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GOVERNMENT OF PAKISTAN
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
IRRIGATION SYSTEMS MANAGEMENT PROJECT

OPERATION AND MAINTENANCE MANUAL
REHABILITATED CANALS

ALMANI BRANCH CANAL SYSTEM

PRC ENGINEERING/CHECCHI
MARCH 1987

EMERGENCY

INSTRUCTIONS

EMERGENCY INSTRUCTIONS

1. The basic cause of an emergency will be the breaching of a canal.

2. The procedures to follow depends on where the breach has occurred; upstream or downstream of the Soomerki Regulator.

Upstream Breach

(1) Warn the people living close to the breach of the danger. Saving lives is first priority.

(2) Send someone or proceed immediately to the Sub-engineer's residence at the Almani Regulator to obtain the key and wheel for the Almani Escape regulator gate.

(3) Proceed to gate, unlock gate and fully open the gate.

(4) Proceed downstream of escape along channel to warn people of the coming water.

(5) Whoever is incharge at the Almani Regulator will immediately notify the SDO.

(6) The Almani gate watcher will proceed to increase the discharges in the distributaries to those shown after the name:

-	Seri Distributary	82 cfs
-	M. Khan Distributary	132 cfs
-	Mulan Minor	23 cfs

(7) Reduce the downstream flow in the Almani Canal by the exact amount of increase made to the three canals. This would be done byslowly closing the Almani gates in order to hold the water surface elevation upstream of the regulator constant.

(8) Wait for further instructions.

<u>Downstream of Soomerki Regulator</u>

(1) Warn the people living close to the breach of the danger. Saving lives is first priority.

(2) Adjust flows at the Soomerki Regulator so that the non-breached canal carries 120% of design discharge and maintain the Almani Canal at the full supply level. The maximum allowable canal capacities are:

-	Soomerki	145 cfs
-	Khachar	200 cfs

(3) Notify the Sub-engineer.

(4) Gate watcher at Soomerki must stay at gate structure to monitor upstream water level in Almani Canal. It must not be allowed to rise above FSL.

(5) The Sub-engineer or Almani Gate watcher should proceed to the escape at RD 12, unlock gate and open it just enough to discharge the same flow that is still in the breached canal.

(6) The gate tender at the Soomerki Regulator may slowly close the gate to the breached canal only if the water surface drops below the full supply level. Care should be taken not to close the gates too rapidly.

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FOREWORD

Section 1: Purpose

The purpose of this manual is to provide specific instructions and guidelines that are required to operate and maintain a rehabilitated sub-system within a larger system. The guidelines presented herein cover the normal conditions involved in operating and maintaining these canals. No manual can cover solutions to all the potential combinations of problems that someday could occur from operating the canals. This is the role of the Canal Officer.

The manual was prepared with the intent of introducing some applicable modern technology into the operation and maintenance of the rehabilitated canal under the current organization of the Irrigation Circle and Provincial Irrigation Department and its policies and guidelines. The manual was prepared for use at the sub-division level. Therefore, references are made primarily to the Sub-division Officer (SDO) but it is fully understood and intended that the Executive Engineer (XEN) retains his authority and responsibilities as the SDO's supervisor and particularly in the control of the allocation (distribution) of water.

Section 2: Authorization

This manual has been prepared under the direction of USAID to meet the requirements of Task V-a of the approved PRC Engineering/Checchi Work Plan, 1986-87. Task V-a requires; "Preparation of a detailed O&M manual for each USAID-funded canal rehabilitation scheme, rehabilitated under Task I.

CHAPTER I

GENERAL INSTRUCTIONS

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GENERAL INSTRUCTIONS

Section 1: Introduction

A. Objective of the Manual

The objective of this manual is to provide the operating staff a comprehensive set of instructions on the operation and maintenance of the rehabilitated Almani Branch Canal System. The instructions and guidelines have been prepared specifically for this system. The procedures defined in the "Operation and Maintenance Manual for Rehabilitated Canals General Instructions" must also be applied to this system. This manual defines the specifics of the system including physical features, organization, operation and maintenance.

1. Operation

The objective of the irrigation system is to provide the sanctioned seasonal discharge to each watercourse at all times except when the demand for water is reduced due to harvesting, excessive rainfall or closure for maintenance. The operational standards will be adhered to.

2. Records

Records will be maintained as required with particular emphasis on the discharges entering each distributary and water levels at control points located along each canal.

3. Maintenance

The objective of the maintenance program is to keep the canal within the defined maintenance standards so that the canal will operate as designed.The procedures for doing this are defined herein and in the general manual referred to above.

(a). Requirements

The operating staff is required to maintain the canal in conformance with the maintenance standards at all times. Particular emphasis must be made to maintain freeboard and embankment dimensions (safety). Desilting will be accomplished as required to maintain water surfacelevels, hence the required flows to each watercourse including the tail clusters.

(b). Scheduling

Repairs and maintenance must be scheduled. Those repairs to structures and the canal prism during the annual closure or other short periods when the canal can be shut down. Maintenance of the embankment must be preformed on a year round basis.

(c) Inspections

A detailed inspection of the canal system must be made each year during closure. This augments the other inspections to be performed during the year.

(d). Budgets

Preparation of the annual budget and monitoring of expenditures is a key management function.

B. Availability of Records and O&M Manuals

The SDO and XEN are required to keep records on the canals under their jurisdiction. The records must be kept current on each rehabilitated canal.A copy of this manual and the accompanying general manual for rehabilitating canals must be available with the records. The minimum required records are:

* Flow measurements into distributaries and other designated points in the system.
* Operation logs.
* Control point water surface records.
* H Register
* Annual inspection reports

* Monitoring program records.
* Outlet Register
* "As-built" long-section and cross-section drawings

This manual should be reviewed annually and any additions or corrections made. The easiest method would be to add paragraphs or new appendices.

C. Technical Reference For O&M

The primary PRC Engineering/Checchi references are:

(1) Operation and Maintenance of Rehabilitated Systems, General Instructions.

(2) General Operation and Maintenance Procedures for:

Volume 1.	Management
Volume 2.	Canal Operation and Water Measurement
Volume 3.	Canal Embankments
Volume 4.	Canal Structures

(3) Improved Operation and Maintenance of Rehabilitated Canal Systems.

(4) Technical Criteria for Rehabilitation of Canal Systems in Pakistan, "Manual of Irrigation Practice," 1943, Government of Pakistan, reprinted in 1963 is the standard reference in Pakistan but is heavily orientated to design and contains only a minimum of maintenance standards and procedures.

(5) The United States Bureau of Reclamation has published a series of books that contain technical material that can assist in solving maintenance problems:

1. Earth Manual, 2nd Edition 1974
2. Concrete Manual, 8th Edition 1981
3. Paint Manual, 3rd Edition 1976
4. Herbicide Manual, 1st Edition 1983
5. Water Measurement Manual, 2nd Edition 1974

Section 2: System Design

A. General

The hydraulic design for the rehabilitation of the Almani Branch Canal System was presented in the report, "Almani Branch Canal System Final Design Report" PRC/CHECCHI, May 1986. The design statements and long sections are presented herein in Appendix A. The hydraulic design criteria used is contained in the publication "Technical Criteria For Rehabilitation of Canal Systems in Pakistan" PRC/CHECCHI, November 1986. The location map of the system is shown on Figure I-1.

B. Distribution of Water

The design of the system is based on the equitable distribution of water as determined from the outlet register. The outlet register provides the registered cultivatable command area (CCA) for each outlet in the system. The maximum crop water requirements occur in the kharif season with a water duty of 1 cfs per 100 acres provided. The design cropping intensity for the kharif season was taken to be 35% of the CCA. This is equivalent to 3.5 cfs per 1000 CCA acres.

The seepage and other losses were determined using the standard loss rate of 8 cfs per million square feet of wetted perimeter. The wetted perimeter was determined by the equation:

$$P = 2.67\ (Q)^{0.5}\ ft^2/ft.$$

Therefore, canal losses would vary according to the flow in the canal between successive outlets. The computed losses in the Almani System amount to slightly more than 10% of the inflow.

C. Distribution of Sediment

The design for the rehabilitated Almani System is based on the equitable distribution of sediment throughout the branch canal and each distributary and minor canal. The branch canal was designed to transport about 80% of the incoming bed load sediment. Therefore, about 20% of the bed load material will have to be removed from the system. A sediment trap has been

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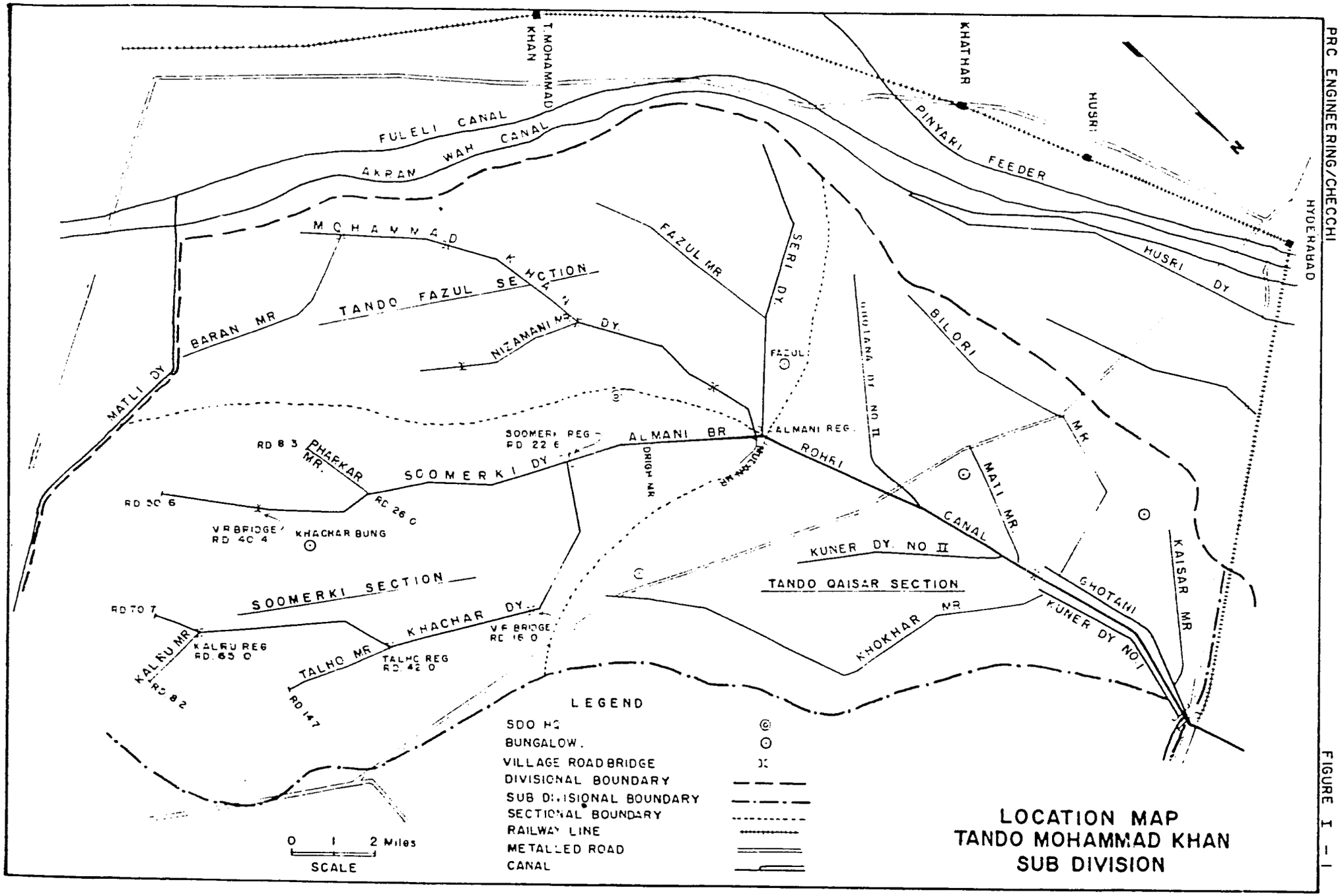
recommended. The precise location of which has not been defined as of March 1987. The recommended sites were (1) upstream of the Almani Cross Regulator; and (2) downstream of it. The upstream site would also provide control for the Seri and Mohammad Khan Distributaries.

D. Canal Bed and Water Surface Levels

Appendix A contains the design statements and the long-sections for the system. The design bed levels are given for both the upstream and downstream ends of each reach. The actual bed levels after operation will stabilize between these two values. The design water surface levels are also provided at each end of each reach of canal. The location of each outlet is shown on the long sections. The design depth and bed width of each reach is also provided in the design statements. The generalize schematic diagram for the system is shown on Figure I-2.

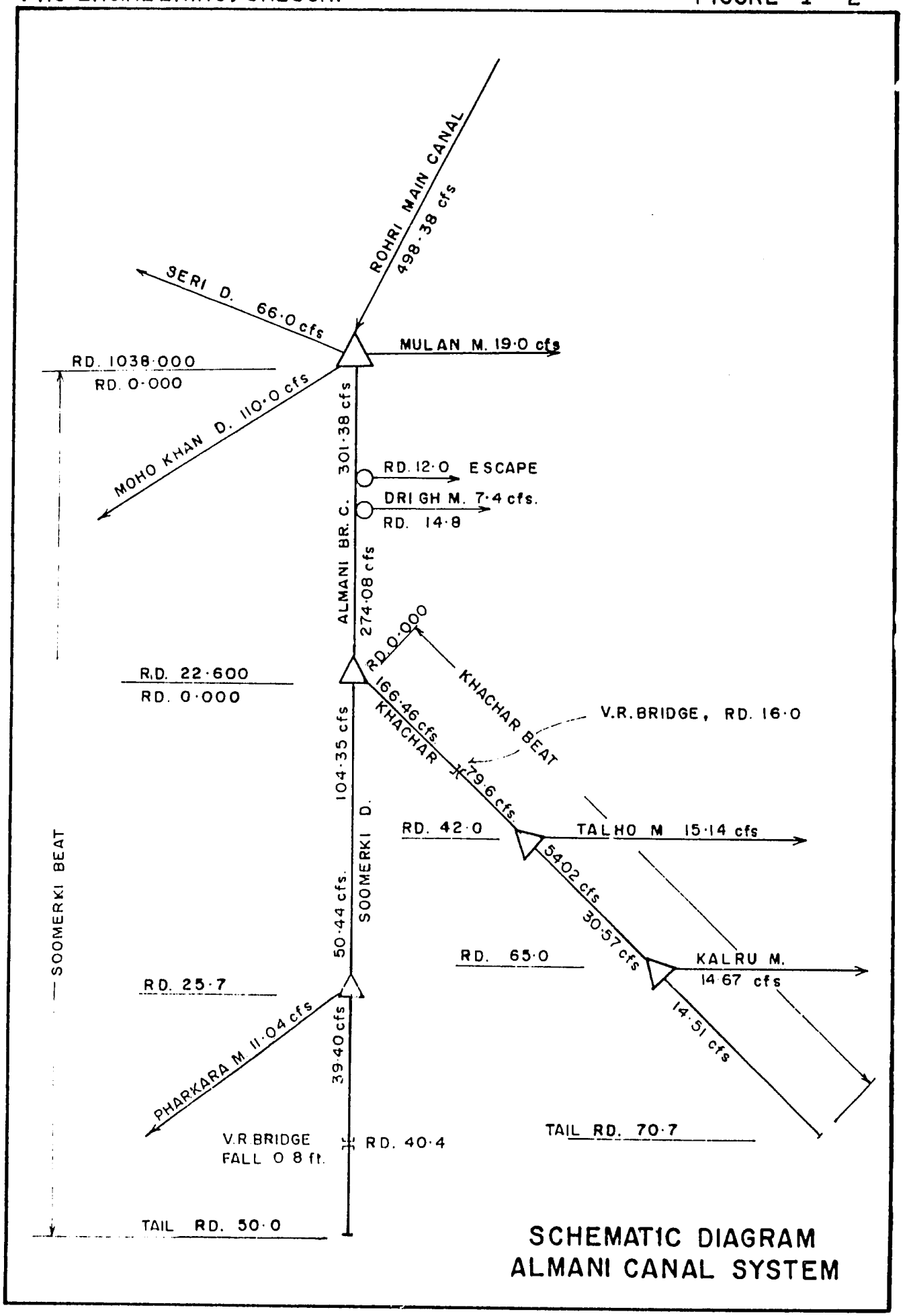
Section 3: Organization and Staffing

The organization, staffing and zones of responsibility are presented in Appendix B. The staffing and zones of responsibility are subject to change by the Sub-division Officer as conditions warrant. Extra beldars are often hired during the kharif season to support the permanent staff by providing an extra degree of safety.



LOCATION MAP
TANDO MOHAMMAD KHAN
SUB DIVISION

FIGURE I - 1



SCHEMATIC DIAGRAM
ALMANI CANAL SYSTEM

CHAPTER II

OPERATION

CHAPTER II

OPERATION

Section 1: Introduction

The proper operation of any irrigation system is very essential in order to achieve optimum results; timely delivery of the correct amount of water to all watercourses to provide sustained production of various crops. So important is proper operation that even the most sophisticated system with the best facilities can not provide the expected results if these facilities are not operated correctly. Successful operation, therefore, will depend largely on the SDO and his staff using the procedures presented herein and any improvements developed by the staff during calibration and future operations.

Operation activities should be closely supervised and well coordinated in order that the desired issues of water are made to the watercourses. The other requisite to good operations is to be able to keep the water level in the canals almost constant; thus allowing uninterrupted delivery of water and maintaining proportionality.

Section 2: Performance Standards

A. Introduction

Performance standards have been established to provide the field staff with the standards to which a rehabilitated canal must be operated. General performance standards are defined in Table II-1 and relate to allocation of water to the watercourses, equitable delivery, maximum and minimum allowable flows and other operating functions. These are defined in more detail in the following paragraphs.

B. Allocation of Water

The allocation of water to each water course is determined from the outlet register. The computational procedures of the distribution of water is defined in Chapter I.2.B. The allocation of water at the design discharge for each

outlet is presented in Table II-2 under the column "Total". The estimated losses are shown in the column "Loss". The estimated flow in the canals immediately downstream of an outlet or control structure is shown in the column "Accum + loss". The design discharge for the Almani Branch Canal is 301.4 cfs.

Table II-2 presents the designers estimates. Field conditions will deviate somewhat from these values. Therefore, calibration will be required to determine the actual values that must be used in order to deliver 5.62 cfs to the tail cluster of the Soomerki Distributary and 4.67 cfs in the Khachar Distributary.

C. Equitable Distribution

Equitable distribution is defined as providing the flow shown in Table II-2 to the watercourses when the design discharge is entering the Almani Branch Canal. Proportionality will prorate flows at other discharges. In order to maintain equitable flows, the water level in the canals, for any given discharge, must remain constant over time. Control points are established to monitor the water surface levels in the canals. Table II-3 presents the recommended control point locations and the design water surface elevations. These are also shown in the design statements presented in Appendix A. The water surface elevations must be verified and/or adjusted during the initial calibration of the system.

D. Equitable Distribution of Sediment

This condition is assumed to occur with the correct setting of the outlets. During the initial calibration period, visual observations may indicate some unequitable conditions. Adjustments can be made by resetting the sill elevation of an outlet. Also, during the initial calibration period, non-equitable sediment distribution would be reflected by deposition of material in certain reaches of the canals.

E. Uninterrupted Delivery

Proper operation provides a continuous flow. Problems and requirements are discussed in Section 4 below.

F. Maximum-Minimum Flows

The maximum allowable flow into the Almani System is 1.2 (301.4 cfs) or 361.7 cfs, say 362 cfs. The minimum allowable flow is 0.55 (301.4) or 165.8 cfs, say 166 cfs. Flow conditions at the Soomerki and Khachar Distributaries (Table II-2, page 1) are:

	Design	Maximum	Minimum
Soomerki	104.4 cfs	125.3 cfs	57.4 cfs
Khachar	166.5 cfs	199.8 cfs	91.6 cfs

The flow at maximum discharge can not exceed a period of two weeks and a period of two weeks is required between periods of exceedance.

G. Maximum Water Levels

The maximum allowable encroachments are limited to 1/2 of the design freeboard which is approximated by the maximum allowable flow condition. Therefore, if sedimentation occurs in a canal the maximum water level criteria will govern and the maximum allowable discharge must be reduced accordingly.

The design freeboard and maximum allowable freeboards are:

Design Depth	Design Freeboard	Maximum Encroachment
Less than 2.5 ft.	12 inches	6 inches
Between 2.5 ft and 4.99 ft.	18 inches	9 inches

Encroachments of 9 inches would be allowed as follows:

Almani Branch Canal	RD 0+000 to RD 22+600
Soomerki Distributary	RD 0+000 to RD 25+700
Khachar Distributary	RD 0+000 to RD 42+000

All other reaches of distributaries and all minors would be limited to encroachments of 6 inches.

Section 3: Initial Calibration

The procedures for making the initial calibration are contained in the "General Manual for Operation and Maintenance of Rehabilitated Systems". Initially cross-sections will be required every 500 ft and at all structures, (including bridges) falls, etc. Table II-2 provides the location of each outlet. It will be necessary to establish a temporary bench mark elevation at each outlet so that exact measurements of water surface levels can be made. The control point locations and the engineers water surface level estimates are shown on Table II-3. These points correspond to outlet location and control structures so that additional survey points are not required.

Studies made during the design process for rehabilitating the Almani Canal System indicated that the watercourse outlets do not receive water according to the values shown in Table II-2 (see Chapter VI, Almani Branch Canal System Final Design Report). The resetting of the gate sill at the Soomerki Cross Regulator by lowering it 0.78 ft to obtain a more equitable distribution of sediment will cause a drop in the water surface level of 0.44 ft. This will reduce the inflow to the outlets along the Almani Branch Canal. The water level at the head end of the Khachar Distributary will also be lowered slightly but it only affects the first two outlets.

The recommended and accepted design for rehabilitation of the Almani System required the outlets to be reset. This should have been done during the rehabilitation construction period. Calibration will verify the new water surface levels, outlet discharges, sill elevations and outlet dimensions for each outlet. The seepage loss in each reach must also be determined. How close the new canal flows match the required flow at the tail clusters of each distributary and minor will indicate what, if any, remedial measures must be taken to provide the sanctioned flows; i.e., 5.62 cfs for Soomerki and 4.67 cfs for Khachar.

Most likely, a few of the outlets will have to be reset again to achieve the required tailend flows. A small difference might be achieved by increasing the inflow from 302 cfs to a slightly larger value. The latter might provide

an easy solution for Soomerki because of the fall at the Soomerki Cross Regulator. In any case, it would be better if the flows reaching the tailend are slightly in excess of design because future sedimentation upstream will reduce them.

Section 4: Method of Operation

The Almani Branch Canal is operated to satisfy the performance standards as stated in Table II-1; and as modified during the initial calibration., i.e., continuous flow at the design discharge maintained at the FSL unless otherwise directed. The background and method of accomplishing this is described in the "General O&M Manual for Rehabilitated Canals". A monitoring program was defined therein that will provide the information necessary to allow an evaluation of the system's operation to ensure compliance with the performance standards.

A. Regulation of Water

Table II-2 provides the design discharges for each outlet which is the basis for resetting the outlets. Calibration will confirm these values or modify them slightly. Concurrently during calibration the controlling water surface levels will be determined. All of this information is entered onto a new form, Table II-4, called "Design and Regulated (Registered) Flows" which provides information on the calculated outlet demand, measured outlet flow, reference water surface and sill levels, RD, outlet dimensions, and tail water elevations. On calibration Table II-4 becomes the basic document for operating the system.

B. Seasonal Allocation

During the kharif season, the system is operated at 100% of the regulated flow (full supply level), nominally 302 cfs.

During the rabi season, the normal operating flows are reduced to 80% of regulated flow, nominally 242 cfs.

