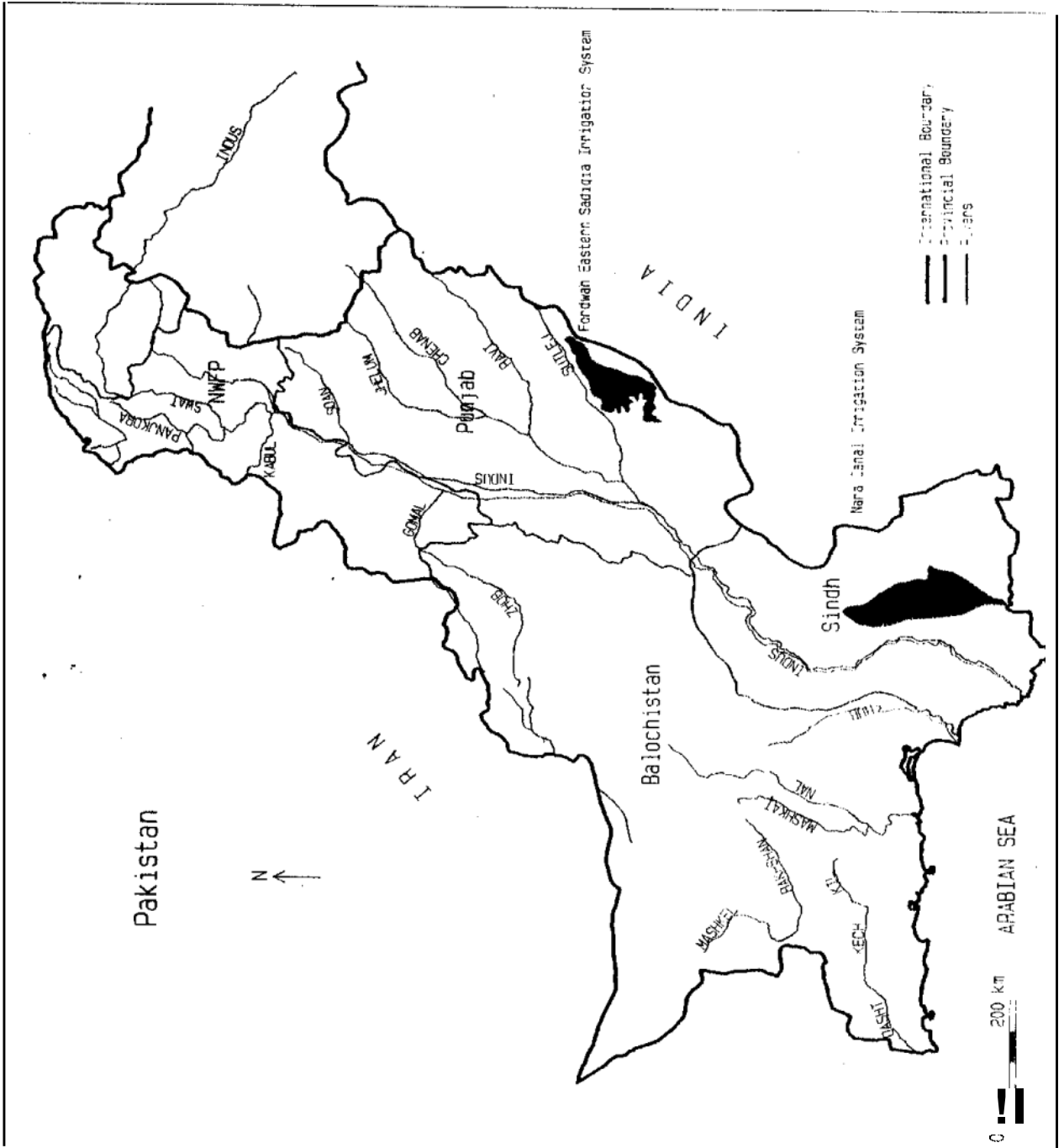


Figure 1: Fordwan Eastern Sadiqia and Nara Canal Systems

Normally, flow data collected in each of the irrigation canal command areas is recorded periodically throughout the day and reported on daily basis. However, the lack of proper procedures to analyze and evaluate this information leads to less than optimal operating conditions in these canal systems. Sometimes, solutions are sought by rehabilitating or modernizing the structures, or in transferring operational responsibilities to the users. Some managers prefer to introduce DSS to enhance management capabilities. These various options have been tried in isolation, or in combination, with more or less success in many irrigation systems. The introduction of DSS alone, or when combined with other management interventions, potentially addresses operating problems in a more comprehensive and efficient way.

There is general acceptance that at least main system level data are required on a daily basis for the proper management of water in an irrigation system. As a decision maker, the irrigation manager wants to make timely appropriate judgements based on available information. Typically, they collect data, store these data in registers, and perform a limited number of computations manually. Processing these data on a daily basis is a tedious job and an irrigation manager would rarely perform this task unless provided with proper facilities for this purpose. This important data quickly becomes useless if it can be retrieved and analyzed quickly.

IRRIGATION MANAGEMENT INFORMATION SYSTEM (IMIS)

IMIS is a simple and flexible computer-based decision support system which assists the irrigation manager in the process of managing the main canal via facilitating the entering of daily data, discharge computations and verification, easy storage and retrieval of data, and the performance evaluation of the system.

IMIS has been developed and adapted by CEMAGREF and IIMI in different irrigation environments since 1991. This technology was introduced in the Kirindi Oya Irrigation System of Sri Lanka where it was tested in collaboration with the Irrigation Department (ID). The introduction of IMIS was welcomed by the ID Sri Lanka who accepted it as a useful and powerful decision support tool and expanded its use to several other irrigation systems. An example in Pakistan is the Fordwah Eastern Sadiqia Irrigation System, Punjab, where IMIS is being implemented.

Main Features of IMIS

The principal characteristics of **IMIS** are:

Simple and flexible decision support tool;
Database mainly consists of permanent and dynamic data;
User friendly with a menu driven system computer software;
Easy way of daily data entering and processing;
Computes the results as indicators (hydraulic performance);
Can view system-wide water distribution; and
dBASE III modular programming approach that facilitates users developing their own programs & then adding them to the main program.

Data Rewired to Operate IMIS

Two types of data are required to run the **IMIS** computer software: (1) permanent or semi-permanent; and (2) dynamic. Permanent data is needed only once (unless there is any physical change in the irrigation system) at the time of developing **IMIS** for a particular system, while the dynamic data is required on a daily basis. Typical informations contained in each type of data set are listed below.

1. Permanent or semi-permanent data

hydraulic structures dimensions
crest elevations of flow control structures
design discharge
culturable command area
upstream gauge zero elevation
downstream gauge zero elevation
discharge rating for each hydraulic flow control structure

2. Dynamic data

daily upstream and downstream gauge readings and gate openings

Chapter 2

NARA CANAL

GENERAL DESCRIPTION

The Eastern Nara, which is a part of an old River, was an inundation canal with its source of supply from the foot of the Punjab hills. After traversing Bahawalpur, it used to enter into the present Nara Canal a few miles downstream of its present head. In those days, the Indus River used to overflow in Bahawalpur and Sind Province above Rohri and the spillovers used to enter the Nara River. Bunds were constructed by the Bahawalpur state authorities to protect their lands against floods and spillovers, which reduced the flood intensities into the Nara River. Similarly, due to low flows in the Indus River in certain years, the Nara River did not get much water. Therefore, the Nara supply channel was excavated in 1858-59 to directly supply water from the Indus River. The supply channel was excavated by 2.5 feet in 1884-85 and by a further 3.5 feet in 1893.

The Sukkur Barrage, completed in 1932, serves to maintain water levels in the Indus River in order to permit irrigation flows to be diverted into a total of seven canals off-taking on both sides of the barrage. Nara Canal is the largest of the off-taking canals, and is located on the left bank furthest upstream from the barrage. With the completion of the barrage, the new Nara Canal Head Regulator was connected to the existing channel by a new head reach canal some 8 miles long. Figure 2 shows the location of Nara Canal and the boundary of the Jamrao Canal command area. The new head reach canal had the following design section:

Bed Width	346 feet
Full supply depth	11.5 feet
Design slope	1 in 13000
Mean velocity	3.3 ft/sec

Most of the 8 mile reach was excavated entirely in cut, while much of the downstream channel was left untouched. A number of meander loops were cut off to straighten the old river channel, thus reducing its length and steepening the natural gradient. The Nara Canal has no cross regulator in a length of 109 miles from the head regulator to the Jamrao Weir, but there are a number of road and rail bridges crossing over the canal.

The Nara Canal Head Regulator is comprised of 16 gated bays, each 25 feet wide, which feeds the four important canal systems listed in Table 1.

Table 1. Canals being supplied water from the Nara Canal.

Name of Canal	Location of Head regulator on Nara Canal (miles)	Q (cfs)	Year of construction
Jamrao	115	3400	1900
Mithrao	145	2024	1879
Khipro	145	1401	1891
Thar	221	3100	1867

The 1932 designs had no provision for direct irrigation diversions offtaking from Nara Canal upstream of Jamrao Canal Head Regulator with the exception of the Patni Distributary. However, in recent years, electric/diesel pump stations have been established along the canal for irrigation purposes. Most of the pumps are private of about one, or less than one, cusec capacity, while the 26 public pump stations are abstracting about 370 cusecs directly from the canal. At present, the overall withdrawal along the Nara Canal is estimated to be on the order of 1000 cusecs as compared to about 600 cusecs at the time of project preparation.

NARA CANAL BED RETROGRESSION

Since the Nara Canal was commissioned in 1932, there has been a continual process of bed retrogression in the upper reaches and sediment deposition in the lower reaches. As a result, a large 40 feet deep scour hole has formed downstream of the head regulator. Similarly, large scour holes have also developed downstream of the bridge structures (ACOP Survey 1985-87). Another important feature of the Nara Canal is the seasonal change in bed levels. Surveys of the canal sections carried out in 1985 (February-December) indicate substantial deposition of sediment during the flood/high flow season (April to September), while degradation occurs during the low flow periods. Normally, the degradation process exceeds the aggradation, and as a result the off-taking channels (especially the Jamrao Canal) receives heavy sediment concentrations. This process has been going on for more than sixty years now and has become a threat to the integrity of the structures

Remedial measures, like dumping stones at the scour holes and constructing brushwood groynes, have been undertaken from time-to-time but their effectiveness has been quite limited. The idea of providing falls at suitable locations along the canal has also been floated several times in order to reduce flow velocities and consequently the bed retrogression.

This idea is going to be materialized under the LBOD Stage-I Project where provision has been made for the remodelling of Nara Canal. Under this Project, two fall structures will be provided at RDs 25 and 135. Simultaneously, with the construction of these falls, improvements to the embankments, where necessary, will also be provided in order to provide stability for increasing the flows to 20,000 cusecs. The increased supplies will be used for two purposes

- i) to bring more area under cultivation, and
- ii) to store the surplus supplies in Chotiari Reservoir for irrigation in the Lower Nara Canal command area during deficient water supply periods.

The Chotiari reservoir, having a live storage of 0.80 million acre-feet (maf) is under construction and will be filled in 3 to 4 years time (probably upto the year 2001) depending upon the availability of water supplies from Nara. Ranto Canal will be used for filling the reservoir.

Chapter 3

JAMRAO CANAL

GENERAL DESCRIPTION

The Jamrao Canal was proposed in 1867 for the first time and the survey work was finally sanctioned in 1872, which was completed in two years. However, the construction of the Canal was put in abeyance due to the following objections raised by Generals Fife and **Marriman** in February 1874:

1. The large volume of water to be withdrawn from the Indus River may affect the rest of the Sindh Province; and
2. Doubts were raised as to the profitability of the Project;

The project was again reconsidered in November 1891 after the recommendations of the Sindh **Irrigation** Committee appointed by the Government of Bombay. The project was finally sanctioned and the construction work started in November 1894. Figure 3 shows the Jamrao Canal command area, major **offtakes** and the boundaries of the irrigation sub-divisions.

As originally designed and sanctioned, the Jamrao Canal bed width was 125 feet and the full supply depth was 8 feet to carry a flow of 3,200 cusecs with a mean velocity of 3.1 feet per second . There was a depression from Mile 10 to 13; therefore, an 8-foot fall was introduced at Mile 7.5 in order to keep the canal banks in cut (rather than fill) in this depression. The bed width was reduced **to** 104 feet below the fall. The upper part of the canal was excavated in pure sand where a bed slope of 1 in 5000 was provided.

As soon as the canal was opened and the full water supply level achieved, the surface velocity was recorded to be 4 feet per second due to which the canal banks began **to** scour in the upper reach. The banks were allowed to scour till the water surface width of 200 feet was reached . To limit the top water surface width to 200 feet, brushwood groynes were installed 50 feet apart along the banks. The huge scouring in the upper 7 miles filled the depression below the fall due **to** which the canal bed above and below the fall came to the same level. Then the canal banks from Mile 9.5 to Mile 12.5 were raised by 3.5 feet.

Mr. Gibbie (XEN Jamrao Canal 1904) has written a note which says that "if a proper survey of the area **to** be irrigated had been carried out beforehand, it is certain that the falls would have been omitted entirely. The minors would have been constructed on the best possible alignment and large villages and long watercourses would have been avoided."

