ECOLE POLYTECHNIQUE, PROMOTION 93
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DEVELOPPEMENT D'UN SYSTEME D'AIDE A LA GESTION DES CANAUX D'IRRIGATION

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Dates du stage : **15 avril - 9 juillet 1996**

"In my kingdom are many rice fields cultivated by means of rain water, but few indeed are those which are cultivated by means of perrenial streams and great tanks. By rocks, and by many thick forests, by great marshes is the land covered. In such a country let not even a small quantity of water obtained by rain, go to the sea, without benefitting man. Rice fields should be formed in every place, excluding those that produce gems, gold and other precious things."

King Parakramabahu I (1153 - 1186) (Mahavamsa)

INFORMATION TO READER

The aim of this report is to give our perception of the problem we had to adress during our study and the results we have achieved. This can also be used as a first introduction to the issue for future programmers on IMIS. But for a more detailed study, it must be clear that reading this report does not exempt from reading:

•IMIS - user's guide

•IMIS - developer's guide

We will write these two documents in the coming weeks. The first one, around 50 pages, will aim at users that are not supposed to have any previous knowledge in informatics. The second one, more than 300 pages, will give complete data base structure and programs listings with detailed explanations for further IMIS developers.

The first and second parts of this report do not claim to bring anything new to irrigation management understanding. What we wrote has simply become our opinion mostly through interviews and readings of others' real innovative studies. Our too short delay compared to our computer work did not allow us to go more than 2 days in the fields to get ideas and feelings by our own.

However, since many inaccurate ideas could be built at first due to not considering every point of view, we have tried to write only what we could positively state. This was a good exercise of intellectual exactness and political correctness.

We would like to call also for reader's indulgence for our failing in English.

ACKNOWLEDGEMENTS

We would like to express all our appreciation to our project leaders for the many hours they spent with us, furthering our understanding of irrigation and development. They are Docteur Jacques Rey and Docteur Pierre Olivier Malaterre in Cemagref and Mister Marcel Kuper from the Netherlands and Madame Zaigham Habib in IIMI Pakistan.

All of this work began for us when Docteur Pascal Kosuth, Director of Irrigation Division, Cemagref and Docteur Pierre Olivier Malaterre, Director of the Modelization and Regulation office, Irrigation Division, Cemagref, decided to give us a chance. We thank them very much for the trust they put in us and for their warm welcome.

We would especially like to thank Mister Alain Revel and Mister Yves Carsalade, among many other chair professors at the Ecole Polytechnique, who let us commit ourselves to this work and accepted to monitor our activities from the Ecole Polytechnique during this course, and to be the jury of our final presentation on 5 July 1996. Mister Revel and Mister Guinaudeau, professor at ENGREF have generously provided us their help to find this course opportunity in autumn 1995.

We are also very thankful for all those who took some of their precious time to share their knowledges and their views with us about our work, about irrigation, about Pakistan and everything. Many thanks to Enginneer Mushtaq Khan and Field Assistant Anwar Iqbal from IIMI's Bahawalnagar field station, to Manju Hemakumara from IIMI Colombo. We can not mention all of them, but we shall not forget.

To close these acknowledgements, we would like to tell all Cemagref and IIMI's staff how we have appreciated their material and moral support during this too short period.

ABSTRACT

The aim of this 3 months training course was to re-program and develop an irrigation management information system created in 1992 for local use in Sri Lanka. The main points of, the new version are:

- ability to manage and to have hydraulic simulations via SIC on a network of branched canals.
- much more user friendly, thanks to the opportunities offered by up-to-date programmation techniques.
- direct application is possible in several parts of Pakistan, facilities for installation and opportunities to adapt.

After a short description of the background, this report study the global interest of computerizing an information system for irrigation canal management. Part 3 explains in the main what data are required and how they are stored in tables, and gives an overview of the software, the output of our work. We advise in part 4 for a list of further improvements.

KEY WORDS : IRRIGATION CANALS, FLOW MONITORING, REGULATION, DECISION SUPPORT SYSTEM, DATABASE MANAGEMENT, OBJECT-ORIENTED PROGRAMMATION.

RESUME

Le but de ce stage de 3 mois était de reprogrammer et de développer un système d'information pour la gestion de canaux d'irrigation. Ce logiciel a été créé en 1992 pour un usage local au Sri Lanka. La nouvelle version se situe comme un outil nouveau, utilisable à grande échelle pour des tâches très différentes. Ses points essentiels sont:

- possibilité de gérer des réseaux ramifiés.
- plus grande facilité d'utilisation grâce aux possibilités offertes par les méthodes de programmation modernes.
- vastes possibilités de développement et d'application.

Après présentation du cadre de travail, ce rapport étudie l'intérêt d'informatiser le système d'information pour la gestion des canaux. La troisième partie décrit de manière simplifiée d'une part les données nécessaires à la gestion et comment ces données sont stockées, et d'autre part le logiciel qui est le résultat de notre travail. Nous donnons dans la dernière partie une série d'indications pour les développements ultérieurs d'IMIS.

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I. The problem.

A. Background.

1. Irrigation.

Irrigated agriculture, though practiced only on 15 to 20% of the world's total cultivated land, accounts for more than 40% of the total world food production. There are 3 times more irrigated areas today than 40 years ago. Irrigation canals bring the water from dams or rivers to end users. Operating and maintaining these canals require important management skills.

2. Irrigation in Pakistan.

Agriculture is the most important part of Pakistan's economy, employing 54% of its workforce, contributing to 26% of the GPD and accounting for 75% of the foreign exchange earnings. 90% of the Pakistan's agricultural output comes from irrigated agriculture, and 16.2 out of 20.7 million hectares cultivable are irrigated.

Irrigation is vital to the agricultural sector since the climate is extremely arid; over half of the country receives less than 200mm of **rainfall** per year, whereas evaporation rate mean value is 8 times higher than mean rain falls.

Pakistan's irrigation system is the world largest contiguous irrigated area. It comprises 3 storage **reservoirs**, 16 **barrages**, 12 **inter-river link canals** and 43 **main canals**. The total length of link canals, main canals, main canal branches and secundary canals (more often called distributaries in Pakistan) is close to 57,000km and the length of the farm channels and water courses is around 1.6 million km.

Rivers are the primary source of water used for agriculture. The average annual inflow of the rivers in the west, as they enter the Indus Plains, is 170 billion cubic meters. Groundwater is another important source of water for irrigation. It is estimated that 50 billion cubic meters of water are available for use in agriculture from the underlying aquifer in the Indus Plain.

The water supply used for irrigation are, however, characterized by unreliability, inequity, and chronic **shortages**. While shortages impact on crop yields, surpluses can create serious drainage problems.

60% of the total irrigated area in Pakistan is **perennial**, the remaining is entitled to irrigation supplies only during the Kharif season (April 16th till October 15th), and closed during Rabi season.

3. Irrigation management issues.

In Pakistan, the goal of irrigation management is to distribute available water equitable and economically efficient manner. It is also very important to deal with sustainability problems: risks of waterlogging and soil salinity.

B. Research for development assistance.

How to step in gouvernment agencies to improve management techniques is a matter of large research in itself. In our case, two partners are working together to provide new techniques and implement them in the fields on exemplary sites. The strategy is to exhibit success stories to help things to change. It is also very important to keep close contacts with the Irrigation Department, organize work shops and write common reports... Cemagref provides technical tools and IIMI use these tools to intervening on its working sites.

1. Le centre d'études du machinisme agricole, du génie rural, des eaux et des forêts: Cemagref

The Cemagref is a gouvernmental research institute that design methods and tools for public action on agricultural and environmental issues. Concerning irrigation, the Cemagref has long been mastering several separated technical aspects: hydraulics, economics, agronomy and equipments. It is now that an integrated approach of the issue is necessary, and new research programs begin in this direction.

To contact Cemagref offices in Montpellier:

Cemagref - division irrigation
361 rue J.F. Breton
BP 5095
34033 Montpellier Cedex
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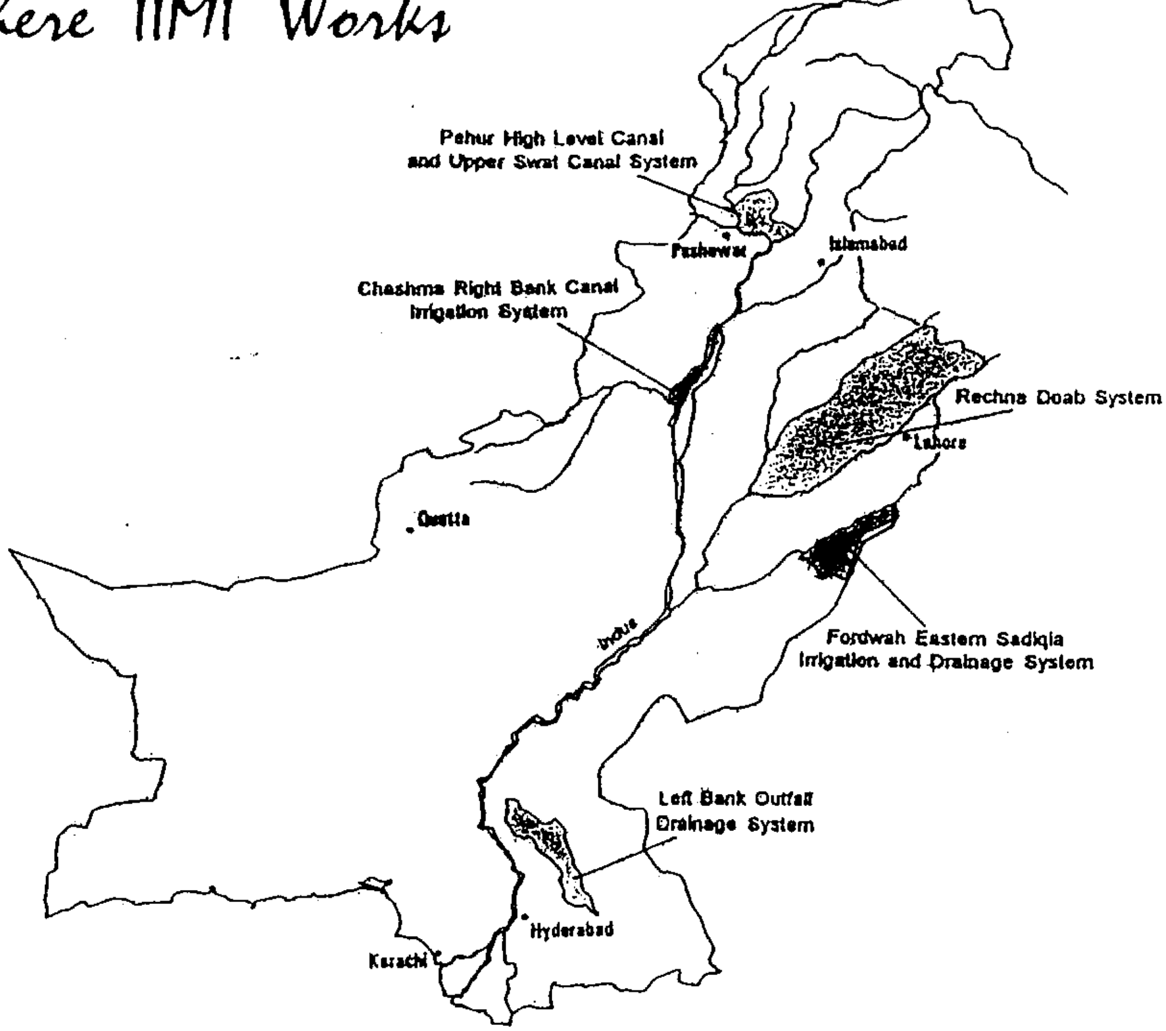
2. The International Irrigation Management Institute: IIMI.

The **International Irrigation Management Institute** is an autonomous, nonprofit international research and training institute supported by the Consultative Group on International Agricultural Research (**CGIAR**). The CGIAR is an informal association of public- and private-sector donors that supports a worldwide network of 18 international agricultural research centers, including IIMI, conducting a global research on agriculture, forestry and fisheries. The CGIAR is sponsored by the Food and Agricultural Organization (FAO), the International Bank for Reconstruction and Development (World Bank), and the United Nations Development Program (UNDP) and comprises more than 45 donor countries, international and regional organizations and private foundations.