C. Operating Modes

1. Normal Conditions

The canal system is operated as a continuous flow system as close to the regulated flow, 302 cfs or 242 cfs depending on season, as possible. The Almani System lies at the tail end of the Rohri Canal some 196 miles downstream of the Sukkur Barrage. Therefore, there may be periods of time where the inflows to the Almani Cross Regulator vary considerably over short time periods. Long term flow measurements indicate this potential but not the extent of it.

Variations in incoming flows are proportionally distributed throughout the system. There will be variations in the water surface level at the Almani Cross Regulator as the incoming flows change. The gate settings would have to be changed to maintain proportionality unless the calibration process indicates otherwise.

2. Low Flow Condition

A low flow condition exists when the incoming flow drops below 60% of the regulated flow or 180 cfs in the kharif season. At this time extra care must be exercised in monitoring the flow entering the system. When the Almani inflow drops to about (55%) 166 to 170 cfs rotation irrigation must be initiated.

A rotation period of seven days for the first cycle and 8 days for subsequent cycles is required. The longer cycle on subsequent rotation is because the receiving canal will require priming and the relinquishing canal will have to be dewatered. Canal filling and dewatering generally requires 24 hours.

Rotation may be accomplished by rotating flows between the Almani Branch Canal and the Mohammad Khan, Seri Distributaries including the Mulan Minor at the Almani Cross Regulator. It may also be accomplished by releasing a constant 166 cfs into the Almani Branch Canal and rotating the flow between the Khachar and Soomerki Distributaries. In this case, the Khachar Distributary would carry 166 cfs less whatever was discharged into the upstream outlets under control of the Soomerki Cross Regulator. When

changing the rotation cycle, the Soomerki could be given up to 125 cfs, the upstream outlet inflows increased and the remainder released down the Khachar Distributary.

In order to provide equitable distribution it would be necessary to rotate back and forth which distributary receives water during the first cycle; i.e., if Khachar receives it first this time, Soomerki should receive it first the next. Care must be taken to open the gate to the canal receiving the rotation flow before closing the other gate to prevent a backwater situation (piling up of water upstream of the cross regulator) that could cause overtopping and breaching.

Maximum water levels in the canals must not be exceeded.

3. Heavy Rainfall Periods

During heavy rainfall periods, water may pond on farmers fields causing a drainage problem. When this happens, the farmers want to close off the watercourse to stop this source of water from also entering their fields. Under no circumstances are farmers allowed to plug up the entrance to these outlet watercourse. Such uncontrolled plugging could cause a downstream breach.

When heavy rainfall periods are either forecast or are seasonally expected, it is possible to reduce the total inflow at the Almani Canal headworks. This would leave extra capacity available to shift flows about within the system.

The SDO, who controls the water distribution in the canals under his jurisdiction, may allow some watercourses to be closed off if he can shift this water to another distributary(s) if the resulting flow does not exceed the 120% criteria (or maximum water level criteria) and the excess can be absorbed therein. The XEN is notified immediately when this is done.

When a large general rainstorm occurs, the SDO will notify the XEN on local conditions. If possible, the XEN will shift flows around within the canals under his jurisdiction in order to halt or reduce inflows into those areas with

drainage problems. When this cannot be done or is only partially accomplished, the XEN notifies the Superintending Engineer of the situation. The S.E. goes through the same type of exercise. He then notifies the XEN as to what changes he can make and at what time he can begin to implement them. Canal travel times are a very big factor in this situation. Changes should not be made downstream until the adjusted inflow arrives at each control structure.

4. Low Demand Periods

Low demand periods (excluding heavy rainfalls) will generally occur during the harvest season where farmers have not diversified their cropping pattern or when they are too busy harvesting to irrigate other land at the same time. This condition is predictable to a certain extent so that it can be scheduled. The problem is such that if canal inflows are reduced all outlets will receive less water.

Under controlled conditions (supervision by the SDO), farmers could plug their outlets. This would allow additional water to be carried downstream. The control must be such that the maximum allowable freeboard condition is not violated thereby preventing the potential for a breach.

Historical records of canal flows will assist in the scheduling for these low demand periods. Similarly, land preparation practices may require water in excess of the normal regulated flow. When water is available, this can be provided but it is important to remember that all outlets will receive the extra flow not just a few.

5. Tail Water Crisis

This refers to the condition when the tail cluster(s) do not receive their proportional share. If during the calibration period it can be arranged that the tail clusters receive water in excess of the calculated requirement, subsequent reductions in tail water flows are somewhat easier to handle because there is more time available to remedy the cause.

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The main cause of tail water depletions is upstream tampering of outlets or sediment deposition at some point in the canal. Both possibilities are difficult to locate because of scale. Generally, it will be a combination of changes in upstream conditions that will reduce tail water flows.

Constant monitoring of the canal water surface and flow records will eventually allow the cause or causes to be located. Once located, remedial action can be taken. Sedimentation will tend to occur in the downstream reaches and is therefore somewhat easier to detect because discharges are much less so that scale effects are less of a problem; i.e., a 2 cfs variation in 20 cfs may be obvious whereas 2 cfs out of 200 cfs may not even be measurable.

Section 5: Operation of Structures

A. Water Control Structures

The Almani Cross Regulator is located at the tail end of the Rohri Canal. It contains the head regulator for the Almani Branch Canal. Its operation is under the control of Tando Muhammad Khan Sub-division Officer as is the Almani System. The Almani Section starts downstream of the head regulator.

The SDO gives instructions to the gate tender (gauge reader) who adjusts the gate openings to deliver the prescribed flows. A set of flow measurements are required every time an adjustment to the gates is made.

The Soomerki Cross Regulator controls the flow at the tail end of the Almani Branch Canal. It contains two gates which control the flow into the Soomerki and Khachar Distributaries and act as the headworks. The operation of the gates is under the direction of the SDO. The Soomerki Section, SBE supervises the operation alongwith his other duties. Flow measurements are made in both distributaries each time the gates are adjusted.

The technical details of gate operations are presented in the "General O&M Manual for Rehabilitated Canals" including the opening and closing instructions. Under no circumstances will the water levels be allowed to

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encroach on the freeboard more than 9 inches either upstream or downstream of the Soomerki Cross Regulator (Chapter II.2.G). When the downstream water levels reach the 9-inch (1/2 of design freeboard) maximum encroachment, the gates must be operated so that no additional increase is allowed. When or if the upstream water level exceeds the maximum allowable the escape must be opened enough to draw off the excess flow. A control elevation/level should be marked on the escape headwall to allow easy regulation of the escape gate to control the water surface level in the canal.

Currently (December 1986) there are three other cross regulators in the system located as follows:

Khachar Distributary at RD 42
Khachar Distributary at RD 65
Soomerki Distributary at RD 26

In all three cases the gates are either missing or in a non-operating condition. Similarly the head regulator gates for the Drigh, Talho, Kalru and Pharkara Minors are all missing.

If all gates are returned to operating condition they would be operated according to the SDO's instructions by the assigned tandel/gauge reader. The Drigh Head Regulator gate must be repaired as it operates directly from the Almani Branch Canal.

The "Final Design Report" recommended that the three cross regulating structures be replaced with weirs that would proportion flows according to those shown in Table II-2. This would eliminate the need for an operator and assure equitable distribution to the minors.

B. Escape

The escape outlet is located at RD 12.0, Almani Branch Canal. Its operation is covered in the Emergency Operation Section located in the front of this manual.

C. Canal Filling and Drawdown (Dewatering)

Contrary to current practice, the rate of canal filling and drawdown should be controlled. This is particularly true for rapid drawdown situations. The normal recommended rate is that 20% of the total inflow change is made every 6 hours. Therefore, a complete change can be made in a 24-hour period. The maximum rate of change allowed is 1-foot per day.

D. Sediment Trap

A sediment trap is a structure placed in the canal to remove bed load sediment from the canal flow. Operation of a sediment trap must be such that only a portion of the total annual load is removed. The rehabilitated canal will have a given transport capacity based sediment parameters, discharge, slope and bank material. A sediment trap has been recommended for the Almani System. Its location and design have not been finalized. Two locations were recommended, one upstream of the Almani Cross Regulator and another just upstream of RD 12.0. Therefore, detailed instructions cannot be given at this time. A monitoring program will be required after construction of the sediment trap to determine the long term monitoring program that must accompany the operation of the sediment basin. A short discussion on some of the features of a sediment management program using a sediment trap is contained in the "General O&M Manual for Rehabilitated Systems".

The hydraulic design of the Almani System was based on an incoming sediment load of 180 ppm. The design indicates that the system will transport 145 ppm or 80% of the incoming load. This was based on the assumption that the average sediment discharge into the watercourses was equal to the sediment load in the canal. In other words, the watercourses were assumed to carry a proportional share of sediment and water. Based on an average discharge of 270 cfs, and a constant sediment concentration of 35 ppm, it was estimated that about 189,000 cubic feet per year would have to be removed from the system.

The design values are only estimates of average conditions and what occurs in the field will differ, not only in total annual volume but also in the year to year volume. Since the system will transport about 80% of the bed load, the

desilting of more than is necessary is an extra cost. Removal of too much sediment will cause the canal to scour downstream. Since desilting is costly, control methods should be devised that minimize this cost.

E. Operating Log

The operating log kept at each cross regulator will be forwarded to the SDO's office after the first of the month to be kept on file. A new log will be initiated on the first day of the month. Exhibit II-1 is the recommended format. The operating log is used to record changes made in the gate operation. All instructions sent by the SDO are logged "in" on this form. Written orders received are attached. It is important to log the time received and the action taken.

Section 6: Monitoring

Monitoring is a continuous process that covers the key items:

* Water measurement
* Water surface levels at control points
* Water surface levels at outlets
* Sedimentation
* Control

A. Water Measurement

Water measurements are made twice a day (0600 and 1800 hours) at all head regulators, each time one or more gates are adjusted and as otherwise directly by the SDO. These include:

* Almani Head Regulator
* Khachar Head Regulator
* Soomerki Head Regulator
* Drigh Head Regulator

It is expected that the vertical lift gates at the Almani and Soomerki headworks will be calibrated and used for water measurement. The Khachar Head Regulator will operate with about 0.2 ft of head loss at design discharge which means the structure would have 100% submergence, which can not be reliably calibrated. A lined reach downstream of the eddy pool was recommended in the "Final Design Report" as a control section in which a stage discharge relation could be established. Post rehabilitation conditions at the Talho, Kalru and Pharkara Minors will define measurement requirements at these locations.

The stage reading are taken and immediately entered on the record sheet. The discharge is then determined from the appropriate curves or rating table. Separate rating curves will be established for each measurement station using appropriate current meter measuring techniques. Exhibit II-2 is an example of a flow measurement record sheet.

The calibration of each flow measurement station will be checked at least once a year and more often if a need arises.

The measured flows are also entered onto the operating log maintained at each cross regulator.

On the first day of the month, the Sub-engineer will pickup the monthly flow record sheets and provide the gauge reader with a new form. The Tandel's record will be cross checked with the record at the SDO's office and any discrepancies will be noted and changed on the SDO's records. The station record is considered to be the true record.

B. Water Surface Levels at Control Points

Control point water surface levels and/or flows, as described in Section II-3 are used to monitor flows within the system to keep a check on the equity. Therefore, measurements to determine the exact level are not made daily. If desired, a stage-discharge relation can be established at the control points by standard current meter methods. It is recommended that the fall located at RD 40.4 Soomerki Distributary be rated and used as a flow measurement

station as well as the control point. The stage-discharge relation can also be adjusted to correspond to the canal inflow gauge readings so as to be direct reading. The control points are established to coincide with the ends of reaches used in the design of the canal. As is explained in Section II-3 this facilities the long term monitoring flow conditions in the canal. The control points are defined on Table II-3. Exhibit II-3 is the recommended form to be used for data collection and processing.

The primary monitoring is accomplished through evaluation of the water surface level. For any given discharge, the water surface level should remain constant at each control point.

It is the responsibility of Sub-engineer to see that the Daroga obtains the required information on his weekly inspections of the canals.

A slow rise in the water surface level for a constant inflow indicates sediment deposition somewhere downstream of the control point. Similarly, a lowering of the water surface is usually caused by increased withdrawals upstream, scour, or channel widening.

Changes in water levels indicate that non-equitable conditions are beginning to occur and water reaching the tail cluster would decrease in most cases. Monitoring the tail cluster provides the best means of maintaining equitability. The SDO or the SBE must determine the reason for the change and take appropriate action. In the case of sedimentation, a desilting program would be prepared to be implemented as soon as practical, usually during the next closure period.

Exhibit II-4 is the recommended form to be used for long term monitoring of each individual control point.

C. Water Surface Levels at Outlets

The water surface levels at each outlet will be determined once a month unless otherwise directed. In the past, the H Register (Exhibit II-4) was used to monitor conditions at the outlet. The H Register only records the depth

of flow at the entrance to the outlet and the working head. It does not relate to the flow in the canal at the time nor what the corresponding depth should be which makes monitoring of change difficult. Exhibit II-5 provides a form that would allow a more complete monitoring of conditions at each outlet and is recommended for use.

Figure II-1 shows a simple method of determining the water surface level. A temporary bench mark of known elevation is established and maintained at each outlet for this purpose.

D. **Sedimentation**

Sedimentation within a canal reach would generally be recognised by monitoring control point water surface levels. An increase in the water surface level for a given inflow to the canal would be an indication that sediment deposition is occurring downstream.

The location of sediment deposits can be determined by surveying appropriate cross-sections as described in the "General O&M Manual for Rehabilitated Systems". The location and removal of sediment must be coordinated with the maintenance program.

The Soomerki Sub-engineer will take one sediment sample on the first of each month downstream of the Almani and Soomerki Regulators. He will use a half gallon plastic bottle with a cork fixed to a string and tied to a pole. The bottle with the cork in the mouth is placed in the boil area to a point near the bottom and the cork pulled out of the bottle and slowly raised to the surface. The contents of the bottle are placed in another bottle and sent to the SDO. The bottle should be marked with location of sample and time and date taken. The time and date these samples are sent to the SDO must be entered in the operating log.

The SDO will forward the sediment sample to the appropriate laboratory section at the Sukkur Barrage for analysis. Facilities should be available there to determine the ppm of the sample. The grain size distribution of bed material samples can also be prepared at the laboratory. The results of the

analysis of samples received by the laboratory should be returned to the SDO within 30 days of receipt.

The sediment monitoring program requires that a bed material sample be taken near RD 1.0. The sample is taken from the canal bed surface; i.e., no deeper than 1-inch. The sample should contain at least one liter of material; i.e. a box 10 cm on a side. (4 inches on a side).

E. Control

Control of the various monitoring programs is maintained by supervision. This is a primary responsibility of the SDO. Inspections and careful study of the records and data will provide control over the work and assure that all standards are being maintained.

TABLE II-1

PERFORMANCE STANDARDS FOR CANAL OPERATION

1. Allocation of Water

The latest Outlet Register used for rehabilitation provides the sanctioned allocation of water to each watercourse. This defines equity.

2. Equitable Distribution of Water

The full supply level, FSL, defines the condition for which the equitable distribution of water was designed to be made to each watercourse. Therefore, at the design discharge the water level in the canal must reflect the FSL at all times; i.e., a deviation indicates a non-equitable condition.

3. Equitable Distribution of Sediment

The design of the turnout includes the consideration of sediment draw. The design of a rehabilitated canal assume the equitable withdrawal of sediment by each watercourse turnout. Therefore, the sill level of an outlet cannot be raised.

4. Uninterrupted Delivery

The uninterrupted delivery provides equitable distribution of water in a continuous flow system. Rotation of flows between canals is required when canal flows are reduced below 55% of the design discharge. Flows can be reduced to watercourse(s) serving an area due to occurrence of heavy rainfall or a low crop water demand. All changes in distribution must be recorded on operations log.

5. Maximum-Minimum Flows

The maximum allowable flow in a canal under certain conditions is limited to 1.2 times the design flow (1.2 Qd). The duration of a discharge greater than the design discharge cannot exceed two weeks under any circumstances. The canals should not be operated at flows less than 55% of design.

TABLE II-1

PERFORMANCE STANDARDS FOR CANAL OPERATION
(Continued)

6. **Maximum Water Level**

The maximum water level can never be allowed to exceed one half of the design freeboard (1/2 fb) under any circumstances.

7. **Inspection and Reports**

Inspections and accompanying reports must meet the following minimum

(1) Sub-engineer must make a weekly inspection and report.

(2) Sub-division Officer is required to make a biweekly inspection and report.

ALMANI BRANCH CANAL SYSTEM IRRIGATION DEMANDS

W/C		AREAS (acres)				DISCHARGES (cfs)						
Nr	RD	CCA	D.K.	Gdn	Gdn 1.5% CCA	Crop	Grdn 83.5 D.K.	Add	Total	Accum	Loss	Accum +loss
ALMANI BRANCH												
Head Works			70475								1.48	301.38
1BL	4.0	711	711		10.7	2.49	0.13	0.21	2.83	293.18	1.65	299.90
1CL	8.5	279	279		4.2	0.98	0.05		1.03	290.35	0.91	295.42
1AR	11.0	526	526	7.0	7.9	1.84	0.18		2.02	289.32	1.38	293.48
DRGH	14.8	1835	1835	12.0	28.0	6.52	0.49	0.36	7.37	287.30	0.14	290.07
1R	15.2	628	628	24.0	9.4	2.20	0.41		2.61	279.92	2.56	282.56
1AL	22.4	838	838	12.0	12.6	2.93	0.30		3.23	277.32	0.07	277.39
1L	22.6	689	689	60.0	10.3	2.41	0.86		3.27	274.08		274.08
SOOM	22.6		25992						104.35	104.35		104.35
KACH	22.6		38977						166.46	270.81		270.81

ALMANI BRANCH CANAL SYSTEM IRRIGATION DEMANDS

W/C		AREAS (acres)				DISCHARGES (cfs)						
Nr	RD	CCA	D.K.	Gdn	Gdn 1.5% CCA	Crop	Grdn @2.5 D.K.	Add	Total	Accum	Loss	Accum +loss
KALRU MINOR												
Head Works											0.60	14.67
2AL	7.5	561	561		8.4	1.96	0.10		2.07	14.02	0.05	14.07
1L	8.2	714	714		10.7	2.50	0.13		2.63	11.95		11.95
2L	8.2	579	579		8.7	2.03	0.11		2.13	9.32		9.32
3L	8.2	727	727		10.9	2.54	0.13		2.68	7.19		7.19
2R	8.2	1224	1224		18.4	4.28	0.22		4.51	4.51		4.51

ALMANI BRANCH CANAL SYSTEM IRRIGATION DEMANDS

W/C		AREAS (acres)				DISCHARGES (cfs)						
Nr	RD	CCA	D.K.	Gdn	Gdn 1.5% CCA	Crop	Grdn @3.5 D.K.	Add	Total	Accum	Loss	Accum +loss
TALHO MINOR												
Head Works											0.41	15.14
3L	5.0	522	522		7.8	1.83	0.10		1.92	14.12	0.15	14.73
3BR	7.0	666	666		10.0	2.33	0.12		2.45	12.20	0.41	12.66
3R	13.2	365	365		5.5	1.28	0.07		1.34	9.74		9.79
4L	13.2	699	699		10.5	2.45	0.13		2.57	8.40	0.04	8.44
3AR	14.0	805	805		12.1	2.82	0.15		2.97	5.82	0.00	5.83
5R	14.1	349	349		5.2	1.22	0.06		1.29	1.29		1.29
5L	14.1	427	427		6.4	1.49	0.08		1.57	2.86		2.86

ALMANI BRANCH CANAL SYSTEM IRRIGATION DEMANDS

W/C		AREAS (acres)				DISCHARGES (cfs)						
Nr	RD	CCA	D.K.	Gdn	Gdn 1.5% CCA	Crop	Grdn @3.5 D.K.	Add	Total	Accum	Loss	Accum +loss
PHARKARA MINOR												
Head Works											0.57	11.04
1AR	8.3	133	133		2.0	0.47	0.02		0.49	8.49		8.49
1R	8.3	536	536		8.0	1.88	0.10		1.97	10.47		10.47
1L	8.3	917	917		13.8	3.21	0.17		3.38	8.00		8.00
2L	8.3	1256	1256		18.8	4.40	0.23		4.63	4.63		4.63

ALMANI BRANCH CANAL SYSTEM IRRIGATION DEMANDS

W/C		AREAS (acres)				DISCHARGES (cfs)						
Nr	RD	CCA	D.K.	Gdn	Gdn 1.5% CCA	Crop	Grdn @3.5 D.K.	Add	Total	Accum	Loss	Accum +loss
SOOMERKI DISTY												
Head Works											0.02	104.35
1AR	0.1	728	728		10.9	2.55	0.13		2.68	96.88	0.04	104.33
1BR	0.3	266	266		4.0	0.93	0.05		0.98	94.20	0.68	101.61
1L	3.5	547	547		8.2	1.91	0.10		2.02	93.22	0.42	99.94
1CR	5.5	514	514		7.7	1.80	0.09		1.89	91.21	0.73	97.51
1R	9.0	1010	1010		15.2	3.54	0.19		3.72	89.31	0.04	94.88
2L	9.2	743	743		11.1	2.60	0.14		2.74	85.59	0.50	91.12
2BR	11.7	367	367		5.5	1.28	0.07		1.35	82.85	0.10	87.89
3BL	12.2	490	490		7.4	1.72	0.09		1.81	81.50	0.26	86.43
3L	13.5	564	564		8.5	1.97	0.10		2.08	79.70	0.25	84.37
3AL	14.8	387	387		5.8	1.35	0.07		1.43	77.62	0.02	82.05
2R	14.9	420	420		6.3	1.47	0.08		1.55	76.19	0.28	80.60
4AL	16.4	136	136	35.0	2.0	0.48	0.45		0.93	74.65	0.09	78.77
4L	16.9	429	429		6.4	1.50	0.08		1.58	73.72	0.20	77.74
2AR	18.0	822	822		12.3	2.88	0.15		3.03	72.14	0.24	75.96
3R	19.3	647	647	6.0	9.7	2.26	0.19		2.46	69.11	0.16	72.69
4R	20.2	457	457		6.9	1.60	0.08		1.68	66.65	0.23	70.08
4AR	21.5	794	794		11.9	2.78	0.15		2.92	64.97	0.17	68.16
5R	22.5	641	641		9.6	2.24	0.12		2.36	62.04		65.07
5AR	22.5	1317	1317		19.8	4.61	0.24		4.85	59.68	0.47	62.71
5L	25.4	1163	1163		17.4	4.07	0.21		4.28	54.83	0.02	57.39
6R	25.5	707	707	1.0	10.6	2.47	0.14		2.62	50.55	0.03	53.09
PKRA	25.7								11.04	47.93	0.15	50.44
7R	26.8	678	678		10.2	2.37	0.12		2.50	36.89	0.63	39.25
5AL	31.7	440	440		6.6	1.54	0.08		1.62	34.39	0.09	36.12
8R	32.4	657	657		9.9	2.30	0.12		2.42	32.77	0.12	34.42
6L	33.4	803	803		12.0	2.81	0.15		2.96	30.35	0.25	31.88
7L	35.6	779	779		11.7	2.73	0.14		2.87	27.39	0.36	28.67
8L	38.9	726	716		10.9	2.54	0.13		2.67	24.52	0.09	25.44
9R	39.8	850	850		12.8	2.98	0.16		3.13	21.85	0.03	22.67
9L	40.1	979	979		14.7	3.43	0.18		3.61	18.72	0.44	19.51
10R	45.3	745	745		11.2	2.61	0.14		2.74	15.11	0.17	15.47
10L	47.5	726	726		10.9	2.54	0.13		2.67	12.37	0.12	12.56
11L	49.3	420	420	2.0	6.3	1.47	0.10		1.57	9.69	0.04	9.77
11R	50.0	680	680		10.2	2.38	0.12		2.50	8.12	0.03	8.15
13L	50.6	720	720		10.8	2.52	0.13		2.65	2.65		2.65
12L	50.6	798	798	2.0	12.0	2.79	0.17		2.96	5.62		5.62