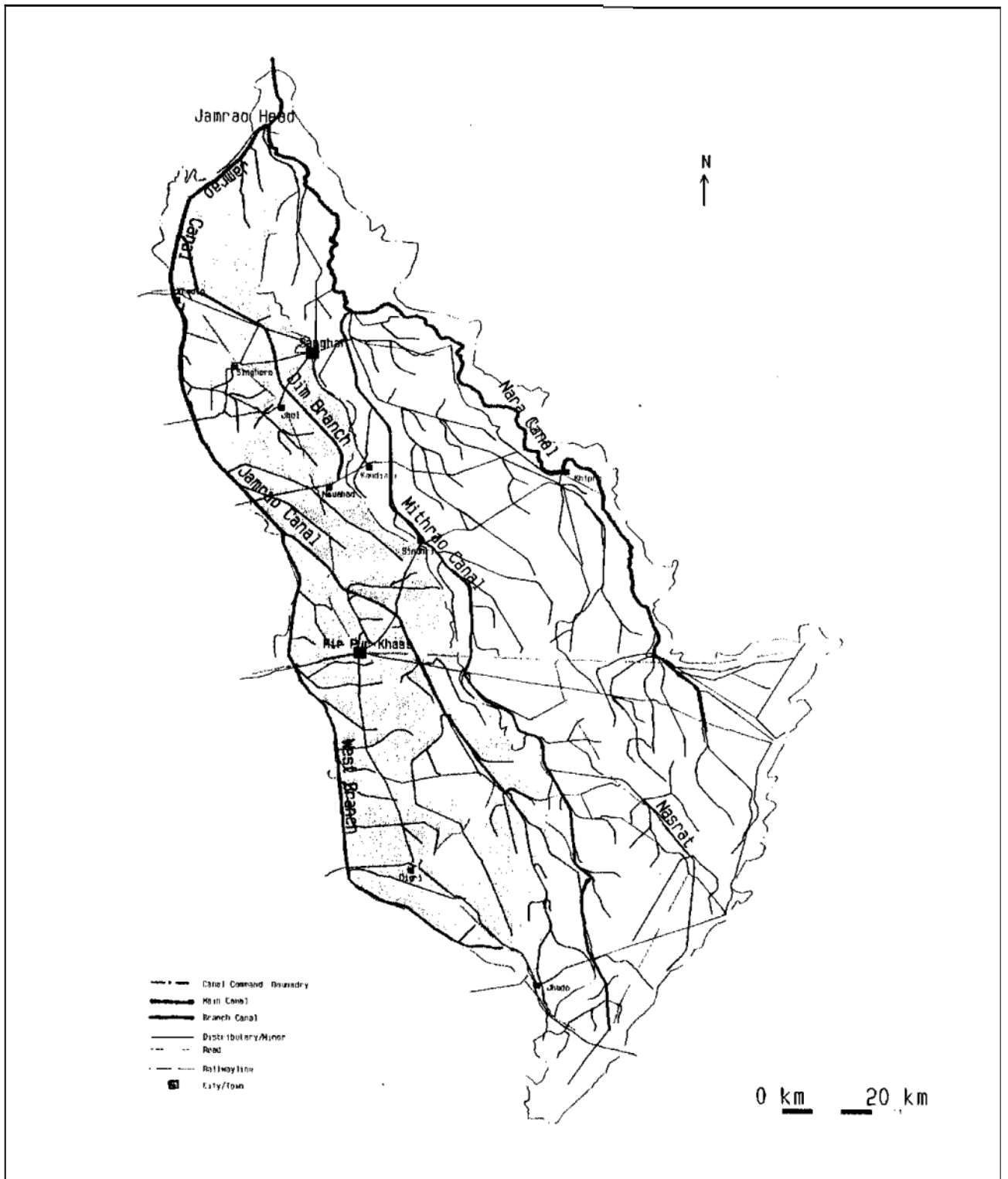


Figure 3: Jamrao Canal, its Offtaking Chennels

After the construction of Sukkur Barrage in 1932, the mode of regulation for Jamrao Canal was changed. Water supplies were considered to be a more reliable and dependable due to availability of adequate supplies from the Nara Canal. Rotational closure in the distribution system was considerably reduced and more areas brought under cultivation. The Shahu and Dim branches, which had been lift irrigation channels, were converted to gravity flow. To feed these two off-taking channels, water levels had to be raised in the main canal by ponding between two cross regulators, which resulted in heavy sedimentation and a rise in the bed level. A silting tank, which had its entry at Mile 1 and exit at Mile 6, was constructed in 1947 which absorbed sufficient sediment but could not improve the performance of the canal. Another silting tank was constructed in 1949, but with the same results.

The total culturable command area (CCA) of Jamrao Canal in 1932 was 8.6 lakh acres out of which approximately 34,000 acres have been transferred to Mithrao Canal. However, some new area of about 63,000 acres has been brought under the Jamrao command for which two minors (Sadrat 1 and 2) have been sanctioned. Similarly, an area of 14,000 acres from the tails of the Rohri Canal system have also been transferred to the Jamrao system. At present, the total CCA is about 8,92,000 acres. The length of the main canal is 124 miles, while the network of distributaries and minors is 426 miles in length. From the management point of view, the Jamrao Canal and its distribution system has been divided into five sub-divisions as shown in Figure

3. These sub-divisions are:

1. Khadro Sub-division (from RD 0 to 163);
2. Jhol Sub-division (from RD 163 to 291);
3. Mirpurkhas Sub-division (from RD 291 to 448 of Jamrao and RD 0 to 143 of West Branch);
4. Kot Ghulam Muhammad Sub-division (from RD 448 to 602 of Jamrao Canal); and
5. Digri Sub-division (RD 143 to 303 of West Branch)

REMODELLING AND TWINNING OF JAMRAO CANAL

The existing Jamrao Canal did not have sufficient capacity for the proposed increased flows resulting from the remodelling of Nara Canal, which will be approximately 50 to 60 percent higher than the current flows. Therefore, it was essential to either enlarge the existing channel or construct a new parallel channel to convey the proposed

increased water supplies. Enlarging the existing canal would require an approximate increase in the water surface with of 25 percent (typically from 150 to 190 feet) which would be difficult to achieve both in terms of earthwork and remodelling of existing structures, but would also cause disruption to water supplies for some time. Increasing the capacity by lining the existing sections would also involve long closures, which would not be desirable. So, twinning, or constructing a new unlined parallel canal along the existing Jamrao Canal alignment was preferred

Initially, it was considered that the new canal would be constructed along the right side of Jamrao Canal, thus commanding the area on the right bank, with the existing Jamrao Canal irrigating the left bank. This arrangement, however, could not be adopted for two reasons;

- i) the water requirements of the right bank command area are estimated to be 1700 cusecs, while that of the left bank command are about 3,500 cusecs, almost double of the right bank which will cause problems in the layout of the vortex tube silt excluder.
- ii) the Mirpurkhas/Kot Ghulam Muhammad railway line runs adjacent to the right bank of Jamrao Canal downstream of RD 408, thereby precluding twinning of the right bank over this section.

Therefore, it was decided that the new parallel canal would be constructed along the right side of the existing Jamrao Canal from the head to RD 291.4 and on the left side from RD 291.4 to **RD 442.6**, which is the limit of the remodelled area. The construction of Twin Jamrao Canal and the remodelling of the existing Jamrao Canal was been completed in June 1994, but the Twin Jamrao Canal cannot be put into operation as long as the remodelling of the Nara Canal is not completed so that the increased flows could be provided.

SEDIMENTATION IN JAMRAO CANAL

The Jamrao Canal has been faced with sedimentation problems from the day operations began. **As** soon as it reached the full supply level after its opening in 1901, the sides in the upper 7 miles started scouring until the top width was 200 feet instead of the designed 125 feet. The actual velocity was **4** feet per second instead of the designed 3.1 feet per second. **All** of the eroded material filled the depression between miles 9.5 and 12.5 to an extent that the fall provided upstream of the depression also disappeared due to sediment deposition. The effects were observed **upto** Mile 30. Continuous sediment-loaded flows from the parent Nara Canal went on causing a continual reduction in the design capacity of Jamrao Canal. This resulted in serious complaints about water shortages from users in 1905, just 4-5 years after its opening.

After the construction of Sukkur Barrage in 1932, sediment flows increased considerably due to scouring in the Nara Canal head reach. Two silting tanks were constructed in 1947 and 1949, respectively, in the head reach in order to provide sediment-free water downstream. Although the tanks trapped a substantial amount of sediment, they did not affect the performance of the canal very much. The Development and Research Division of the Irrigation Department carried out sediment studies in Jamrao Canal before and after the construction of Sukkur Barrage. The pre-barrage analyses show 1150 silt grains per cubic feet, while the post-barrage (1938) figures are 1857 grains per cubic feet (i.e nearly 61% more).

During 1947-48 the banks of Jamrao Canal from Miles 9 to 13 were raised and sediment clearance was conducted to provide a bed slope of 1 in 8333 . The canal operated satisfactorily for a short period of time, but steady sediment deposition resulted in the gradient becoming 1 in 5000. Banks were raised during 1969-70 so that the system could be run at full supply discharge to meet shortage of water caused by sedimentation of the bed. Different proposals were framed from time-to-time regarding the remodelling and sediment problems, but effective measures were not taken until 1976 when two dredgers were employed in the head reach from RD 0 to 90 to work round the year for about 8 hours a day to flush out the incoming sediment. However, at present, the bed level of Jamrao Canal has risen by about 8 feet when compared with the original design. Some improvements regarding banks and structures were introduced during the implementation of the Irrigation System Rehabilitation Project (ISRIP) during the 1980s.

Sediment Exclusion and Settling Basin for Jamrao Canal

In order to prevent further aggradation of Jamrao Canal, facilities having a sediment trapping efficiency of 80 percent have been proposed to be provided at the head. Under the remodelling project of Jamrao Canal, two sets of vortex tubes will be provided at the heads of Jamrao as well as Twin Jamrao canals, which will extract some of the heavy sediment load. The water extracted from both the vortex tubes will be discharged into a low area on the right side of Twin Jamrao Canal, which would be bunded to form a settling basin of about 250 acres. The design of Twin Jamrao Canal allows for re-use of water extracted by the vortex tubes. Sediment free water will be allowed to enter this canal at the settling basin outlet regulator.

MIRPURKHAS SUB-DIVISION

Under the Left Bank Outfall Drain (LBOD) Stage-I project, IIMI is undertaking pilot studies to test the viability of farmer-managed irrigated agriculture at the distributary or minor level so that more efficient and equitable management of canal water and drainage facilities can be achieved. These three pilot sites are located in three districts: namely, Nawabshah, Sanghar and Mirpurkhas. The three pilot sites are located under the canal command areas of Rohri, Nara and Jamrao, respectively. Under the "Operational Management at Main System Level Sub-component" of the Dutch funded project, a Decision Support System (DSS) would be established upstream from each of the pilot areas. Initially, **Mirpurkhas** Sub-division of Jamrao Canal has been selected for this study, which would later on be extended to other pilot areas. The site selected is ideally suited for a DSS study from the operational management standpoint. The Jamrao System has been recently remodelled where all the gauges, rating tables and previous discharge calibrations have been disturbed and need to be redone. Because of the remodelling and the twinning process of the Jamrao Canal, the communication system has also been disturbed/demolished.

Mirpurkhas is the third sub-division of Jamrao Canal which comprises of the Jamrao Canal (from RD 291 to 443), West Branch (from RD 0 to 143) and their distribution system in the given reaches. Figure 4 shows the schematic layout of this sub-division.

JAMRAO CANAL (RD 291 TO 443)

The design discharge of Jamrao Canal below the West Branch Head Regulator at RD 291 is 1250 cusecs. However, sometimes the actual flows are higher than design flows during the peak demand period. The Jamrao Irrigation System has been remodelled, whereby improvements to cross regulator structures, embankments and off-takes have been provided. New staff gauges both upstream and downstream of the cross regulators and head regulators have been mounted. There are three cross regulators in this part of the Mirpurkhas Sub-division, including the upstream turnover regulator. The system below RD 443 to the tail (the Jhlori cross regulator and its upstream off-taking channels i.e. Dabco, Puran & Degan included) fall under the Kot Ghulam Muhammad Sub-division. The location of these regulators and the off-taking channels are given below in Table 2.