IIMI's mission is to foster the development, dissemination and adoption of lasting improvements in the performance of irrigated agriculture in developing countries. With its headquarters in Colombo, Sri Lanka, IIMI conducts a worldwide program to generate knowledge to improve irrigation management and policymaking, strengthen national research capacity, and support the introduction of improved policies and management approaches.

Where IIMI Works



The IIMI-Pakistan office was established in Lahore in September 1986, and moved in December 1995 to its present building located:

Multan Road, 12 km
Chowk Thokar Niaz Baig
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The broad purpose of the action research project on "Managing Irrigation for Environmentally Sustainable Agriculture in Pakistan" is to develop and implement a set of improved management strategies and techniques which can reduce the aggravating effects of irrigation on waterlogging and salinity; to expand the institutional capacity to effectively manage the solutions; and to maximize the role of farmers and rural communities in irrigation management for increasing agricultural production.

IIMI's activities in Pakistan can be divided into 3 main parts:

1. **Operational Management**: main system management, water course management.

2. **Institutional Development**: mainly Water Users Organisations development.

3. **Salinity Management**: soil chemistry & ground water, salinity & sodicity, waterlogging.

The "Operational Management" issue is conducted in Punjab's Fordwah Eastern Sadiqia (FES) Irrigation and Drainage Project where more than 200,000 ha are cultivated for Operation Management.

C. Irrigation management information system.

Part 2 of this report, based on a field experince, discuss the need of a computerized information system.

1. A Decision Support System for irrigation canals.

According to IIMI's research objectives, a "visible success story" on **Decision Support System** for Main System Management should be created in 1998, so that it can be disseminated among all the Provincial Irrigation Department. A good decision support system should include an **information system** (for exemple IMIS: Irrigation Management Information System), and depending of the goal, some **simulation models**, such as SIC (irrigation canals hydraulic simulation model, software developed by Cemagref), a GIS (geographical information system), a crop water requirements software like CROPWAT developed by FAO, an economical model, an agronomical model...

2. An experience in Sri Lanka.

IMIS (Irrigation management information system) is a database management software. It has progressively been developed from 1991 to 1993 locally on Kirindi Oya Right Bank

Main Canal site (Sri Lanka) as an IIMI Sri Lanka project by Dr Jacques Rey (X85). This prototype has then been exported to other sites in Pakistan in 1993.

The original software was designed for the lowest level of management to facilitate his decision making by monitoring and keeping history of system's functionning and actual and targeted operations (in the form of discharges).

Its main functions are: **data storage and decision support through timely monitoring and performance assessment**. It also includes an interface with SIC model in steady and unsteady flow.

Its main quality is to store an image of the system which is very close to the canal manager point of view, so that the user can easily understand the straight-forward operations happening in the machine. It is also close to field people needs in term of informations to help managing the system.

For the applications planned in Pakistan, this software has 2 inadequacy:

- direct access to tables and spreadsheets makes it necessary for users to have a prior good knowledge of dBase III and Lotus.
- only linear canals can be modelized, the distributaries are only represented by the offtake.

D. Purpose of the study.

1. Achievements requested.

After learning Visual FOXPRO 3.0 programmation and the use of the former version of IMIS, we had to swap the existing programs from dBase III, Pascal and Lotus to Visual FOXPRO 3.0 professional edition, improving performances and interface, and making it manage branched and looped networks.

The exact definition of the work schedule, as it was first defined and as it was arranged after 3 weeks, is given in annex 1.

2. Main events of the 3 months course.

- from April 15 till May 3: discovering IMIS and FOXPRO in Cemagref, Montpellier, refreshing the database tables and fields structures to make it fit the new requirements (branched and looped canals...).
- May 5th: arrival in IIMI - Lahore, assessment of the requirements and possibilities.
- May 12th to May 16th: first IMIS (former version) training course for Irrigation Departement engineers and researchers. Documents about this training course are given in annex 2.
- June 9th to June 13th: second IMIS training course

- June 24th and 25th: visit to the fields in Bahawalnagar, visit of Chistian sub-division of Fordwah canal and Malik branch (see the program in annex).

- June 29th: return to France

- July 1st to 4th: conclusion of the course in Montpellier.

- July 5th: final report and oral presentation in Paris.

II. Why an information system for irrigation canals? the exemple of Fordwah - Eastern Sadiqia system.

A. Overview of the system

3 km from the Indian border, at the end of Pakistanese part of Sutlej river is Suleimanke headworks. From that point, a 8 gates main canal is providing water to the **Fordwah - Eastern Sadiqia irrigation system** (from the names of British Mr Ford and local ruler Nawab Sadiq). It has been build between 1925 and 1930 and is a master-piece of sustainable development, since it has been working very well until the beginning of the eighties. A large part of this system was built on a former desertic area. It is boardered at south by Cholistan desert.

Operational rules have been precisely defined when the system was designed. Irrigation managers were also supposed to give notice of the scheduling of water deliveries in the villages.

Up to 15 years ago, the system was correctly maintained by dedicated gate, and the gouvernment engineers sometimes came by night to check if everything was all right, and people who deliberately damaged an outlet would go 6 months in jail. Discharge calculation formula were also monthly updated considering sediment deposit.

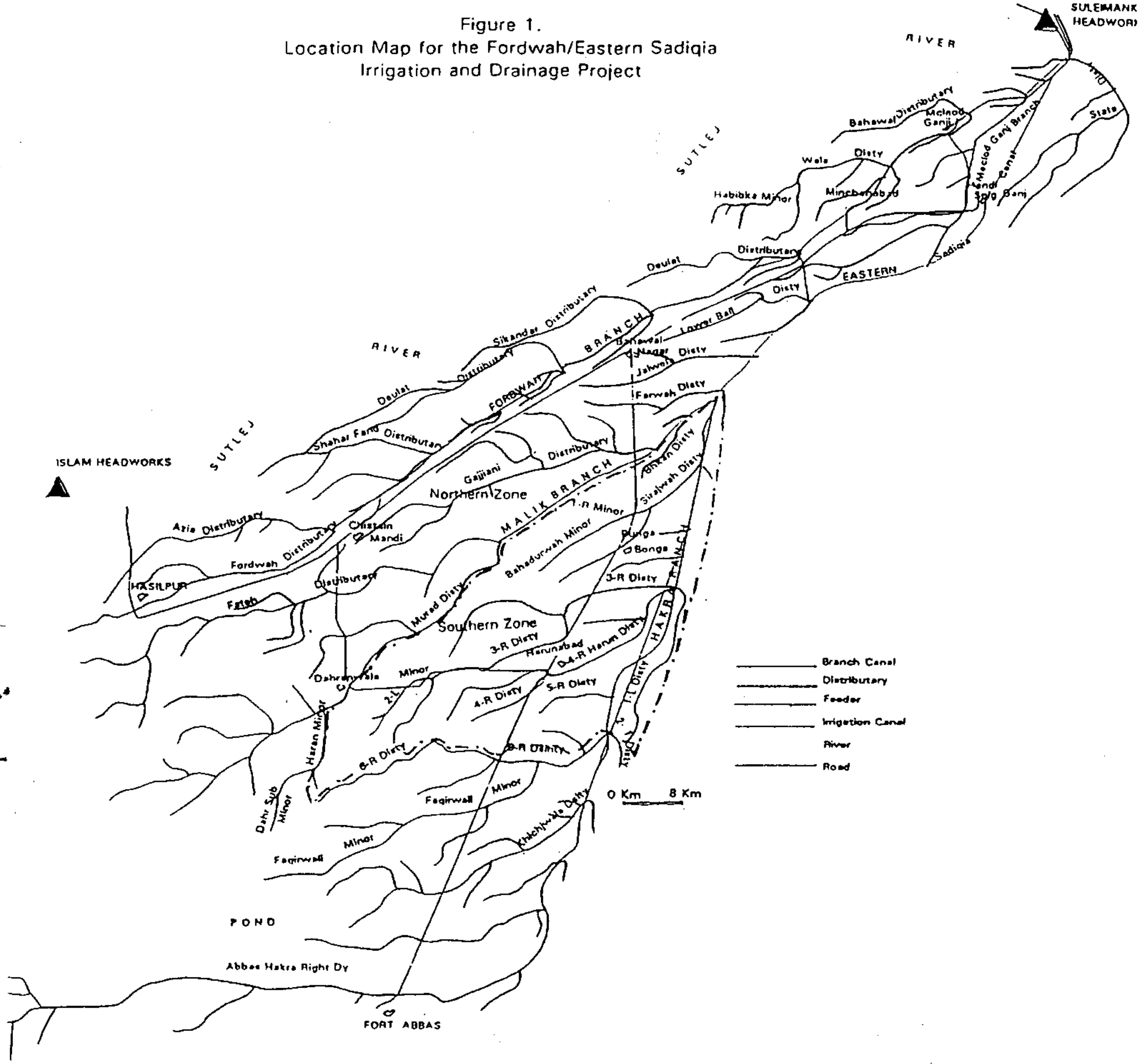
Today, excessive political pressure strongly jeopardizes the system. Since the police has a hard task preventing social disorders, how can they seriously prevent cuttings in the canal? Since influencial people can manage to get water others would need, how could reasonnably be punished those how steal water for their crops because they don't get enough from the legal way?

From the hydraulic point of view, the water taken south of Sutlej river at Suleimanke headworks is divided into Fordwah branch and Eastern Sadiqia canal, itself further divided into Malik branch and Hakra branch. Fordwah branch, as a division, is divided into 3 sub-divisions. We have visited and have been working with only Malik branch and Chistian sub-division, the tail part of Fordwah canal.

The hierarchy of the gouvernment agency -the Irrigation Department- is parallel: an executive engineer (XEN) is centralizing the informations at the division level, a sub-division officer (SDO) is managing the water supply at the sub-division level with one sub-engineer for each of the 3 sections of the sub-division. A complete hierarchy of the people working in the Chistian and Malik agency is given in annex.

An ancient telegraph system permits communication between the staff agency in the area. At the last level, the gate keeper provide information every day through reporting of the current discharge measured at his location.

Figure 1.
Location Map for the Fordwah/Eastern Sadiqia Irrigation and Drainage Project



B. *Discharges scheduling and distribution.*

1. The rule.

According to the Pakistanese law, water share scheduling is based on the principle of shortage sharing. A basic design feature of the irrigation system has been to spread water over as large an area as possible to expand the settlement opportunities. It was wisely taken for granted from the beginning that it could not supply enough water for every farmer's needs. Priority rotation frame are defined for the system and turn-of-water distribution refer to "warabandi" rotation at the watercourse level. This kind of management is called **supply based scheduling**. In a lot of other countries, the scheduling is rather crop-based.

At each level, the manager has several sub-systems, equally weighing in terms of design discharge from the main canal. At the beginning of the season, he is defining a rotation of priority for the season, by periods of 7 to 10 days. For example, in the first 10 days, sub-system 1 will have the first priority and will get 100% of its design discharge if available for the whole system. Sub-system 2 will get remaining water, up to 100% of its design discharge, and sub-system 3 will have the rest. The next 10 days, sub-system 2 will have the first priority, sub-system 3 will have the second one and sub-system 1 the third one. And so on until the end of the season.

To avoid sediment deposit and breach, standing instructions require that channels flow should not go out of the 80% to 110% range of the design discharge.

In case of emergency, the canal manager can override the rotationnal scheduling. For exemple, in case of big rains, farmers don't need water to irrigate and the closure of some of the distributaries can be requested, even if they had the first priority.

This scheduling method is not perfect because it is not based on the demand, but it may have the advantage of transparency. It means that theoretically (and also practically in some areas), unhappy farmers can come to see the canal manager and ask why they did not get the water they wanted. The canal manager can explain why, according to the law and to canal maintenance necessities, they could not get some water.

2. Decision making at the management office.

Decision making for gates opening and closing is sub-division officer's and higher official duty. Practically, in case of emergency, gate keepers do not wait for official orders to take measures.

Some irregularities in allocation are observed at each level. Another aspect, which must not be forgotten for the sake of doing justice to everyone, is that:

1. It is economically difficult to live, maintain the canal in a proper way and allocate water equitably. Land lords often get more water than small farmers also because when there is a need of canal bottom cleaning, he will be called for sending some of his people to do it.

2. The managers are not fully independant from local interferences: even if managers should stay at least 3 years in charge according to the law, undesirable ones can be quickly removed from their duty by political intervention.