ALMANI BRANCH CANAL SYSTEM IRRIGATION DEMANDS

W/C		AREAS (acres)				DISCHARGES (cfs)						
Nr	RD	CCA	D.K.	Gdn	Gdn 1.5% CCA	Crop	Grdn @3.5 D.K.	Add	Total	Accum	Loss	Accum +loss
KACHAR DISTY												
Head Works											0.55	166.46
1EL	2.0	397	397		6.0	1.39	0.07		1.46	152.59	0.90	165.01
1CL	5.8	160	160		2.4	0.56	0.08		0.59	151.12	0.78	163.54
1L	8.0	245	245		3.7	0.86	0.05		0.90	150.53	0.54	162.22
1R	10.0	309	309		4.6	1.08	0.06		1.14	149.63	0.19	160.78
2R	10.7	567	567		8.5	1.98	0.10		2.09	148.49	0.00	159.45
1BL	10.7	463	463		6.9	1.62	0.09		1.71	146.40	0.69	157.36
1DL	13.3	857	857		12.9	3.00	0.16	1.45	4.61	144.70	0.16	154.96
2AR	13.9	1037	1037		15.6	3.63	0.19		3.82	140.09	0.00	150.20
1AL	13.9	420	420	25.0	6.3	1.47	0.38		1.85	136.27	0.54	146.38
3EL	16.0	441	441		6.6	1.54	0.08	0.50	2.12	134.42	0.03	143.99
3R	16.1	644	644	49.0	9.7	2.25	0.72		2.97	132.29	0.13	141.84
2L	16.6	345	345		5.2	1.21	0.06		1.27	129.32	0.87	138.74
4R	20.1	499	499		7.5	1.75	0.09		1.84	128.05	0.15	136.59
2AL	20.7	404	404		6.1	1.41	0.07		1.49	126.21	0.20	134.61
3L	21.5	445	445		6.7	1.56	0.08		1.64	124.72	0.27	132.92
3DL2	22.6	835	835		12.5	2.92	0.15		3.08	123.08	0.02	131.01
3DL1	22.7	1738	1738	76.0	26.1	6.08	1.25	0.65	7.98	120.01	0.02	127.91
3CL	22.8	922	922		13.8	3.23	0.17		3.40	112.02	0.71	119.91
4AR	25.9	352	352	39.0	5.3	1.23	0.54		1.77	108.63	0.16	115.80
3BL	26.6	356	356		5.3	1.25	0.07		1.31	106.85	0.09	113.86
3AL2	27.0	534	534		8.0	1.87	0.10		1.97	105.54	0.09	112.46
3AL	27.4	346	346	32.0	5.2	1.21	0.46		1.67	103.58	0.47	110.41
5R	29.5	575	575	16.0	8.6	2.01	0.30		2.31	101.91	0.20	108.27
6R	30.4	686	686		10.3	2.40	0.13		2.53	99.59	0.84	105.76
4L	34.3	532	532		8.0	1.86	0.10		1.96	97.07	1.00	102.39
7BR	39.0	352	352		5.3	1.23	0.06		1.30	95.11	0.04	99.43
4AL	39.2	242	242		3.6	0.85	0.04		0.89	93.81	0.13	98.09
5L	39.8	847	847		12.7	2.96	0.16	0.32	3.44	92.92	0.04	97.07
5AL	40.0	915	915		13.7	3.20	0.17	0.85	4.22	89.48	0.24	93.59
7R	41.2	652	652		9.8	2.28	0.12		2.40	85.26	0.10	89.13
6L	41.7	813	813		12.2	2.85	0.15		2.99	82.86	0.00	86.63
7AR	41.7	1081	1081		16.2	3.78	0.20		3.98	79.86	0.06	83.63
6BL	42.0	749	749		11.2	2.62	0.14		2.76	72.90	0.00	76.62
6AL	42.0	808	808		12.1	2.83	0.15		2.98	75.88	0.00	79.59
TLHO	42.0								15.14	65.45	1.04	69.16
7L	42.0	1275	1275		19.1	4.46	0.23		4.70	70.14	0.00	73.86
8R	48.7	659	659		9.9	2.31	0.12		2.43	50.31	0.80	52.98
7AL	54.0	1159	1159		17.4	4.06	0.21		4.27	47.88	0.42	49.75
9R	56.9	911	911		13.7	3.19	0.17		3.36	43.61	0.64	45.07
10R	61.6	711	711		10.7	2.49	0.13		2.62	40.25	0.08	41.07
8L	62.2	762	762		11.4	2.67	0.14		2.81	37.64	0.28	38.37
9L	64.4	753	753		11.3	2.64	0.14		2.77	34.83	0.04	35.28
11R	64.7	508	508		7.6	1.78	0.09		1.87	32.05	0.04	32.47
KLRU	65.0								14.67	28.80	0.27	29.18
9AL	65.0	366	366	3.0	5.5	1.28	0.10		1.39	30.18	0.00	30.57
12R	68.4	586	586		8.8	2.05	0.11		2.16	14.13	0.00	14.24
9BL	68.4	1105	1105		16.6	3.87	0.20	0.62	4.69	9.36	0.11	9.47
13R	68.4	708	708		10.6	2.48	0.13		2.61	11.97	0.00	12.08
10AL	70.7	610	610		9.2	2.14	0.11		2.25	2.25		2.25
10L	70.7	658	658		9.9	2.30	0.12		2.42	4.67	0.00	4.67

TABLE II-3

RECOMMENDED CONTROL POINT LOCATIONS
(Detailed Monitoring Program)

Canal	Location Rd	Calculated ** Water Surface Level
Almani Branch		
Head end	0.05 *	68.00
Tail end	22.56	65.10
Soomerki Distributary		
Head end	0.05 *	63.21
2L	9.2	61.82
2R	14.9	60.93
3R	19.3	60.22
Pharkara M	25.7	59.16
6L	33.4	57.70
7L	35.6	57.07
8L	38.9	56.39
Fall	40.4	56.07
10R	45.3	54.14
13L (tail)	50.6	52.85
Khachar Distributary		
Head end	0.05 *	64.90
1AL	13.9	63.00
3DL	22.8	61.75
6R	30.4	60.63
5AL	40.0	59.17
Talho M	42.0	58.86
7AL	54.0	56.55
Kalru M	65.0	54.55
9BL	68.4	53.54
10AL (Tail)	70.7	52.85
Pharkara Minor		
Head end	0.05 *	55.88
Tail end	8.3	53.78
Talho Minor		
Head end	0.05 *	56.73
Tail end	14.1	53.28
Kalru Minor		
Head end	0.05 *	53.32
Tail end	8.2	51.40

Note: * Location should be far enough downstream of regulator to obtain good water level reading.

** Taken from Design Statements.

Table II-4

ALMANI BRANCH CANAL SYSTEM DESIGNED,REGULATED FLOWS

Water Course			Design Discharge			Calibrated Discharge			Type of Outlet	Sill elev.	F.S.L. W.S. Elev.	Dimensions of Elevations		
NR	FD	CCA	Sanc. Flow	Loss	Accum. +loss	Measured Flow	Loss	Accum. +loss				Width	Dist. to Crest	TBM Elev.
ALMANI BRANCH														
Head Work	0.00			1.48	301.38									
1BL	4.0	711	2.83	1.65	299.90									
1CL	8.5	279	1.03	0.91	295.42									
1AR	11.0	526	2.02	1.38	293.48									
ORGH	14.8	1835	7.37	0.14	290.07									
1R	15.2	628	2.61	2.56	282.56									
1AL	22.4	838	3.23	0.07	277.39									
1L	22.6	689	3.27		274.08									
KACH	22.6		166.46		270.81									
SOOM	22.6		104.35		104.35									

Table II-4

ALMANI BRANCH CANAL SYSTEM DESIGNED,REGULATED FLOWS

Water Course			Design Discharge			Calibrated Discharge			Type of Outlet	Sill elev.	F.S.L. W.S. Elev.	Dimensions of Elevations		
NR	RD	CCA	Sanc. Flow	Loss	Accum. +loss	Measured Flow	Loss	Accum. +loss				Width	Dist. to Crest	TBM Elev.
DRIGH MINOR														
Head Work	0.0			0.36	7.37									
1R	14.8	853	3.26		7.01									
1L	14.8	982	3.75		3.75									

Table II-4

ALMANI BRANCH CANAL SYSTEM DESIGNED, REGULATED FLOWS

Water Course			Design Discharge			Calibrated Discharge			Type of Outlet	Sill elev.	F.S.L. W.S. Elev.	Dimensions of Elevations		
NR	RD	CCA	Sanc. Flow	Loss	Accum. +loss	Measured Flow	Loss	Accum. +loss				Width	Dist. to Crest	TBM Elev.
KALRU MINOR														
Head Work	0.0			0.60	14.67									
2AL	7.5	561	2.07	0.05	14.07									
1L	8.2	714	2.63		11.95									
2L	8.2	579	2.13		9.32									
3L	8.2	727	2.68		7.19									
2R	8.2	1224	4.51		4.51									

Table II-4

ALMANI BRANCH CANAL SYSTEM DESIGNED,REGULATED FLOWS

Water Course			Design Discharge			Calibrated Discharge			Type of Outlet	Sill elev.	F.S.L. W.S. Elev.	Dimensions of Elevations		
NR	RD	CCA	Sanc. Flow	Loss	Accum. +loss	Measured Flow	Loss	Accum. +loss				Width	Dist. to Crest	TBM Elev.
TALHO MINOR														
Head Work	0.0			0.41	15.14									
3L	5.0	522	1.92	0.15	14.73									
3BR	7.0	666	2.45	0.41	12.66									
3R	13.2	365	1.34		9.79									
4L	13.2	699	2.57	0.04	8.44									
3AR	14.0	805	2.97	0.00	5.83									
5R	14.1	349	1.29		1.29									
5L	14.1	427	1.57		2.86									

Table II-4

ALMANI BRANCH CANAL SYSTEM DESIGNED,REGULATED FLOWS

Water Course			Design Discharge			Calibrated Discharge			Type of Outlet	Sill elev.	F.S.L. W.S. Elev.	Dimensions of Elevations		
NR	RD	CCA	Sanc. Flow	Loss	Accum. +loss	Measured Flow	Loss	Accum. +loss				Width	Dist. to Crest	TBM Elev.
PHARKARA MINOR														
Head Work	0.0			0.57	11.04									
1AR	8.3	133	0.49		8.49									
1R	8.3	536	1.97		10.47									
1L	8.3	917	3.38		8.00									
2L	8.3	1256	4.63		4.63									

Table II-4

ALMANI BRANCH CANAL SYSTEM DESIGNED, REGULATED FLOWS

Water Course			Design Discharge			Calibrated Discharge			Type of Outlet	Sill elev.	F.S.L. W.S. Elev.	Dimensions of Elevations		
NR	RD	CCA	Sanc. Flow	Loss	Accum. +loss	Measured Flow	Loss	Accum. +loss				Width	Dist. to Crest	TBM Elev.
KACHAR DISTY														
Head Work	0.0			0.55	166.46									
1EL	2.0	397	1.46	0.90	165.01									
1CL	5.8	160	0.59	0.78	163.54									
1L	8.0	245	0.90	0.54	162.22									
1R	10.0	309	1.14	0.19	160.78									
2R	10.7	567	2.09	0.00	159.45									
1BL	10.7	463	1.71	0.69	157.36									
1DL	13.3	857	4.61	0.16	154.96									
2AR	13.9	1037	3.82	0.00	150.20									
1AL	13.9	420	1.85	0.54	146.38									
3EL	16.0	441	2.12	0.03	143.99									
3R	16.1	644	2.97	0.13	141.84									
2L	16.6	345	1.27	0.87	138.74									
4R	20.1	499	1.84	0.15	136.59									
2AL	20.7	404	1.49	0.20	134.61									
3L	21.5	445	1.64	0.27	132.92									
3DL2	22.6	835	3.08	0.02	131.01									
3DL1	22.7	1738	7.98	0.02	127.91									
3CL	22.8	922	3.40	0.71	119.91									
4AR	25.9	352	1.77	0.16	115.80									
3BL	26.6	356	1.31	0.09	113.86									
3AL2	27.0	534	1.97	0.09	112.46									
3AL	27.4	346	1.67	0.47	110.41									
5R	29.5	575	2.31	0.20	108.27									
6R	30.4	686	2.53	0.84	105.76									
4L	34.3	532	1.96	1.00	102.39									
7BR	39.0	352	1.30	0.04	99.43									
4AL	39.2	242	0.89	0.13	98.09									
5L	39.8	847	3.44	0.04	97.07									
5AL	40.0	915	4.22	0.24	93.59									

Table II-4

ALMANI BRANCH CANAL SYSTEM DESIGNED,REGULATED FLOWS

Water Course			Design Discharge			Calibrated Discharge			Type of Outlet	Sill elev.	F.S.L. W.S. Elev.	Dimensions of Elevations		
NR	RD	CCA	Sanc. Flow	Loss	Accum. +loss	Measured Flow	Loss	Accum. +loss				Width	Dist. to Crest	TBM Elev.
7R	41.2	652	2.40	0.10	89.13									
6L	41.7	813	2.99	0.00	86.63									
7AR	41.7	1081	3.98	0.06	83.63									
6BL	42.0	749	2.76	0.00	76.62									
6AL	42.0	808	2.98	0.00	79.59									
7L	42.0	1275	4.70	0.00	73.86									
TLHO	42.0		15.14	1.04	69.16									
8P	48.7	659	2.43	0.80	52.98									
7AL	54.0	1159	4.27	0.42	49.75									
9R	56.9	911	3.36	0.64	45.07									
10R	61.6	711	2.62	0.08	41.07									
8L	62.2	762	2.81	0.28	38.37									
9L	64.4	753	2.77	0.04	35.28									
11R	64.7	508	1.87	0.04	32.47									
KLRU	65.0		14.67	0.27	29.18									
9AL	65.0	366	1.39	0.00	30.57									
12R	68.4	586	2.16	0.00	14.24									
9BL	68.4	1105	4.69	0.11	9.47									
13R	68.4	708	2.61	0.00	12.08									
10AL	70.7	610	2.25		2.25									
10L	70.7	658	2.42	0.00	4.67									

Table II-4

ALMANI BRANCH CANAL SYSTEM DESIGNED,REGULATED FLOWS

Water Course			Design Discharge			Calibrated Discharge			Type of Outlet	Sill elev.	F.S.L. W.S. Elev.	Dimensions of Elevations		
NR	RD	CCA	Sanc. Flow	Loss	Accum. +loss	Measured Flow	Loss	Accum. +loss				Width	Dist. to Crest	TBM Elev.
SOOMERKI DISTY														
Head Work	0.0			0.02	104.35									
1AR	0.1	728	2.68	0.04	104.33									
1BR	0.3	266	0.98	0.68	101.61									
1L	3.5	547	2.02	0.42	99.94									
1CR	5.5	514	1.89	0.73	97.51									
1R	9.0	1010	3.72	0.04	94.88									
2L	9.2	743	2.74	0.50	91.12									
2BR	11.7	367	1.35	0.10	87.89									
3BL	12.2	490	1.81	0.26	86.43									
3L	13.5	564	2.08	0.25	84.37									
3AL	14.8	387	1.43	0.02	82.05									
2R	14.9	420	1.55	0.28	80.60									
4AL	16.4	136	0.93	0.09	78.77									
4L	16.9	429	1.58	0.20	77.74									
2AR	18.0	822	3.03	0.24	75.96									
3R	19.3	647	2.46	0.16	72.69									
4R	20.2	457	1.68	0.23	70.08									
4AR	21.5	794	2.92	0.17	68.16									
5R	22.5	641	2.36		65.07									
5AR	22.5	1317	4.85	0.47	62.71									
5L	25.4	1163	4.28	0.02	57.39									
6R	25.5	707	2.62	0.03	53.09									
PKRA	25.7		11.04	0.15	50.44									
7R	26.8	678	2.50	0.63	39.25									
5AL	31.7	440	1.62	0.09	36.12									
8R	32.4	657	2.42	0.12	34.42									
6L	33.4	803	2.96	0.25	31.88									
7L	35.6	779	2.87	0.36	28.67									
8L	38.9	726	2.67	0.09	25.44									
9R	39.8	850	3.13	0.03	22.67									

Table II-4

ALMANI BRANCH CANAL SYSTEM DESIGNED,REGULATED FLOWS

Water Course			Design Discharge			Calibrated Discharge			Type of Outlet	Sill elev.	F.S.L. W.S. Elev.	Dimensions of Elevations		
NR	RD	CCA	Sanc. Flow	Loss	Accum. +loss	Measured Flow	Loss	Accum. +loss				Width	Dist. to Crest	TBM Elev.
9L	40.1	979	3.61	0.44	19.51									
10R	45.3	745	2.74	0.17	15.47									
10L	47.5	726	2.67	0.12	12.56									
11L	49.3	420	1.57	0.04	9.77									
11R	50.0	680	2.50	0.03	8.15									
13L	50.6	720	2.65		2.65									
12L	50.6	798	2.96		5.62									

Exhibit II-1

OPERATING LOG

Position	Operators

Structure _____

Canal _____

Month Year Date	Time	Base head or Opening	Measured Discharge Cfs	Hours run	Entries
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					

Exhibit II-2

RECORD OF DAILY DISCHARGES

Division:_____ Flow Point No:_____

Sub Division:_____ Location:_____

Date	Reading (as found)				Reading (as left)				Remarks
	H_1(ft)	H_2(ft)	Q-(cfs)	Time	H_1(ft)	H_2(ft)	Q-(cfs)	Time	
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									

Note: 1. For weirs and staff gages only H_1, Q and Time should be recorded.

2. Indicate under remarks column, any unauthorized adjustments of gate and illegal checking.

Prepared by: Checked and Submitted by:

_____ _____

Weir/Gate Keeper Sub-Engineer

EXHIBIT II-3

FLOW MONITORING CONTROL POINTS

Canal: _____ Div. _____

Discharge: _____ Sub Division _____

_____ Date _____

Downstream W.S. elev. _____ Sub Engr _____

Control Points				Current Situation				
Reach RD No.	Structure Data			Dist. to W.S. (d) (in) (ft)	W.S. Elev	Stage ft	Est. Q cfs	Control Q cfs
	No.	Dir	RL					

W.S. = Water Surface

Q = Discharge

d = Distance from Reduced Level to Canal Water Surface.

Exhibit II-4

LONG TERM FLOW MONITORING RECORD

Canal Name _____

Structure/Control point _____

Design discharge _____

Calibrated Water Surface Level _____

Location (RD) _____

Reduced level _____

Division _____

Subdivision _____

Date of last Q Calibration _____

Date	Dist. to W.S. (d) (inch) (ft)	W.S. Elev. (ft)	Stage (ft)	Est. Q cfs	Control Q cfs

W.S. = Water Surface

Q = Discharge

d = Distance from Reduced Level to Canal Water Surface.

STATEMENT SHOWING WORKING OF OUTLETS

EXHIBIT II-5

[Working head of non-modular outlets is underlined]

R. D. of Outlet	Tide	Type of Outlet	Designed		April			May			June			July			August		
			'H'	M.M.H.	'H'	Working Head	Date	'H'	Working Head	Date	'H'	Working Head	Date	'H'	Working Head	Date	'H'	Working Head	Date
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

I. B. No. 462-A

STATEMENT SHOWING WORKING OF OUTLETS.

EXHIBIT II-5

Page 2 of 2

(Working head of non-modular outlets is underlined)

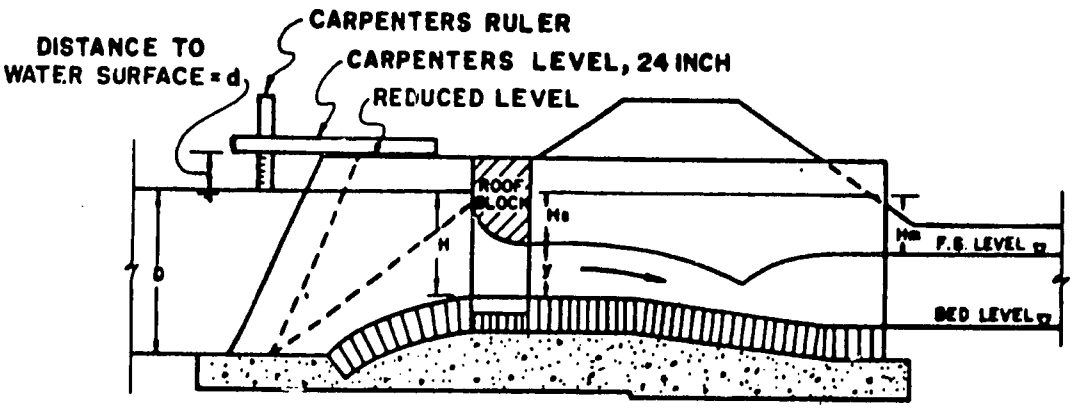
SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER			JANUARY			FEBRUARY			MARCH		
'H'	Working Head	Date	'H'	Working Head	Date	'H'	Working Head	Date	'H'	Working Head	Date	'H'	Working Head	Date	'H'	Working Head	Date	'H'	Working Head	Date
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41

Name of Canal: _____
Discharge: _____
Date: _____

OUTLETS FLOW MONITORING

Outlets		Sanctioned dimension etc					Canal Side							Watercourse Side						Measured width		Discharge Q cfs
No.	Dir.	RD	RL	Type	Sanc crest elv	Sanc width	Dist. to W.S.		Canal W.S. Elev.	Dist to crest		Crest elev	Head	Dist.to U.S.W.S.		Dist to w.c. W.S.		Depth of flow	Head Loss			
							in	ft		in	ft		ft	in	ft	in	ft	ft	ft	in	ft	

Exhibit II-6

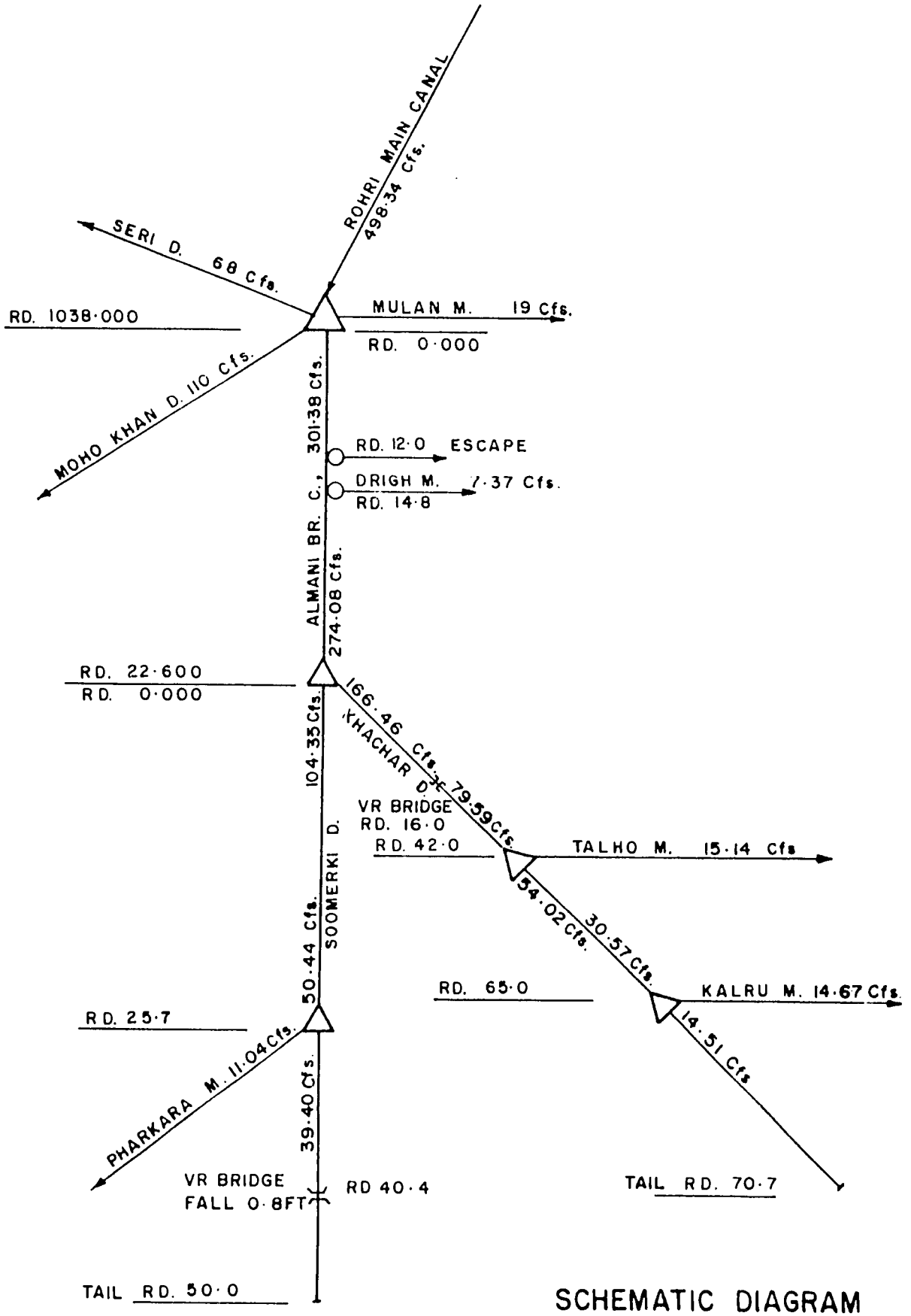


Note:

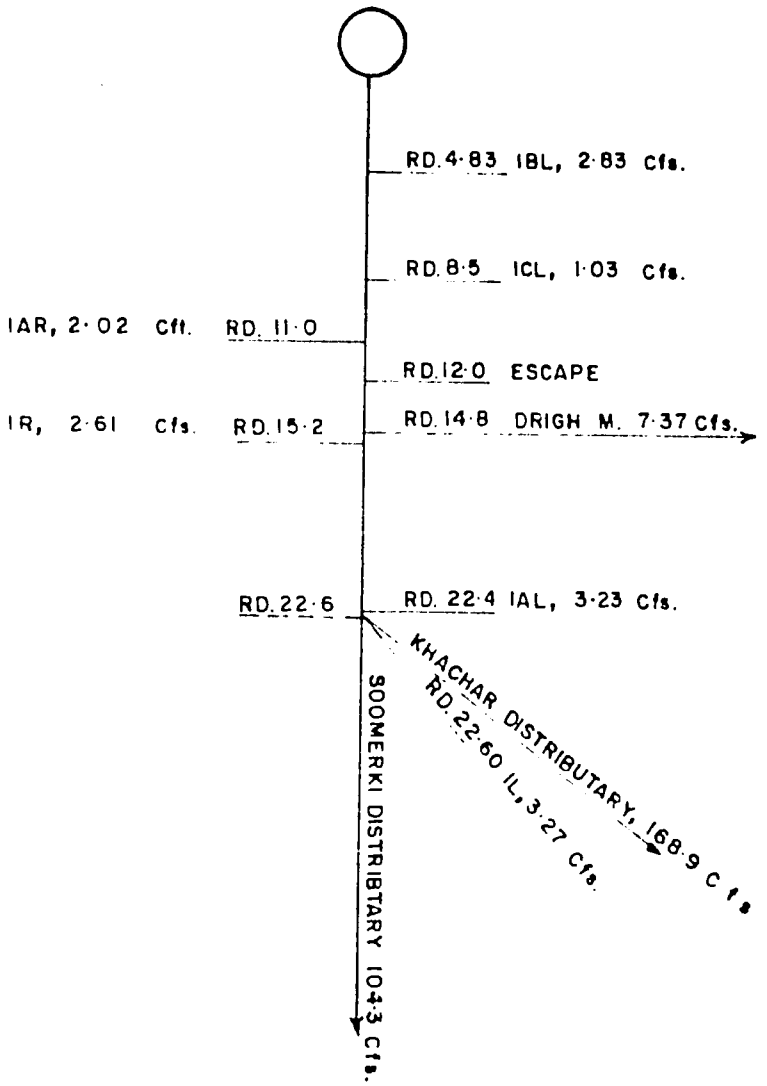
1. Reduced level set on outlet masonary cap.

2. Can substitute 6-foot steel tape for carpenters Rule.

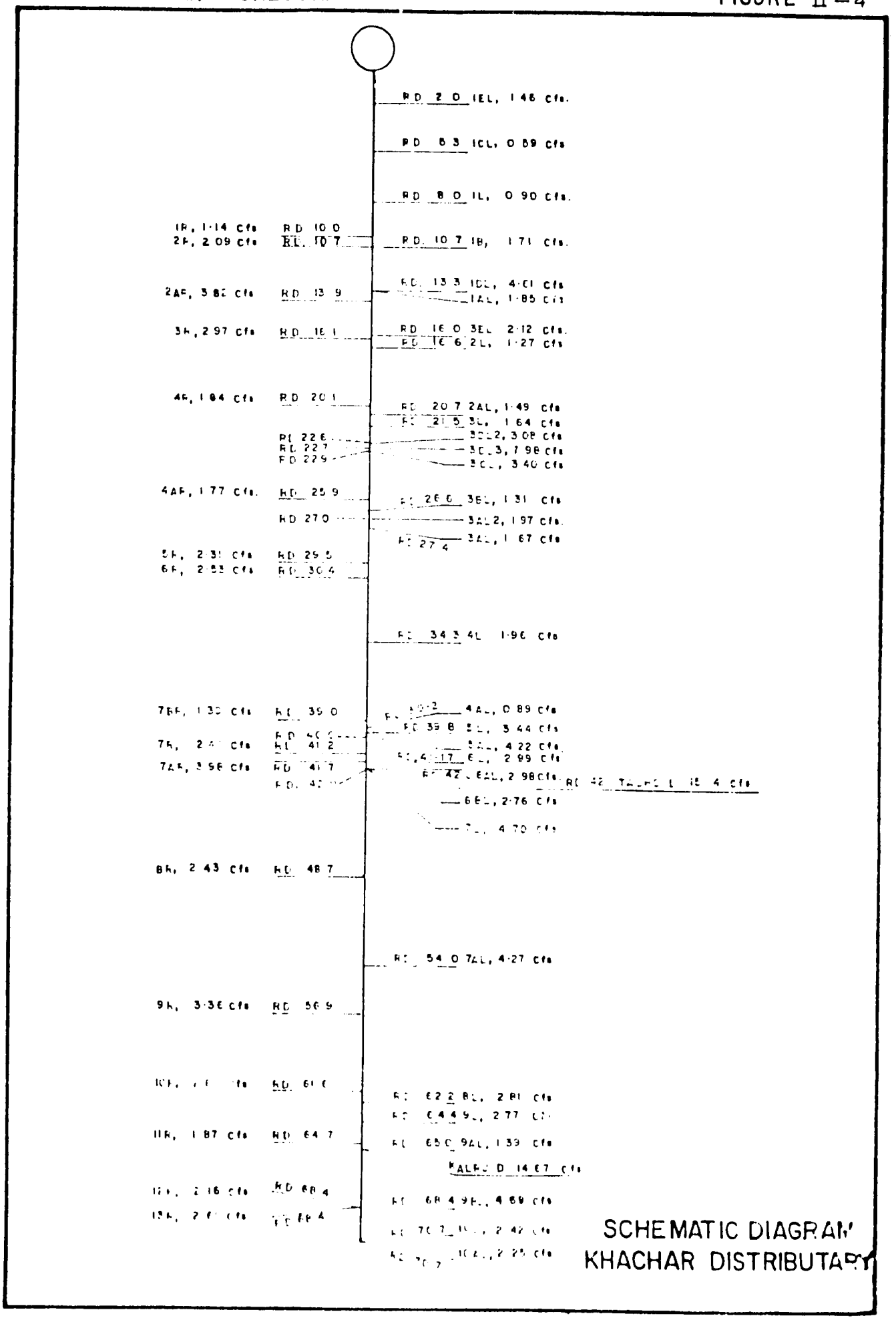
MEASURING WATER SURFACE LEVEL AT CONTROL POINT



SCHEMATIC DIAGRAM
DESIGN FLOW DISTRIBUTION
AT CONTROL STRUCTURES

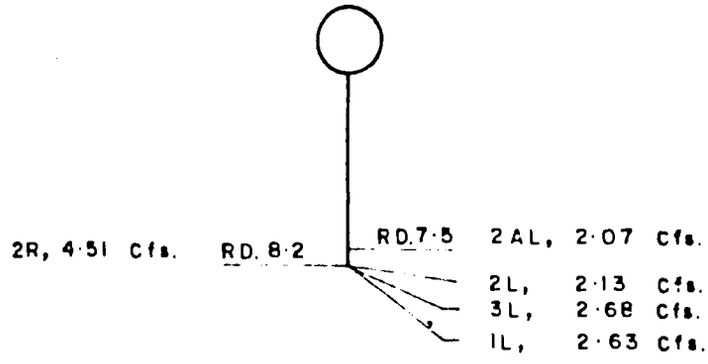


SCHEMATIC DIAGRAM
ALMANI BRANCH CANAL

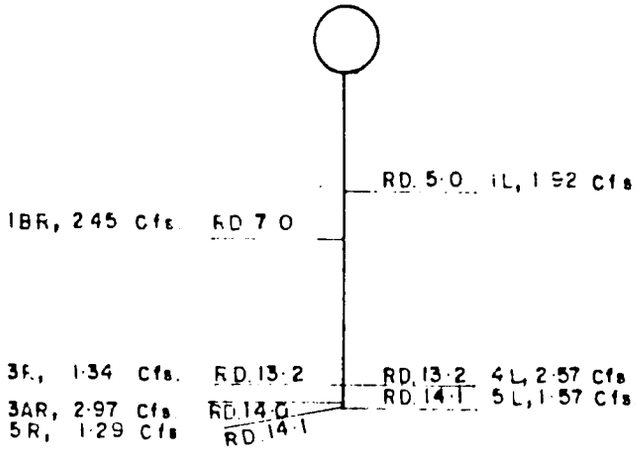


SCHEMATIC DIAGRAM
KHACHAR DISTRIBUTARY

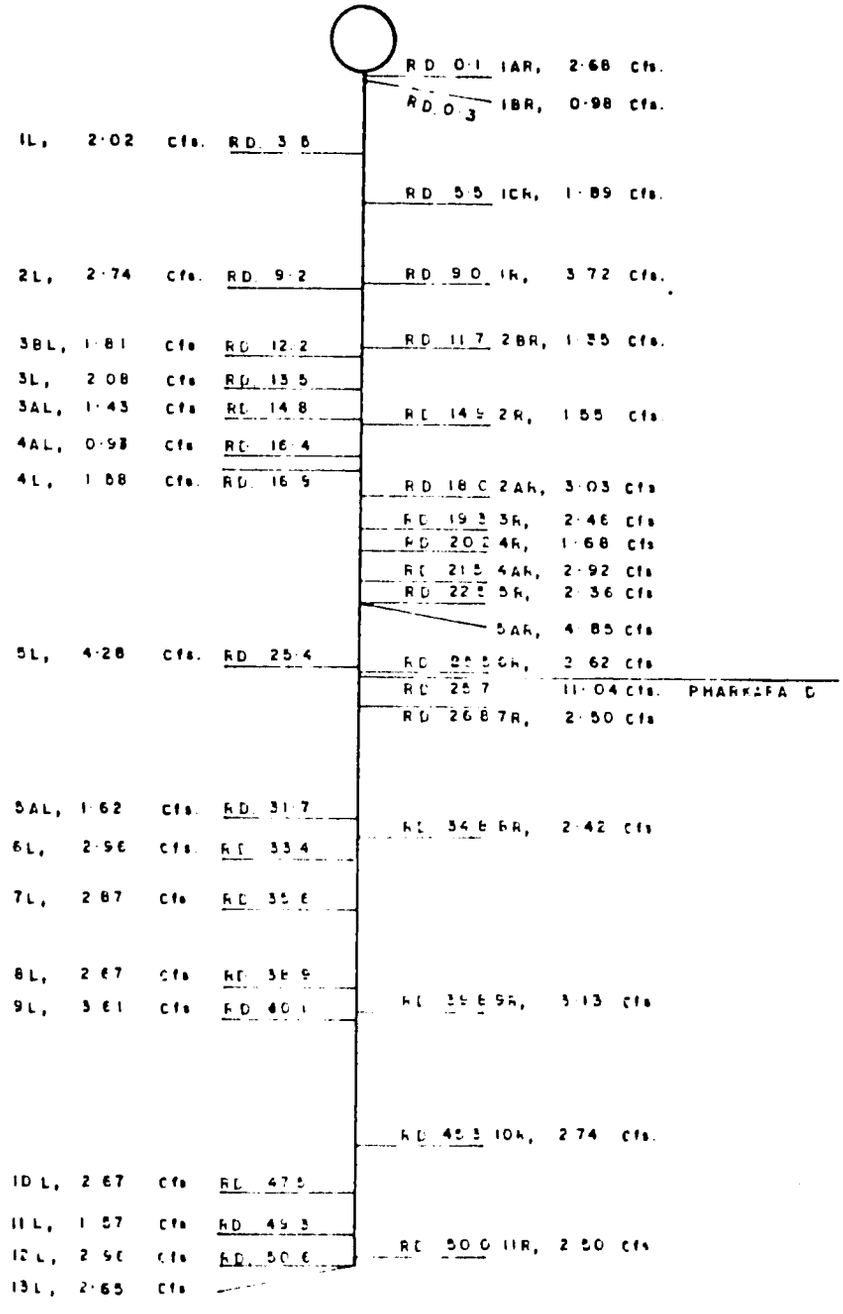
KALRU MINOR



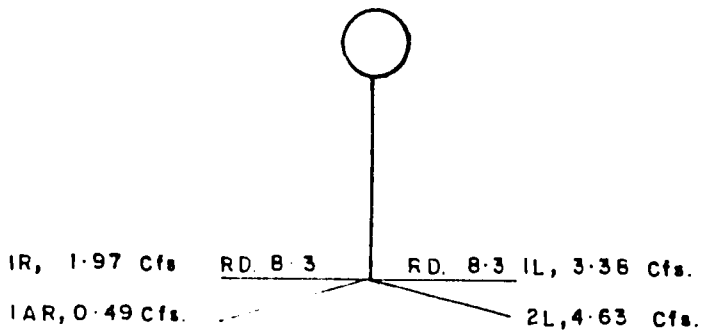
TALHO MINOR



SCHEMATIC DIAGRAM
KALRU AND TALHO MINORS
(KHACHAR DISTRIBUTARY)



SCHEMATIC DIAGRAM
SOOMERKI DISTRIBUTARY



SCHEMATIC DIAGRAM
PHARKARA MINOR
(SOOMERKI DISTRIBUTARY)

CHAPTER III

MAINTENANCE

CHAPTER III

MAINTENANCE

A. Standards

The "General Manual of O&M for Rehabilitated Canals" contains the detailed discussion of a good maintenance program. It is of the utmost importance that the maintenance standards for the canals and associated structure be maintained. Table III-1 contains the written maintenance standards and Figure III-1 provides a visual description of these same standards. Table III-2 presents the design standards for canal sections which provides the details for embankment top widths, slopes, freeboard and berm widths. The data on Table III-2 is not part of the hydraulic design statements contained in Appendix A. The details shown on Table III-2 would be included on the As-built drawings that would be provided following completion of the rehabilitation construction program.

1. Embankment Standards

The performance standards are the minimum allowable freeboard erosion (S_1) is 5 inches the minimum allowable outside slope erosion (S_2) is 10 inches and the minimum width (Wm) is Wd - 0.875 ft where Wd is the design top width.

The major maintenance problems that concern the canal embankment standards are where concentrations of animals enter the canal and at unbridged canal crossings. The latter are generally located where local roads or trails abut or cross the canal. The problem of concentrated animal use of the canal is discussed in the "General Manual of O&M for Rehabilitated Canals" in detail. The use or implementation of the semi-permanent ghat is emphasized because it will provide a reliable means of maintaining canal maintenance standards, particularly top width and freeboard.

2. Prism Standards

The hydraulic design for the rehabilitation of the Almani System indicated that there is sometimes considerable difference between existing and design cross sections. The "Design Criteria for Rehabilitating Canals" stated that if

the design width was no more than 1.1 times the existing bed width no widening shall be done. The design criteria (see Table III-2) also calls for berms to be constructed on all canals with a design flow depth greater than 2.5 feet. Berm design is based on the width of the berm at the canal bed level. Canals with a design depth between 2.5 and 3.99 feet require a berm width of 2.0 feet which adds 4.0 feet to the combined bed width of a canal; i.e., the distance between the toes of both embankments.

The head ends of both the Soomerki and Khachar Distributaries have hydraulic design depths that require berms. It is not clear (December 1986) what the PID will design and construct. It is quite conceivable that berms will be omitted since neither canal now has a definable berm. The omission will save considerable construction funds because widening to include a berm will require the removal and resetting of all the outlets along one bank.

Berms are required to protect the toe of the embankment. Their absence places the safety of canal embankment in a much more critical position. Erosion of berms does not cause a critical safety problem as the embankment toe is not touched. That is the reason for rather liberal maintenance standards. A much more rigid maintenance standard is required for a canal with a water depth greater than 2.5 feet where erosion of the toe is concerned. For this condition the criteria was established that no embankment erosion above the water line would be allowed. This means that the top width (t) of the prism (water surface width) is not allowed to increase. This is shown on Figure III-1, Sheet 2.

When a canal bank without berms starts to erode one of two conditions must be met; (1) killa bush spurs are constructed or (2) the embankment is widened out a horizontal distance of 1.5 feet. The 1.5 foot horizontal distance is equivalent to placing a 10 inch layer of compacted material on the outside slope. The addition of the extra blanket of material will allow the continued erosion of the embankment. The second solution is recommended when the average incoming discharge released into canal is more than 1.1 times the design discharge. Allowing the canal to hydraulically increase its wetted area may be a more cost effective method in the long run. With a higher flow

killa-bushing would be a constant maintenance requirement required to preserve the original prism area.

For canals equal to or less than 2.5 feet in depth, bank erosion may be allowed up to the point where it begins to intersect the point where the bank slope and bank top meet, see Figure III-1, Sheet 2. The average slope of an eroded canal bank approaches 0.5 to 1 (H to V) as it stabilizes.

Eroding banks will tend to cause downstream sediment problems but it is difficult to predict how much and where. Once a rehabilitated canal is calibrated, the "where" should be more predictable.

3. Water Control Structures

a. Regulators

There are eight water control facilities in the Almani System; four cross regulators with headworks, one escape, one fall and the separate head regulator for the Drigh Minor. The locations are shown in Figure II-2. The Almani Cross Regulator is not considered to be in the Almani System although it contains the head regulator to the system.

The canal regulator gates were inspected in 1986 and the operating conditions observed were:

		RD	Fully Open	Part Open	Orifice Plate (gate removed)	Gate missing or derelict
Almani	B H Reg	0	x			
Almani	B E Reg	12				
Drigh	M H Reg	15			x	
Soomerki	B C Reg	22.6				
Khachar	D H Reg	0	x			
Khachar	D C Reg	42				x
Talho	M H Reg	0			x	
Khachar	D C Reg	65				x
Kalru	M H Reg	0				x
Soomerki	D H Reg	0		x		
Soomerki	D C Reg	26				x
Pharkara	M H Reg	0			x	

Note: H = Head Regulator, and
C = Cross Regulator

The fall is located at RD 40.4 on the Soomerki Distributary and is combined with a village road bridge. It is recommended that the fall be rated and used as a flow measurement station since no additional construction is required.

These structures should have been rehabilitated at the time the canal was rehabilitated. A complete inspection of each structure should be made before the shakedown period starts. The exact condition of each structure should be noted and a request made for any necessary repairs to be made immediately so that they are completed during the shakedown period.

It is the responsibility of the Sub-engineer to keep the water control structures in good operating condition. The structures are the headworks for the two distributaries and three minors. Damaged gates, gate hoists and other metal work repairs are accomplished by fixed procedures with the Mechanical Circle. The repair of the masonry structures is accomplished using normal contracting procedures utilizing local contractors.

b. **Water Measurement Facilities**

Water measurement facilities did not exist prior to rehabilitation at the Soomerki Cross Regulator. Their construction was recommended as part of the rehabilitation process. These facilities are required if any degree of control is to be exercised over water deliveries and to provide better information on system operation and performance. It provides documentation for accountability. The head gate for the Soomerki Distributary could be calibrated as sufficient fall exist. There is insufficient head available at the Khachar gate to obtain a reliable rating. An alternative would be lined reaches, 150-200 feet long located a short way downstream would suffice and would not introduce additional head losses into the system. The use of current meters to rate these facilities would be required as would the periodic checking of the rating curve.

c. **Outlets**

The type of outlets employed include both open flow and adjustable orifice semi module (ASOM) type. Plain orifice plates have been installed in some distributary outlets on the Almani Branch Canal. There are adjustable orifice

and open type outlets on Khachar Distributary, but only open type on the Soomerki Distributary. The location of the outlets is defined on Table II-2 and on Figure II-3 through II-7.

Submerged flow conditions exist on a number of outlets. This is unsatisfactory since it interferes with the control which modular flow provides and which in turn is required for proportional distribution. Since the water levels vary in any canal from time to time, the discharge of submerged outlets can vary from submerged to modular conditions. The resulting variations in watercourse discharge may affect canal discharges downstream and contribute to the discharge fluctuations at the canal tails.

The cross sections made for the initial embankment monitoring program will also provide detailed records for each outlet. The extra data collected would show inlet invert elevation and conditions in the head end of the watercourse, bed levels and water levels. The monitoring program along with the H Register will allow a complete and accurate record of the outlets to the watercourses to be kept. Any tampering should be spotted immediately and appropriate action can be taken up with the canal and civil authorities.

4. Non-Control Structures

The non-control structures that have to be maintained are bridges and ghats. Currently there are no ghats in the system. Village bridges are located as follows:

Soomerki Distributary	RD 40.4
Khachar Distributary	RD 16.0

Bridges are also incorporated into the cross regulators. At the Soomerki Cross Regulator located at RD 22.6, Almani Branch Canal, bridges are provided to cross both distributaries. The two cross regulators on the Khachar Distributary (RD 42.0 and RD 65.0) include bridges across the distributary. The same is true on the Soomerki where the cross regulator at RD 25.7 provides a crossing of the distributary.

The use and construction of semi-permanent ghats is fully covered in the "General Manual for O&M of Rehabilitated Canals". Their use is highly recommended, particularly in non-village situations where there is room available. In settlement areas, only the permanent ghats can be used.

B. Scheduling Maintenance

Routine maintenance work items defined in Table III-3 are a continuous process that involves the daily efforts of all beldars. As such there is no formal schedule of what is done. The zones of responsibility of the Darogas and beats of the beldars are defined in Appendix B.

Annual maintenance work consists of work that can only be done during the closure period when the canal is dewatered. The majority of this work is contracted out to individual contractors. Therefore, the scheduling procedure must ensure that a complete description of the work to be done during closure is included in the contract. The SDO must schedule his people to make the necessary surveys to (1) allow the determination of quantities to be excavated for desilting contracts and (2) making the required survey and cross sections for the canal monitoring program. In some cases, it may be necessary to conduct the cross section survey with water in the canal.

The non-closure period work which concentrates on embankment repairs can be scheduled during periods when local labor is available. Agriculture has high demands for labor during certain critical crop production periods and maintenance work should not be scheduled during these periods unless it is absolutely critical.