Figure 4: Proposed Nara Canal Control and Telecommunication System

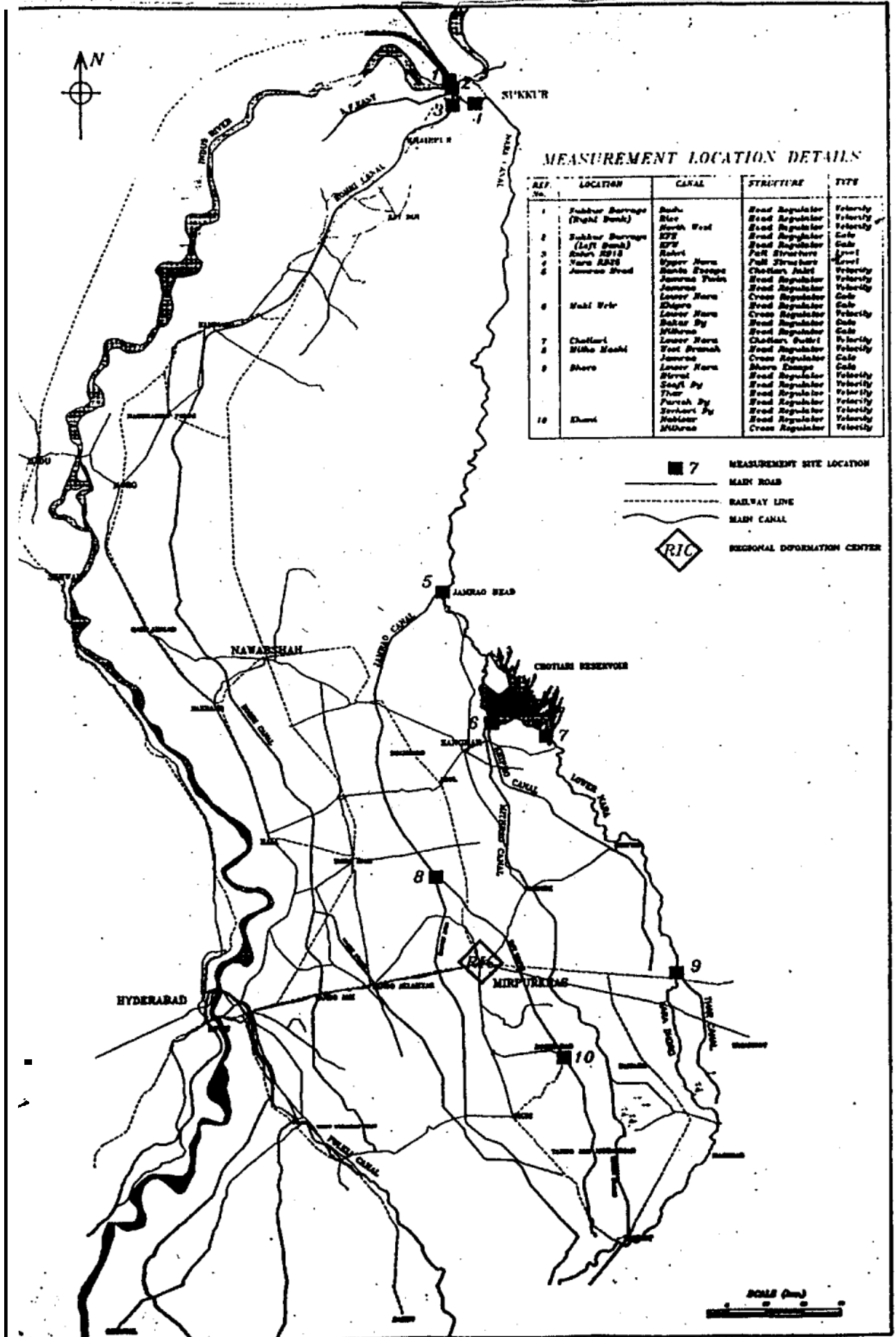


Table 2. Cross-regulators in Mirpurkhas Sub-division.

Name of Regulator	Location (RD)	No. of Gates	Gate Width (ft)	Off-taking channels
Mitho Mahci cross regulator	291	8	10	-
69-mile X-reg. (Mira Mori)	343	7	10	Mirpur, Doso Dharoro
78-mile X-reg.	408	5	10	Sanro, Bareji

There are two minors which are drawing directly from the main canal. These minors are:

1. Kahu Visro Minor diverting 32 cusecs at RD 383 on the right side; and
2. Kahu Minor diverting 34.4 cusecs at RD 389 on the left side.

Every cross regulator or head regulator has been provided with new gauges both upstream and downstream of each flow control structure. Although the gauges are new, most of them have become rusted or obliterated. The Mile 78 cross-regulator has been provided with a silt ejector below each gate. All of the radial gates for the cross regulators are manually operated with automatic circular scales for gate opening readings. Usually, all the gates are symmetrically operated by the tindal (gauge reader). In case that some of the gates have to be closed, then the side gates are closed first.

The old channel below the Mile 78 cross-regulator has been abandoned and replaced by a new channel constructed between RD 408 and 443 to improve water delivery. Wooden groynes on both sides of the new channel have been built in order to develop strong berms. At some points, trees have been cut and put in the canal to narrow the cross-section to avoid sediment deposition in certain reaches. Direct observations in 1996 have shown that a depth of about 2 to 4 feet of sediment has been carried away by the increased velocities.

During the peak demand period (May to July), the system is run above the full supply level and most of the offtakes extract more than their design discharge. Since the embankments were raised during remodelling, the system has enough capacity to carry surplus water supplies.

All the distributaries and minors taking-off from Jamrao Canal have been provided with proper gates at the head regulators, which facilitates proper regulation of the distribution system. During the remodelling of the system, additions have been made to the top of the outlet structures to allow increased flows because of the Nara Canal remodelling. However, no changes have been made in the sizes of these outlets. In all, there are 34 direct outlets (APM) in this part of the Mirpurkhas Sub-division. Because of the tampering that frequently occurs, the design parameters for most of the outlets have changed.

DISTRIBUTARIES AND MINORS OFF-TAKING FROM JAMRAO CANAL

There are four distributaries, two minors and thirty-four outlets drawing directly from the Jamrao Canal in this reach. Besides, there are four minors which are fed by the distributaries. During the remodelling of the system, new outlets have been constructed mostly in the head reaches of some distributaries/minors with higher crest levels. These are supposed to run when increased flows are available through the Twin Jamrao Canal. The main features regarding these channels are given Table 3.

Table 3. Distributaries and minors off-taking from Jamrao Canal.

S.NO	Name of Disty/Minor	Parent Channel	Off-take (RD)	Q (cus)	GCA (ac)	CCA (ac)
1	Mirpur Dy.	Jamrao	343	64	20965	20693
2	Mirpur Mr.	Mirpur Dy.	33	3.5	824	787
3	Piro Mr.	Mirpur Dy.				
4	Doso Dharoro Dy.	Jamrao	343	76.5	23574	22373
5	Old Doso Mr.	Doso Dharoro Dy.	30	5	1512	1467
6	Kahu Visro Mr.	Jamrao	383	18	58981	5838
7	Kahu Mr.	Jamrao	3851	44.51	151371	14984
8	Sanro Dy.	Jamrao	408	70	18349	18100
9	Sanro Mr.	Sanro Dy.	10	25	6486	6470
10	Bareji Dy.	Jamrao	408	65	27179	25409

Sometimes, the system is short of water supplies and a rotation schedule in the distribution system is implemented. However, the implementation is most of the times selective, both spatially as well as temporally.

Mirpur Distributary

This is the first distributary in the Mirpurkhas Sub-division taking-off from Jamrao Canal at RD 343 upstream of the Mile 69 cross regulator. The head regulator consists of three gates, which has been constructed during the remodelling of the main canal. Both the upstream and downstream gauges have been mounted on the head regulator structure, but are difficult to read due to rusting. The embankments and the cross section (in some reaches) of the ten-mile-long distributary have been improved in 1993/94 as a part of the remodelling project. New outlets having higher sill levels than the old ones were also constructed, specially in the head reach, to cater for increased flows after the Nara Canal remodelling. These outlets are supposed to replace the old ones; however, their operation seems difficult because the farmers would definitely prefer to have the existing outlets in order to have more water, or they may run both of the outlets simultaneously.

The distributary has almost a straight alignment with two cross regulators at RDs 15 and 33. Both the regulators are in good working condition. They have been provided in order to ensure sufficient water supplies to the two minors, Piro and Mirpur. All the outlets are APM type, except the tail cluster where open flumes have been provided. The tail cluster of four open flumes has recently been constructed, but have been tampered. Similarly, many other outlets have also been tampered or broken.

Mirpur Distributary has sufficient head to draw adequate supplies of water to serve its command area. Normally, the tail is operating. The tail reach frequently experiences sediment deposition which is periodically removed by the farmers themselves. The total or partial closure of outlets is also practiced whenever needed.

Piro Minor takes-off from Mirpur Distributary on the left side at RD 15 upstream of the first cross regulator. The head regulator structure is broken and water supplies have no hinderance to enter into the minor. There is heavy vegetation all along both sides of this minor which also has weak embankments. The minor has been poorly maintained and its banks are many times vulnerable to breaches and illegal cuts. In many cases, the outlets are broken and tampered with.

The staff gauges at the cross regulators are broken and need to be replaced. No record of these readings is maintained. At present, the traditional process of developing rating curves and tables in the Irrigation Department for control structures has also stopped. Therefore, the regulating structures of this distributary have not been calibrated after its improvement.

Doso Dharoro Distributary.

This distributary also takes-off from the Jamrao Canal at RD 343 on the left side in front of the Mirpur Distributary. The head regulator consists of three vertical gates which were constructed during the remodelling of the main canal in 1993/94 and has been provided with gauges both the upstream and the downstream sides. These gauges have become obliterated; however, approximate readings are collected daily.

The channel has a good cross-section throughout its length. Chances of overtopping and breaches are almost nil. The Old Doso Minor which is taking-off on the left side at RD 30 is fed through an open flume to supply 5 cusecs of water for 1467 acres. The condition of this minor is quite bad as compared with the distributary itself. Also, this minor has drawn little attention regarding its maintenance. There is thick vegetative growth on both sides which makes it difficult to conduct a survey or make any measurements.

Some of the new outlets in the head reach, which are supposed to be operated after increased water supplies are made available through the Twin Jamrao Canal, are running and the old ones have been abandoned. Some of the outlets are tampered. The On-Farm Water Management staff have done a considerable job in this area by lining a majority of the watercourses.

Kahu Visro Minor

This is a small minor taking-off directly from the main canal on the right side at RD 383 to serve an area of 5,838 acres through eight outlets. The one-gated head regulator, channel cross section and embankments have been improved as a part of the remodelling project. The new outlets have replaced the old ones as the bed level has risen due to sediment deposition to such an extent that operating the new outlets is preferred.

Water level information is gathered daily and sent to Mirpurkhas office through darogha. A direct telephone line has been provided for the transmission of Kahu Visro and Kahu Minors' data/messages but has not been in working order for sometime.

Kahu Minor.

This minor is taking-off at RD 385 on the left bank of Jamrao Canal through a head regulator having three vertical gates. The design discharge is 44.5 cusecs to cover a culturable command area of about 15,000 acres. Generally, the physical condition of the channel is good. Sediment clearance has been done in July 1996 with the help of a dragline which has dumped the sediment on the banks and the service road (inspection path) from where it is falling back into the minor. This sediment removal has improved the channel capacity for extra water supplies as well as allowing water to reach tail outlets.

A majority of the traditional APM or open flume type outlets are tampered or broken. A couple of them are completely dismantled, where temporary structures have been erected by the farmers according to their needs. Partial or total closure of outlets is also practiced by the farmers during rains or time periods when there is no demand for water.

Sanro Distributary

This distributary is taking-off from the Jamrao Canal on right side at RD 408 upstream of the Mile 78 cross regulator. The physical condition is not bad, however, at some points it is very poor. Banks and berms are weak; spillovers, leakages and breaches are expected to happen at full supply levels and during heavy rainfall periods. The trespassing and bathing by animals is one of the major causes for the miserable condition of this channel. Poor upkeep associated with the carelessness of farmers has added to the deteriorating performance of the system. The physical condition of the inspection path has also worsened due to jungle, vegetation and the excavated sediment piled on the banks.

New outlets have been provided in the head reach, but are inoperative at present. The outlets are APM, pipe or open flume types, where the majority have been interfered with.

The figures of the upstream and downstream gauges fixed at head regulator have become obliterated due to rusting; however, the approximated head data is collected daily and sent to Mirpurkhas by the Mile 78 cross regulator tindal through darogha. A direct telephone link provided at the Mile 78 cross regulator is used to inform the Sub-divisional Office about the water levels in the system. Whenever, the telephone line is out of order, the darogha for this section communicates the information to the concerned office himself.

Bareii Distributary

This is the last distributary of Mirpurkhas Sub-division emanating from Jamrao Canal at RD 408 on the left side. The head regulator comprises of three vertical gates which were constructed during the remodelling of the main canal in 1993/94. The regulator is in good working order and is working without having any problem. In general, the eight mile long distributary has a good channel prism which is free of weeds and has enough freeboard to accommodate extra water supplies. There are a few weak points caused by cattle trespassing where breaches may take place during high flows or rains. The removal of sediment deposits is carried out, specially in the tail reach, whenever required by the water users.

Water is supplied to the farms through APM or open flume type outlets to cover a culturable command area of 14,318 acres. The tail reach is in cutting where lift irrigation is also practiced. Lift pumps generate considerable fluctuations in the distributary water level, which affects the downstream command area. In many cases, the outlets are tampered or broken and extract excess supplies, which results in inadequate water at the tail during peak periods. However, during slack periods, when the upstream outlets are closed, the tail area is flooded.

The numbers on the gauges at the head can no longer be read, which requires repainting or replacement. Similarly, the regulator also needs to be calibrated for proper regulation of the system.