C. *Water management at the gate keeper level.*

1. Gate keepers know-how.

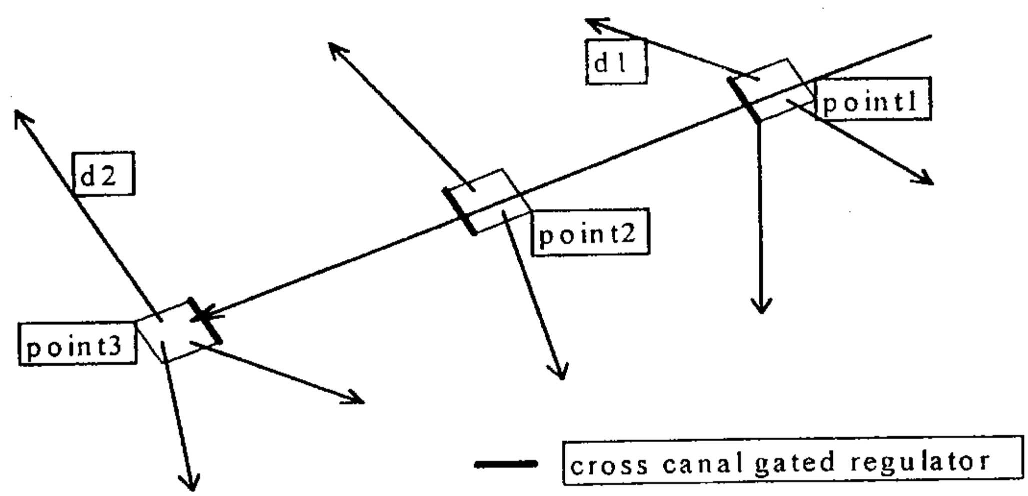
In case of quite normal flow, highly experienced gate keepers know-how is enough to estimate the discharge, open and close the gates in order to provide the requested water in the distributaries. A good gate keeper knows, when the upstream level is getting higher, how many turns he must make on the crank to restore the correct downstream level.

If no orders are given by the management, in case of shortage or excess of water, the gate-keeper will:

- if he is not at the tail of the canal, fulfil the needs of its distributaries and convey the balance of water downstream
- if he is at the tail,pass the excess or shortage of water to one or several of its distributaries.

2. Example of crisis.

Let's take an abstract example.



Let's suppose that the scheduling was 1000 cubic feet per second (cusec) for the period for the whole system drawn. Then, the gates are opened at the headworks. Let's suppose that unexpected rains happen on the upstream part of the canal, and that point1 gate keeper close the distributaries on the demand on the farmers. We could also suppose that there is a accidental breach on distributary d1 (see the drawing) and that this canal is close in emergency. Even if measures are taken at the headworks to close the gates from the river, it will take 2 days to impact on the discharge at the tail.

So, point1 was supposed to absorb 400 of the 1000 cusec and does not use this water. Point2 gate keeper was supposed to measure 600 cusec upstream, convey 300 of it in its distributaries and let 300 cusec go downstream. Without any special information, he may suppose that point3 asked for more water, or without supposing anything, just take the water he was supposed to take and open the cross canal regulator gates in order to let the extra water go to the tail.

Point3 gate keeper has then to deal with 700 cusec instead of 300, and has neither downstream canal to absord the unwished water, nor drain. He will:

- close the regulator gates for a while to use the main canal as a storage reservoir;
- when the level in the main canal reach its design discharge, he will provide water to all the distributaries to their maximum capacity even if farmers do not need water.
- if those measures are not enough and if the water keeps on flowing in the canal, he will have to take a decision to manage the crisis, while waiting for the upstream level to go down. In this case, the most important will be not to create a breach on the main canal. As in example, it will always be d2 distributary that will bear the consequencies first (both for water shortage and for over-topping risks).

This example illustrates the extrem case of total absence of global crisis management. It shows that even with very competent field staff, these events will automatically lead to a canal breach, unless there are a good information network and decision making in higher level.

D. *Actual current practices.*

Apart from crisis situation, standard performances of a routine management may be very poor also. This will also be, in a great extent, due to lack of correct informations.

For each structure, the local person in charge of it (the gate keeper) measures daily the downstream level and report on the form this depth of water and the discharge he can read on his table of correspondance (depth in feet - discharge in cusec). Then he will bring it to the local Irrigation Departement office where these data can be passed on to the head office by telegraph. There is 24 hours a day someone with the telegraph, and the gate-keeper comes back to his house, close to the structure, to intervene quickly in case of flow changing. In case of emergency, the gate keeper reacts most of the time before the orders from higher-level.

It appears that:

- Downstream gauge measurement facilities are inaccurately used due to lack of maintenance. In the past, the depth of sediment deposit was measured monthly, and substracted from the measured water depth. Gate keepers seem to be aware of this problem, but they do not have to maintain the measurement equipment by themself. They probably can estimate properly by themself the depth of water, but they have to keep blinkers because in case of control, he would have troubles to explain why he did not use the gauge.
- The discharges tables used by the Irrigation Department, sometimes 15 years old, are also outdated. The formula used is:

$$Q = K_d (h_d)^{5/3}$$

K_d coefficient is measured by calibration, or can be recovered comparing with the structure formula.

- The formula used is cheap in terms of required data (only downstream level), but maybe not accurate enough. Good structure formula would include also upstream level and openings for gated structures.

As a consequence of inaccuracy in collected data (which can be moderated but not beyond a certain limit), it is very difficult for canal managers to have proper monitoring activities on their canal. Then, the main water distribution rule will be local decision making all along the canal. In this context, how can tail water courses have their need of water?

E. Why a computerised information system?

Actually, unless everything was automated, it is clear that computers can't make measurements, can't take final decisions and can't make sure that those decisions are followed.

The quality of the output will always depend on the quality of the data entered, and the structure of the output will only be what one has programmed, and no further comments. It is up to the user to make sure that the data collected and entered are quite correct, and to take decisions and make them carried out properly. That involves investment or proper maintenance not only in informatic hardware but also in measurement material and communication equipment. We must also consider staff training as a key point of success.

Then, one may wonder if the computerized component is necessary, if the traditional system is correctly restored. There are many factors responsible for the present situation, a few of them can be identified as:

a) Political interference and pressures;

b) Bad communication system

c) Shortage of technical staff

d) Lack of precise knowledge about the system

e) Improper maintenance due to lack of funds, improper use of funds and lack of precise knowledge of the system.

Computer based information techniques can help to solve some of these problems.

The first point is that a computerized information system forces staff to pay more attention to data acquisition, because of the computer requirements. That means: good maintenance of the system and real attendance in the fields of the person responsible for head decision making.

The second point could be called transparency but the political arrangements are generally already transparent and one can always find a way to modify recorded data. However, informatics is a good tool to provide relevant weekly, monthly and seasonal computed statistics that can help managers to assess system performances globally and to identify the most accute problems. Moreover, there are different proposals about the

restructuring of the system and all of them include an active role of users, more information sharing, and transparency.

More generally, computerized information system is the path to use new improvements for management: simulation models for hydraulics but also economics (in collaboration with Revenue Department perhaps), agronomy (in collaboration with Agricultural Department)...

III. Development of the computer tool.

A. Data structure.

As noticed earlier, one of the great advantages of the former IMIS version compared to other similar softwares, is that the data definition is really close to the canal manager's point of view.

1. Description of the system (permanent data).

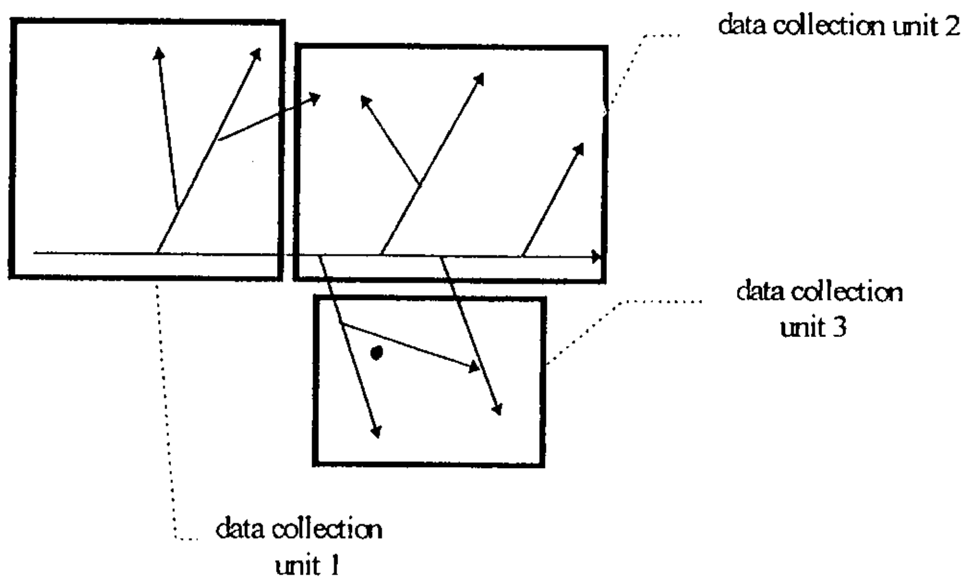
...which are not all that permanent since some of them need to be updated regularly...

a) *3 cuttings out of the network.*

For the user's point of view, there are 3 different ways of cutting the network:

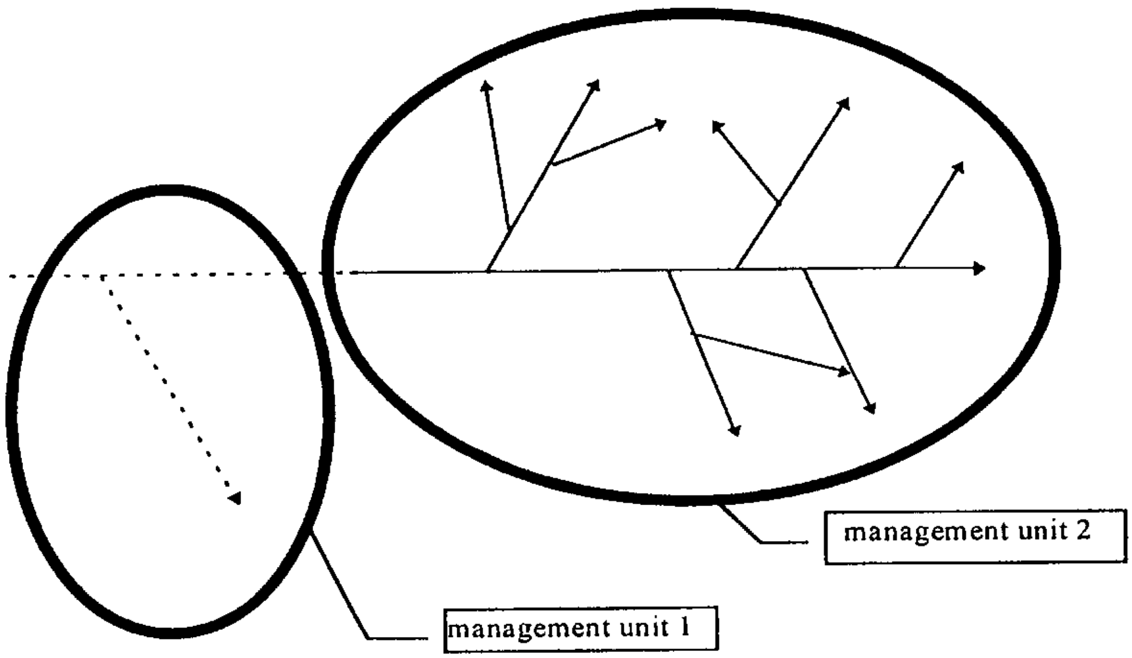
(1) data collection units:

One gate keeper is responsible for collecting data on several structures. The form he has to fill in every day compiles informations (depths of water and sometimes gates opening) on one part of the canal: a data collection unit. This cutting out of the system will be used in the softwarefor data entry sessions.