The two main work programs to be scheduled would be the repair and strengthening of embankments at ghats and crossings and replacement of freeboard and embankment material that has eroded to the point the maintenance standards can no longer be met. The work required at ghats and crossings is critical but requires relatively small volumes of earth material and equipment. Scheduling and contracting should not present a difficult problem.

The scheduling of freeboard and embankment replacement becomes a difficult task because it requires a complete replacement of the freeboard on those reaches which cannot meet the standards. On the average one fifth of the total length of canals in any given system will require restoration each year. Planning and scheduling this massive effort may be controlled at the Circle level with coordination at the Division level and the XEN. There is a good possibility that most of Almani System would require restoration at the same time.

If it is decided that it will be accomplished at the sub-division level, the SDO will then schedule it according to his individual requirements. The Almani Branch Canal System has lengths of canal:

Branch	RD 22.6
Distributary	RD 121.3
Minor	RD 46.0

Total:	RD 189.9

Due to the nature of the work and the volumes involved it would appear that each minor would be a separate contract as would the branch canal itself. Similarly it would be possible to divide the distributaries into 5 or 6 separate reaches that would lend themselves to individual contract packages.

Decisions on scheduling and contracting for freeboard restoration will have to be made at the various levels of command. Initially, it may be up to the SDO to plan, schedule and budget the work when it becomes apparent that he will not be able to maintain the maintenance performance standard for another year. Restoration may not occur until 5 or 6 years or even longer if the maintenance procedures described above are really done correctly.

Emergencies cannot be scheduled. Therefore, contingency funds must be available at the Division or Circle level. Breaches are the major cause of an emergency and contingency plans are kept by the XEN and SE to supply the equipment and materials as quickly as possible. These contingency plans are activated upon notice of an emergency by the SDO.

C. Budgeting

The SDO must keep good records on all phases of the work accomplished each year. Particular emphasis must be placed on the volume of earth and then supplies/stores required for various works as well as labor requirements as these are the two largest expenses. The material and labor requirement are particularly important because the cost/rates for these will gradually increase but the amount of work required should tend to stabilize. Currently there are no real experience factors available that can be used to assist the SDO. The yardsticks used by the PID are too general for use at the Sub-division level as they were designed to allow the Circles or higher organizations to workout annual budgets. They can not be used to program and schedule work.

Budgeting starts with the determination of what work has to be done and when. A work program and schedule is then prepared. This requires preparing a detailed estimate of quantities of excavation, borrow, fill placement, compaction, and construction materials; labor production rates; timing, scheduling and any other work item required to complete the work program. Then the unit costs for doing the work and costs of materials are computed to provide the engineers cost estimate. If the work is to be spread out over several months then a payment schedule must be also prepared. Where contractors are to perform work, an allowance for overhead and profit must be included.

The budgeting of routine maintenance is much simpler because it is primarily a labor cost and the numbers are more or less fixed. It is a constant rate for permanent staff and an add on for casual labor.

D. Equipment Utilization

Currently the PID does not preform general canal maintenance with equipment. Little or no equipment is assigned to the Division/XEN for internal use. Contractors may or may not use tractor-trolleys in their operations. Head baskets and donkeys are still used extensively but their use may slowly decrease as the availability of cheap labor decreases.

There are three equipment items missing from all of the above operations (1) a water wagon with spreading apparatus, (2) a double disk (farm implement) for mixing soil and water, and (3) a vibrating sheepsfoot or steel roller that can be towed by the farm tractor to obtain compaction. These three pieces of equipment would allow a contractor to haul and spread the soil material using head baskets, donkeys or a tractor-trolley combination, raise the moisture content to optimum, mix the material to reduce lumps, uniformly distribute the moisture, and compact the soil to the proper density. All this is available today. The Highway Department is able to specify and control its use in all their projects. Therefore, it should not be difficult for the PID to do the same.

It will be upto the SDO and XEN to prepare bid specifications and tender documents with these requirements and then enforce their use during contract administration by utilizing a thorough inspection process that rejects and requires the contractor to remove the material not meeting specifications and to replace it with that which does. As is the normal case, enforcement is the key to success.

E. Inspection

Inspection is the key to determining what is happening within the system and supervising and controlling what needs to be done to meet the performance standards. The monitoring process will augment the inspection process with respect to defining the exact amounts of work required; i.e., sediment removal and freeboard replacement. These two items are difficult to gage by eye alone.

The forms to use, timing, and other aspects of conducting inspections are given in the "General Manual for O&M of Rehabilitated Canals. Their use must be encouraged.

The control of maintenance is accomplished by close supervision and the ability to get the work done that needs to be done to day and not let is wait until tomorrow.

TABLE III-1
PERFORMANCE STANDARDS FOR CANAL MAINTENANCE

1. Freeboard

The freeboard (FB) is never allowed to erode or be worn off more than 5 inches. The freeboard must be replaced as soon as the minimum freeboard is reached at any point on the canal embankment.

2. Capacity

The canal capacity must never be allowed to become less than the design capacity.

3. Maximum Discharge

The maximum discharge allowed in the canal is 1.2 times the design discharge at full supply level (FSL). The duration of a discharge greater than the design discharge cannot exceed two weeks under any circumstances.

4. Maximum Water Level

The maximum water level can never be allowed to exceed one half the design freeboard (1/2 fb) under any circumstances. This standard fixes the siltation standard.

5. Siltation

Silt accumulation in a distributary or minor is not allowed to exceed 9 inches. When 6 inches of sediment is observed or measured above the design bed level of the canal desilting must be programed for the next closure period.

6. Canal Width

There are three separate conditions that govern the performance of a canal with regard to canal width; (1) a canal with berms, (2) a canal without berms with depth h greater than 2.5 feet and (3) a canal without berms with depth h less than 2.5 feet.

TABLE III-1

PERFORMANCE STANDARDS FOR CANAL MAINTENANCE
(continued)

a. Canal with Berms

The average width of a canal will be allowed to vary between the design width (b) and 1.1 times the design width (1.1 b) without concern. No canal will be allowed to become narrower than the design width. A canal will not be allowed to widen beyond 1.2 times the design width without corrective action being taken.

b. Canal without Berms, h >2.5 ft

A canal without berms with a water depth greater than 2.5 feet does not conform to the design standards but may be allowed by the PID during rehabilitation to save cost on a distributary canal. Because of that eventuality the following criteria was established (It is equally valid for existing non rehabilitated distributary canals). Under no circumstances would the canal bank be allowed to erode above the intersection of the FSL and the embankment. This means the top width of the canal, t, cannot be allowed to increase at all. Only the toe of the embankment below the FSL is allowed to erode, thereby providing a steeper bank slope. When the canal starts to slough embankment material above the FSL killa bushing or other remedial measures are required.

c. Canal Without Berms, h <2.5 ft

The canal banks are allowed to erode to the point where the bank intersects the top of the embankment before remedial measures are required.

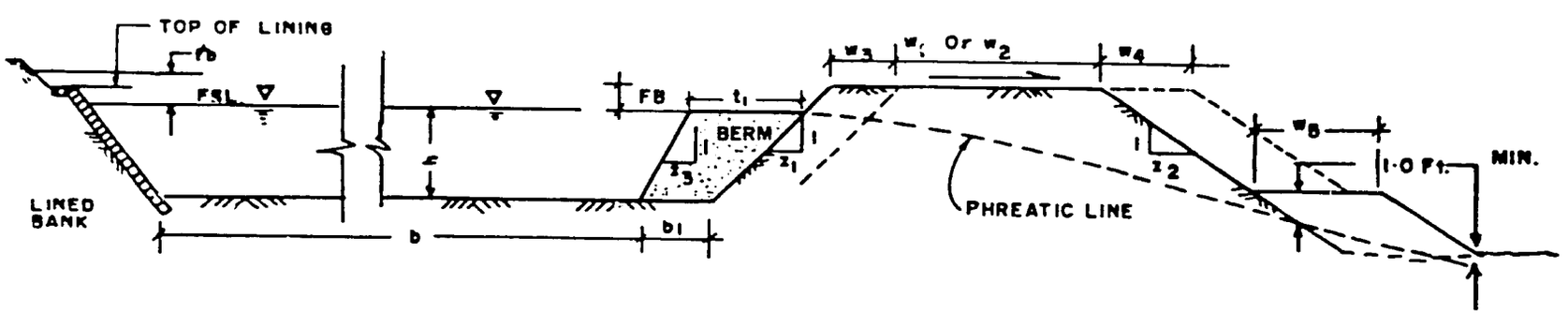
The bottom width is the critical dimension. The average top width is used to judge the condition of the canal. Minor scalloping due to animal ingress and egress, is not considered in evaluating the canal width as it does not affect hydraulic performance.

TABLE III-2

REHABILITATED CANAL EMBANKMENT DESIGN STANDARDS

Depth of flow h (ft)	Freeboard: Rigid Lining 1/ (ft)	Freeboard: Design fb (ft)	Freeboard: Rehab. - FB: Earth (ft)	Freeboard: Rehab. - FB: Metalled (ft)	Min. top Width W_1 (ft)	Road Width - W_2: Equip Maint. (ft)	Road Width - W_2: Patrol (ft)	Road Width - W_2: Village (ft)	Road Width - W_2: Highway (ft)	Berm Width b_1 (ft)	Slopes: Inside (z_1)	Slopes: Outside (z_2)	Slopes: Berm (z_3)
2.50	0.5	1.0	1.5	1.0	4	5	0	18	30	0	1.5	1.5	1.5
2.5 - 3.99	0.5	1.5	2.0	1.5	5	7	12	18	30	2	1.5	1.5	0.5
4.0 - 4.99	0.6	1.5	2.0	1.5	6	7	12	18	30	3	1.5	1.5	0.5
5.0 - 5.99	0.75	2.0	2.5	2.0	8	9	15	18	30	4	1.5	1.5	0.5
6.0 - 7.99	1.0	2.5	3.0	2.5	10	9	15	18	35	5	1.5	1.5	0.5
8.0 - 9.99	1.5	2.5	3.0	2.5	12	12	20	20	40	6	1.5	2.0	0.5
10.0 -11.99	1.6	3.0	3.5	3.0	15	12	20	20	40	7	1.5	2.0	0.5
>12.0	Site Specific Study Required												

Notes:
1. Distance from FSL to top of lining (earth freeboard also required)
2. W_3 = Dowel and W_4 = Avenue; W_3 = W_4 = 5 foot; neither are required but may be retained if already on existing embankment.
3. W_1 = Minimum top width where maintenance road is not required.
4. W_5 = Outside berm required to cover existing seepage surface if necessary.
5. b_1 = Designed to protect toe; maintained using top width (z_1).
6. FB = f_b + 5 inches = Freed board established during rehabilitation.



SCHEMATIC DESIGN SECTION

TABLE III-3

ROUTINE MAINTENANCE PROCEDURES

Item	Procedure
1. Remove Fallen Trees From Canal	The tree must be removed as soon as possible to limit scour damage to berm/bank. As many limbs as possible should be cutoff and removed to lighten the tree. A tractor with a chain a steel cable can be used to pull the tree up. Start near the top with the cable as the load will be lighter. As the tree comes out of the water, additional branch can be removed. Once the trunk is out and on the berm it can be cut up and removed.
2. Killa-bush Berm Repair	Killa-bush spurs can be placed 10 to 12 feet apart along reaches that require additional berm. In severe cases parallel revetment with branch laid behind it can be constructed.
3. Raincut Repair	Raincuts must be dug out and then the replacement material compacted in place. A hand tamper can be used. Soil material must be moistened before it is placed to obtain good compaction.
4. Rain Hole Filling and Repair	The rain hole must be fully opened up, cleaned and backfilled with compacted material. A hand tamper can be used. The soil must be moistened as it is mixed and placed.

TABLE III-3

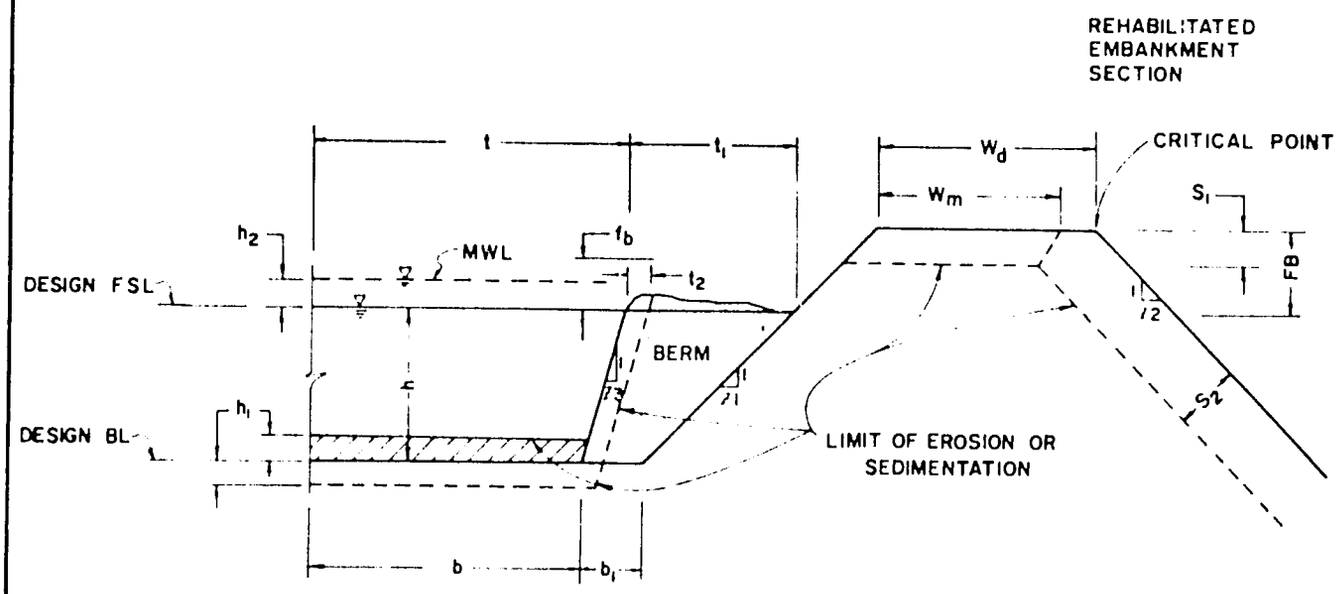
ROUTINE MAINTENANCE PROCEDURES
(Continued)

5.	Freeboard/Cattle Cut Repair	Same procedures as for raincuts or rain hole repair.
6.	Vegetation Control	Oxen and goats will keep grass cut. New brush or tree growth must be cutoff at ground level with a machete or other implement.
7.	Sodding Bare Spots	At the beginning of the monsoon season large bare spots on the embankment should sprigged or sodded with a drought resistant spreading type grass.
8.	Blow Sand Control	Fencing made of small vertical bamboo or reeds woven together and stood vertically will retard drifting sand. Post spaced about 12-feet apart buried 3-feet in the ground with a wire strung near the top of the post to hold up the woven fencing. The fence should be located about 100 feet on windward side of canal.
9.	Temporary Repair of Piping Around Structures	Piping around an outlet can be temporarily stopped by rodding or tamping material along the edge of the structure to reduce or close the opening through which water is moving. Additional earth may be required to help fill the void. Complete repair must be made during closure.

TABLE III-3

ROUTINE MAINTENANCE PROCEDURES
(Continued)

10.	Painting Exposed Metal	Exposed metalwork should be painted work during the rabi season following closure. All loose paint must be chipped and wire brushed to remove all rust and loose particles. The cleaned area should receive a prime coat of paint; iron oxide or similar type. The outer protective coat is applied as soon as prime coat in dry so that dust or other extraneous materials do not coat the surface.
11.	Grease and Oil	Exposed gears, gate slides and other equipment must be greased periodically. Normally every three months or as otherwise instructed.
12.	Exercise Gates	Gates should exercised at least once a month. This applies primarily to escapes or other gates which are not used for water control.
13.	Remove Floating Trash From In Front of Structures	A long handled rake can be used to help pull trash out of the canal.

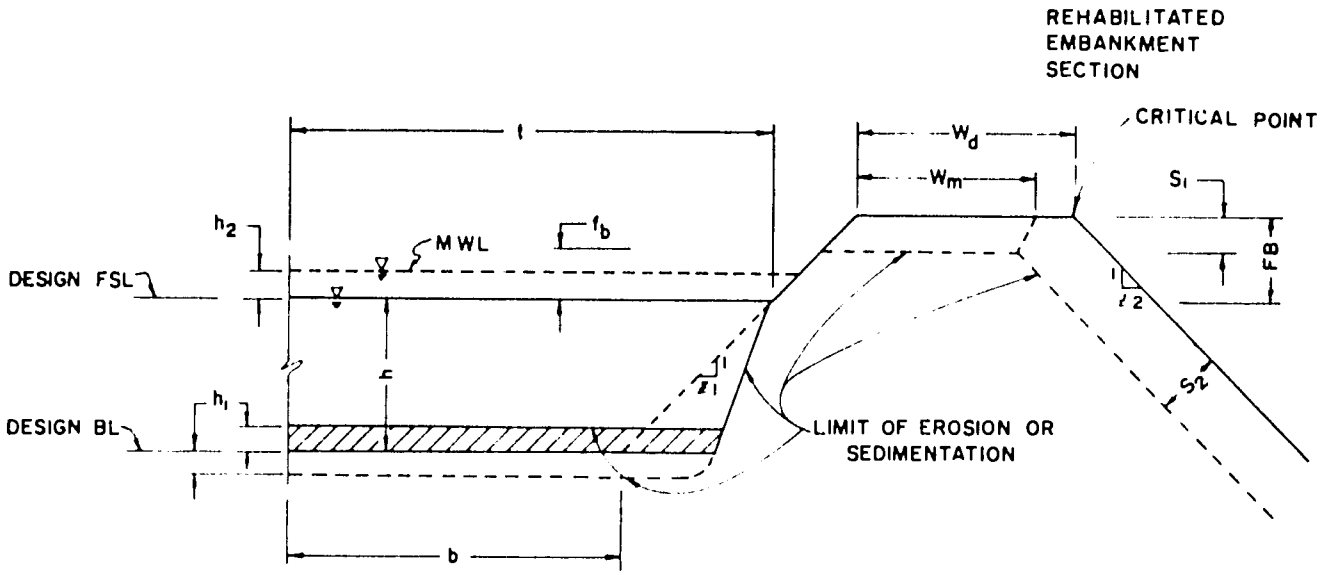


CANAL SECTION WITH BERMS

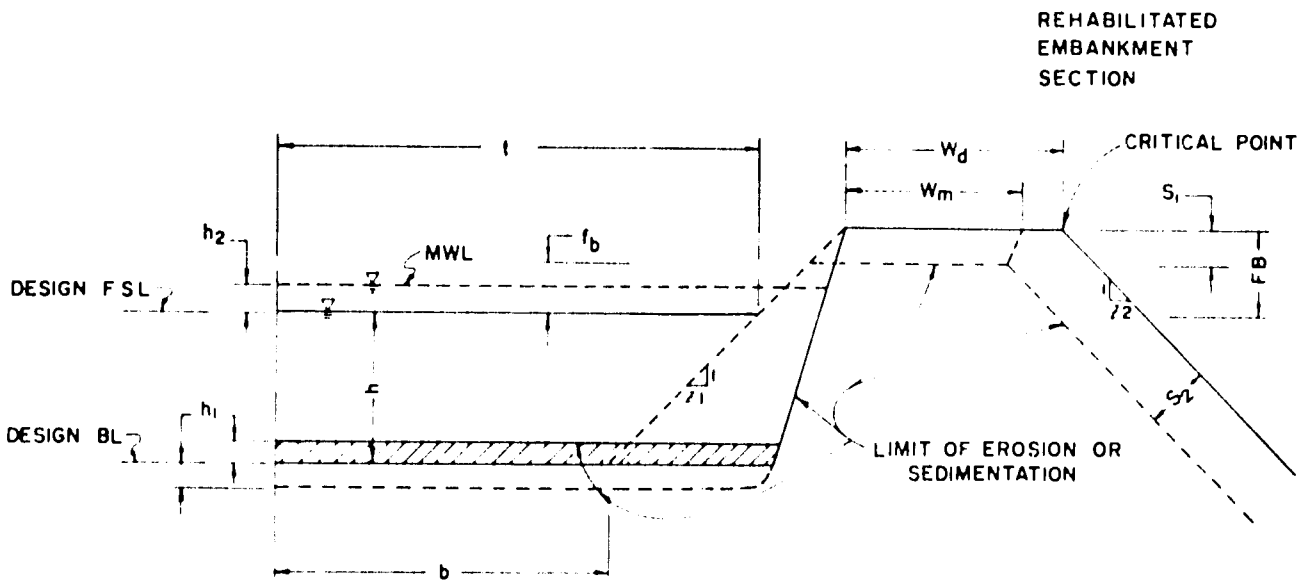
Legend

- b = Design width of canal.
- b_1 = Design berm width.
- h = Design depth.
- f_b = Design freeboard.
- h_1 = Maximum allowable depth of sediment accumulation/bed erosion.
- h_2 = Maximum water level encroachment on design freeboard = 0.5 fb.
- FB = Constructed freeboard = fb + 5 inches.
- S_1 = Maximum allowable freeboard erosion = 5 inches.
- S_2 = Maximum allowable embankment erosion = 10 inches.
- W_d = Design top width of embankment.
- W_m = Minimum top width of embankment = W_d - 0.875 (ft).
- t = Top width of canal prisum.
- t_1 = Berm top width corresponding to b_1.
- t_2 = Maximum allowable bank erosion = 0.1 b .
- FSL = Full supply level.
- BL = Bed level.
- MWL = Maxinim allowable water level.

PERFORMANCE STANDARDS
CANAL MAINTENANCE



CANAL SECTION WITHOUT BERMS
(h > 2·5 Feet)



CANAL SECTION WITHOUT BERMS
(h < 2·5 Feet)

PERFORMANCE STANDARDS
CANAL MAINTENANCE

APPENDIX A

DESIGN STATEMENTS AND LONG SECTIONS

TABLE A-1
CASE 3 DESIGN STATEMENT
ALMANI BRANCH CANAL SYSTEM

Canal : ALMANI

	Reach		EXISTING					CALCULATED									
	Rd u/s	Rd d/s	Disch	Outlet	Depth	Top width	Slope	Disch Error	Opt Hdc	Depth	Top Width	Velo-city	Slope	Con	Sed Trap	Sed Section
1	0	22600	301.	30.57	4.10	45.	9187.	.0	1	4.64	37.	1.88	7794.	145.	.208E+06	.00

Canal : SOOMERKI
Offtaking from ALMANI at RD 22600.

	Reach		EXISTING					CALCULATED									
	Rd u/s	Rd d/s	Disch	Outlet	Depth	Top width	Slope	Disch Error	Opt Hdc	Depth	Top Width	Velo-city	Slope	Con	Sed Trap	Sed Section
2	0	9200	104.	16.20	3.60	21.	4670.	.0	1	3.20	22.	1.60	6616.	145.	.000E+00	.00
3	9200	14900	88.	9.10	3.00	19.	4670.	.0	1	3.01	20.	1.57	6374.	145.	.000E+00	.00
4	14900	19300	79.	8.70	2.60	17.	4670.	.2	1	2.90	19.	1.54	6222.	145.	.000E+00	.00
5	19300	25700	70.	19.90	2.10	16.	4670.	.3	1	2.78	18.	1.52	6062.	145.	.000E+00	.00
6	25700	32400	39.	7.40	1.50	12.	4670.	.1	1	2.26	14.	1.40	5520.	145.	.000E+00	.00
7	32400	35600	32.	6.40	1.70	11.	4670.	.0	1	2.09	12.	1.35	5076.	145.	.000E+00	.00
8	35600	38900	25.	2.80	1.50	11.	4670.	.0	1	1.93	11.	1.31	4926.	145.	.000E+00	.00
9	38900	40400	23.	7.20	1.50	8.	4670.	.0	1	1.85	10.	1.29	4703.	145.	.000E+00	.00
10	40400	45300	15.	2.90	1.20	7.	4670.	.0	1	1.61	9.	1.22	4320.	145.	.000E+00	.00
11	45300	50600	13.	12.50	1.10	7.	4670.	.0	1	1.49	8.	1.19	4123.	145.	.000E+00	.00

Canal : PHARYARA
Offtaking from SOOMERKI at RD 25700.

