Report No. R-66

COMPUTERIZED PLANNING FOR OPERATING
CHASMA RIGHT BANK CANAL

APPLICATION OF CROP-BASED IRRIGATION OPERATIONS TO CHASMA RIGHT BANK CANAL

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ABBREVIATIONS

AF	Acre Feet
CBIO	Crop-Based Irrigation Operations
CCA	Culturable Command Area
CRBIP	Chasma Right Bank Irrigation Project
CRBC	Chasma Right Bank Canal
GCA	Gross Command Area
FSL	Full Supply Level
FDD	Full Design Discharge
IRSA	Indus River System Authority
IIMI	International Irrigation Management Institute
MAF	Million Acre Feet
MSBO	Modified Supply-Based Operations
NWFP	North West Frontier Province
PC-1	Planning Comission Document 1
PHLC	Pehur High-Level Canal
SAR	Staff Appraisal Report
SBO	Supply Based Operations
SIC	Simulation of Irrigation Canals
SPMT	Systems Performance Monitoring Project
TAM	Technical Assistance Mission
USC	Upper Swat Canal
WAA	Water Apportionment Accord
WAPDA	Water and Power Development Authority

GLOSSARY OF LOCAL TERMS

Chak	Area irrigated for a simgle watercourse.
Chakbandi	Process of demarcating the individual chaks.
Kharif	The hot (summer) season.
Mogha	Outlet from minor o distributary into the watercourse.
Nucca	Outlet from watercourse into a farm ditch.
Nullah	Gully (flood or hill torrent channel).
Rabi	The cool (winter) season.
Warabandi	seven-day water allocation or scheduling pattern where each farmer is alloted a date and time for water diversion to his fields from the nuccas.

FOREWORD

There has been a lot of controversy about crop-based irrigation operations (CBIO). Often, it has been thought that CBIO is demand driven. This confusion comes from the term "crop-based". But, as this report shows, the daily discharge schedules for the Chasma Right Bank Canal (CRBC) Headworks, each cross-regulator and each distributary is prepared in advance. Thus, they are not demanding schedules. Perhaps, a better term for CBIO would be "Modified Supply-Based Operations" (MSBO).

The results in this report are primarily the M.S. research of the senior author, Mr Juan Carlos Alurralde. He has done a magnificent job. Mr Alurralde is a citizen of Bolivia who is completing a M.S. degree in Agricultural Engineering at the Katholic University in Leuven, Belgium.

Dr Carlos Gandarillas has been the catalyst for the work contained in this report. We interfaced together on the arrangements to have Mr Alurralde spend six months (April-October 1998) with IIMI in Lahore. Also, Dr Gandarillas has spent considerable time in advising on this effort. As the CRBC Chief Design Engineer representing Harza Engineering as a member of the CRBC Stage-III Consultants, he has been especially co-operative in both supplying data and making numerous suggestions to support this study.

At the same time, we would like to thank the former Chief Engineer, Chasma Right Bank Irrigation Project, Mr Jan Paracha of WAPDA, for meeting with us both in D.I. Khan and Lahore for very detailed discussions regarding this study.

The support from representatives of the Asian Development Bank is very much appreciated. This effort is the result of discussions two years ago with Mr Jeremy Bird. Also, this topic has been discussed a number of times with Mr Pieter Smidt regarding Pehur High-Level Canal.

Finally, we would like to thank the Principal Investigator for this project, Ms. Zaigham Habib, Systems Analyst, IIMI. Her good-natured discussions are always helpful.

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1. INTRODUCTION

1.1 BACKGROUND

Water Duty is a term that expresses the allocation of water (expressed as a discharge rate) per unit of cultivated land. In Pakistan, water duty has been calculated as the design discharge at the head of a canal in cusecs divided by the culturable command area (CCA) of the canal command area in thousands of acres. Thus, water duty is presented in terms of cusecs per thousand acres of CCA.

Most of the 43 canal commands in Pakistan were designed with a water duty in the range of 3.5-4.5 cusecs per thousand acres of CCA. During the last decade, or more, irrigation development in North West Frontier Province (NWFP) has focused on achieving higher canal water duties, such as 8-12 cusecs per thousand acres of CCA. For example, Lower Swat Canal has been remodelled to provide a water duty of 14 cusecs per thousand acres of CCA. Pehur High-Level Canal (PHLC) is presently under construction from Tarbela Reservoir on the Indus River to Machai Branch of Upper Swat Canal (USC) that will result in a water duty of 8.6 cusecs per thousand acres of CCA. Stages I and II of the Chasma Right Bank Canal (CRBC) has been completed and the construction of Stage III is underway that will complete this project having a water duty exceeding 8 cusecs per thousand acres of CCA.