WEST BRANCH RD 0 TO 143

West Branch Canal is the largest off-take from Jamrao Canal having a design capacity of 900 cusecs which takes-off the main canal at **RD 291** on the right side to cover a culturable command area of 230,800 acres. Unlike the main Jamrao Canal, no significant change is observed in cross-section or any other hydraulic structure of this branch. However, the service road has been improved in some reaches and sediment removal was carried out during 1992.

The head regulator is comprised of three old gates which are most of the times completely open to allow maximum deliveries downstream. The downstream gauge has been fixed in a stilling well, but is incomplete and difficult to read. There is only one cross regulator at RD 38 along the 30-mile reach in Mirpurkhas Sub-division, which is called the Jhando Mari Cross Regulator. The upstream gauge at Jhando Mari cross-regulator is in two pieces of 8 and 2.5 feet, while there is no downstream gauge.

The channel has very thick vegetation on the banks, especially the right bank. An interesting feature of the West Branch Canal is that all the distributaries and minors in the Mirpurkhas Sub-division jurisdiction are off-taking from the left bank. The command area of *West* Branch Canal is seriously waterlogged and saline; therefore, domestic water needs are also dependent on canal water.

DISTRIBUTARIES AND MINORS OFF-TAKING FROM THE WEST BRANCH

The distribution system of the West Branch Canal consists of two distributaries, three minors and sixty-two outlets drawing water directly from the West Branch in this reach. Besides these, there are three minors or sub-minors which are fed by these channels. The major information regarding these channels is given in Table 4.

S.NO	Name of Disty/Minor	Parent Channel	Off-take (RD)	Q (cus)	GCA (ac)	CCA (ac)
1	Lakhakhi Disty	West Branch	38	64	17826	17723
2	Bhittaro Minor	West Branch	69	27	4628	4512
3	Sangro Disty	West Branch	88	105	30806	29029
4	Jarwari Minor	Sangro Dy.	10	24	7562	7178
5	Chahu Minor	Sangro Dy.	29	36	10278	9948
6	Daulatpur Minor	West Branch	115	49	13853	13556
7	Bellaro Minor	West Branch	143	42	13522	13244
8	Khumbri Sub-Minor	Bellaro Minor	18	10	2965	2808

The total number of outlets diverting water directly from the West Branch Canal in the reach from RD 0 to 143 is 62. Many of them have been broken or tampered with by the farmers. At a couple of locations in this branch, twin outlets have been constructed below the old ones in order to have more water. They are larger in size and would be able to draw more water because of increased head. The closure of outlets by water users is a common phenomenon on this canal. At several points sandbags, bushes and bricks have been observed near the outlets, which are used to close them either fully or partially whenever required.

The general physical condition of the channel from the West Branch Canal Head Regulator to the Jhando Mari Cross Regulator (RD 38) is poor. There is vegetation like a jungle on both sides; the service road is very bad at several places; and there are few bridges for crossing over to the other side.

Rotation in the distribution system is practiced whenever the need arises. The duration and frequency is dependent upon the season and the flow situation in the parent channel.

Lakhakhi Distributary

This is the first major off-take from the West Branch Canal which occurs on the left side. The head regulator consists of one gate which is located at RD 38 of West Branch, upstream of Jhando Mari Cross-Regulator. Although the physical condition of the head regulator is poor, it is working properly. Generally, the channel is in extremely bad condition with the exception of a couple of small reaches. At several locations

along the channel, the embankments are very weak, and the berms and the freeboard have also disappeared. Direct irrigation from the distributary without a proper outlet is possible due to weak banks. Heavy jungle has grown on both sides, especially the right side, which could provide protection to illegal cuts by the users. The command area is comparatively heavily populated, therefore, animals trespassing, specially buffaloes, are also contributing to the miserable condition of the channel.

Little attention has been paid to the maintenance of this distributary (maybe due to law and order problem in this area). At some locations, the jungle has encroached upon the service road while at other places, the culverts have collapsed and there is difficulty traveling along the channel. Similarly, sediment removed from the channel has been deposited on the banks, where it can again be transported into the channel, especially during the monsoon season.

The gauge in the main canal at Jhando Mari Cross Regulator is used to regulate flows into Lakhakhi distributary. Although the gauge is mounted in pieces, the experience of the gauge reader allows a good approximation of water levels both for the main canal as well as the distributary. There is no downstream gauge. The telecommunication system all along the West Branch Canal has been disrupted many years ago and has not been put back into operation so far. The collected information/messages are transmitted normally by the darogha himself.

Due to scouring in Nara Canal, the Jamrao Canal and its distribution system receives tons of sediment load every year. Lakhakhi distributary also gets its due share of sediment, which along other factors contributes to water shortages in the tail area.

Bhittaro Minor

The four-mile long Ehittaro minor is fed through a rectangular orifice on the left bank of the West Branch of Jamrao Canal. Excess flows are being diverted because of good working head and a modular flow condition. Similarly, the outlets are also overdrawing and that is why outlet closures by farmers are observed on this minor. The tail is normally operating full, but gets flooded when the upstream outlets are closed. Overall, the channel cross-section is good, with some vegetation near the head and the tail reaches.

Ehittaro Minor serves its command area through 9 outlets, out of which 7 are APM and 2 are open flumes. Extra supplies are available to farmers because most of them have been tampered. There is no gauge at any point from head to tail of this minor for proper regulation of irrigation water.

The command area is heavily saline and waterlogged, which will take sometime to get reclaimed due to drainage facilities being provided under the Left Bank Outfall Drain Stage-I Project.

Sangro Distributary

This is the third major off-take on the West Branch Canal. The supplies are managed through a two-gated head regulator at RD 88 of the West Branch Canal. The head regulator is working satisfactorily and always runs under a submerged flow condition.

The channel all along the length is in good working condition, sufficient freeboard and berms are available, except near the head, where excess flows will overtop the banks on both sides. Portions of the middle and tail reaches has been **desilted** recently. Jungle has grown on both sides of the distributary in the middle reach, which disrupts the inspection path at some points. The tail reach is heavily vegetated which causes sediment deposition that requires frequent clearance. The tail cluster has three open flume type outlets, which have been provided with gates, probably by farmers, a bit downstream of the head structure.

Sangro Distributary has two cross regulators, one at RD 10 and another at RD 29 where two minors, Jarwari and Chahu, are off-taking on the left and right banks, respectively. The head regulator of Jarwari Minor is functioning well, however, it is difficult to know the amount of flow being delivered to the minor as no mechanism is available on the spot to observe water levels at this location. Overall, the Jarwari Minor cross-section is good, except for small reaches near dwellings where animals are trespassing and other uses have damaged the embankments. Some points are vegetated, but the flow is not affected. The tail reach passes through a part of Mirpurkhas town where it supplies water with two outlets for drinking as well as other municipal purposes. The small reach having four outlets below the water supply schemes are usually short of water because it is not allowed to flow downstream as long as it is needed by the municipality.

The head regulator of Chahu Minor is in good working condition. The channel is almost free of vegetation, does not have weak points where breaches or leakages will occur, has enough freeboard and strong berms.

Like the rest of the Jamrao system, most of the outlets have lost their original size and shape due to farmers interference and lack of management. Similarly other hydraulic parameters have also been affected due to sedimentation and interventions by water users. The distributary head has a downstream gauge, while there is no gauge at any point all along the minor.

Daulatpur Minor

The Daulatpur Minor originates from the West Branch at RD 115 having a design flow capacity of **49 cusecs** to serve a culturable command area of 13,500 acres. The head regulator consists of two old gates which are working properly. Both the upstream and downstream gauges have been provided.

The physical condition of the channel is good, the cross section is in satisfactory condition, with the exception of some points near an abadi due to cattle trespassing. There is almost no vegetation which could disturb the flow but sediment has deposited in some reaches. Sediment removal has been carried out in the tail reach to improve water delivery to the tail outlets. The command area on both sides is saline and waterlogged. Ground water is extremely brackish and the people have to rely on canal water for all of their needs. The outlets are tampered. Usually the tail is receiving water.

Belaro Minor

This is the last minor of Mirpurkhas Sub-division off-taking from the West Branch at RD **143**. The head regulator comprises one gate which is leaking from the bottom as well as from the sides, even when it is closed. The cross section of the minor looks good but there are serious sedimentation problems. Sediment clearance is frequently conducted, but the tail still experiences water shortages. Another reason for tail shortage is the 'wider than design' section in this reach, where sediment deposits rapidly accrues due to low flow velocities. The tampering of outlets is a common practice here as well. The inspection path in the middle reach is in extremely bad condition due to jungle on the embankment and a couple of collapsed culverts, while that of the tail reach is quite good.

Chapter 6

OPERATION, DATA COLLECTION AND TRANSMISSION IN MIRPURKHAS SUB-DIVISION

Sukkur Barrage is the second to last barrage on the Indus River. Nara Canal and ultimately Jamrao Canal, can obtain surplus supplies as long as the channel capacity is not a constraint. The design discharge of Jamrao Canal at the head is 3,400 cusecs; however, it actually draws about 4,000 cusecs. The management tries to push as much water as possible to the main canal, as well as the distribution system. Sometimes, water spills over the berms during the peak demand period, but still farmers' thirst for water is not quenched and always they press for larger water supplies.

Usually, the **Mitho Machi** Cross Regulator is adjusted according to the requirements immediately upstream and that of the West Branch Canal. The operation of this cross regulator is quite infrequent as there is no other off-take just above this regulator which would necessitate its frequent operation, except the West Branch Canal Head Regulator. Cross regulators at RD 343 and 408 are regularly operated according to the requirements of the upstream off-taking channels. The operation of West Branch Head Regulator is guided by water levels in the main canal and the requirements of the distribution system. The West Branch Canal also has to provide the required supplies of Digri Sub-division at RD 143. The frequency of gate adjustments is not high as the system is usually run at full supply level. Similar is the case with the Jhando Mari Cross Regulator where it has to serve the Lakhakhi Distributary which is the only major off-take upstream.

Management of the distribution of water for irrigation is achieved by adjusting gates of the regulators. Gate adjustments are made on the basis of information received concerning water levels in the canals and on the basis of historic supply pattern. The beauty of the Jamrao Canal irrigation system is that all of the distributaries and minors have been provided with gated head regulators, which makes the operation and regulation quite easy. As a normal practice, all of the off-takes are operated at full supply discharge as long as permitted by the flow condition in the main canal. Otherwise, rotational closure is resorted to among the off-takes. However, the implementation of rotational schedule is a bit selective both spatially as well as temporally because of external influence.

The direct outlets are operated by the farmers themselves according to their needs. Because the majority of the outlets are tampered and higher than design head is available, the outlets are drawing more than their due share of water. Sandbags and **weeds/bushes** are used for (partial or total) plugging of the outlets when the demand is slack.

The primary objective of equitable water distribution to all offtakes can be achieved through constant monitoring and maintaining the flow records at each control point. As described earlier, the gauges are read daily and transmitted to Mirpurkhas through a telephone or darogha, usually once a day. Water levels at the Mitho Machi Cross Regulator and that at the West Branch Canal Head Regulator are transferred to Mirpurkhas through a public telephone in the morning. The radial gates have automatic circular scales for gate openings; however, these are not recorded. No record is maintained at site. Water levels at the Mile 69 cross regulator and its off-taking channels are recorded in the morning and sent to Mirpurkhas through a darogha. Staff gauge readings at the Mile 78 cross regulator and its off-taking channels are also communicated through a darogha. Although a telephone line has been provided at this structure, it remains inoperative most of the time.

Regulation and operation data at the head regulators of distributaries and minors is also gathered daily and transmitted to Mirpurkhas. Water level readings at the cross regulators are collected by the gauge reader of the respective regulator while the others are taken by (sub)darogha and communicated to the concerned office.

At present, the Jamrao Canal lacks the facilities for quick information transfer from the field to headquarters. With the exception of a couple of control structures where a telephone facility is available (direct line or through public call office), messages/information are transmitted manually to Mirpurkhas. The telephonic/telegraphic system of Jamrao Canal was destroyed during the remodelling of the channel and has not been replaced so far. Efforts are underway to build a modern telecommunication system along the Nara Canal irrigation system by the end of 1997, which will link all of the important control points and the sub-divisional headquarters directly.

The proposed Nara Canal Control and Telecommunication Project will provide automated base line flow data at key regulators from Sukkur Barrage throughout the Nara Command, including the Jamrao Canal. All of the data will be relayed through the network either automatically or manually to a Regional Information Center (RIC) to be located at Mirpurkhas. As shown in Figure 4, the Nara Canal Control and Telecommunication Project will consist of:

- (i) flow monitoring stations at 10 sites within the Nara Canal Command, involving the measurement of water levels, gate openings, and/or flow velocity using ultrasonic techniques;
- (ii) installation of a telecommunication network, based on VHF radios located at a total of 64 fixed sites and 28 mobile units, for the transmission of voice and data; and
- (iii) the installation of computer systems for the storage and analysis of data, linked via the radio system to the flow monitoring sites.