	Reach		EXISTING					CALCULATED									
	Rd u/s	Rd d/s	Disch	Outlet	Depth	Top width	Slope	Disch Error	Opt Hdc	Depth	Top Width	Velo-city	Slope	Con	Sed Trap	Sed Section
12	0	8300	11.	11.00	1.10	6.	3640.	.1	1	1.42	7.	1.17	3952.	148.	.000E+00	.00

TABLE A-1
CASE 3 DESIGN STATEMENT
ALMANI BRANCH CANAL SYSTEM

Canal : KACHAR
Offtaking from ALMANI at RD 22600.

	Reach		EXISTING					CALCULATED									
	Rd u/s	Rd d/s	Disch	Outlet	Depth	Top Width	Slope	Disch Error	Opt Hdc	Depth	Top Width	Velo-city	Slope	Con	Sed Trap	Sed Section
13	0	13900	166.	22.47	3.00	36.	5036.	.0	1	3.80	28.	1.71	7329.	145.	.000E+00	.00
14	13900	22800	144.	28.19	2.46	29.	5195.	.0	1	3.60	26.	1.68	7100.	145.	.000E+00	.00
15	22800	30400	116.	13.41	2.32	28.	5839.	.0	1	3.33	23.	1.45	6769.	145.	.000E+00	.00
16	30400	40000	102.	13.26	2.32	23.	5854.	.0	1	3.18	22.	1.60	6586.	145.	.000E+00	.00
17	40000	42000	89.	21.01	2.20	23.	5854.	.0	1	3.03	20.	1.57	6389.	145.	.000E+00	.00
18	42000	54000	53.	7.92	1.30	13.	5286.	.0	1	2.51	16.	1.46	5693.	145.	.000E+00	.00
19	54000	65000	45.	16.15	1.25	12.	5319.	.0	1	2.37	15.	1.42	5490.	145.	.000E+00	.00
20	65000	68400	14.	9.60	1.10	5.	5263.	.0	1	1.57	8.	1.21	4243.	145.	.000E+00	.00
21	68400	70700	5.	4.67	1.10	6.	5000.	.0	1	1.04	5.	1.04	3296.	145.	.000E+00	.00

Canal : TALHO
Offtaking from KACHAR at RD 42000.

	Reach		EXISTING					CALCULATED									
	Rd u/s	Rd d/s	Disch	Outlet	Depth	Top Width	Slope	Disch Error	Opt Hdc	Depth	Top Width	Velo-city	Slope	Con	Sed Trap	Sed Section
22	0	7000	15.	5.34	1.10	8.	3774.	.0	1	1.60	9.	1.22	4303.	145.	.000E+00	.00
23	7000	14100	10.	9.80	1.00	7.	3774.	.0	1	1.37	7.	1.15	3904.	145.	.000E+00	.00

Canal : KALRU
Offtaking from KACHAR at RD 65000.

	Reach		EXISTING					CALCULATED									
	Rd u/s	Rd d/s	Disch	Outlet	Depth	Top Width	Slope	Disch Error	Opt Hdc	Depth	Top Width	Velo-city	Slope	Con	Sed Trap	Sed Section
24	0	8200	15.	14.67	.88	6.	3417.	.0	1	1.58	8.	1.22	4272.	145.	.000E+00	.00

TABLE A-1
CASE 3 DESIGN STATEMENT
ALMANI BRANCH CANAL SYSTEM

Canal : ALMANI

	Reach		EXISTING					CALCULATED				
	Rd u/s	Rd d/s	Disch	Bankl. upstr.	Bankl. dnstr.	Bedl. upstr.	Bedl. dnstr.	Fall upstr.	Waterl. upstr.	Waterl. dnstr.	Bedl. upstr.	Bedl. dnstr.
1	0	22600	301.38	68.60	68.90	62.76	61.24	.00	68.00	65.10	63.36	60.46

Canal : SOOMERKI
Offtaking from ALMANI at RD 22600.

	Reach		EXISTING					CALCULATED				
	Rd u/s	Rd d/s	Disch	Bankl. upstr.	Bankl. dnstr.	Bedl. upstr.	Bedl. dnstr.	Fall upstr.	Waterl. upstr.	Waterl. dnstr.	Bedl. upstr.	Bedl. dnstr.
2	0	9200	104.35	63.70	61.10	59.20	57.45	1.69	63.21	61.82	60.01	58.61
3	9200	14900	88.15	61.10	59.70	57.45	56.98	.00	61.82	60.93	58.60	57.91
4	14900	19300	79.05	59.70	59.40	56.98	56.49	.00	60.93	60.22	58.03	57.32
5	19300	25700	70.35	59.40	61.90	56.49	55.61	.00	60.22	59.16	57.44	56.38
6	25700	32400	39.20	61.90	56.80	55.61	54.22	.20	58.96	57.70	56.71	55.45
7	32400	35600	31.60	56.80	56.50	54.22	53.59	.00	57.70	57.07	55.61	54.98
8	35600	38900	25.40	56.50	55.20	53.59	53.85	.00	57.07	56.39	55.14	54.45
9	38900	40400	22.60	55.20	54.60	52.85	52.63	.00	56.39	56.07	54.53	54.22
10	40400	45300	15.40	54.60	57.40	53.63	51.74	.80	55.27	54.14	53.66	52.52
11	45300	50600	12.50	57.40	54.60	51.74	51.79	.00	54.14	52.85	52.64	51.36

Canal : PHARKARA
Offtaking from SOOMERKI at RD 25700.

	Reach		EXISTING					CALCULATED				
	Rd u/s	Rd d/s	Disch	Bankl. upstr.	Bankl. dnstr.	Bedl. upstr.	Bedl. dnstr.	Fall upstr.	Waterl. upstr.	Waterl. dnstr.	Bedl. upstr.	Bedl. dnstr.
12	0	8300	11.00	60.20	55.90	55.00	52.89	3.28	55.88	53.78	54.46	52.36

TABLE A-I
CASE 3 DESIGN STATEMENT
ALMANI BRANCH CANAL SYSTEM

Canal : KACHAR
Offtaking from ALMANI at RD 22600.

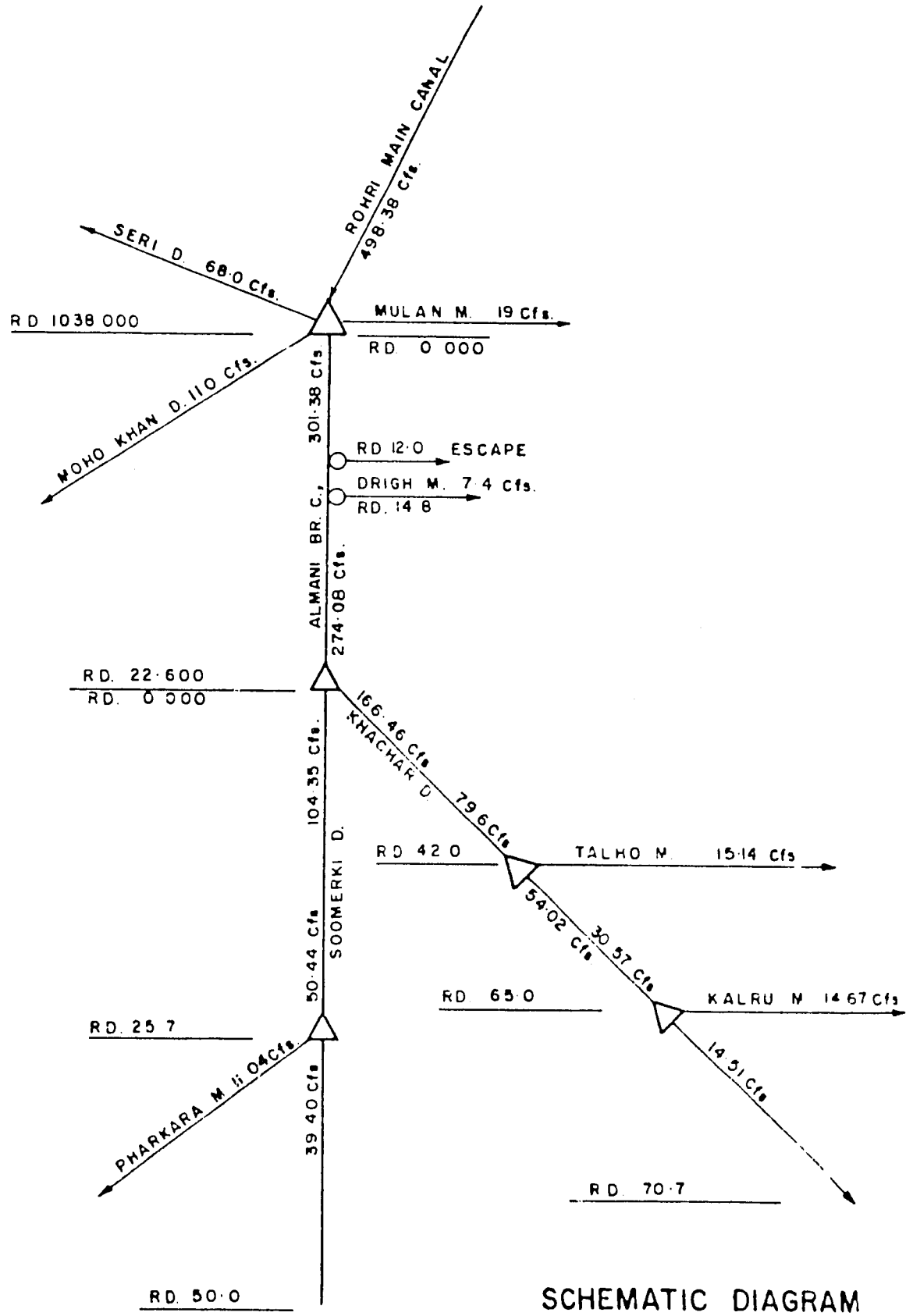
	Reach		EXISTING					CALCULATED				
	Rd u/s	Rd d/s	Disch	Bankl. upstr.	Bankl. dnstr.	Bedl. upstr.	Bedl. dnstr.	Fall upstr.	Waterl. upstr.	Waterl. dnstr.	Bedl. upstr.	Bedl. dnstr.
13	0	13900	166.46	66.90	64.62	62.70	62.02	.20	64.90	63.00	61.10	59.21
14	13900	22800	143.99	64.62	63.20	60.02	58.30	.00	63.00	61.75	59.40	58.15
15	22800	30400	115.80	63.20	62.08	58.30	56.86	.00	61.75	60.63	58.42	57.30
16	30400	40000	102.39	62.08	60.70	56.86	55.60	.00	60.63	59.17	57.45	55.99
17	40000	42000	89.13	60.70	60.46	55.60	56.26	.00	59.17	58.86	56.14	55.83
18	42000	54000	52.98	60.46	59.19	56.26	53.99	.20	58.66	56.55	56.15	54.04
19	54000	65000	45.06	59.19	57.88	53.99	51.92	.00	56.55	54.55	54.18	52.18
20	65000	68400	14.24	57.88	58.08	51.92	51.38	.20	54.35	53.54	52.78	51.98
21	68400	70700	4.64	58.08	56.00	51.38	51.03	.00	53.54	52.85	52.50	51.80

Canal : TALHO
Offtaking from KACHAR at RD 42000.

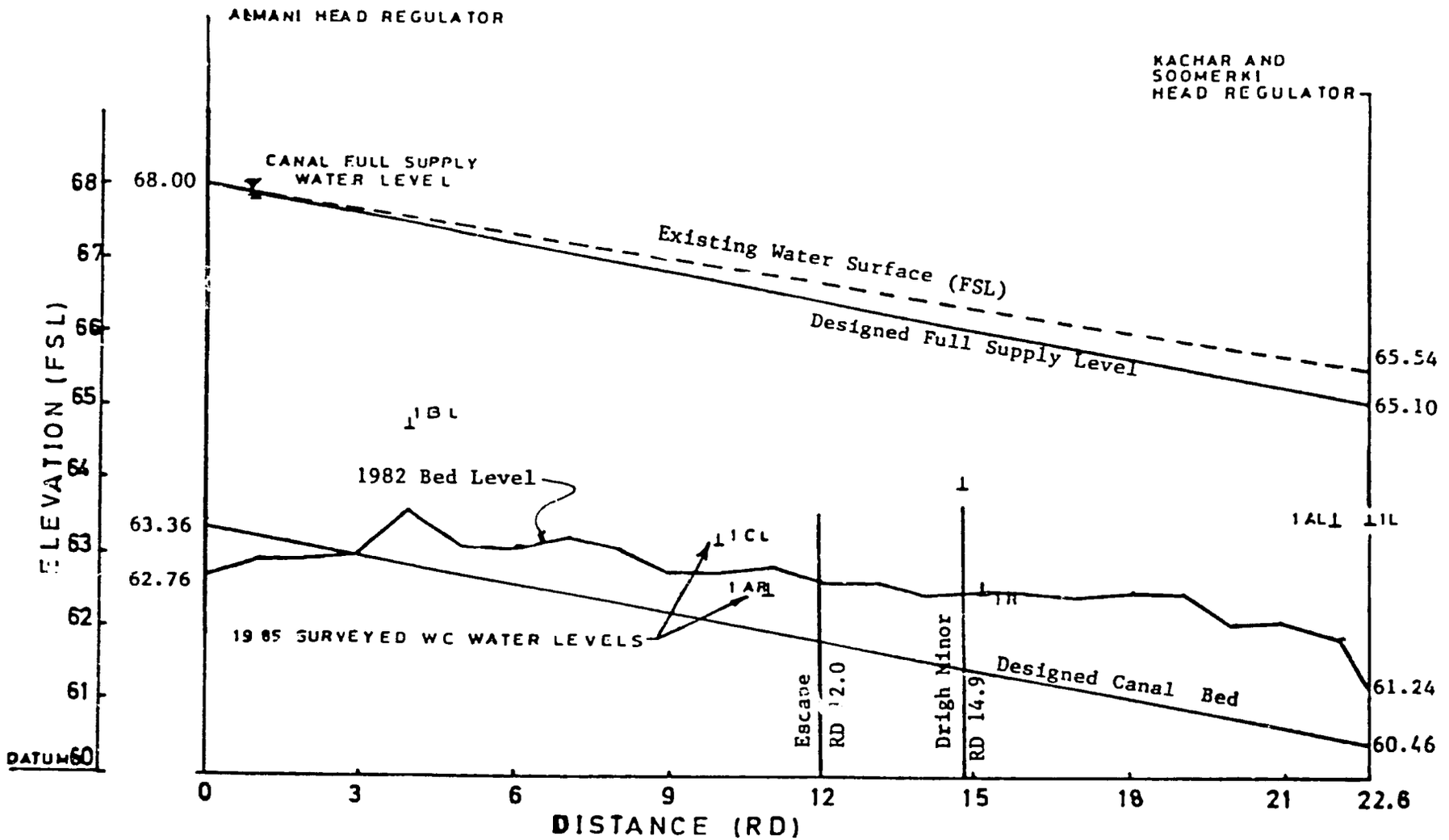
	Reach		EXISTING					CALCULATED				
	Rd u/s	Rd d/s	Disch	Bankl. upstr.	Bankl. dnstr.	Bedl. upstr.	Bedl. dnstr.	Fall upstr.	Waterl. upstr.	Waterl. dnstr.	Bedl. upstr.	Bedl. dnstr.
22	0	7000	15.14	57.15	56.50	54.75	53.14	2.13	56.73	55.10	55.13	53.50
23	7000	14100	9.80	56.50	59.00	53.14	51.50	.00	55.10	53.28	53.74	51.92

Canal : KALRU
Offtaking from KACHAR at RD 65000.

	Reach		EXISTING					CALCULATED				
	Rd u/s	Rd d/s	Disch	Bankl. upstr.	Bankl. dnstr.	Bedl. upstr.	Bedl. dnstr.	Fall upstr.	Waterl. upstr.	Waterl. dnstr.	Bedl. upstr.	Bedl. dnstr.
24	0	6200	14.67	57.07	58.[illegible]	51.90	50.00	1.23	53.32	51.40	51.74	49.82