(2) management units:

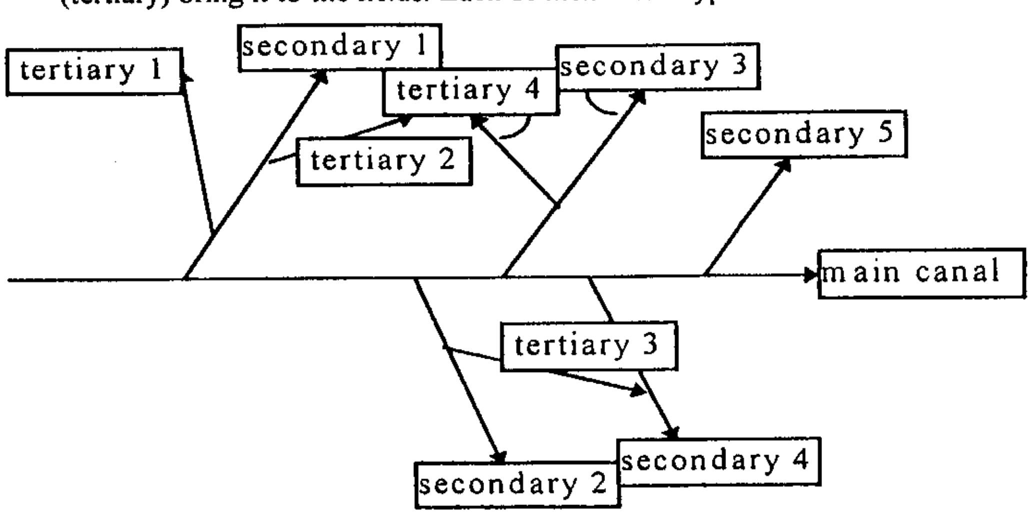
A management unit is a part of the system for which there is a sub-manager (in Pakistan, the canal manager is the S.D.O. and the sub-manager is «sub-engineer». The manager is likely to ask for statistics on separated management units.



(3) canal units:

The canal units definition is the hydraulic definition of the system. If one wishes to define a new structure or describe a new cross section of the canal, he will need to specify its exact location. For this aim, he will have to input the name of the canal unit and the chainage on this canal.

The hydraulic engineer will consider a main canal, a few secundary canals and many tertiary canals. For the canal manager, the typology of the canals does not depend on their situation on an arborescence, but on their use. To simplify, a main canal brings the water from the headworks deep into the land (up to 100 km into the land in Pakistan), distributaries (secondary canals) spread the water all around and the water courses (tertiary) bring it to the fields. Each of them has a typical dimension.



b) singular points of the network.

Singular points of the network are mostly cross canal regulators and offtakes.

In most of the cases (at least in Pakistan), a regulator will be gated or ungated: a group of gates (with a weir on both sides in Sri Lanka) or a weir and a distributor will be either a group of gates or a particular device: open flume, A.P.M., O.F.R.M., pipe ...

To enter these structures in the database, a sum up classification has been used: the network is seen as group of structure, and a structure as group of devices. See user's guide for more details.

c) geometry of the canal

The geometry of the canal has to be entered in case of use of hydraulic simulation model (SIC). See SIC interface chapter to understand more precisely which data are necessary for SIC, and how the canal is seen from the hydraulic point of view.

There is a data entry form for the cross sections of the canals. Cross sections can be defined by comparison with a geometric figure: rectangle, trapeze or ellipe, or by entering a group of abscisses-elevations or width-elevation (the bottom will be modelized as a linear interpolation of defined points).

2. Objectives and measurements (Historic.data).

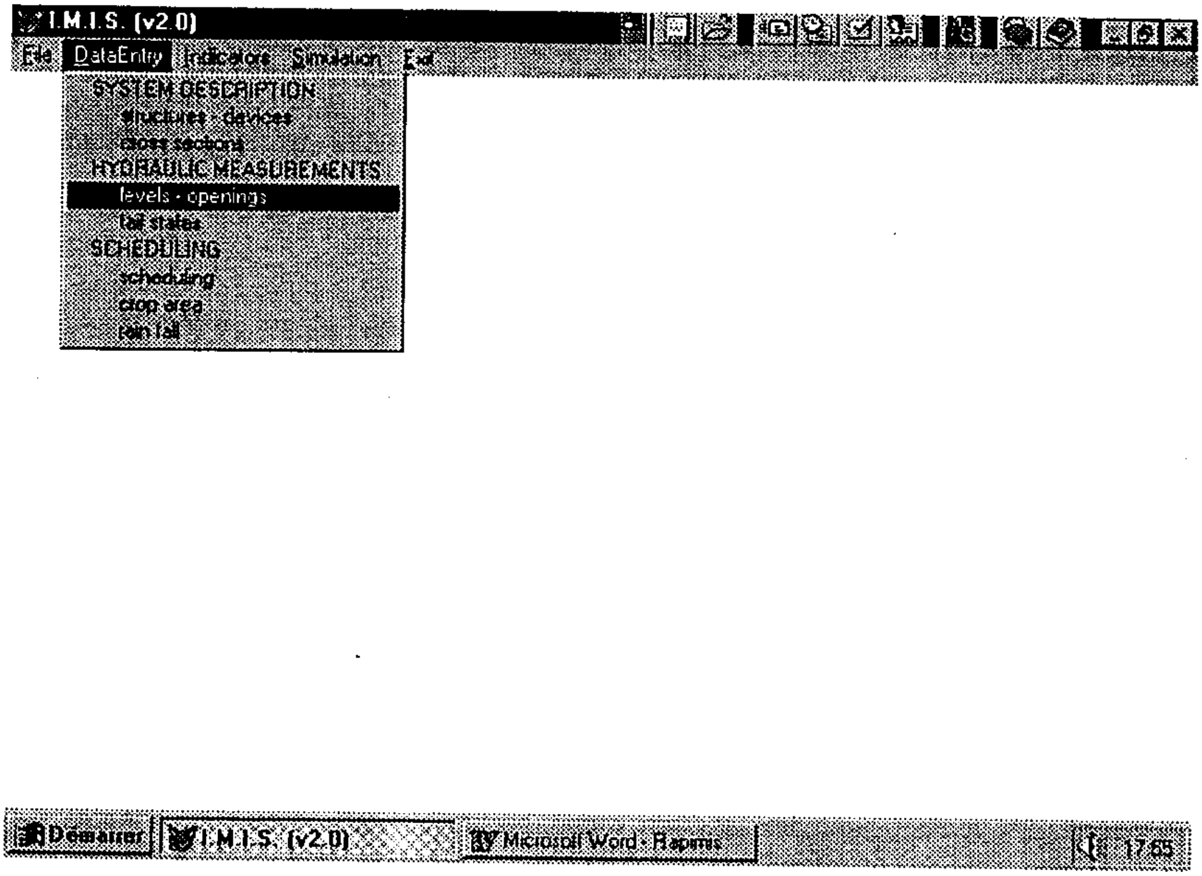
The most important data entry, more or less daily, consist in gates opening and water depths on relevant points of the system, like downstream gauges for structures. Another set of important data consist in scheduling, that will enable to have many statistics to compare proposed allocation and real allocation.

There are also seasonal data: crop area under each outlet, fixed rotational scheduling rules...

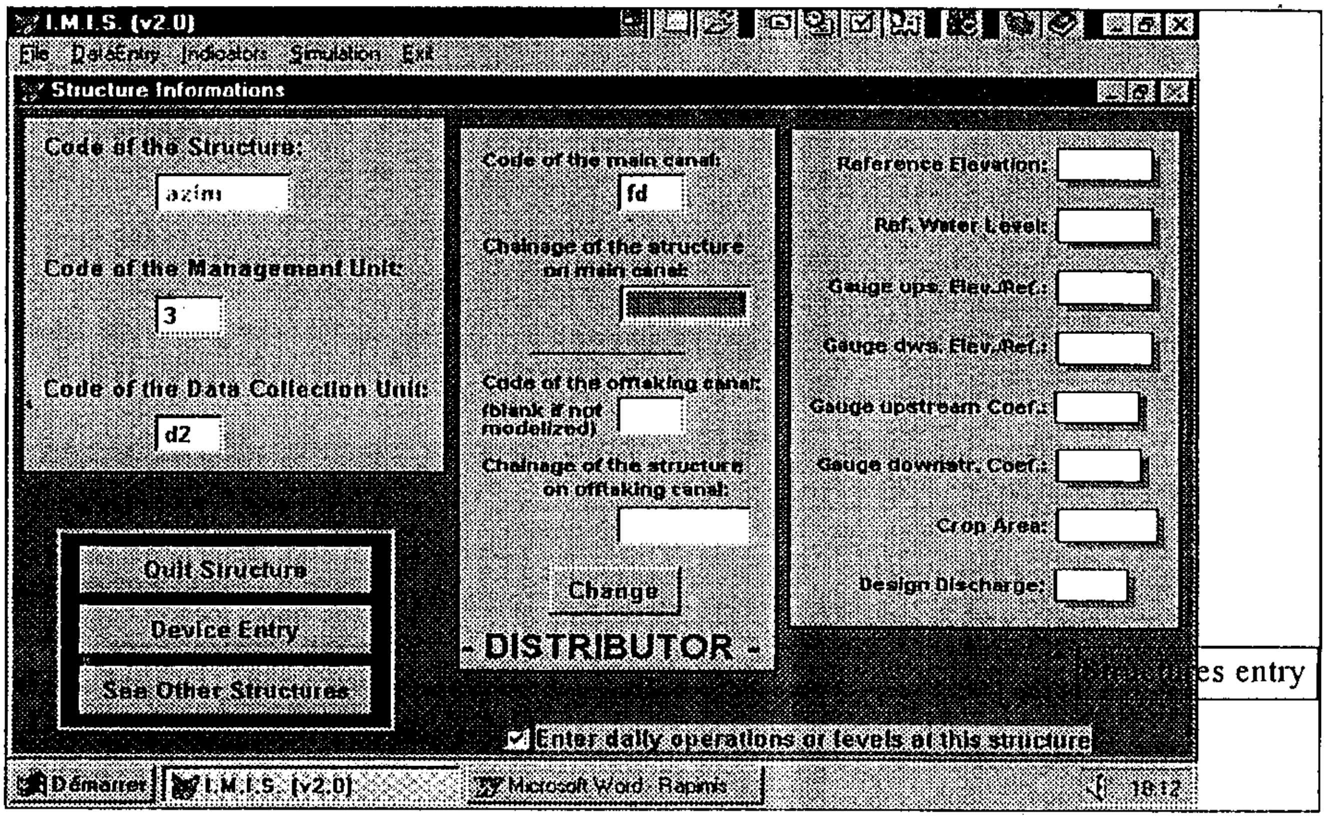
B. Data handling.

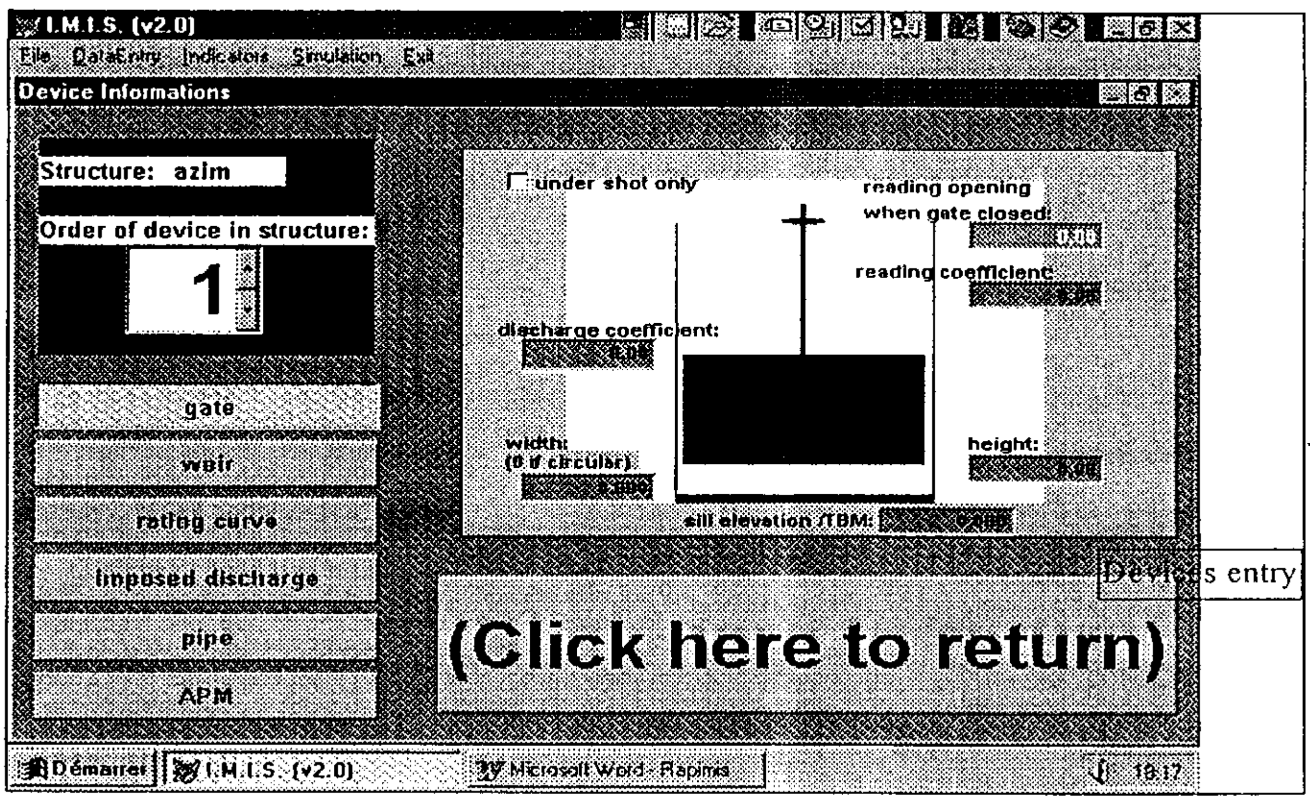
1. Menus.