The Jamrao Canal irrigation system will be provided with flow velocity measuring transducers at different locations. At the Jamrao Canal head (RD 291), the ultrasonic transducer will be installed in the stilling well downstream of the head regulator. On Twin Jamrao Canal, the measurement site will be located downstream of the outlet from the settling basin. Two sites have been proposed for the ultrasonic transducers installation in the Mirpurkhas Sub-division jurisdictions. These sites are:

- (a) downstream of the West Branch Canal head regulator where flow disturbances caused by the head regulator have decreased to an acceptable level; and
- (b) two gate position transducers will be installed at **Mitho Machi Cross Regulator** of Jamrao Canal. One of them will be installed on the first or last gate and the other one on one of the middle gates. Water levels will also be measured both upstream and downstream of the regulator.

Currently, there is no direct link among the staff of control points all along the system. The only source of communication for transferring information from one point to another is darogha or other regulation staff, which is available during the working hours only. The operating staff is unable to quickly inform the downstream control point of any changes that are occurring in the system so as to enable him to plan adjustments according to the upstream situation or vice versa.

Although a lot of information is collected daily, no record is maintained in the field at any location. The field staff at the cross regulators have been provided with registers, but no entries are made in them.

Chapter 6

ISSUES

From the above study, it can be easily concluded that Mirpurkhas Sub-division is confronted with different types of issues. These issues are:

1. Sedimentation;
2. Operational Management;
3. Maintenance; and
4. Social.

1. SEDIMENTATION ISSUES

The most important problem in the Jamrao Canal irrigation system is sedimentation. The Jamrao Canal and its offtakes are faced with serious sedimentation problems from the day operations began in 1901. The embankments in the upper seven miles had eroded to such an extent that the top width was 200 feet instead of the designed 125 feet. The situation was further aggravated after the construction of Sukkur Barrage in 1932, when sediment loaded water was passed into Jamrao Canal due to scouring in the upper reach of Nara Canal.

Different remedial measures have been taken to control sediment deposition in the main canal and its distribution system, but have proved ineffective. The two sediment settling tanks constructed in the head reach in 1947-49 could not improve the performance of the system either. Similarly, two dredgers were provided in 1974-76 to remove sediment in the head reach (RD 0-90), but still the bed level has risen by about 8 feet due to sediment deposition. This has changed the hydraulics of the channel. Outlets are overdrawing water due to increased working head. Sediment removal from distributaries, minors and even watercourses have to be conducted frequently. In some cases, the off-takes are not drawing their fair share of sediment due to design flaws, which also affects other channels.

The proposed construction of two fall structures at RDs 25 and 135 on Nara Canal, and the provision of vortex tubes with settling basin at the head of Jamrao Canal under the Nara/Jamrao Canals Remodelling Project, may prove helpful. The construction of fall structures on Nara Canal will help in controlling the scouring of the channel bed, while the vortex tubes and the settling basin are supposed to trap considerable amounts of sediment at Jamrao Canal head.

2. OPERATIONAL MANAGEMENT ISSUES

The Mirpurkhas Sub-division of Jamrao Canal starts at the bifurcation of the main canal into Jamrao and West Branch canals at RD 291. The water supply is received from Jhol Sub-division and feeds Kot Ghulam Muhammad Sub-division at RD **443** of Jamrao Canal and Digri Sub-division at RD **143** of West Branch Canal. Knowing the water balance of the Mirpurkhas Sub-division is essential, both at the head (inflow) as well as tail (outflow). However, at present, it is quite difficult to have this information because none of the control points have been actually calibrated after the remodelling of Jamrao Canal. New gauges had been mounted at all the important structures, but have become obliterated, which makes it difficult to collect accurate water level data at cross regulators.

Although no structural changes were introduced into the West Branch Canal which would have necessitated their recalibration, but the old rating tables have not been revised either for a long time. The changes in bed and full supply levels affected by sediment deposition have necessitated re-establishment of these rating curves and tables.

At present, it **is** quite difficult to accurately estimate the water balance for Mirpurkhas Sub-division. Due to the construction of new cross regulators, the old discharge ratings have been rendered invalid. However, no field measurements have been carried out so far to establish new ratings according to the new benchmarks. The management does not know exactly how much is being received into the sub-division and how much **is** leaving.

For equitable distribution of water, it is necessary to know the amount of water drawn by each off-take along the canal. The newly constructed head regulators for distributaries and minors of Jamrao Canal are being operated to make sure that each off-take is running full without knowing whether it is drawing its due share, because the rating tables are not available. Similarly, a majority of the outlets have lost their original dimensions due to farmers interventions, so that they are overdrawing water most of the time.

A staff gauge is essential in the regulation of the irrigation systems of Pakistan, but the gauges in this sub-division have either become rusted or are nonexistent at all. Likewise, an efficient communication system to transmit important information and messages is also essential for an efficient irrigation system. The telephone line which was disrupted due to the construction/ remodelling activities has not been replaced so far. Other direct lines are also not working in many cases. The manual transfer of information is time consuming, arduous and uneconomical.

3. MAINTENANCE ISSUES

An irrigation system will not be able to carry its design discharges unless it is consistently maintained. The old cross regulators and head regulators along the Jamrao Canal in Mirpurkhas Sub-division have been replaced with new ones as a part of the Jamrao Canal Remodeeling Project during 1993-94, and presently have no serious repairs and maintenance problem so far. The head regulator of West Branch Canal has been poorly maintained and would not be able to meet the increased requirements of the system when larger water supplies are available from Nara Canal after its remodelling. Similarly, the head regulators of distributaries and minors on West Branch Canal are working satisfactorily, but their physical condition is poor, especially the head regulator of Bellaro Minor.

The main canals (Jamrao and West Branch) are not faced with any serious maintenance problems. Jamrao Canal is new and does not need any immediate maintenance, but the West Branch Canal has very thick vegetation, especially on the right bank. The distribution system has critical maintenance problems. Direct observations of the channel cross-sections and longitudinal sections reveal that the physical conditions are no longer close to design. The cross-sections of most of the channels have enlarged in many reaches and the embankments have severely eroded in several places throughout the length. Sediment deposition is common throughout the system and as a result, the full supply water levels are higher than designed in the upper reaches.

The tampered/broken outlet structures are the most critical issue in the distribution system of this sub-division, which deserves preferential treatment. Over-drawals (caused by tampering and sediment deposition) by these outlets in the upper reaches deprive the water users of their due share in the lower reaches during peak demand periods on the one hand, and flood them when the outlets are closed (partially or fully) during slack demand periods on the other hand.

Weak and poor banks throughout the distribution system are causing breaches, leakages and even illegal (direct) irrigation from the channels. Vegetation in the channel and on the banks, along with sediment deposition, contribute to the deteriorating performance of the system.

The condition of the service roads along the West Branch Canal and some of the distributaries is deplorable. In some cases (e.g. Lakhakhi Distributary), it is even difficult to travel along the channels to conduct surveys and take measurements due to the thick vegetation and poor maintenance. At some points, the desilted material has been dumped on the road.

4. SOCIAL ISSUES

Water users were considered to be managing irrigation water below the outlet. However, they seem to have taken over the outlets and to some extent the head regulators of the distributaries and minors as well. In most cases, the outlets are operated by the farmers themselves. Water is running when needed and closed (without informing the Irrigation Department) when they do not need water. The most serious aspect of this issue is the illegal alteration of outlets by water users. More than **50** percent of the outlets in Mirpurkhas Sub-division have been interfered with by farmers to alter them according to their requirements.

Frequent transfers of managers are also affecting the performance of the system. Whenever an engineer starts to understand and control the system, he is transferred. The newcomer takes his own time to know and control the system. Political and individual influence and pressure is another important factor that contributes to the poor performance of the irrigation system.

Decisions are made at the highest level without consulting the field staff, who are the most knowledgeable people about the problems of a system. This top-down approach does not help much in solving the problems. Similarly, few opportunities are available to the operation and maintenance staff for equipping them with the state-of-the-art technology that could improve the performance of their system.

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OUTLETS RECORD

CANAL
OFF-TAKES

= JAMRAO
= DIRECT OUTLETS

S.NO	O/L NO	RD	Outlet Data						Remarks
			GCA(ac)	CCA(ac)	Type	B(ft)	Y(ft)	Q(Cusec)	
1	82/4AL	308.0	195	195	APM	0.20	0.20	0.55	
2	81A/4	312.0	491	473	APM	0.20	0.42	1.32	
3	92/1A	315.0	508	506	APM	0.25	0.32	1.42	
4	798/2L	323.0	1702	1696	APM	0.32	0.96	4.77	
5	78/1L	322.4	3468	3069	APM	1.00	0.99	8.61	
6	121/1L	327.0	506	505	APM	0.20	0.60	1.43	
7	92/3A	332.0	1856	1854	APM	0.63	1.20	5.25	
8	121/1AL	332.0	277	277	APM	0.20	0.28	0.78	
9	121/2L	333.0	2609	2517	APM	0.50	0.80	6.00	
10	121/2HL	338.5	250	250	APM	0.20	0.22	0.67	
11	92/2P	341.0	1528	1526	APM	0.25	1.22	4.31	
12	94/1A	334.0	1079	1072	APM	0.50	0.59	3.06	
13	94/2R	341.0	1076	1072	APM	0.50	0.39	3.06	
14	121/3L	341.0	1167	1146	APM	0.50	0.41	3.22	
15	111/1A	342.0	930	815	APM	0.32	0.76	2.27	
16	112/1A	352.0	969	911	APM	40.00	1.30	3.00	
17	127/1AL	370.0	815	787	APM	0.32	1.00	2.26	
18	94/1A	334.6	503	503	APM	0.32	0.60	1.43	
19	115/2AR	372.0	887	882	APM	0.25	0.60	2.53	
19-A	116/1A	374.0	443	443	APM	0.20	0.42	1.23	NEW O/L
20	118/3R	390.6	1907	1894	APM	0.25	1.40	5.39	
20-A	138/2A	389.7	684	667	APM	0.20	0.60	1.86	NEW O/L
21	138/1AL	395.0	1042	1030	APM	0.25	0.80	2.97	
22	120/6R	401.0	M.P.KH	SUGAR	APM	0.25	0.42	2.00	
23	120/6P	401.0	M.P.KH	SUGAR	PIPE	0.16		0.50	
24	243/1R	417.0	620	528	APM	0.32	6.00		
25	239/1L	422.0	227	227	APM	0.20	0.20	0.60	
26	237/1AL	429.0	825	797	APM	0.50	0.29	2.19	
26-A	224/2L	435.0	1246	1038	APM	0.20	1.16	2.59	NEW O/L
27	236/1AL	436.0	628	563	APM	0.32	0.35	1.50	
28	217/LL	436.0	962	875	APM	0.25	1.00	2.49	
29	250/1R	436.0	1900	1611	APM	0.25	1.26	4.82	
29-A	249/2L	436.0	637	637	APM	0.20	0.66	1.80	NEW O/L
30	250/4	442.0	30	30	PIPE	0.25	PIPE	0.25	

OUTLETS RECORD

CANAL = JAMRAO
 OFF-TAKE = MIRPURKHAS DISTRIBUTARY
 LOCATION = RD 343

S.NO	O/L NO	RD	Outlet Data						Remarks
			GCA (ac)	CCA (ac)	Type	B (ft)	Y (ft)	Q (cusec)	
1	93/3R	3.00	478	466	APM	0.32	0.46	1.32	
2	111/2L	7.22	257	257	APM	0.20	0.42	0.71	
3	94/4R	7.24	264	259	APM	0.20	0.46	0.81	
4	112/2R	7.24	392	392	APM	0.20	0.61	1.13	
5	94/5R	10.78	75	74	APM	0.25	0.25	0.22	
6	99/2	11.11	268	265	APM	0.20	0.32	0.74	
7	100/1R	12.30	120	117	APM	0.20	0.20	0.43	
8	112/PIPE	12.30	80	80	PIPE	0.33			
9	100/1EL	13.10	168	168	APM	0.20	0.26	0.60	
10	100/AR	14.80	169	169	APM	0.20	0.22	0.59	
11	100/1B	15.75	187	187	APM	0.20	0.37	0.75	
11-A	99/3	17.00	331	331	APM	0.20	0.44	0.96	
12	113/3	22.73	376	376	APM	0.25	0.50	1.09	
12-A	113/2AR	21.40	472	472	APM	0.32	0.50	1.36	
13	113/2L	14.80	392	389	APM	0.25	0.52	1.15	
14	113/3A	24.00	426	420	APM	0.25	0.74	1.26	
15	100/2	25.30	700	700	APM	0.50	0.64	1.99	
16	114/1AL	25.30	362	362	APM	0.32	0.38	1.12	
17	113/46	25.32	423	423	APM	0.25	0.93	1.32	
18	100/3R	26.85	360	345	APM	0.32	0.62	1.16	
19	100/2AR	27.30	230	228	APM	0.40	0.48	1.00	
20	100/4R	27.90	200	200	APM	0.20	0.60	1.14	
21	110/1R	33.50	129	129	APM	0.20	0.20	0.36	
22	110/1AR	33.60	82	82	APM	0.20	0.24	0.32	
23	117/1L	33.60	437	430	APM	0.32	0.50	1.27	