High water duties are very beneficial to farmers because they can choose crops that have higher crop water requirements (e.g. rice) and higher farm income (e.g. sugarcane). However, larger discharges will most likely result in greater recharge to the groundwater and a higher likelihood of waterlogging. Also, there is a tendency at times to "drown" the surface drain network.

Crop-based irrigation operations (CBIO) is to be employed at both USC-PHLC and CRBC. This is an improvement on supply-based operations wherein less water is supplied early in the season and late in the season when crop water requirements are lower. CBIO is definitely not a demand method of operations. In fact, the term "crop-based" tends to indicate or imply an operational methodology where the crop water requirements are being satisfied. A more understandable terminology would be "modified supply-based irrigation operations."

1.2 ISSUES

A methodology needs to be developed for applying CBIO to operate CRBC. The CBIO schedules resulting from applying this methodology will be included in the operations scenarios to be tested using the unsteady flow hydrodynamic model, "Simulation of Irrigation Canals (SIC)" at a later date. Afterwards, the results from testing a number of operations scenarios using SIC will be presented to decision-makers at a two-day workshop, where hopefully an agreement can be reached regarding the appropriate operation of CRBC.

The major issue being addressed in this report is demonstrating the application of the methodology for developing CBIO schedules. An important point is that these water delivery schedules can be developed prior to an irrigation season. These schedules include the times for each distributary when open or closed, which can be posted at each distributary head regulator; in addition, the discharge rate schedule for each cross-regulator and the headworks of CRBC is provided.

1.3 APPROACH

The International Irrigation Management Institute (IIMI) has a contract with the Irrigation Department of NWFP on "Operations Support for Pehur High-Level Canal Project". Beginning in February 1998, IIMI began developing a CBIO model with the assistance of a consultant, Dr Kobkiat Pongput, Kasetsart University, Thailand.

The CBIO model was used in this study reported herein. This is a very simple model that provides the open/closed schedule during the early and late portions of an irrigation season for clusters of distributaries located along a canal reach between two cross-regulators.

Applying the CBIO model to CRBC has provided insights regarding the open/closed scheduling of individual distributaries. Two methods have been developed : (1) rotation schedule for each of the distributaries in a reach when the cross-regulators are far apart, such as in NWFP; and (2) rotation schedule among reaches when there are sufficient cross-regulators such as in Punjab Province.

The learning derived from applying the CBIO model to CRBC will be incorporated into an improved CBIO model. A document will be published in a few months describing in detail this model. Then, this model will be applied to the USC-PHLC system under the PHLC contract.

2. CHASMA RIGHT BANK IRRIGATION PROJECT

2.1 PROJECT DESCRIPTION

The Chasma Right Bank Canal is a major perennial surface irrigation project designated to irrigate 230.680 ha (569.767 acres) with a 258.5 km long (160.5 miles) gravity flow main canal, carrying a discharge capacity of 141.5 m^3/sec (5000 cusecs). The canal feeds a network of subsidiary canals with an aggregate length of 603.37 km (357 miles). The water supplies are derived from the combined river flows of the Indus and Kabul rivers as regulated by Tarbela Dam and again downstream by the Chasma Barrage on the Indus.

The CRBIP project, currently under implementation, has been designed in three stages for construction purposes. Stage I serving 142,000 acres (56,800 ha), Stage II serving 93,885 acres (37,857 ha), and the Stage III serving 131,698 ha (326,611 acres), being nowadays under construction. Stage III is not scheduled to be in operation until the second year of the next century.

2.2 MAIN CANAL SYSTEM

The CRBC traverses a plain comprising flat and barely discernible overlapping alluvial fans, with flood channels and sand dunes being the main topographical features that break the flatness of the terrain.

The main canal has a very flat grade that parallels the Indus River. To maintain as much command area as possible for gravity irrigation, the canal has to be as flat as the limits of practicability permit.