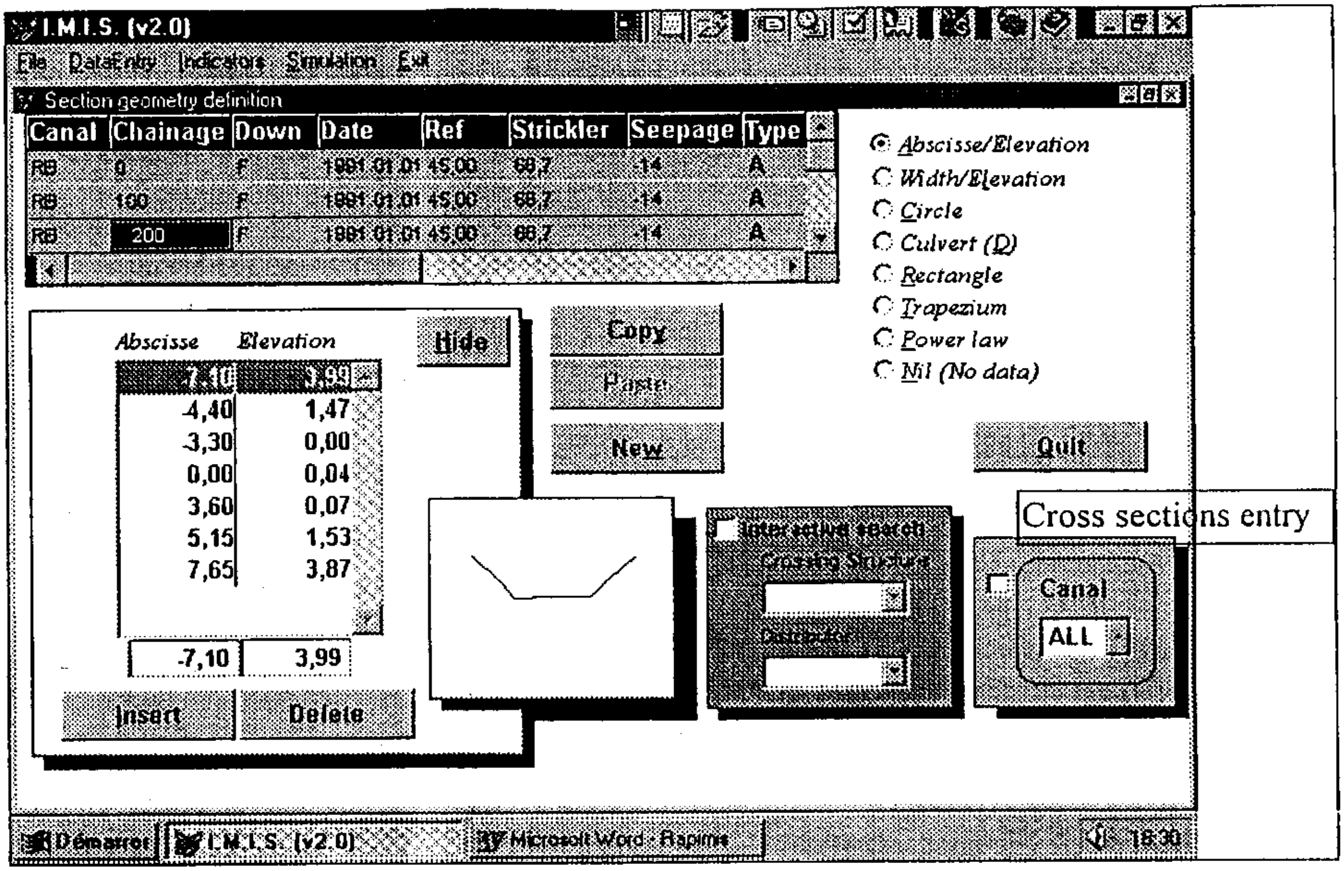
As a proper windows software, IMIS has a structure of scrolling menus. Here they are presented in Windows 95 design :


I.M.I.S. (v2.0)
File DataEntry Indicators Simulation Exit
SYSTEM DESCRIPTION
structures - devices
cross sections
HYDRAULIC MEASUREMENTS
levels - openings
fail states
SCHEDULING
scheduling
crop area
rain fall
Démarrer
I.M.I.S. (v2.0)
Microsoft Word - Rapimis
17:55