S.NO	O/L NO	RD	Outlet Data						Remarks
			GCA (ac)	CCA (ac)	Type	B (ft)	Y (ft)	Q (cusec)	
24	114/3A	32.50	124	116	APM	0.20	0.28	0.34	
25	110/7R	25.50	289	282	APM	0.20	1.12	1.10	
26	114/3L	35.50	651	643	APM	0.40	0.65	1.94	
27	117/1AL	35.60	221	221	APM	0.25	0.35	0.66	
28	117/2L	37.30	360	354	APM	0.25	0.69	1.20	
29	117/2AL	38.00	258	258	APM	0.32	0.52	1.20	
30	117/3L	38.24	78	59	APM	0.20	0.20	0.18	
31	117/3AR	40.50	52	49	PIPE	PIPE		0.30	
32	ROAD PI	40.50	51	51	APM	0.20	0.20	0.30	
33	ROAD PI	40.50	109	107	APM	0.20	0.27	0.36	
34	117/4L	42.82	95	95	APM	0.20	0.21	0.35	
35	120/1AR	43.30	24	24	OPEN			0.08	
36	120/1R	43.63	430	171	APM	1.00	0.31	2.27	
37	S.M.A.		399	210	OPEN	0.40		1.27	
38	S.M.B.		FOR R	WAY	OPEN	0.49		1.57	
39	120/1BR	44.50	289	286	APM	0.40	0.56	2.09	
40	120/2R	45.43	375	357	APM	0.32	0.43	1.34	
41	117/5L	47.40	409	409	APM	0.32	0.60	1.40	
42	120/3R	48.40	1496	1493	OPEN	0.90		4.36	
42-A	S.M.I.		131	131	OPEN	0.15		0.47	
42-B	S.M.II		437	437	OPEN	0.38		1.20	
42-C	S.M.III		928	925	OPEN	0.83		2.66	
43	120/4R	48.40	444	441	OPEN	0.28		1.48	
44	120/5T	48.40	820	421	OPEN	0.65		2.07	
45	117/6T	48.40	309	308	OPEN	0.25		0.80	
46	111/2AL	8.22	152	152	APM	0.20	0.29	0.52	
47	120/4A	48.40	168	168	OPEN	0.15			
48	S.M.I	48.40	168	169	OPEN	0.23		0.74	
49	S.M.II	48.40	276	273	OPEN	0.24		0.77	

OUTLETS RECORD

CANAL = MIRPURKHAS DISTRIBUTARY
 OFF-TAK = MIRPUR MINOR
 LOCATION = RD 33

S.NO	O/L NO	RD	Outlet Data						Remarks
			GCA (ac)	CCA (ac)	Type	B (ft)	Y (ft)	Q cusec	
1	110/3L	1.11	36	36	OPEN	0.10		0.11	
2	110/2L	2.27	201	147	OPEN	0.16		0.66	
3	110/4L	4.21	34	19	OPEN	0.08		0.11	
4	109/3	4.21	107	7	OPEN	0.08		0.08	
5	110/5R	4.30	136	135	OPEN	0.15		0.89	
6	30/36	6.42	15	15	OPEN	0.08		0.04	
7	HEAD		514	344	OPEN	0.26		2.33	
8	284/285	7.00	24	4	OPEN	0.08	DIA...		

OUTLETS RECORD

CANAL = MIRPUR DISTRIBUTARY
 OFF-TAK = PIRO MINOR
 LOCATION = RD 343

S.NO	O/L NO	RD	Outlet Data						Remarks
			GCA (ac)	CCA (ac)	Type	B (ft)	Y (ft)	Q cusec	
1	112/2AL	4.20	76	76	OPEN	0.08		0.27	
2	113/1R	4.50	452	444	APM	0.27		1.32	
3	114/1R	7.18	115	115	OPEN	0.08		0.33	
4	112/3L	8.75	150	150	OPEN	1.20	0.09	0.42	
5	114/2	9.50	393	383	APM	0.25	1.01	1.27	
6	114/2AR	11.75	523	519	OPEN	0.25	0.92	1.56	
7	115/3T	12.89	397	397	OPEN	0.34		1.10	CLOSED
8	115/2T	12.84	525	514	OPEN	0.45		1.43	CLOSED
9	114/1A	6.80	104	104	OPEN	0.08		0.31	

OUTLETS RECORD

CANAL = JAMRAO OFF-TAKES = DOSO DHARORO DISTRY LOCATION = RD 343

S.NO	O/L NO	RD	Outlet Data						Remarks
			GCA(ac)	CCA(ac)	Type	B(ft)	Y(ft)	Q(cusec)	
1	125/1A	0.6	499	452	APM	0.25	1.11	1.42	
2	123/2L	7.6	696	688	APM	0.25	0.84	1.93	
3	125/1R	8.0	542	532	APM	0.40	7.00	1.50	
4	125/2	10.2	386	377	APM	0.25	0.39	1.07	
5	126/1R	11.0	827	801	APM	0.60	0.68	2.22	
6	123/1AL	10.9	610	610	APM	0.25	0.62	1.71	
7	123/1L	11.9	862	862	APM	0.32	0.94	3.22	
8	123/3L	13.6	541	374	APM	0.20	0.50	0.71	
9	125/3	15.0	347	342	APM	0.20	0.70	0.96	
10	126/2	20.3	476	462	APM	0.25	0.60	1.30	
11	124/1L	22.0	393	331	APM	0.25	0.70	0.93	
12	126/3R	22.7	434	401	APM	0.25	0.42	1.15	
13	127/1R	23.8	457	453	APM	0.32	0.44	1.30	
14	124/2L	24.6	1616	1505	APM	0.25	0.94	2.14	
14-A	PAF BPI	23.6	297	297	PIPE	0.50		2.00	NEW O/L
15	127/2R	25.5	477	477	APM	0.32	0.62	1.35	
16	124/3B	27.6	965	904	APM	0.50	0.56	2.57	
17	124/3	27.5	346	346	APM	0.40	0.50	1.04	
18	126/3AR	27.7	434	393	APM	0.25	0.56	1.19	
19	124/3A	28.0	488	486	APM	0.32	0.46	1.19	
20	128/1R	29.0	824	741	APM	0.32	0.80	2.22	
21	128/2	29.0	297	291	APM	0.20	0.44	0.84	
22	124/4L	31.5	173	173	APM	0.20	0.31	0.49	
23	124/4AL	23.3	122	122	APM	0.20	0.36	0.34	
24	128/3	33.4	810	793	APM	0.40	0.90	2.32	
25	124/5L	35.6	334	333	APM	0.20	0.75	0.94	
26	129/1	37.8	1666	1628	APM	0.80	0.90	4.70	
27	BK/1	38.0	697	673	APM	0.32	0.90	1.84	
28	130/1AR	46.4	918	848	APM	0.50	0.51	2.39	
29	CP/1L	47.5	158	148	APM	2.00	0.36	0.40	
29-A	CP/1A	42.5	210	210	APM	0.32	0.27	0.62	NEW O/L
30	130/1R	50.0	1017	945	OPEN	0.45		2.46	
31	131/1T	50.0	896	896	OPEN	0.51		2.49	
32	130/2	50.0	1425	1425	OPEN	0.59		4.03	
33	127/3	27.0	640	624	APM	0.32	0.74	1.81	
34	NEW 12	4.0	132	113	APM	0.20	0.20	0.32	
35	124/2A	20.8	186	186	APM	0.20	0.35	0.52	

OUTLETS RECORD

CANAL = JAMRAO
 OFF-TAKES = KAHU VISRO MINOR
 LOCATION = RD 383.

S.NO	O/L NO	RD	Outlet Data						Remarks
			GCA (ac)	CCA (ac)	Type	B (ft)	Y (ft)	Q (Cusec)	
1	116/2R	3.3	665	635	OPEN	0.35			
2	119/2L	3.3	586	577	OPEN	0.57			
3	116/1R	3.3	368	374	OPEN	0.22		1.00	
4	119/5L	5.6	11	11	OPEN	0.08		0.06	
5	116/3R	6.2	13	13	OPEN	0.08			
6	118/4T	6.17	493	490	OPEN	0.42		1.38	
7	118/1L	6.2	703	702	OPEN	0.75			
8	118/2T	6.2	820	820	OPEN	0.79			

OUTLETS RECORD

CANAL = JAMRAO
 OFF-TAKE = KAHU MINOR
 LOCATION = RD 385

S.NO	O/L NO	RD	Outlet Data						Remarks
			GCA (ac)	CCA (ac)	Type	B (ft)	Y (ft)	Q (cusec)	
1	138/1	0.5	651	604	APM	0.40	0.58	1.69	
2	132/1L	4.9	690	608	APM	0.40	0.45	1.72	
3	138/2	0.5	765	758	APM	0.40	0.64	2.18	
4	132/2L	1.5	468	440	APM	0.32	0.47	1.25	
5	132/3	3.7	585	577	APM	0.25	1.16	1.74	
6	132/1A	5	343	342	APM	0.25	0.52	1.02	
7	137/1R	10.8	244	244	APM	0.20	0.47	0.7	
8	133/1L	12.6	1124	1106	APM	0.80	0.64	3.14	
9	137/2R	13.37	451	447	APM	0.40	0.43	1.25	
10	133/1AL	13.4	269	267	APM	0.25	0.96	0.86	
11	137/3R	14.9	609	609	APM	0.40	0.57	1.67	
12	137/3A	15.2	1020	990	APM	0.63	0.62	2.79	
13	134/1	17	892	892	OPEN	0.52		2.54	
14	136/1T	18	1147	1139	OPEN	0.96		3.25	
15	134/2T	18	882	874	OPEN	0.52		2.54	
16	135/1T	18	555	551	OPEN	0.31		1.52	
17	138/3R	4.01	356	349	APM	0.25	0.44	0.99	NEW
18	132/3B	8.5	1219	1219	APM	1.32	0.54	3.52	

OUTLETS RECORD

CANAL = JAMRAO
 OFF-TAK = SANRO DISTRY
 LOCATION = RD408

S.NO	O/L NO	RD	Outlet Data						Remarks
			GCA (ac)	CCA (ac)	Type	B (ft)	Y (ft)	Q (cusec)	
1	242/1L	0.3	903	807	APM	0.40	1.1	2.27	
2	241/1R	2	1407	1245	APM	0.40	0.98	3.46	
3	244/1R	4	368	368	APM	0.32	0.44	1.04	
4	242/1R	4.25	177	163	APM	0.20	0.2	0.45	
5	244/2R	4.9	481	448	APM	0.25	0.86	1.61	
6	242/2L	2.8	95	83	APM	0.20	0.2	0.23	
7	244/3R	10.2	1010	929	APM	0.40	0.79	2.68	
8	PIPE	11.8	49	49	OPEN	0.33		0.15	
9	243/2L	14.8	486	396	APM	0.25	0.62	1.16	
9-A	243/2L	14	50	50	PIPE		PIPE	0.14	
10	246/1R	18.2	681	628	APM	0.25	0.94	1.82	
11	246/1A	20.2	335	308	APM	0.25	0.66	0.92	
12	243/3	23.1	496	496	APM	0.40	0.52	1.38	
13	248/1R	23.5	1783	1659	APM	0.63	1.07	4.68	
14	249/1	27.5	1236	1226	OPEN	1.44		3.45	
15	249/2T	27.5	499	451	OPEN	0.54		1.27	

OUTLETS RECORD

CANAL = JAMRAO
 OFF-TAKE = BAREJI DISTY
 LOCATION = RD 408

S.NO	O/L NO	RD	Outlet Data						Remarks
			GCA (ac)	CCA (ac)	Type	B (ft)	Y (ft)	Q (cfs)	
1	239/1R	0	371	347	APM	0.20	0.59	0.97	HEAD
2	240/1	0.5	318	254	APM	0.20	0.5	0.7	
3	229/1L	0.5	776	685	APM	0.25	0.8	2.01	
4	240/1AR	1.75	250	248	APM	0.32	0.4	0.72	
5	239/2R	4.9	918	829	APM	0.40	0.66	2.32	
5-A	239/2A	4.9	297	294	APM	0.32	1.08	1.89	NEW O/L
6	228/1L	5.7	873	806	APM	0.32	0.92	2.26	
6-A	239/2AA	4.9	297	294	APM	0.32	0.54	1.1	NEW O/L
7	240/2R	6.7	683	601	APM	0.40	0.72	1.74	
8	228/1A1	11.5	775	670	APM	0.50	0.4	1.88	
9	240/3R	11.5	504	481	APM	0.32	0.75	1.29	
10	228/2L	12.1	165	144	APM	0.20	0.25	0.4	
11	227/1A	12.1	1657	1590	APM	0.63	0.75	4.36	
12	227/1L	13.1	730	661	APM	0.32	0.72	1.84	
13	226/1L	14	560	523	APM	0.25	0.72	1.44	
14	226/2L	17.3	613	583	APM	0.25	0.8	1.63	
15	225/1L	20	565	547	OPEN	0.35		1.54	
16	239/3R	22.9	147	136	APM	0.20	0.24	0.39	
17	238/2R	25.1	541	451	OPEN	0.40		1.27	
18	238/1R	25.1	834	777	APM	0.40	0.76	2.25	
19	225/1A	25.4	809	722	OPEN	0.18		0.91	
20	237/1R	29.2	831	807	OPEN	2"		2.26	
21	225/2L	30.3	381	339	APM	0.20	0.41	0.52	
22	224/1L	33.5	404	354	OPEN	0.18		0.58	
23	236/1AR	36	492	356	APM	0.25	0.74	1	
24	224/2L	39.31	719	647	OPEN	0.46		1.5	
24-A	224/2	39.31	719	647	OPEN	0.48		1.53	NEW O/L
25	1 & PI	5.7	180	180	PIPE	DIA4"		0.52	