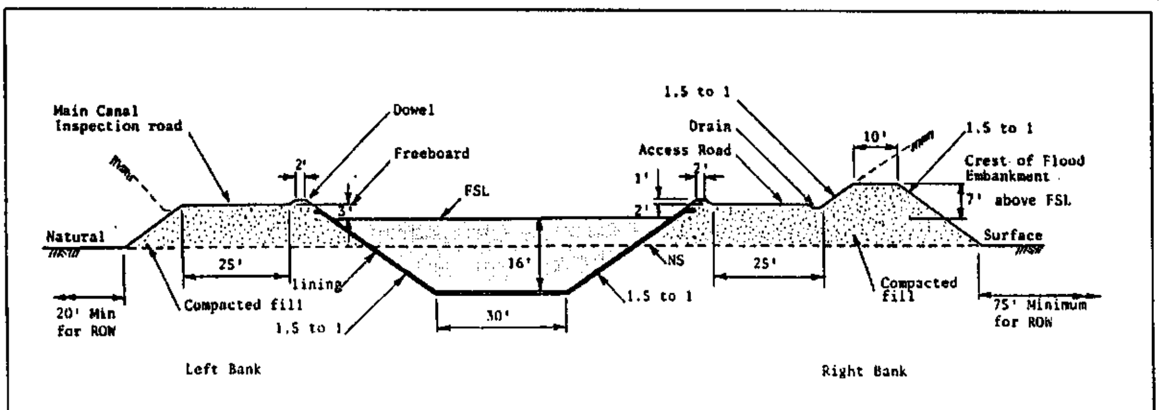

Figure 1. Typical cross-section of Chasma Right Bank Canal.

Figure 1 presents the principal characteristics of the canal using a drawing illustrating a typical cross-section.

2.2.1 Main Structures

A general description of the main structures along the canal is described below, but not the ancillary structures such as bridges and canal drains.

2.2.1.1 Cross Regulators

The main functions of these gated regulating structures are:

- Maintain the upstream water level required for the off-taking distributaries; and
- Regulate the supply of water (discharge) downstream depending on the demand.

Each structure consists of four main parts:

- Upstream and downstream masonry and concrete warped transitions from the trapezoidal canal section to the rectangular gate sections;
- Vertical lift fixed wheel gates sealing against the crest;
- Cistern (stilling basin) to dissipate the energy of the flow; and
- Bridge incorporated on the structure for access across the canal.

A photograph of a typical cross-regulator (x-regulator) is shown in Figure 2.

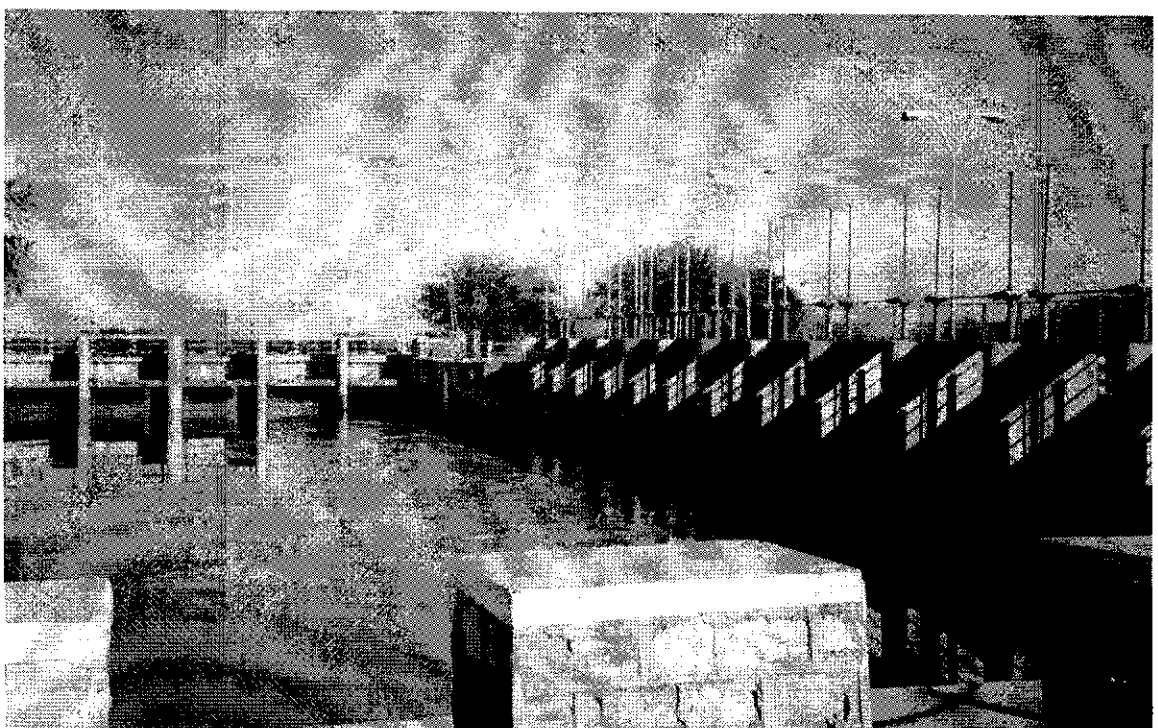

Figure 2. . Cross-regulator at Reduced Distance (RD) 257 + 147 (right side of photo) and looking across CRBC at escape structure on left bank (left centre of photo).