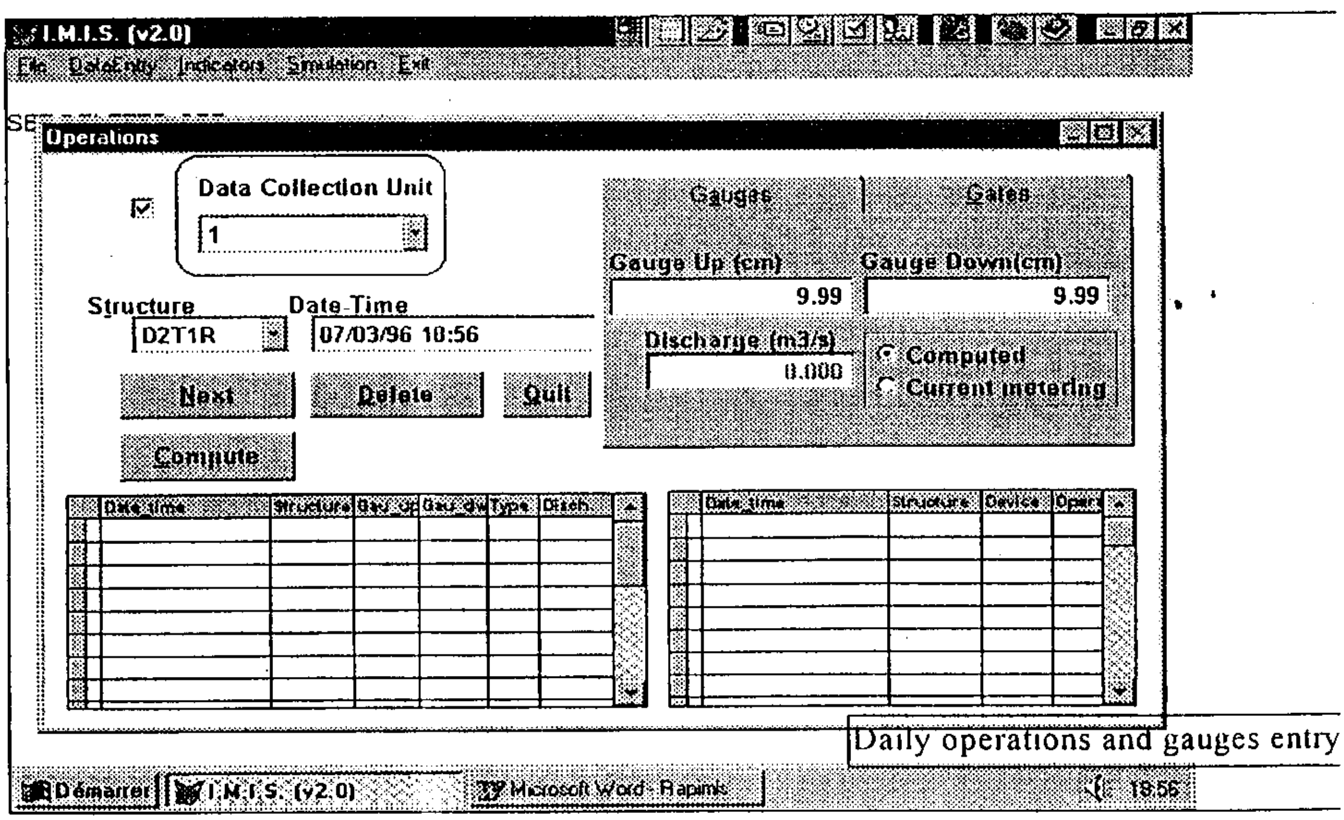
2. **Data entry forms.**





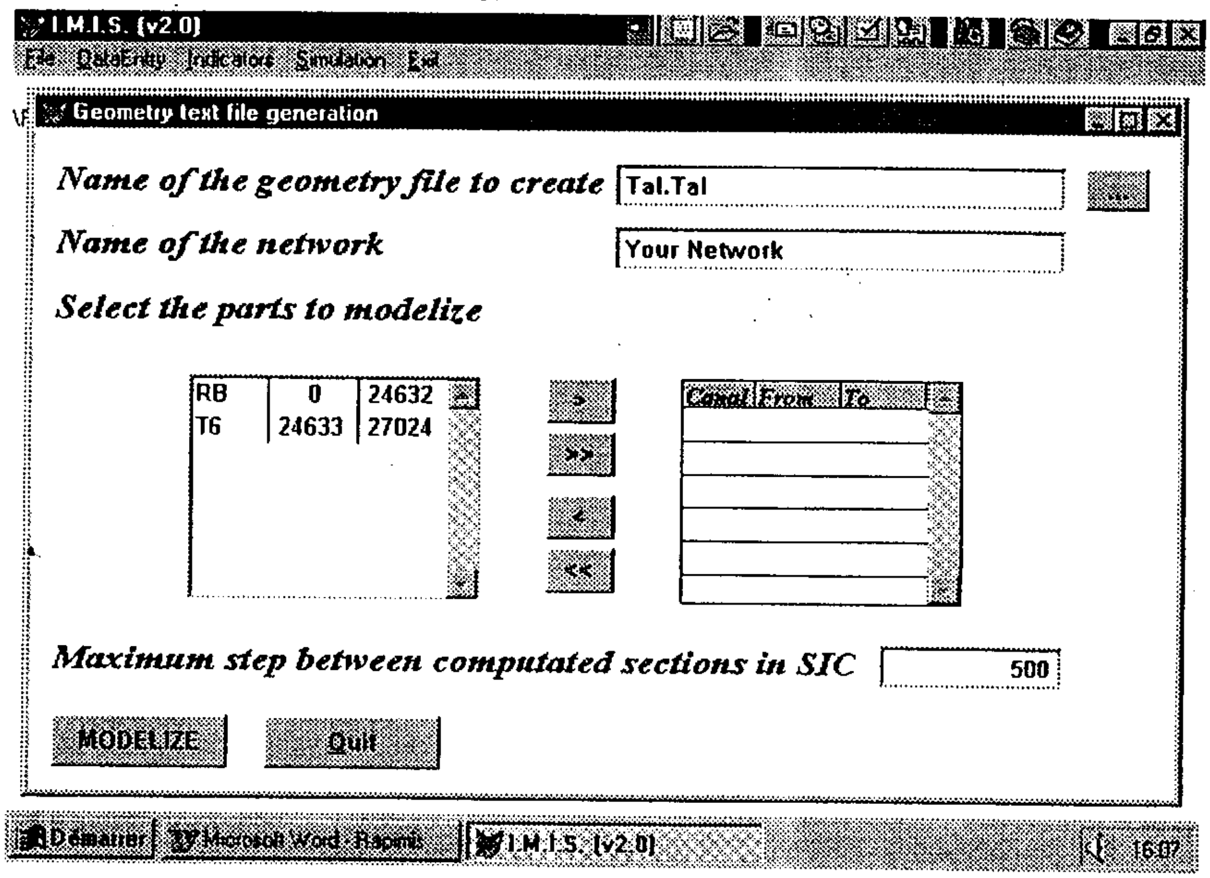


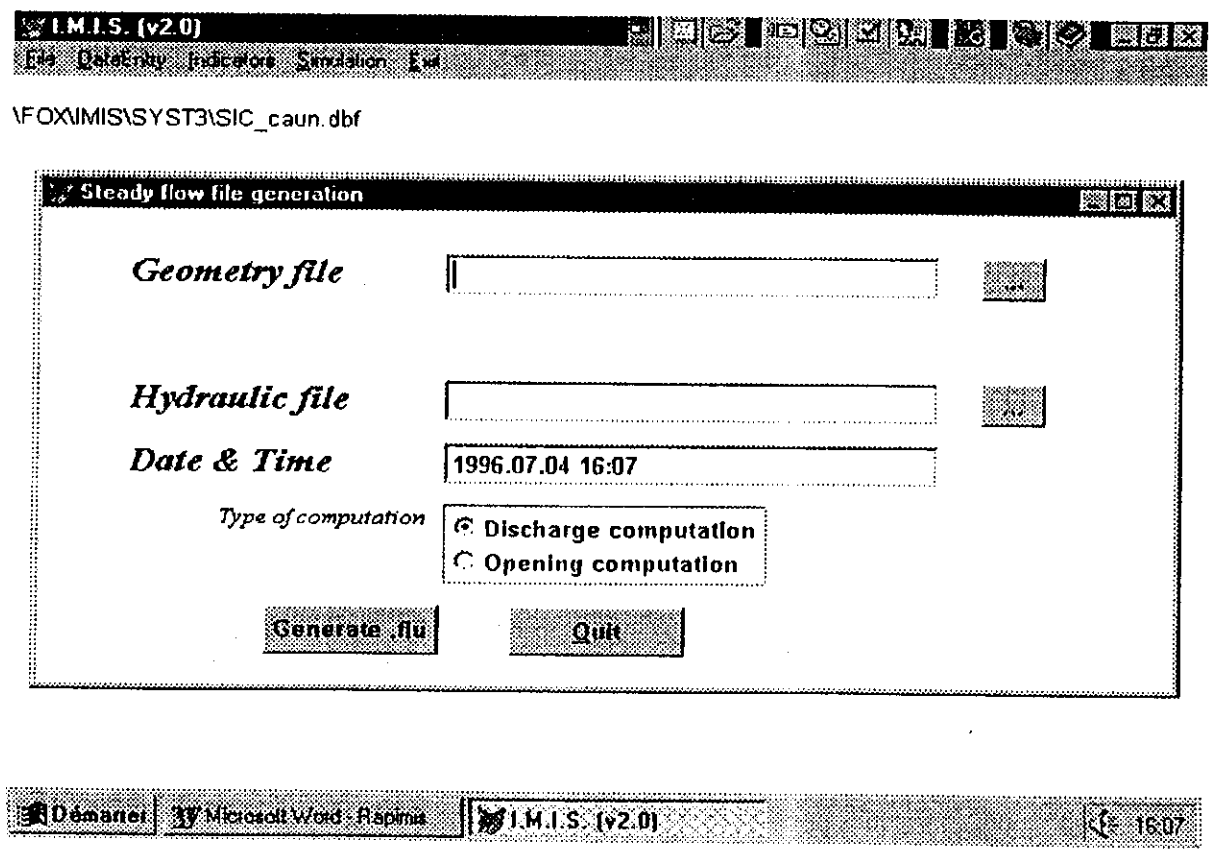
Cross sections entry



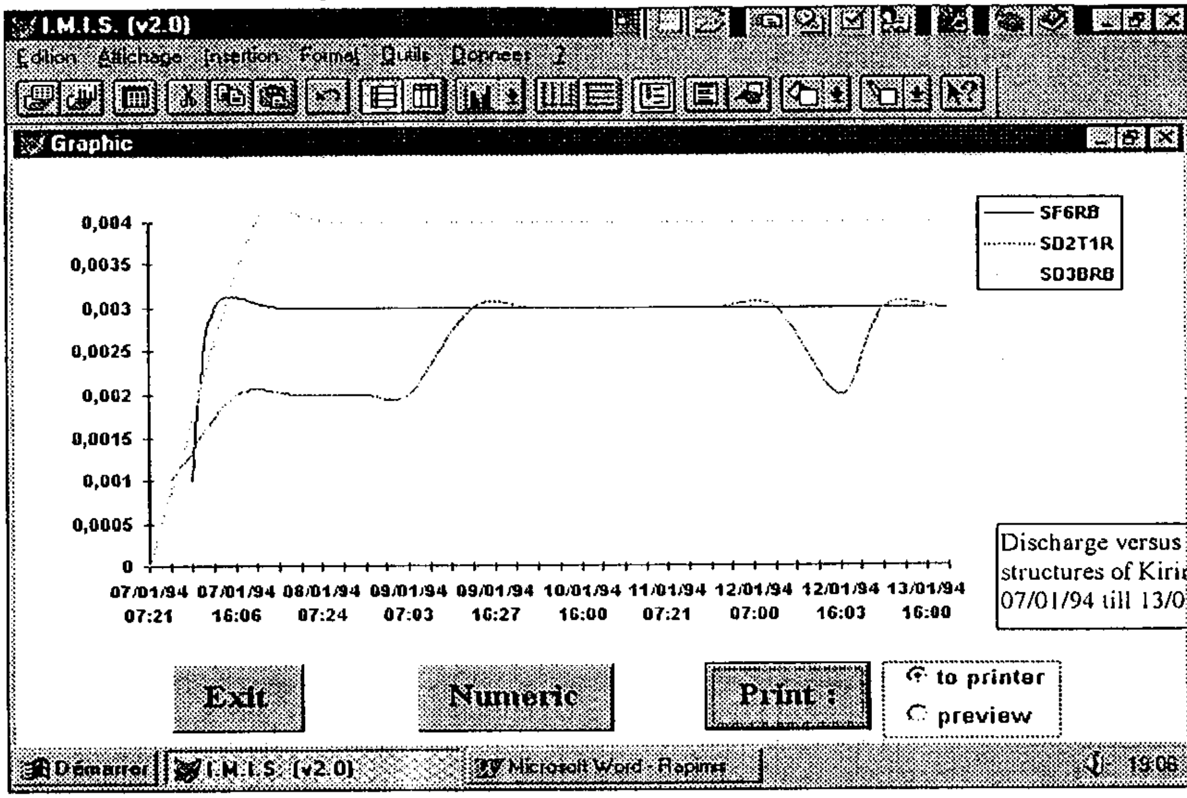
Daily operations and gauges entry

3. Interface S.I.C.

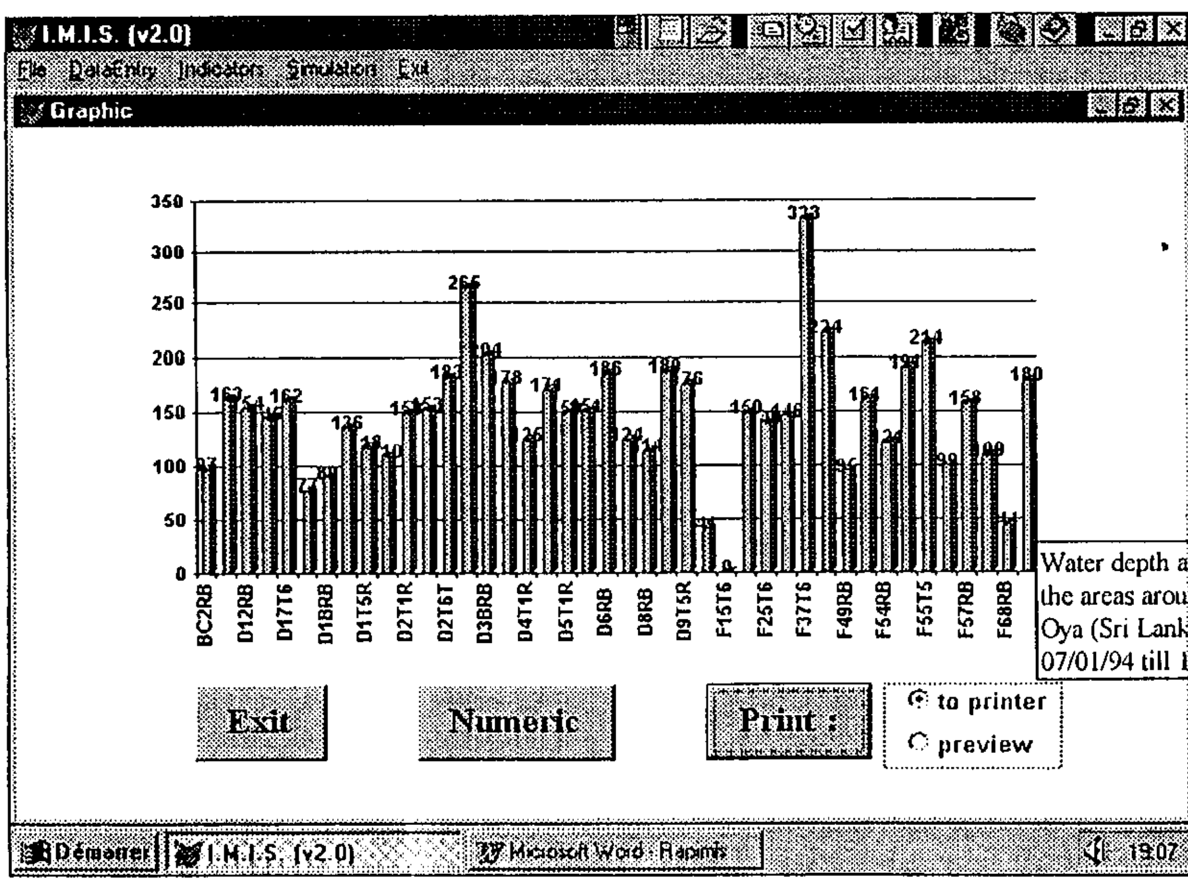




4. Reports and Evaluations.



Discharge versus time for 3 structures of Kirindi Oya from 07/01/94 till 13/01/94



Water depth allocated for the areas around Kirinda Oya (Sri Lanka) from 07/01/94 till 13/01/94

IV. Further improvements.

1. More statistics computations.

More statistics computations, including comparisons between water distribution scheduling and real operations. Molden and Gates performance indicators were programmed in the former version. They are not a first priority for canal managers use, but give a interesting assessment of the performance of the system.

2. Scheduling functions.

Actually, it must be done for each kind of context. Now, proposed allocation must be entered like real operations by the user.

For rotational priority scheduling on a supply based model, a scheduling package should have :

1. a seasonal data entry to check : which regulator is the head of the system, what is the system efficiency (seepage rate) what are the sub-systems, how the rotation is initialized, what is the rotating period...
2. a computation program to fix a proposed allocation for a structure. This program need the following parameters : structure code, date, head discharge, system mean efficiency (available discharge will be : head discharge * system mean efficiency).
3. a modified scheduling entry form with a button to compute proposed discharge according to rotational priorities.

For a crop based scheduling pattern, it is possible to create an interface with a crop water requirements model like CROPWAT, developed by F.A.O.

3. Option page.

An option page should allow the user to select his language, units, discharge computation formulas and working directories.

4. More storages.

The software should store the result of weekly performance indicators to have quicker recalls and seasonal statistics. It should also keep in memory the history of devices modifications in order to have a good maintenance module in the future. These points will raise difficulties like : if a anti-dated change occur on a device, does it have to recompute all the stored indicators for that time, or does it take a risk to have fake seasonal statistics if those are based on simple weekly indicators ?

5. Database maintenance facilities.

A menu called database maintenance should be created to enable data entry specialists to have a direct access to tables to :

1. enter one month daily data very quickly by using a minimal interface.

2. quickly correct mistakes unexpert user could have input in the tables.

6. On line help - User's guide.

This was the first improvement priority according to IMIS training course participants. A detailed and provident on line help (with access with right mouse button click or F2 key for example) can change IMIS use, make a pleasant activity from an awful drudgery, and save it from abandon.

CONCLUSION

So far, IMIS has been used in its former version in the fields by Irrigation Departments in Kirindi Oya in Sri Lanka and in Chistian sub-division of Fordwah canal, in Eastern Punjab, Pakistan.

Apart from this official use, IIMI's researchers have been working with IMIS. It is a quite important use also. When data are nicely organized, it really can allow deep analysis of the system.

What will happen to IMIS?

For Cemagref point of view, integrated approach is going to become a first priority for irrigation issue study. IMIS new version will be used first as one of the bases for thinking about the design of an integrated management tool. If Visual Foxpro is considered as the ideal programmation software and if strategic choices are such, what we programmed will be in the center of any decision support system provided by Cemagref in a few years. Inch'Allah.