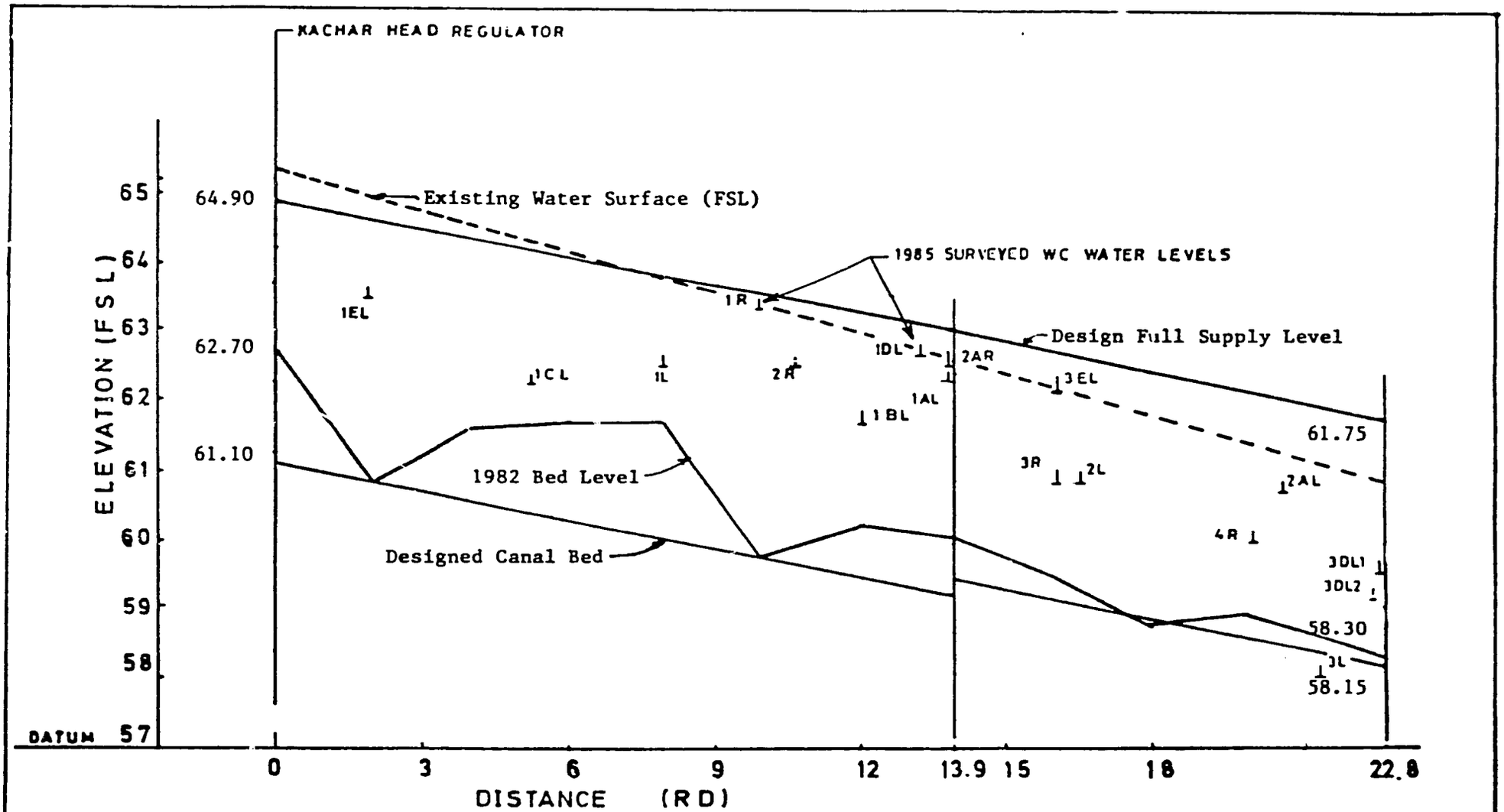
SCHEMATIC DIAGRAM
DESIGN FLOW DISTRIBUTION
AT CONTROL STRUCTURES



Notes: 1. Hydraulic Design Data given in Table IV-2
2. WC = Watercourse

HYDRAULIC DESIGN
ALMANI BRANCH CANAL
RD 0-22.6 TAIL

FIGURE A-2

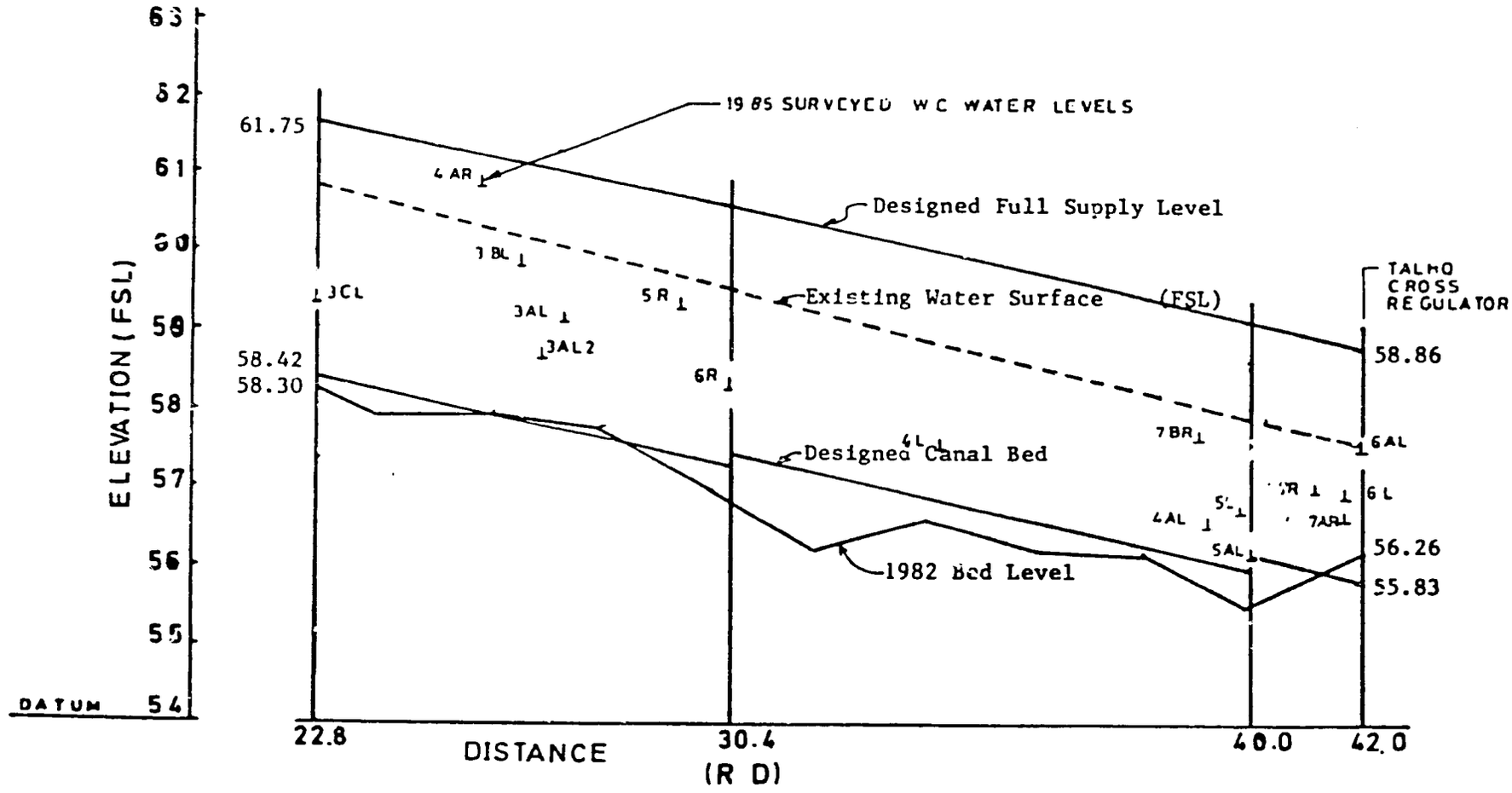


Notes: 1. Hydraulic Design Data given in Table IV-2
2. WC = Watercourse

HYDRAULIC DESIGN
KHACHAR DISTRIBUTARY
RD 0-22.8

PRC ENGINEERING/CHECCHI

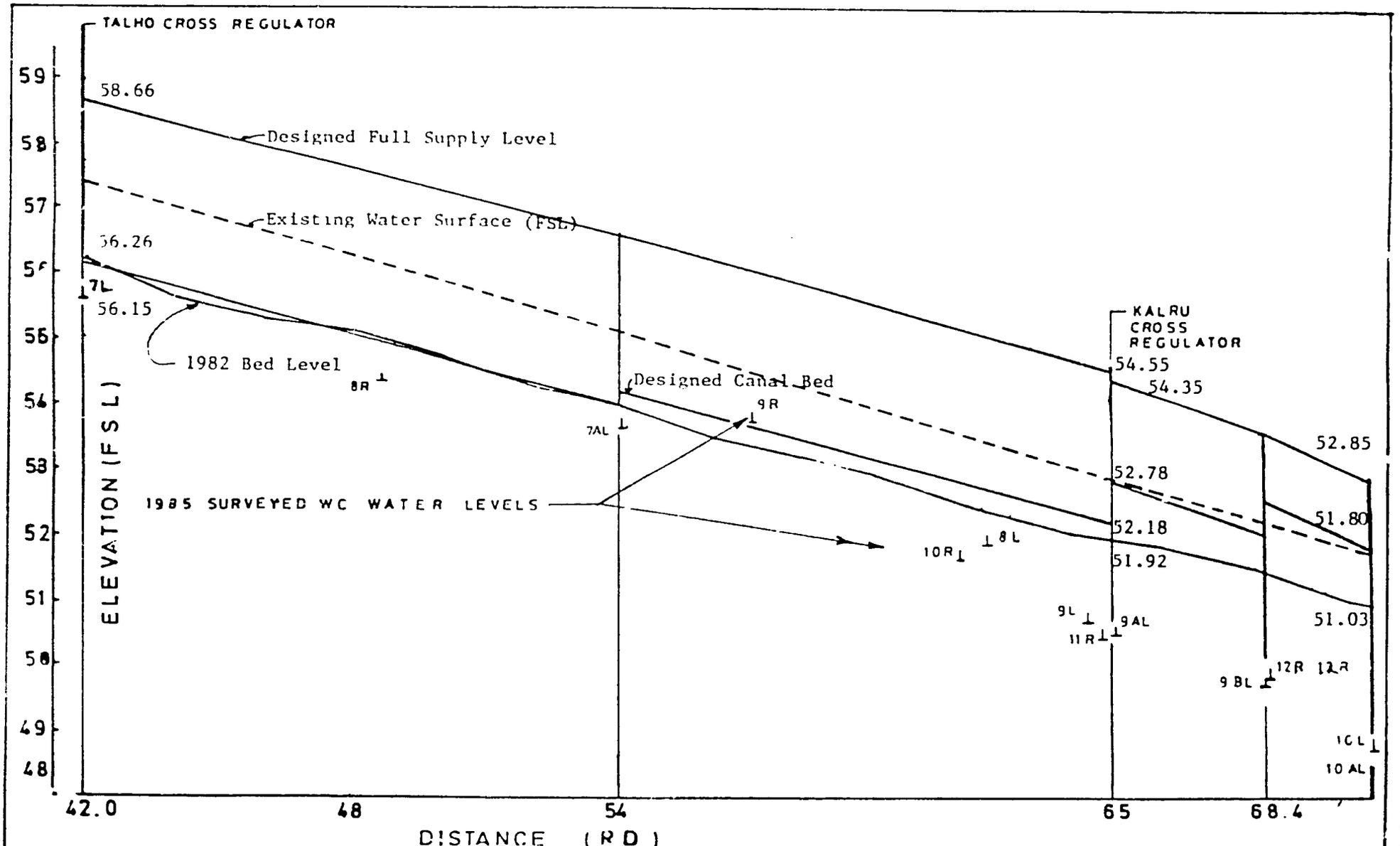
FIGURE A-3



Notes: 1. Hydraulic Design Data given in Table IV-2
2. WC = Watercourse

HYDRAULIC DESIGN
KHACHAR DISTRIBUTARY
RD 22.8-42.0

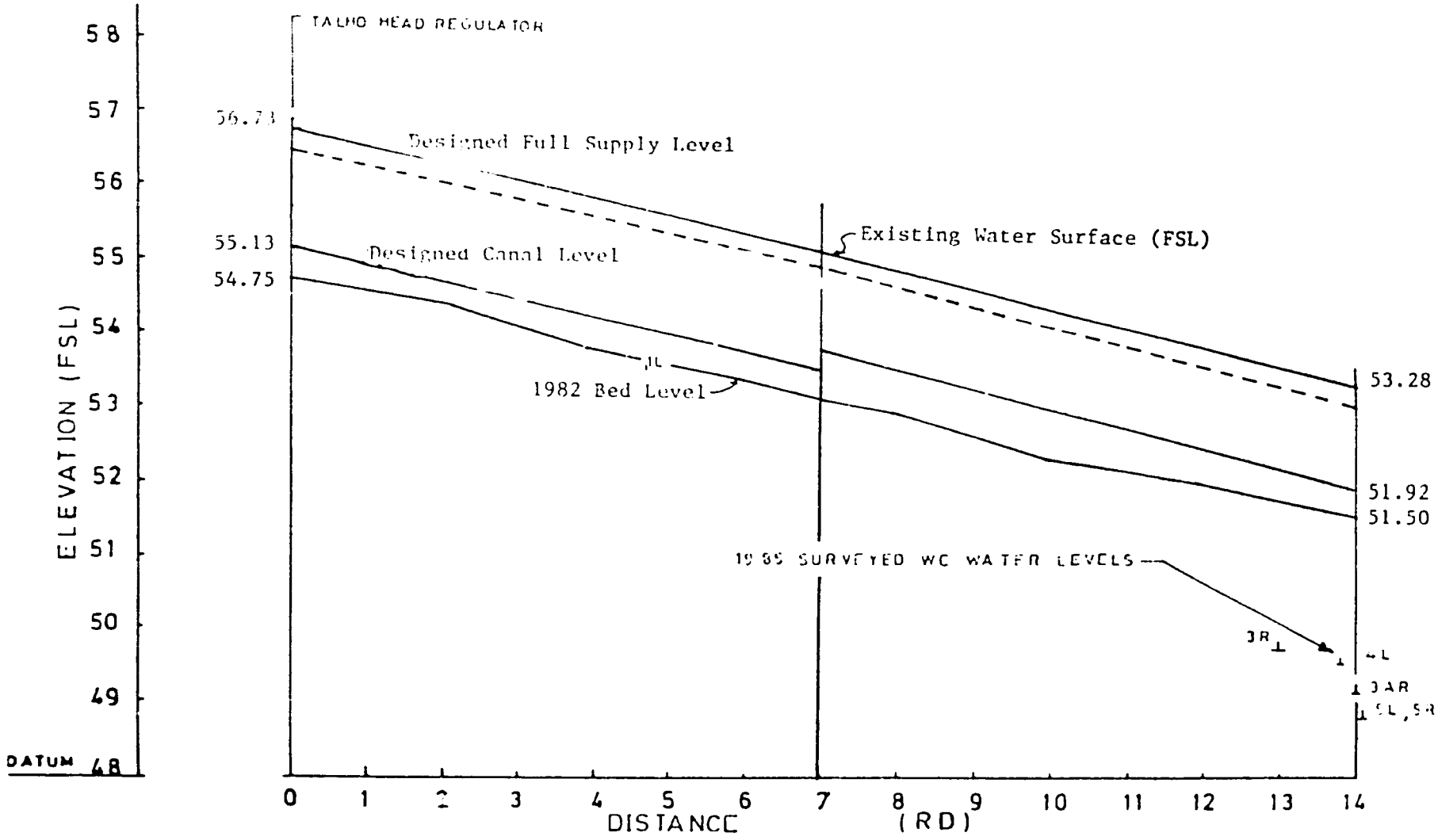
FIGURE A-4



Notes: 1. Hydraulic Design Data given in Table IV-2
2. WC = Watercourse

HYDRAULIC DESIGN
KHACHAR DISTRIBUTARY
RD 42.0-70.7 TAIL

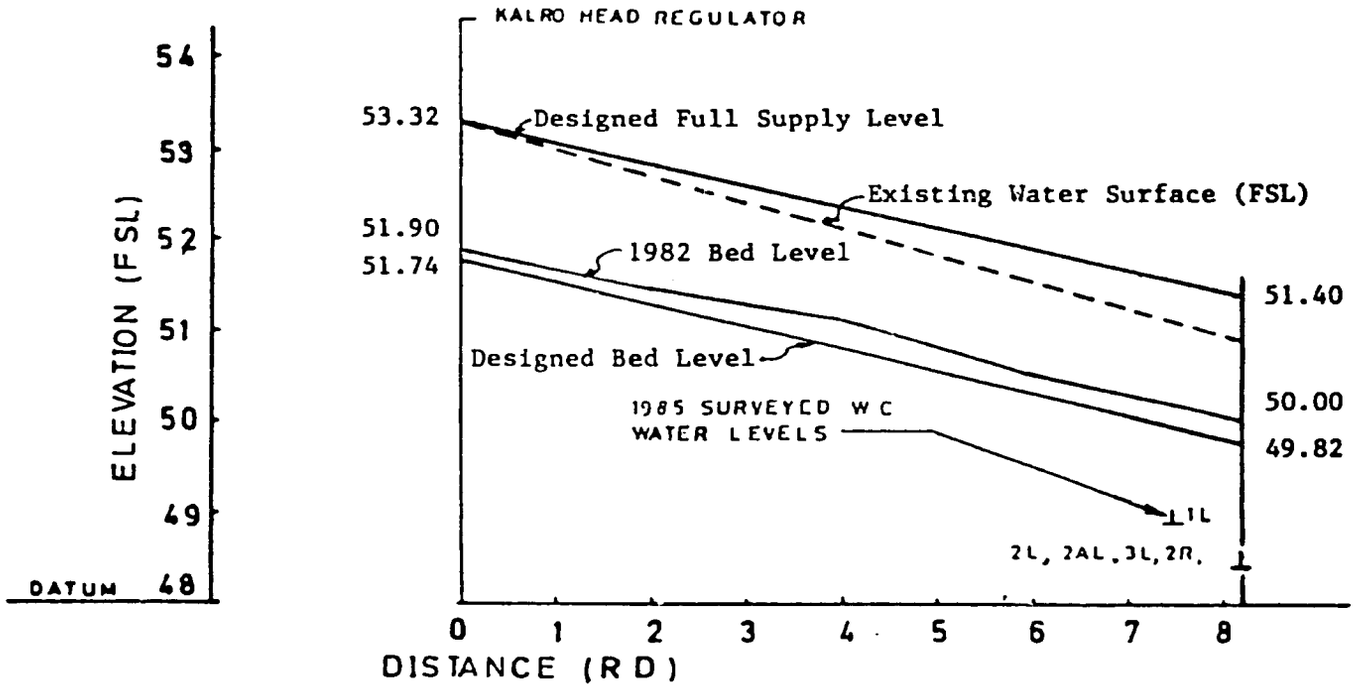
FIGURE A-5



Notes: 1. Hydraulic Design Data given in Table IV-2
2. WC = Watercourse

HYDRAULIC DESIGN
TALHO MINOR
RD 0-14.0 TAIL

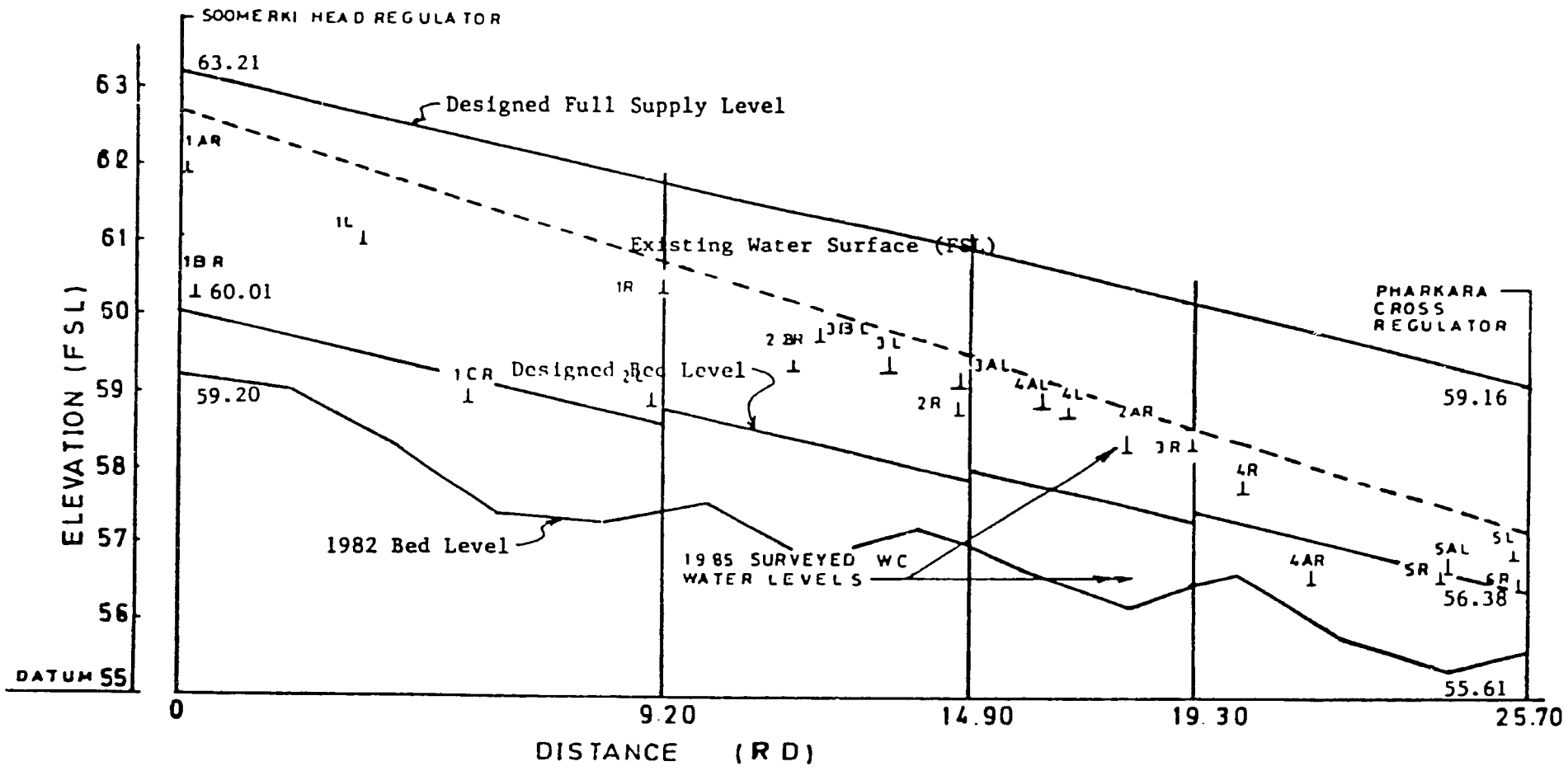
FIGURE A-6



Notes: 1. Hydraulic Design Data given in Table IV-2
2. WC = Watercourse

HYDRAULIC DESIGN
KALRU MINOR
RD 0-8.2 TAIL

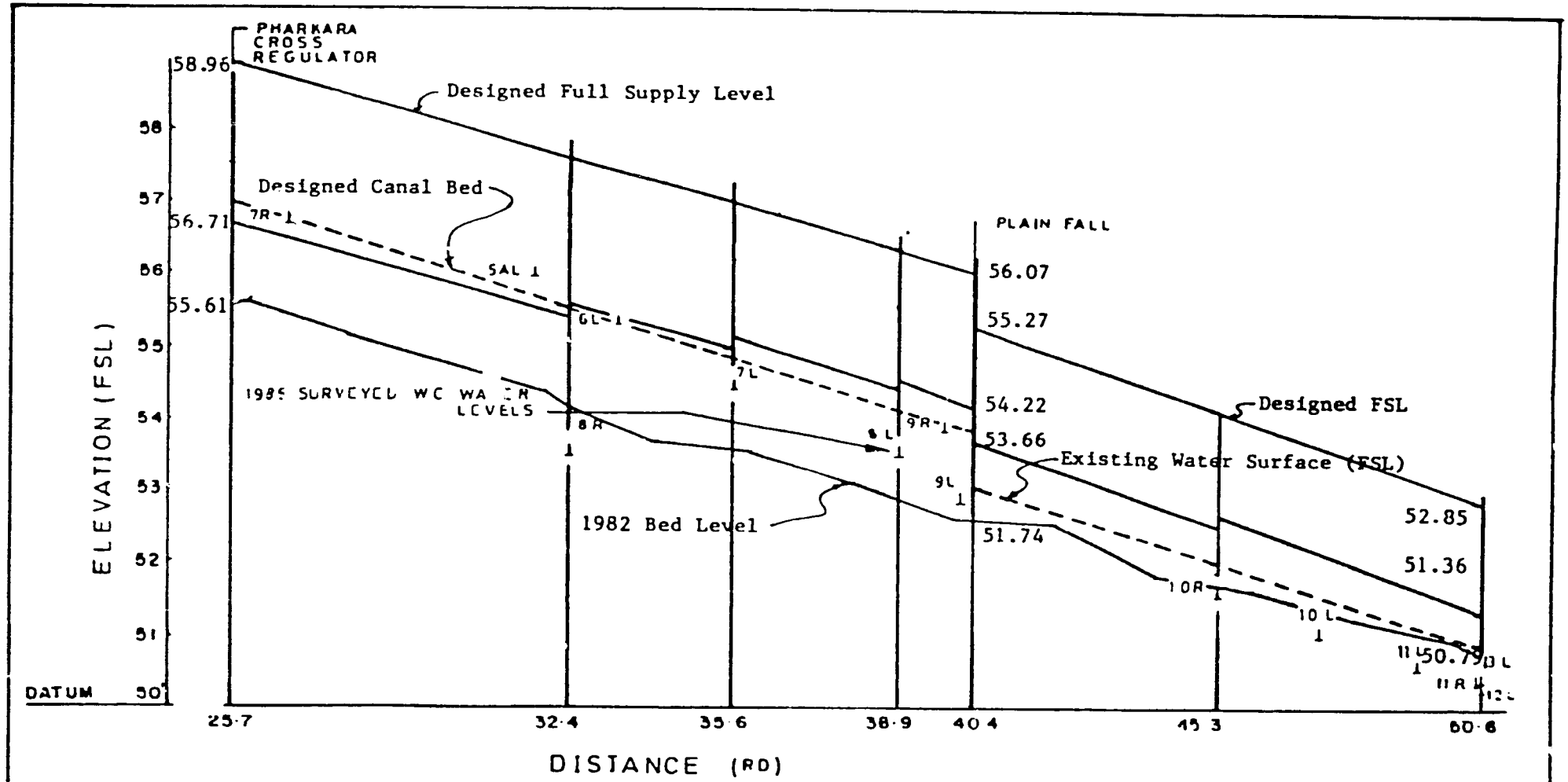
FIGURE A-7



Notes: 1. Hydraulic Design Data given in Table IV-2
2. WC = Watercourse

HYDRAULIC DESIGN
SOOMERKI DISTRIBUTARY
RD 0-25.7

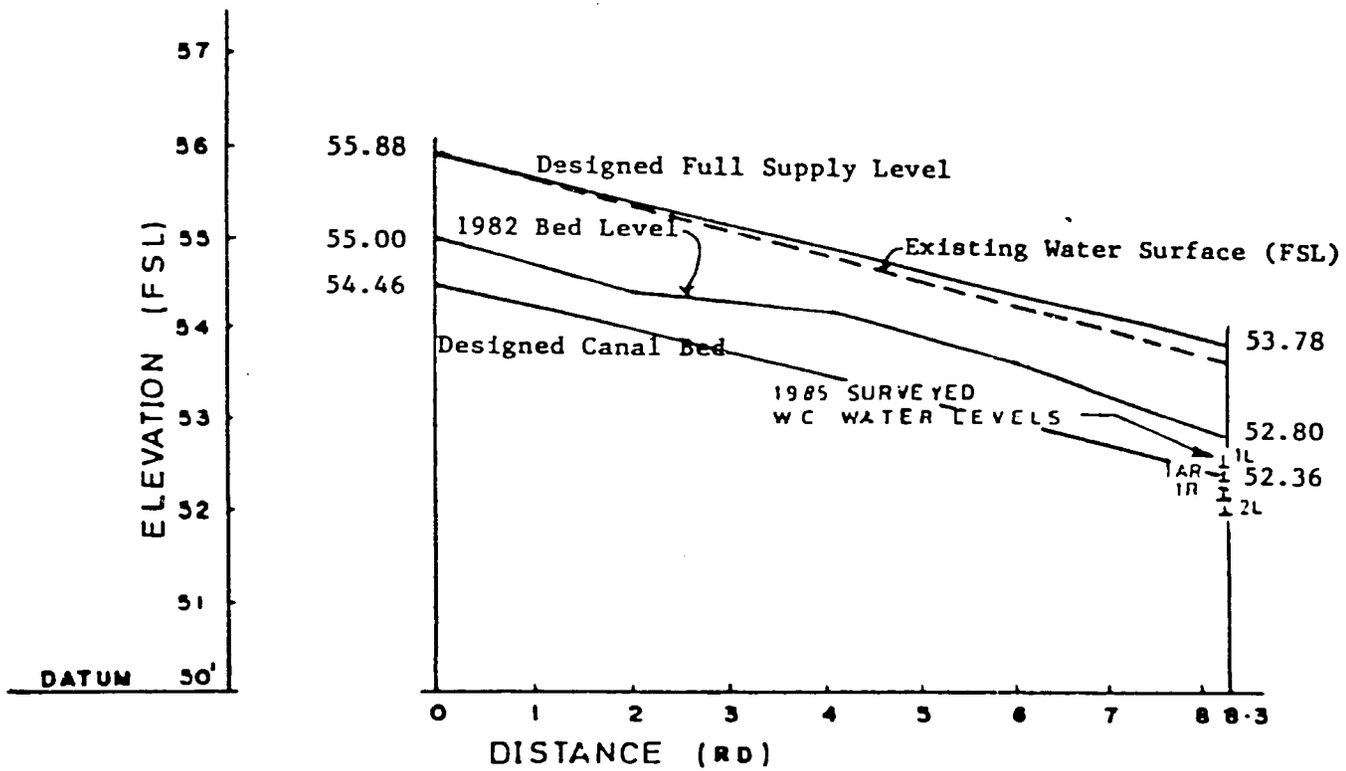
FIGURE A-8



Notes: 1. Hydraulic Design Data given in Table IV-2
2. WC = Watercourse

HYDRAULIC DESIGN
SOOMERKI DISTRIBUTARY
RD 25.7-50.6 TAIL

FIGURE A-9



Notes: 1. Hydraulic Design Data given in Table IV-2
2. WC = Watercourse

HYDRAULIC DESIGN
PHARKARA MINOR
RD 0-8.3 TAIL

FIGURE A-10

APPENDIX B

ORGANIZATIONS AND FACILITIES

APPENDIX B

ORGANIZATION AND FACILITIES

Section 1: General Description of the Irrigation System

The Almani Branch Canal System is located at the tail end of the Rohri Canal. The Rohri Canal terminates at RD 1038 and the Almani Cross Regulator. The Almani Cross Regulator is the terminal regulator which serves two distributaries and one minor in addition to the Almani Branch Canal. The rehabilitated design canal capacities at the Almani Cross Regulator:

-	Almani Branch Canal	302 cfs
-	Seri Distributary	68 cfs
-	Mohammad Khan Distributary	110 cfs
-	Mulan Minor	19 cfs
	Total:	499 cfs

The current Cultivatable Command Area (CCA) is 70,475 acres with a kharif season intensity of 36.5%. The CCA is not likely to change much, but the intensity will increase as tubewells are installed.