OUTLETS RECORD

CANAL = WEST BRANCH
 OFF-TAKE = DIRECT OUTLETS

S.NO	O/L NO	RD	Area (Acre)Outlet Data						Remarks
			GCA(ac)	CCA(ac)	Type	B(ft)	Y(ft)	Q(cusec)	
1	87/1L	3.2	374	367	APM	0.25	0.25	1.04	
1-A	1R	4.0	790	790	APM	0.20	0.82	2.23	NEW O/L
2	87/2L	6.2	752	744	APM	0.20	0.58	2.08	
2-A	1/AR	9.3	706	706	APM	0.20	0.72	1.98	NEW O/L
3	88/1L	10.7	448	448	APM	0.25	0.31	1.25	
3-A	2/A	0.0	597	597	APM	0.20	0.50		NEW O/L
4	88/2L	6.8	733	729	APM	0.25	0.50	2.04	
4-A		12.5	2503	2503	APM	0.32	0.82	4.00	NEW O/L
4-B		12.5	2503	2503	APM	0.32	0.82	4.00	NEW O/L
5	88/3L	16.3	585	585	APM	0.25	0.37	1.65	
6	89/1L	17.0	437	437	APM	0.40	0.23	1.22	
7	89/2L	19.0	381	361	APM	0.20	0.30	1.08	
8	89/3L	20.2	1030	1025	APM	0.25	0.69	3.05	
9	90/2L	26.5	1094	1063	APM	0.25	0.80	3.16	
9-A	Moriani	26.5	4309	4271	APM	0.40	0.96	6.00	
10	New pipe	26.5	4309	4271	APM	0.32	1.10	5.99	
10-A	Mroiani	26.5	1242	1242	APM	0.40	0.54	3.50	
11	91/1I	29.8	1072	1071	APM	0.25	0.68	3.01	
12	91/2I	32.9	949	949	APM	0.25	0.60	2.68	
13	M PIPE		10	10	PIPE	Dia pip			
14	95/1L	37.0	636	630	APM	0.25	0.48	1.77	
14-A	New IBR	39.0	185	185	APM	0.20	0.20	0.52	NEW O/L
15	96/1L	49.6	1101	1085					
16	VALGOS	40.2	584	584	APM	0.20	0.47	1.65	
17	WARGA	45.6	516	616	APM	0.20	0.38	1.43	
18	96/1L	49.6	1101	1085	APM	0.25	0.65	3.03	
18-A		55.8	843	843	APM	0.25	0.64	2.42	NEW O/L
19	108/1BR	58.5	170	168	NOT AD	AS NO	EXISTI		
19-A	1/R	53.0	926	928	APM	0.20	0.70	2.60	NEW O/L
20	104/1L	59.6	1254	1235	APM	0.25	0.84		
20-A	W.C	59.9	5	5	APM	0.50	1.47		NEW O/L
21	104/2L	59.6	1353	1353	APM	0.25	1.00	3.81	
21-A	1	63.0	1514	1514	APM	0.40	0.82	4.44	NEW O/L

S.NO	O/L NO	RD	Area (Acre)Outlet Data						Remarks
			GCA(ac)	CCA(ac)	Type	B(ft)	Y(ft)	Q(cusec)	
22	M/1R	69.5	482	482	APM	0.25	0.45	1.75	NEW O/L
22-A	M/1R	69.5	482	482	APM	0.25	0.45	1.75	NEW O/L
23	1/R	77.2	1720	1600	APM	1.00	0.90	6.67	
24	107/1L	77.5	864	774	APM	0.20	0.72	2.17	
24-A	HP/1R	66.2	2879	2879	APM	0.40	1.32	8.10	NEW O/L
25	107/1AL	79.4	420	393	APM	0.25	0.27	1.03	
25-A		79.5	1626	1628	APM	1.00	0.28		NEW O/L
26	2/R	79.5	781	729	APM	0.25	0.54	2.04	
26-A	NEW 2A	83.7	194	194	APM	0.40	0.40	1.12	NEW O/L
27	107/2L	80.5	1567	1543	APM	0.32	0.80	4.10	
28	107/1A/	95.0	233	225	APM	0.25	0.22		
28-A	NEW 3R	94.8	408	408	APM	0.20	0.34	1.41	NEW O/L
28	4AR	104.5	597	597	APM	0.50	1.40	2.70	
30	4R	106.0	425	413	APM	0.40	1.30	1.33	
31	3/AL	106.0	775	694	APM	0.20	0.85	2.20	
32	NEW 3A	111.0	332	312	APM	0.20	0.44	1.06	DUE GEN
32-A	NEW 3B	114.0	220	220	APM	0.20	0.25	0.60	NEW O/L
33	6R	115.0	607	593	APM	0.32	0.58	2.25	
33-A	5AR	117.5	958	956	APM	0.32	0.62	2.80	NEW O/L
34	6/A	121.0	363	363	APM	0.25	0.31	1.03	
35	7A	129.0	600	600	APM	1.00	0.58	2.95	
36	7/AR	129.0	721	721	APM	0.20	0.42	1.00	
37	377/1	121.0	710	652	APM	0.20	0.67	1.83	
38	378/1A	130.2	300	284	APM	0.25	0.48	0.90	
39	378/1BL	131.4	392	366	APM	0.32	0.20	1.02	
40	8/R	133.0	345	345	APM	0.25	0.25	0.96	
40-A	8/AR	139.0	328	292	APM	0.20	0.28	0.82	NEW O/L
41	379/1	138.5	558	528	APM	0.20	0.52	1.48	
42	9/A	141.0	431	431	APM	0.25	0.60	1.21	
43	10/A	143.8	161	181	SERTEL		0.93	1.01	
44	10/AR	145.3	179	179	SERTEL		0.88	0.91	
45	10BL	146.0	504	504	APM	0.32	0.82	1.41	
46	NEW O/L	24.0	3708	8700	APM	1.00	1.20		

OUTLETS RECORD

CANAL = WEST BRANCH
 OFF-TAKE = LAKHAKI DISTRY
 LOCATION = RD 38

S.No	O/L NO	RD	Outlets Data						Remarks
			GCA(ac)	CCA (ac)	Type	B(ft)	Y(ft)	Q(Cusec)	
1	91/3L	1.03	59	59	SCR	1.75		0.17	
2	43/1L	5.22	1267	1267	APM	0.50	1.01	3.73	
3	95/2R	5.84	408	408	APM	0.20	0.579	1.20	
4	93/2L	5.87	524	518	APM	0.20	0.72	1.48	
5	97/1R	11.02	169	169	APM	0.20	0.205	1.5	
6	98/6L	13.60	237	237	APM	0.20	0.30	0.65	
7	97/1AR	13.99	201	196	APM	0.20	0.27	0.55	
8	98/6A	15.2	550	550	APM	0.50	0.80	1.77	
9	97/2R	15.25	223	223	APM	0.20	0.285	0.60	
10	97/3R	18.7	480	478	APM	0.32	0.39	1.34	
11	98/7L	18.98	320	320	APM	0.32	0.63	0.93	
12	98/8L	19.70	484	484	APM	0.20	0.63	1.36	
13	101/1L	28.75	526	526	APM	0.32	0.44	1.52	
14	101/2L	26.7	1302	1302	APM	0.50	1.15	3.65	
15	101/3L	26.87	308	308	APM	0.32	0.30	1.01	
16	106/1L	26.87	282	276	APM	0.20	0.42	0.77	
17	102/1R	26.87	933	933	APM	0.50	0.49	2.65	
18	102/2R	33.75	453	440	APM	0.40	0.64	1.46	
19	106/2L	34.25	565	565	APM	0.25	0.78	1.62	
20	102/3R	35.92	374	366	APM	0.32	0.32	1.10	
21	106/4L	36.64	409	409	APM	0.20	0.65	1.19	
22	106/3L	40.0	678	678	APM	0.32	1.03	2.26	
23	102/4R	41.66	96	96	APM	0.25	0.38	0.57	
24	108/1AR	42.34	402	374	APM	0.25	0.48	1.11	
25	108/1AA	42.36	270	270	APM	0.40	0.70	1.09	

S.No	O/L NO	RD	Outlets Data						Remarks
			GCA(ac)	CCA (ac)	Type	B(ft)	Y(ft)	Q(Cusec)	
26	108/1R	42.36	470	453	APM	0.32	0.68	1.68	
27	108/1AS		616	599	OPEN	1.02			
28	108/1BS		89	89	OPEN	0.16		0.34	
29	106/5L	44.06	186	186	APM	0.20	0.30	0.55	
30	108/1CR	43.30	171	171	APM	0.32	0.40	1.13	
31	108/1DR	44.0	49	49	APM	0.20	0.20	0.13	
32	106/6L	46.71	100	100	APM	0.20	0.24	0.29	
33	106/7L	46.8	546	535	APM	0.40	0.48	1.53	
34	108/1ER	46.0	150	127	APM	0.32	0.48	0.8	
35	109/1R	47.9	360	229	APM	0.32	0.50		
36	109/1AR	47.91	160	160	APM	0.20	0.36	0.64	
37	E.PIPE	50.0	1	1	SCR			2.0	
38	109/2L	51.24	399	396	APM	0.80	0.38	1.96	
39	109/3L	54.3	167	156	SCR	0.75		1.13	
40	ROAD	53.30	3	3	SCR				
41	109/4L	55.24	25	25	SCR				
42	PIPE	55.24	10	10	SCR				
43	109/5R	55.31	110	105	SQ			0.52	
44	109/6L	56.40	44	43	APM	0.20	0.27	0.43	
45	PIPE	57.80	2	2	SCR				
46	D.PIPE	57.90	22	22	SCR			2.4"	
47	R.PIPE	57.9R	21	21	SCR			3.3"	
48	108/1BR	58.46	21	19	PIPE	0.12		0.06	
49	C.R.S	58.46	89	89	SCR			9.3"	
50	G.F.F	58.70	114	112	SCR			8.8"	
51	109/1	58.70	3	3	SCR			1.7"	
52	109/1T	59.25	64	64	OPEN	0.21		0.60	
53	K.M.S	59.25	81	62	OPEN	0.09		0.30	
54	L.EXT:	59.25	34	14	OPEN	0.08		0.11	
55	108/1DR	57.46	15	12	Ari-	0.17		0.25	

OUTLETS RECORD

CANAL = WEST BRANCH
 OFF-TAKES = BHITARO MINOR
 LOCATION = RD 38

S.No	O/L	RD	Outlets Data						Remarks
			GCA(ac)	CCA(ac)	Type	B(ft)	Y(ft)	Q(cusecs)	
1	105/DL	0.3	62	62	APM	0.20	0.20	0.20	
2	105/1AR	0.3	310	308	APM	0.25	0.74	1.02	
3	103/2L	3.8	449	442	APM	0.20	0.94	1.20	
4	105/1R	4.2	326	314	APM	0.20	0.77	0.90	
5	105/2L	6.6	423	423	APM	0.32	0.60	1.20	
6	105/3R	8.8	445	442	OPEN	0.17		1.33	
7	105/4L	10.7	417	407	OPEN	0.18		1.17	
8	105/5R	13.6	559	541	OPEN	0.5		1.46	
9	105/6T	13.6	759	751	OPEN	0.65		2.09	

OUTLETS RECORD

CANAL = WEST BRANCH
 OFF-TAKE = SANGRO DISTRIBUTARY
 LOCATION = RD 88

S.No	O/L NO	RD	Outlets Data						Remarks
			GCA	CCA	Type	B (ft)	Y (ft)	Q (cusecs)	
1	107/1A	0.2	314	284	APM	0.20	0.62	0.86	
2	107/1AA	0.2	1431	1254	APM	0.32	0.98	3.76	
3	107/1R	0.5	205	159	APM	0.20	0.20	0.49	
4	107/2L	1.6	741	632	APM	0.20	0.86	1.80	
5	1AR	6.7	357	282	APM	0.20	0.58	0.92	
6	107/2AL	6.7	195	158	APM	0.20	0.23	0.45	
7	107/4L	9.7	409	406	APM	0.20	0.75	1.22	
8	107/5L	12.8	292	271	APPM	0.25	0.56	0.80	
9	107/3R	13.3	332	288	APM	0.20	0.85	0.89	
10	6R	15.1	171	155	OPEN	3.25		0.66	
11	5/AAL	18.1	778	758	APM	0.40	0.62	2.33	
12	5/AL	18.1	281	267	APM	0.25	0.59	0.88	
13	7R	20.1	233	233	OPEN	0.25		0.80	
14	7AR	21.5	83	78	APM	0.25	0.40		
15	8	24.0	434	399	OPEN	0.16		1.19	
16	9	24.9	200	174	OPEN	0.12		0.49	
17	9AR	26.0	352	352	OPEN	0.32		1.13	
18	10L	26.6	436	404	OPEN	1.50		1.21	
19	10AR	27.0	567	485	OPEN	0.22			
20	12L	27.5	553	491	OPEN	0.17		1.46	
21	11R	28.0	381	361	APM	0.20	0.70	1.02	CLOSE
22	11AR	30.0	463	535	OPEN	0.40	0.52		
23	12A	38.5	425	408	OPEN	0.21		1.27	