For IIMI, a computerized information system tool is strictly necessary for applied research. Its use is planned from October onwards in Sindh province, near Hyderabad and in North West Province Frontier on Pehur High Level and on Upper Swat Canal. For these last applications in N.W.F.P., crop based management functions (interface with F.A.O.'s CROPWAT for example) will be implemented.

ANNEX 1: WORK SCHEDULE

On the following pages are:

1. Ms Zaigham Habib's proposal for our work.
2. Our updated work schedule, arriving in Pakistan.
3. Antoine Rozenknop's contract for further developments

Next >>

To : Jacques Rey copy : Marcel Kuper
From : Zaigham
Date : 11 April 1996

Dear Jaques,
It is a good news that you will be available in CEMAGREF to supervise IMIS students. I would like to share my opinion about the further developments of IMIS and the tasks of the students.
IMIS as a package should be able:

i) to handle all field information and databases related to irrigation scheduling, water distribtion, canal operations, crops, water demand and topology of an irrigation network.
ii) To have an interface with hydraulic model [SIC] to process and transport physical (topography) and hydraulic data of the primary (one in our case) and secondary (14 disties of Fordwah) channels.
iii) to display/draw a sketch of the network showing important points (nods, structures) on it, ideally specifying the management units; link with a drawing package.
iv) To produce output through a menu selection including tables and graphics.
iiv) For data analysis part, ability to add any number of tools for example IIMI's gross performance indicators. IMIS is quite flexible in this regard; a menu option can be provided to link/call a separate module.

To have these changes we proceed like this:

i) Shifting IMIS from dBase III to FOXPRO window version; it will provide better control over data, more memory and access to a drawing package,
ii) modifications in IMIS structure to accommodate branched irrigation network; a change in file naming algorithm, identification keys and data entry setup will be followed (quite a bit changes in programming),
iii) interface with the window version of SIC,
iv) development of IMIS reporting module,
v) some small changes like entry of permanent data through user's interface etc,

Students' work can be planned with reference to IMIS application in Fordwah area where we are using it in two sub-divisions.

* one student can work for the transfer of IMIS from dBase III to FOXPRO, he can also work for reporting module using Malik Branch sub-division as a case study.

* 2nd student can work for the branched network and IMIS-SIC interface using Fordwah as a case study. IIMI is going to use SIC for the Fordwah branch canal and its fourteen distributaries in a linked way for the integrated approach and IMIS will be used to process all physical and hydraulic data sets of these channels.
New work should be done in FOXPRO, so, probably, it will be more practical for both students to work together on the shifting of the package first and then split the work.

Zaigham

Best regards.

state of advancement and development schedule of IMIS

1996, May 5th

Cyril Loisel - Antoine Rozenknop

We can split our tasks into 8 parts:

- database reformat (fields, indexes and relations between tables):
  This task supposed a reflexion on branched canals treatment.
  This was done in Montpellier.

- data acquisition: data-entry forms building
  This chapter, dealing with object-oriented programmation is one of the most difficult. 2 permanent data entry forms will be created: one for hydraulical informations (appending X tables: structures, canal units, management units, data collection units) and one for geometrical informations (appending 2 tables: sections and section points). Other forms concern seasonnal data: water allocation proposed, areas, rains and tails, and daily data: opennings and levels.

- calculation programs:
  From entered data, they must compute discharges and indicators. It should not be very hard to program once fields to use and formulas are well defined, but they are very numerous.

- reports:
  Weekly, seasonnal and annual reports with graphs and statistics, following the desires of the end users (1 interviews, 1 first basic set of reports, second interview, final version of the reports).

- main menu:
  It also includes compilation, distribution matters, setup, clean-up and exit procedures, general choices (measurement units, discharge formulas...) and perhaps help and password entry.

- SIC interface:
  From the 3 files that must be generated to access SIC simulations, 2 of them are already issued by talmaker and flumaker programs developped in Montpellier. We still have to generate the .SIR file and the feedback from SIC to IMIS. For these tasks, we need to have the result of Jacques Rey and Pierre-Olivier Malaterre debate about SIC.

- manual:
  To facilitate use and post-developments.

- personnal report.

For all these purpuses, we propose the following schedule:

week	activity
5 May	structures form
12 May	other forms: sections, seasonnal inputs, daily inputs
17 May	calculation programs: discharge, indicators
26 May	holidays
2 June	.SIR and SIC feedback
9 June	application: requests (+ more programs)
16 June	application: IMIS-SIC interface (+ more programs)
23 June	manual, help, error tests, complete interface
1 July	personnal report + small last debugging

Cemagref

EXTENSION DU STAGE DE ANTOINE ROZENKNOP
PROGRAMME DE TRAVAIL

Le travail de stage réalisé en binome par Antoine Rozenknop et Cyril Loisel en liaison avec le Cemagref et l'IIMI Pakistan a permis de développer sous Visual Foxpro une version améliorée du logiciel de gestion hydraulique des canaux d'irrigation IMIS. Le temps imparti aux deux stagiaires n'ayant pas permis de mener à terme la programmation de certaines options ni la rédaction de manuels, il est proposé à Antoine Rozenknop une prolongation de stage d'un mois (08/07/96 - 08/08/96). L'indemnité de stage versée par le Cemagref sera de 2000F et le programme de travail à réaliser en contrepartie par Antoine Rozenknop est détaillé ci-dessous.

Développements complémentaires :

(a) à faire :
- Option générale pour le choix des unités et des formules de calcul de débit utilisés par le logiciel.
- Possibilité de travailler avec plusieurs systèmes d'irrigation en parallèle.
- Calcul d'indicateurs (4 indicateurs de Molden & Gates, ratio débit mesuré/débit objectif, ratio débit mesuré/débit design, degré d'ennoiement des structures, degré de fluctuation des niveaux d'eau à l'amont des structures, % de temps durant lequel l'aval des canaux est à sec[1]).
- Modification des options pour générer le fichier .FLU de SIC (aux prises: calcul du débit, calcul de l'ouverture en fonction du débit objectif ou du débit mesuré).
- Développement d'un rapport présentant l'état hydraulique d'un canal donné un jour donné (débits mesurés et objectifs en tête, à l'aval, prélevés).

(b) uniquement si le temps imparti le permet :
- Gérer l'évolution de la géométrie du réseaux.
- Interface SIC pour les simulations en transitoire (Fichier .OUV).
- Choix du langage utilisé par le logiciel.

Vérifications :

- Vérification du bon fonctionnement de toutes les options sur le jeu de données du canal Kirindi Oya et sur un système test à créer (maillé et comprenant toute la gamme d'ouvrages possibles).

Appui utilisateur :

- Rédaction d'un manuel d'utilisation et d'un manuel de programmation.
- Aide à l'installation du logiciel.

cc. A. Rozenknop, P. Kosuth, P.O. Malaterre.

[1] on choisira la solution de considérer ce point de mesure aval comme une structure 'cross' sans 'device', avec un niveau d'eau de référence stocké dans le champ FSL de la structure.

GROUPEMENT DE MONTPELLIER
361 rue J.F. Breton, BP 5095

ANNEX 2: IMIS TRAINING COURSE PARTICIPANTS ADVICES

On the following pages are:

1. the training schedule
2. suggestions for further developments of the 3 work groups
3. a diploma
4. the two transparents of our presentation.

Training Course on
Irrigation Management Information System
May 12 to May 16

Training Schedule:

May 12

14:00 - 15:00	Entry and Introduction of the participants
15:00 - 16:00	Introduction to the training program

May 13

Skogerboe

09:00 - 09:30	Introduction of the course
09:30 - 10:00	Information techniques for irrigation managers
10:00 - 10:30	IMIS as a tool: options & functions
10:30 - 12:30	Examples of IMIS implementation from Pakistan and Sri Lanka
12:30 - 14:00	Lunch
14:00 - 16:00	Training of IMIS Package: - overview of the package - data-entry and processing

May 14

09:00 - 16:00	Training of IMIS Package; - data entry and Information processing - Management functions in IMIS

May 15

09:00 - 16:00	Training of IMIS Package - Performance evaluation of an irrigation system using IMIS - New version of IMIS, presentation and discussion

May 16

09:00 - 10:00	Group activities
10:00 - 11:00	Group presentation
11:00 - 11:30	Discussion and feedback from participants
11:30 - 11:45	Evaluation of training program
11:45 - 12:15	Scope of IMIS in Pakistan
12:15 - 12:30	Concluding remarks
12:30 - 13:30	Distribution of certificates

Dt. 15/05/96

Suggestions for IMIS : Group I

This Program i.e IMIS is quite useful for irrigation managers, but requires to include performance evalution with the means of water delivery efficiency, equitability & reliability

- Although the training course is quite good, but it should be more organized and pre-lecture notes, diagrams & other help should be provided in advance.

The time schedule of this training program is quite tight & limited in view of such a large package.

In this training program it is quite helpful to launch simultaneous program with IMIS to dBase package.

- It will be more appropriate if the allied softwares like dBase III etc. is studied ~~earlier~~ prior to run the IMIS.

In new version memory of the software should be considered. It should cover less memory & quick run.

The new version should be compatible with the older version of IMIS

A Good help file should be added to the programme

weekly record, monthly and yearly with certain graphical representation. Also showing the previous year's trend. Forecast the future requirement,

If the new version can make a data sheet of weekly Wali requirements during the previous season or year by using the older data. It may be helpful in ~~xx~~ indenting in a ~~x~~ supply based system.

Like other Soft wares, IMIS must have help facility.
It is necessary to have a list of the data required for IMIS in the beginning for a new beginner.

3. The set of performance indicators given in the program i.e. the Molden and Gates are not used any more. Therefore, a new set of indicators may be included. ~~As~~ (i.e. the set of indicators recommended by Dr. Chris Perry).

4. It should have the facility of graphs which is anyway incorporated in the new version.

Hakeem Khan
15/5/96.

IIMI

12 Km, Multan Road, Chowk Thokar
Niaz Baig Lahore-53700, Pakistan

This is to certify that

Ms. Zaigham Habib (Systems Analyst)

participated in the Training Course on

"Irrigation Management Information Systems"

Organized by the

International Irrigation Management Institute

held from 12 - 16 May, 1996

at Lahore, Pakistan

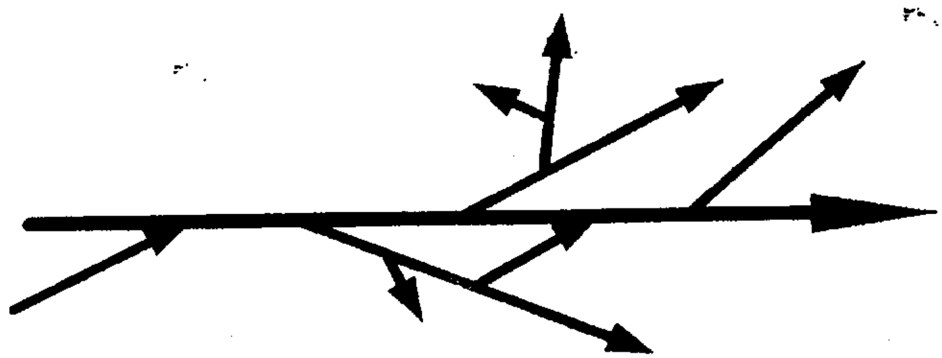
for Gaylord V. Skogerboe
Director IIMI - Pakistan

H.M. Hemakumara
Senior Research Officer IIMI - HQ

IMIS NEW VERSION

TECHNICAL IMPROVEMENTS

- Managing branched and looped networks:



- SIC interface with complex networks:
.TAL, .FLU, .SIR files writing and feedback.

- Output reports with graphs.

- Nearly same tables and menus structures

SOFTWARE CHARACTERISTICS

- Shift from dBaseIII to Visual FoxPro 3.0 professional edition

- User friendly:
  - + all operations in a Windows-type interface
  - + no direct access to tables
  - + no spreadsheets used
  - + nice design

- Probably much quicker but will require more memory

- Programs listings more readable, easier to modify and develop

ANNEX 3:IIMI'S PROPOSAL FOR UPPER SWAT LEVEL AND PEHUR HIGH LEVEL - EXTRACTS

3.3 OPERATION OF USC-PHLC SYSTEM

This is the largest and most important component of the operations support activities. Also, the long-term success of this activity is absolutely dependent on highly effective field collaboration between ID and IIMI staff.