A location map showing the general layout of the Almani System is shown on Figure I-1. It comprises the Almani Branch Canal, Khachar and Soomerki Distributaries and Talho, Kalru, Pharkara and Drigh Minors.

Figure I-2 presents a generalized schematic diagram of the Almani System including the headworks for the two distributaries and the minor located at the Almani Cross Regulator. This and the long sections are the major information available for use in both operations and maintenance programs.

Section 2: Organization

A. General

The Almani Branch Canal System is a very small part of the Rohri Canal System which heads on the Indus River at the Sukkur Barrage. The Rohri System is under the jurisdiction of the Chief Engineer Sukkur. Responsibility for the Rohri Canal rests with the Superintending Engineer, Rohri Canal Circle, Hyderabad. The Rohri Circle is divided into five divisions to facilitate operations and maintenance. The Almani System is under the jurisdiction of the Executive Engineer, Nasir Division, Hyderabad. The Nasir Division is divided into four sub-divisions:

(1) Tando Allah Yar
(2) Bukerani
(3) Khairpur
(4) Tando Muhammad Khan

The Tando Muhammad Khan Sub-division is responsible for the Almani Branch Canal System as part of a much larger area.

B. Tando Muhammad Khan Sub-Division

The Tando Muhammad Khan Sub-Division starts at the Khesano Regulator, RD 970.0, Rohri Main Canal. The Sarfraz Branch Canal which also heads on the Khesano Regulator is under the jurisdiction of the Bukerani Sub-division.

The Tando Muhammad Khan Sub-division is divided into three sections:

(1) Tando Qaiser
(2) Tando Fazal
(3) Soomerki

The Tando Qaiser Section is responsible for all of the distributary and minor canals between the Khesano and Almani Regulators.

The Tando Fazal Section is responsible for the two distributaries and the minor which head on the Rohri Main Canal at the Almani Regulator: 1) Seri Distributary; and 2) Muhammad Khan Distributary; and 3) the Mulan Minor. Each of these distributaries is a separate beat under the Section's Sub-engineer.

The Soomerki Section is responsible for the Almani Branch Canal and the Soomerki and Khachar Distributaries and associated minors.

The organization chart for the Tando Muhammad Khan Sub-division is presented in Figure B-3. A generalized map of the Tando Muhammad Khan Sub-division is shown in Figure I-1. The Sub-division is the smallest organizational that has an administrative staff and has the authority and responsibility to make decisions and have control of the water and what happens in the Sub-division. The Sub-division is headed by a Sub-divisional Officer (SDO). The Sub-engineers who are in charge of a section do not operate with an office staff but supervise the darogas, beldars and tandels.

C. Soomerki Section

The Almani system which is under the jurisdiction of the Soomerki Section which has been divided into two Beats or areas of responsibility as shown in Figure I-2. The Almani system starts at the downstream face of the Almani Head Regulator.

The Soomerki Beat covers the Almani Branch Canal, Drigh Minor, Soomerki Distributary and the Pharkara Minor. The Khachar Beat covers the Khachar Distributary and the Talho and Kalru Minors. The Soomerki Beat covers an area with a CCA of 31,498 acres and 47 outlets.

The Soomerki Section is headed by a Sub-engineer who has the responsibility of operating and maintaining the Almani System. The Section is divided into two "beats", Soomerki and Khachar, each of which is supervised by a "Daroga" (foreman). The Daroga supervises several "Beldars" (laborers) who are responsible for a fixed reach of canal or zones as shown in Figures B-2 and B-3.. In addition, a "tandel" (gate operator) and a "Khalasi" (assistant gate

operator) are required for each branch canal regulator and one set for every two regulators on distributaries. The organization chart for the Soomerki Section is presented in Figure B-4.

The Khachar Beat serves a CCA of 38,977 acres and 60 outlets.

The O&M personnel assigned to the Soomerki Section as of December 1986 is listed in Table B-1.

TABLE B - 1

ASSIGNMENT OF PERSONNEL

Sub-Division: Tando Mohammad Khan

Section : Soomerki

SDO : Syed M. Hassan Shah

Approved by : _____

Form No. _____

Page 1 of 2

Date _____

No.	Persons Name	Job Designation	Canal Name	Assignment: Embankment From RD	Embankment To RD	Embankment Length RD	Structures Description	Structures Location RDs	Remarks
1.	Khudadad Samo	Sub Engineer Soomerki Sec.	Almani Branch						HQ Soomerki Reg.
2.	Qadir	Daroga Soomerki Beat							HQ Soomerki Reg.
3.	Nabi Buksh	Tandel	Almani				Soomerki Reg.	22.6	
4.	Ibrahim	Khalasi	Almani				Soomerki Reg.	22.6	
5.	Sharif Mohammad	Beldar Zone 1	Almani	0	12.0	12	Escape	12.0	3 outlets
6.	Manu	Beldar Zone 2	Almani	12.0	22.6	10.6	Drigh Minor	14.8	3 outlets
7.	Vikyo	Beldar Zone 3	Soomerki	0	25.7	25.7			21 outlets
8.	Buksho	Beldar Zone 4	Soomerki	25.7	50.6	24.9			15 outlets
9.	Ismail	Beldar Zone 5	Pharkara	0	8.3	8.3	Pharakara Headwork	25.7	On Soomerki 4 outlets

TABLE B - 1

ASSIGNMENT OF PERSONNEL

Sub-Division: Tando Mohammad Khan

Section : Khachar

SDO : Syed M. Hassan Shah

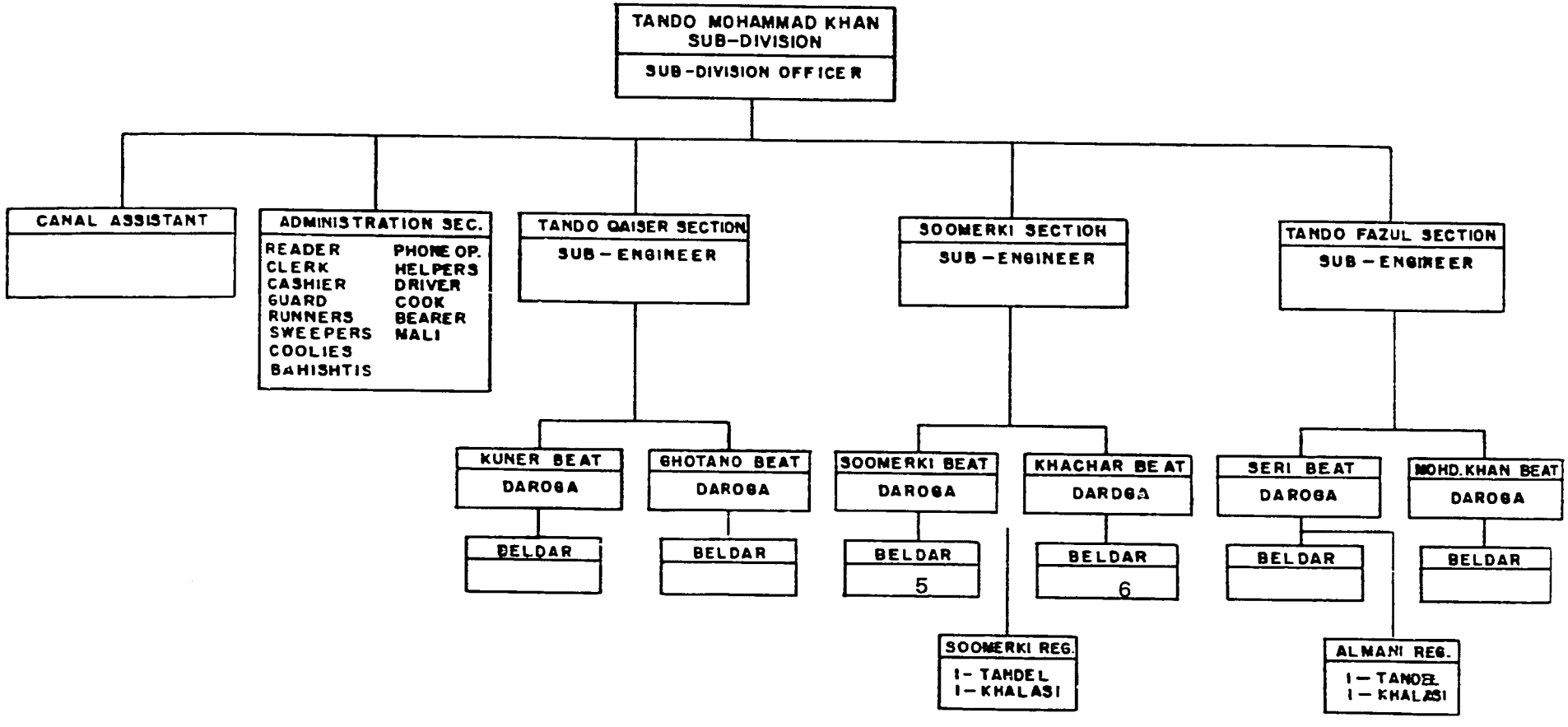
Approved by : _____

Form No. _____

Page 2 of 2

Date _____

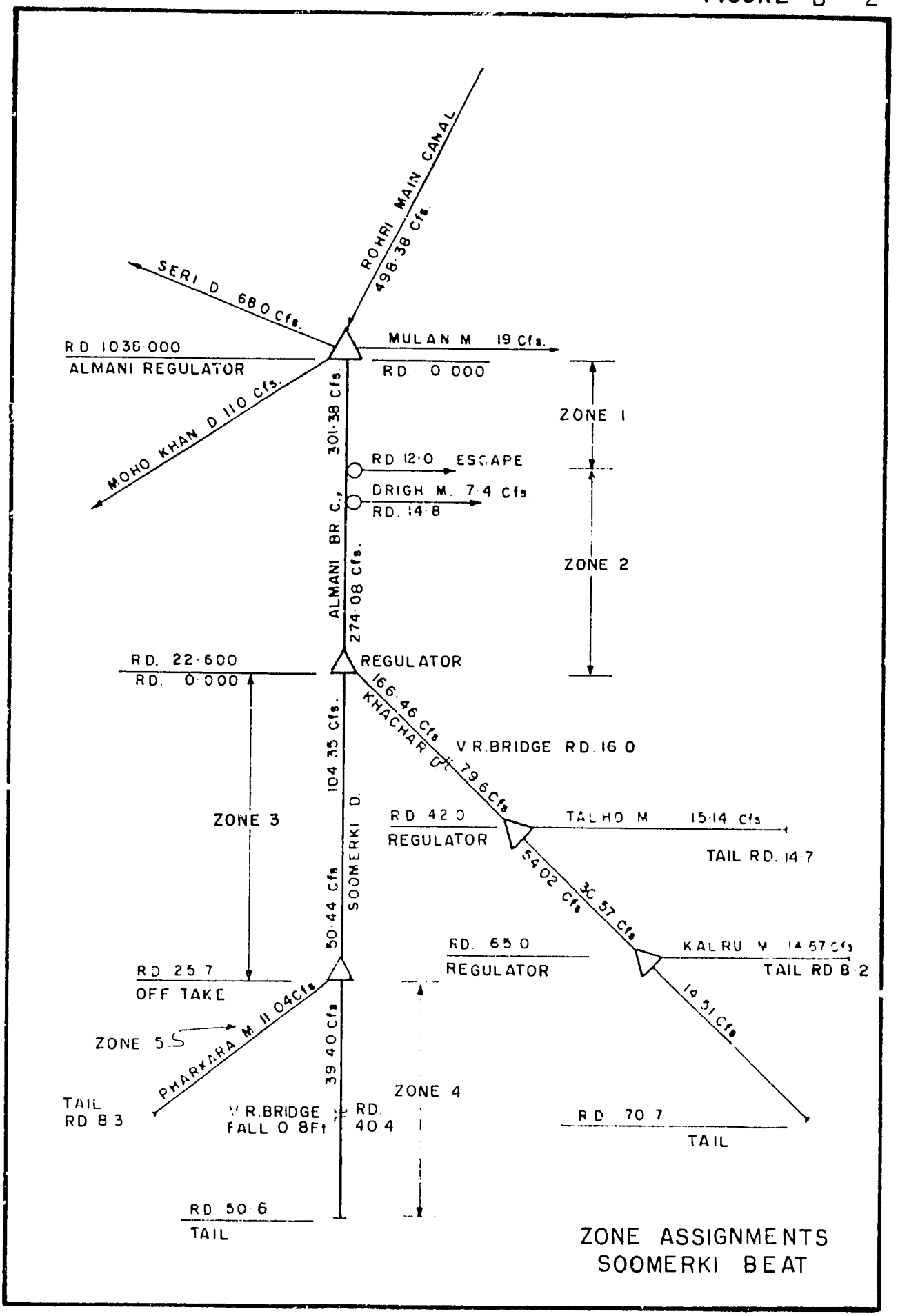
No.	Persons Name	Job Designation	Canal Name	Assignment: Embankment From RD	Embankment To RD	Embankment Length RD	Structures Description	Structures Location RDs	Remarks
1.	Khudad Samo	Sub. Engineer							HQ Soomerki Reg.
2.	M. Saleh Bhatti	Daroga Khachar Beat					Kalru Regulator	60.5	HQ Kalru Reg.
3.	Murid	Beldar, Zone 1	Talho	0	14.7	14.7	Talho Reg.	42.0	
4.	Umed Ali	Beldar, Zone 2	Khachar	0	16.6	16.6			7 outlets
5.	G. Mohammad	Beldar, Zone 3	Khachar	16.6	30.4	13.8			12 outlets
6.	Ali	Beldar, Zone 4	Khachar	30.4	42.0	11.6			12 outlets
7.	Yaru	Beldar, Zone 5	Khachar	42.0	65.0	23.0			11 outlets
8.	Ahmed	Beldar, Zone 6	Khachar	65.0	70.7	14.0			8 outlets
			Kalru	0	8.3				5 outlets
									5 outlets



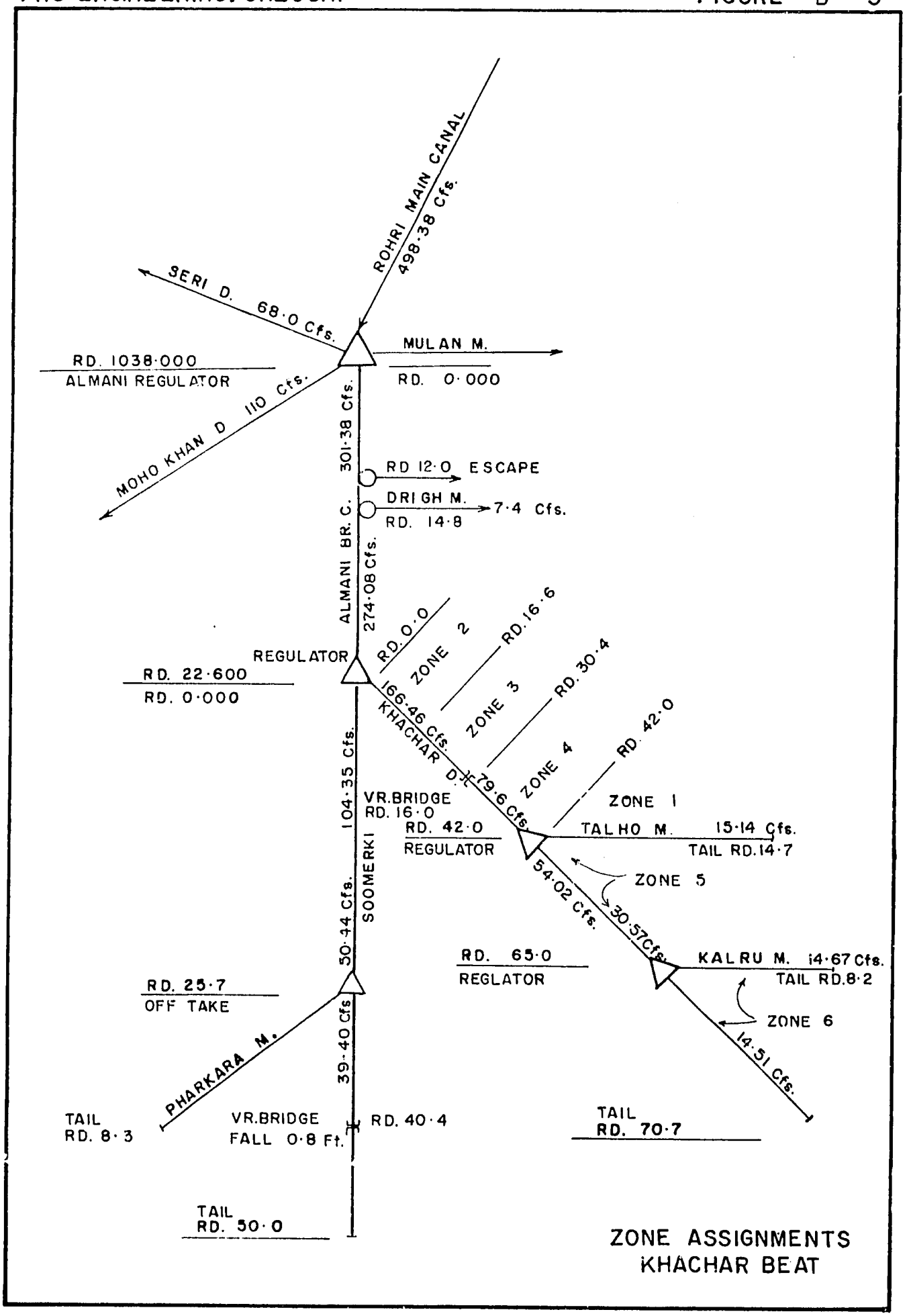
ORGANIZATION CHART
TANDO MOHAMMAD KHAN
SUB-DIVISION

PRC ENGINEERING/CHECCHI

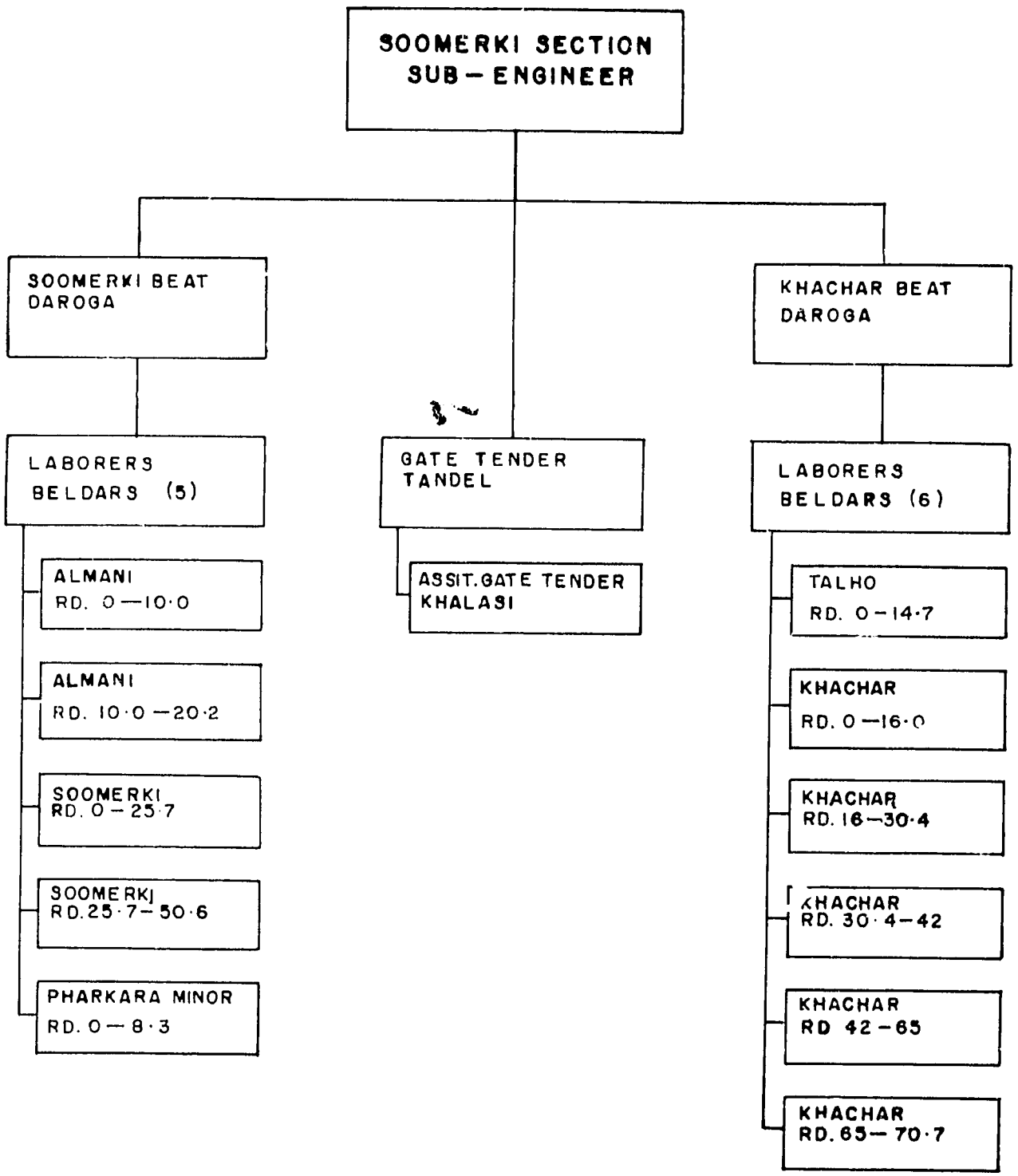
FIGURE B-1



ZONE ASSIGNMENTS
SOOMERKI BEAT



ZONE ASSIGNMENTS
KHACHAR BEAT



ORGANIZATION CHART
SOOMERKI SECTION

SECTION 4.0: WORK PLAN

4.1 SCOPE

The scope of this effort involves utilizing construction equipment and labor to raise and widen the banks of Nasarana Disty which forms part of LCC(W) canal system. The quantity of earth to be moved to RD 0-85 utilizing construction equipment is 32,04,450 cft on the left and right banks. The work is covered by ISRP and is USAID funded (ISRP-UP-49). There is no water logging around the periphery of the canal banks and also the water table is low.

The project area extends all along the length (head to tail) of Nasarana Disty. The effort involves rebuilding of its both right and left banks as shown in the PC-I prepared by the Provincial Irrigation Department. The PID proposes to complete the entire project utilizing only manual labor, excavating borrow areas 100 feet from the toe of the canal as follows:

a. Earthwork excavation of ordinary soil from 100 feet away from the canal land limit = 67,82,000 cft.

b. Compaction of dowel = 133,000 cft.

c. Extra for dowel dressing = 325.5 chains.

d. Earthwork compaction by moisturing to optimum moisture content and compaction in layers by animal driven roller = 49,000 cft.

e. Uprooting of sarkanda and disposal at 100 feet = 1,07,55,000 cft.

f. Uprooting of stumps and disposal at 100 feet = 8,963 Nos

The Workplan presented in this paper proposes to execute the work to be completed into two parts, i.e., RD 0-85 with machinery by the PID Machinery Circle and RD 85-179 with manual labor by the PID LCC (W).

The portion of work to be executed with machinery will involve following works:

a. Excavation, hauling, and compacting= 31,43,450 cft

b. Excavation, hauling, and compacting dowel= 61,000 cft

Total: 31,43,450 + 61,000 = 32,04,450 cft

110