S.No	O/L NO	RD	Outlets Data						Remarks
			GCA	CCA	Type	B (ft)	Y (ft)	Q (cusecs)	
24	13L	40.6	334	312	OPEN	0.14		1.04	
25	12BL	39.0	95	95	PIPE			0.27	
26	13AL	10.6	186	182	OPEN	0.35		1.11	
27	14R	40.6	737	694	OPEN	0.52		2.40	
28	15L	45.0	589	567	OPEN	0.37		1.64	
29	15A	46.3L	315	304	OPEN	0.33		0.85	
30	16R	46.3	177	136	OPEN	0.18		0.38	
31	16AR	47.8	469	444	OPEN	0.39		1.27	
32	18	47.8	621	597	OPEN	0.87		1.70	
33	17	51.5	737	682	OPEN	0.63		2.04	
34	N.PIPE	45.3	39	39	SCR	0.25		0.13	
35	10SL	27.0	273	270	OPEN	0.16		0.81	
36	N16BR	47.5	385	385	OPEN	0.37		1.20	

OUTLETS RECORD

CANAL= SANGRO DISTIBUTARY OFFTAKES= JARWARI MINOR LOCATION = RD10

S.NO	O/L NO	RD	Outlet Data						Remarks
			GCA(ac)	CCA(ac)	Type	B(ft)	Y(ft)	Q cusec	
1	2/AL	1.5	33	32	OPEN	1.00		0.09	
2	2/L	3.9	441	413	APM	0.25	0.68	1.29	
3	1/R	4.2	275	250	APM	0.32	0.60	0.92	
4	3/R	8.0	480	434	APM	0.32	0.52	1.28	
5	3/AL	14.5	436	402	APM	0.50	0.62	1.60	
	3/DR	14.5	219	219	APM	0.25	0.50	0.62	
6	4/L	17.6	380	362	APM	0.25	0.70	1.80	
7	57	21.6	187	164	OPEN	0.15		0.76	
	N PIPE	21.2			PIPE	2		0.11	
8	6/R	21.6	476	441	OPEN	0.40		1.33	
9	6/AR	22	52	52	OPEN	0.15		0.25	
10	7/R	24.5	695	673	OPEN	4.00		1.94	
11	GFFPIP	24.5	98	98	OPEN	6.00			
	N 5AL	23.8	105	105	APM	0.2	0.2	0.3	
12	5/B.L	25.9	202	149	OPEN	1.50		0.49	
13	5/CR	26.4	55	55	OPEN	0.14		0.86	
14	5/AR	27.9	40	40	OPEN	2.50			
15	8/R	27.9	445	365	OPEN	5.00		1.78	
16	PIPE	30AR	20	16	OPEN	4.00			
17	9/R	30.9	492	492	OPEN	0.38		1.67	
18	10/R	30.9	490	464	OPEN	0.38		1.66	
19	11/R	31.3	816	780	OPEN	9.25		2.24	
20	9/AL	36.3	277	195	OPEN	0.66		0.84	
21	12/LT	36.5	248	308	OPEN	0.27		0.87	
22	13/TC	36.5	596	560	OPEN	0.48		1.63	
23	NEW W.	19.0	103	103	APM	0.20	0.36	0.59	
24	11/AL	31.0			OPEN	7.50	1.00	2.00	
25	11/BL	31.0			OPEN	7.50	1.00	2.00	
26	3/BR	7.7	126	126	APM	0.25	0.30	0.35	

OUTLETS RECORD

CANAL = WEST BRANCH
 OFF-TAKES = CHAHU MINOR
 LOCATION = RD 29

S.No	O/L NO	RD	Outlets Data (ft)						Remarks
			GCA(ac)	CCA(ac)	Type	B(ft)	Y(ft)	Q(cusecs)	
1	1	3.4	498	465	APM	0.32	0.80	1.80	
2	2L	5.4	409	387	APM	0.40	0.46	1.25	
3	3L	9.3	422	404	APM	0.20	0.88	1.36	
4	4	12.0	548	526	APM	0.20	1.10	1.62	
5	3AR	15.1	279	260	APM	0.20	0.62	0.77	
6	5L	15.1	738	704	APM	0.63	0.65		
7	6R	21.1	518	482	APM	0.32	0.70	1.37	
8	7	23.4	763	736	APM	0.50	0.63	2.00	
9	8L	25.7	727	693	APM	0.63	0.56	1.91	
10	9	28.8	748	697	APM	0.40	0.75	2.00	
11	10	29.8	986	964	APM	0.50	0.68	2.70	
12	11R	32.2	497	474	APM	0.32	0.67	1.41	
13	11AR	33.2	408	395	APM	0.25	0.58	1.10	
14	12	33.9	678	641	APM	0.32	0.80	1.79	
15	13T	37.4	415	392	OPEN	0.40		1.10	
16	14	37.4T	353	338	OPEN	0.38		1.04	
17	15T	37.4T	1238	1196	OPEN	1.13		3.07	
18	1AL	1.0	389	310	APM	0.32	0.60	0.90	

OUTLETS RECORD

CANAL = WEST BRANCH OFF-TAKES= DAULATPUR MINOR LOCATION= RD 115

S.N o	O/L	RD	Outlets Data						Remarks
			GCA(ac)	CCA(ac)	Type	B(ft)	Y(ft)	Q(cusecs)	
1	385/1AL	1.2	142	130	APM	0.20	0.76	1.00	
2	385/1BL	1.2	620	572	APM	0.40	0.52	1.86	
3	385/1L	2.5	745	703	APM	0.25	0.94		
4	385/2L	8.4	759	711	APM	0.32	0.68		
5	377/2R	11.4	378	358	APM	0.32	0.62	0.97	
6	385/2A	11.3	104	103	APM	0.20	0.20	0.29	
7	377/2AR	12.9	287	281	APM	0.20	0.44	0.75	
8	384/1L	15.1	547	522	APM	0.32	0.70	1.44	
9	378/1R	15.1	183	173	APM	0.20	0.25	0.51	
10	378/2R	16.8	286	256	APM	0.32	0.40	0.72	
11	384/2L	18.5	849	815	APM	0.50	1.40	3.06	
12	379/1R	19.3	420	353	APM	0.40	0.45	1.03	
13	384/3L	21.1	479	455	APM	0.40	0.73		
14	379/1R	21.1	136	127	APM	0.20	0.30	0.36	
15	379/2R	21.3	337	316	APM	0.32	0.48	0.66	
16	383/1A	21.9	248	105	OPEN	0.12		0.29	
17	383/1	23.6	384	364	APM	0.25	0.68	0.96	
18	379/3	23.6	79	77	PIPE			0.20	
19	379/4	24.6	337	325	APM	0.50	0.50	0.91	
20	380/1R	26.1	378	368	APM	0.25	0.58		
21	380/2	26.1	462	395	OPEN	3.50		1.12	
22	N383/1A	25.5	167	167	APM	0.32	0.25	0.50	
23	383/1BL	26.5	285	285	APM	0.32	0.40		
24	380/3R	26.5	692	618	OPEN	0.46		1.75	
25	380/4	31.2	343	339	OPEN	0.42		0.96	
26	382/1TL	31.8	641	616	OPEN	0.45		1.71	
27	382/2T	31.9	709	681	OPEN	1.0			
28	381/2	31.9	596	551	OPEN	0.33		1.43	

OUTLETS RECORD

CANAL = BELARO MINOR
 OFF-TAKE = KHUMBRI SUB-MINOR
 LOCATION = RD 18

S.No	O/L	RD	Outlets Data						Remarks
			GCA(ac)	CCA(ac)	Type	B(ft)	Y(ft)	Q(cusecs)	
1	Head		2559	449	APM	1.00	0.96	7.40	
2	2R	6.5	578	683	APM	0.50	0.72	1.56	
3	3R	12.5	483	449	OPEN	4.00			
4	4-TAIL	13.3	725	683	OPEN	8.00			
5	5-TAIL	13.3	776	713	OPEN	0.67			

OUTLETS RECORD

CANAL = LAKHAKHI DISTRIBUTARY
 OFF-TAKE = MITHRO MINOR
 LOCATION = RD

S.NO	O/L NO	RD	Outlets Data						Remarks
			GCA(ac)	CCA(ac)	Type	B(ft)	Y(ft)	Q(cusecs)	
1	98/1L	1.3	130	126	OPEN	1.50		0.37	
2	98/2L	4.5	88	85	OPEN	0.11		0.31	
3	98/3A	6.2	76	74	OPEN	1.25		0.37	
4	98/3L	7.6	903	898	OPEN	0.71		2.69	
5	98/4L	10.7	236	236	OPEN	0.22		0.68	
6	98/LT	10.7	215	215	OPEN	2.00		0.60	
7	89/1L	10.7	810	806	OPEN	0.82			
8	99/1L	10.7	784	780	OPEN	8.50		2.20	
9	105/6T	13.6	759	751	OPEN	0.65		2.10	

OUTLETS RECORD

CANAL = WEST BRANCH
 OFFTAKES = BELLARO DISTRIBUTARY
 LOCATION = RD 143

S.No.	O/L No.	RD	Outlet Data						Remarks
			GCA (ac)	CCA (ac)	Type	B (ft)	Y (ft)	Q (cusec)	Closed
1	1L	1.0	540	504	APM	0.32	0.82	1.41	
2	3R	6.1	734	711	APM	0.32	0.72	1.98	
3	4L	6.0	708	693	APM	0.25	0.90	1.93	
4	5R	13.3	610	581	APM	0.63	0.48	1.66	
5	4AL	14.6	206	206	APM	0.25	0.38	0.80	
	N4AAL	16.6	591	582	APM	0.20	1.02	1.61	
6	6R	16.8	808	716	APM	0.50	0.74	2.16	
7	LB/PIPE	16.8	8	8	PIPE	1.00			
8	4/BL	17.1	679	679	APM	0.50	0.80	2.00	
9	7BR	17.1	542	499	APM	0.40	0.78	1.44	
10	6AL	18.1	161	154	APM	0.20	0.42	0.43	
11	7R	19.4	285	271	APM	0.40	0.34	0.82	
12	7AR	24.5	426	409	APM	0.32	0.45	1.19	
13	8R	27.6	932	879	APM	0.63	0.73	2.78	
14	9R	27.6	382	382	APM	0.40	0.50	1.80	
15	10R	27.7	645	628	APM	0.63	0.53	2.16	
16	11AL	26.2	468	454	APM	0.40	0.60	1.26	
17	9AR	28.6	365	365	APM	0.50	0.35	1.10	
18	11BL	35.3	103	101	APM	0.50	0.44	1.01	
19	12CR	35.5	405	405	APM	0.63	0.44	1.13	
20	11R	35.5	481	480	APM	0.63	0.40	1.29	
21	10BL	36.7	222	218	APM	0.25	0.46	0.63	
22	10AL	37.0	564	549	APM	0.63	0.42	1.47	
23	12R	41.8	475	567	APM	0.50	0.54	1.18	
24	12AL	41.8	820	820	APM	0.50	0.74	2.30	
	I		820	820	OPEN	0.71		2.30	
	II		225	225	OPEN	0.19		0.64	
25	12BL	41.8	685	685	APM	0.50	0.68	1.87	
	12AAL	41.8	225	225	APM	0.20	0.42	0.63	
26	12DL	44.4	456	456	OPEN	0.57		1.29	
27	14/LT	45.1	922	922	OPEN	13.0		2.57	
28	16/TR	45.1	529	529	OPEN	8.00		1.49	

IIMI-PAKISTAN PUBLICATIONS

PLANNING REPORTS

Report Number	Title	Author	Year
P-1	Pilot Project for Farmer-Managed Irrigated Agriculture under the Left Bank Outfall Drain Stage I Project, Pakistan: Inception Report and Implementation Plan	IIMI-PAKISTAN (Project Leader D.J.Bandaragoda)	Oct 1995
P-2	Research Opportunities in Canal Irrigation Management in Malik Sub-division, Sadiqia Canal Division, Bahawalnagar: Inception Report	M. Shabbir Haider Mushtaq Khan	March 1996
P-3	Managing Irrigation for Environmentally Sustainable Agriculture in Pakistan: Plan of Operations	IIMI-PAKISTAN (Project Leader G. V. Skogerboe)	May 1996
P-4	Managing Irrigation for Environmentally Sustainable Agriculture in Pakistan - Decision Support Systems, Sindh: Inception Report	A. Hakeem Khan	Sept 1996
P-5	Social Organization for Improved System Management and Sustainable Irrigated Agriculture in Small Dams: Inception Report	IIMI-PAKISTAN (Project Leader D.J.Bandaragoda)	Sept 1996