During Year 1, IIMI will interface with the design consultants. The design of the irrigation network will be placed in the computer model, "Simulation of Irrigation Canals (SIC)", that was developed by CEMAGREF, which is the French national research organization for water, agriculture and forests. This is the same model that has been used by IIMI for Stage I of the Chashma Right Bank Canal. The design of irrigation networks is commonly done using principles of steady-state hydraulics complemented with calculating backwater profiles. The advantage of SIC is that it simulates unsteady flow conditions, as well as steady-state flows. Surprisingly, many of the large canals in Pakistan are often operating under unsteady flow conditions. Thus, SIC is a valuable tool for simulating a variety of flow conditions that provides valuable insights for design modifications.

During Year 5, the SIC model for USC-PHLC will be updated according to "as constructed" drawings. The dimensions of the flow control structures will be field checked. For the USC system, discharge ratings will be undertaken for the flow control structures. For the larger flow control structures, the International Sedimentation Research Institute, Pakistan (ISRIP) of WAPDA will participate with the Provincial Irrigation Department (PID) and IIMI in developing discharge ratings.

During Year 6, the IIMI GIS unit will prepare maps of the PHLC project area using satellite imagery. This will provide a geo-referenced set of maps that are accurate at one point in time regarding cultivated area served by each distributary.

Before the start of the season, a seasonal plan needs to be formulated that gives the operational targets for distributaries and control structures. The plan can be developed, based on information about probable available water resources and agricultural production (cropping patterns and cropping intensities) the preceding year based on farmer interviews and the records of the Patwaris who collect abiana (land-water tax). These data need to be easily accessible for irrigation managers.

A PC-based Irrigation Management Information System (IMIS) will be developed for the USC-PHLC system to help irrigation managers to compare actual flows with targets (generated by the seasonal plan), enabling the manager to initiate actions to close the gap between the two. The information system has three components:

(a) data collection network
(b) communication system
(c) data processing unit

The data collection network (a) will target the following types of information: agricultural data (irrigated area/crops), (semi-) permanent hydraulic data (structure dimensions,/coefficients of discharge, etc.) and flow data (water levels converted into discharges) and data on available water resources (Swat River supplies, rainfall/snow melting in catchment areas, water level in Tarbela Reservoir). The intensity of data collection will be determined later by interacting with the irrigation managers and will depend largely on the information requirements.

Good communication lines (b) between the decision-making centre (manager) and the field (control structures) is a pre-requisite. In addition, the manager will need communication with Tarbela and with stations in the catchment area or upstream in the Swat River. Information needs to be relayed from the field to the manager, as well as instructions to be passed on to the field staff.

The processing unit (basically a database with computation modules) will store (semi-) permanent data, such as structure dimensions, while dynamic data (e.g., water levels) will be inputted routinely into the unit. Information regarding the actual flows in the system will be presented to the manager in a comprehensive and easily readable format, which can be used to better match actual flows with targets (operations). In addition to that, information will be available for ex-post evaluation. Managers will be able to evaluate the past season's/month's/ week's performance of their irrigation system through a set of appropriate indicators.

Finally, the information system will be linked with the SIC model. All the information stored in the database will be formatted to fit SIC's input requirement, thus facilitating the use of this simulation tool.

The PHLC is scheduled to begin operating during the kharif season of 1999 (Year 5). The primary focus during start up will be developing discharge ratings in a relatively short time period. Prior to obtaining these ratings, the SIC model will be operating using design discharge equations. Thus, PID and IIMI will be able to use SIC for operating USC-PHLC from Year 5 onwards, but the input data will be refined based on actual field measurements. However, the most important activity during Year 5 will be the actual operation of USC-PHLC by the Irrigation Department with backup support from IIMI. Year 5 becomes the year for refining the SIC model for PHLC and making field operational adjustments based on actual experience.

There will be two consultancies each year during Years 5 and 6. One consultant will be a person who is very much involved with the development of SIC at CEMAGREF in Montpelier, France. The other consultant will be a specialist in sediment transport from Delft Hydraulics, The Netherlands. Both consultants will work with IIMI and ISRIP on behalf of ID, with all organizations working side-by-side during these consultancies in order to share the expertise in order to arrive at better solutions.

3.4 COMPUTERIZED MONITORING AND EVALUATION OF SYSTEM PERFORMANCE

With all of the activities described above, the seasonal hydraulic performance of the USC-PHLC system can be easily accomplished as a computer printout. The maintenance conditions throughout the system will require some effort, but IIMI staff have been involved previously in computerized maintenance planning. Also, in order to prioritize canal maintenance, this type of effort is preferred.

For the long-term Monitoring and Evaluation (M&E), a Performance Assessment Program will be established. This will include, as stated above, the hydraulic performance of the irrigation channels, as well as distributary cropping patterns and cropping intensities. In addition, a sampling procedure will be devised for evaluating crop yields. Also, as part of optimizing the use of water supplies in the Swat River, required watershed measurements for forecasting discharge rates will be investigated.. Because of the large water supplies available for this project, past experience has demonstrated that the drainage system tends to become overloaded during certain periods of the year. Thus, a few key locations will be identified in the surface drains for monitoring discharge rates, which will also be performance indicators for evaluating the effectiveness of the Crop-Based Operational Procedures.

The development of the M&E program will be the responsibility of the IIMI Irrigation Engineer/Associate Expert, who will work with a graduate student from NWFP. During Years 5, 6 and 7, when field operations are underway, quite a number of performance indicators will be evaluated. By Year 7, it will become important to have developed a manageable Performance Assessment Program that can be sustained on a long-term basis after project loan funds are no longer available.

3.5 PRIORITIZING CANAL MAINTENANCE

In the near future, the sediment load in the Upper Swat Canal (USC) will be reduced, while the sediment load will continually increase in the Pehur High-Level Canal (PHLC). A sediment excluder will be constructed at the headworks of the USC, thereby decreasing the sediment loads. However, at Tarbela Reservoir, sediment deposition is expected to reach the dam about the years 2005-2006. Thus, from the first year of operating PHLC in 1999, the sediment load will continually increase until 2006, when the sediment concentration will be essentially the same as run-of-the-river. Even then, the sediment load in the Indus River can be expected to slowly increase with time unless a major watershed management program is undertaken in order to reverse the present trend.

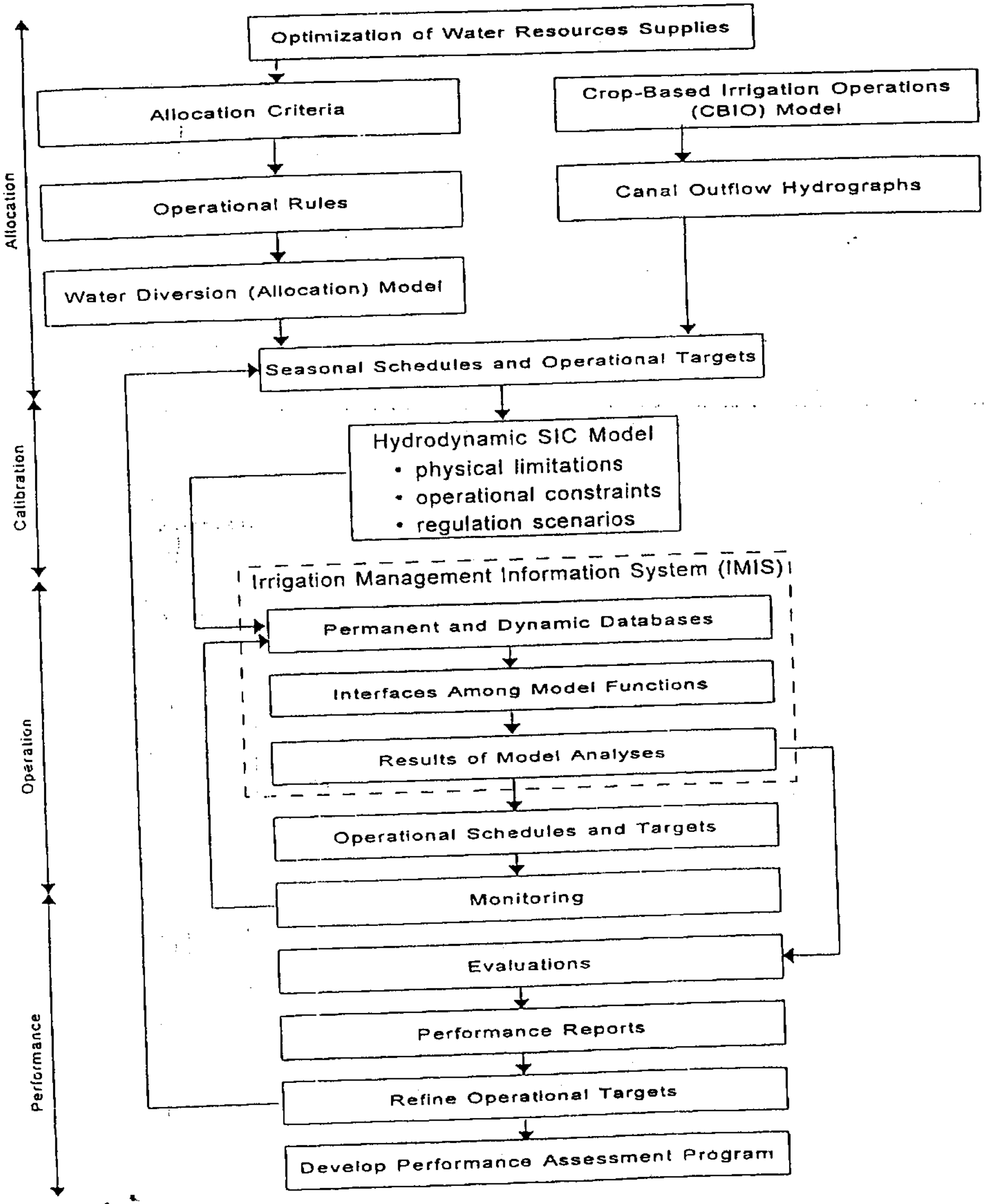


Figure 3. Schematic of Relations and Roles for Operations Models.

4.3.5 Implementing the IMIS Program

Preceding the beginning of field operations under Phase III, an initial IMIS program will be formulated for the USC-PHLC system. This program will be periodically refined (like after each season) based on: (1) the development of actual field calibrations that are inputted into the SIC model; and (2) field operations experiences.

The initial IMIS training will be provided prior to the 1999 kharif season. Both ID and IIMI staff will be participants in this training, including staff of the Regulation Cell and the office of the XEN Swabi. This training will be repeated in Year 7, but will be given at other times if deemed appropriate.

The IMIS program is the "heart" of Phase III. Consequently, considerable effort will go into making the implementation of this program a successful venture.

4.3.6 Prioritizing Maintenance

A major maintenance requirement for irrigation channels in Pakistan is the removal of sediment deposits. Initially, the SIC model calibrated to constructed dimensions will be used to develop a proposed program for prioritizing maintenance activities related to sediment removal. This program will be refined using the SIC model calibrated for actual field conditions.

During canal closure early in Year 6 (2000), a sediment deposition survey will be conducted for the USC-PHLC system. This data will be inputted into the SIC model and the hydraulics of this sedimentation will be evaluated. Then, the removal of various sediment deposits will be evaluated in the computer model in order to ascertain which sediment deposits, or portions thereof, have the most effect upon the hydraulics of the system. In this manner, the removal of various sediment deposits can be ranked, thereby resulting in a prioritized maintenance schedule for sediment removal.

Towards the end of Year 6, prior to canal closure, another survey of sediment deposition in the USC-PHLC system will be undertaken jointly by ID and IIMI. Again, this data will be inputted into the SIC model and the removal of various sediment deposits will be ranked in accordance with their effect upon the hydraulics of the system. Then, the Irrigation Department can decide how much of these deposits should be removed during canal closure.

Another sediment deposition survey will be jointly conducted by ID and IIMI field staff towards the end of Year 7, prior to canal closure. This data will be inputted into the final version of the SIC model, which will be retained by the ID Regulation Cell. Again, the removal of various sediment deposits will be ranked. Finally, the ID can establish the degree of sediments to be removed during canal closure.

4.3.7 Performance Assessment

The IMIS program is very good for evaluating the hydraulic performance of the USC-PHLC system This information can be obtained as a printout from the IMIS model.

Under Phase II, a proposed Monitoring and Evaluation Program will be developed. During Phase III, considerable attention will be given to refining this M&E program. The proposed program will be reasonably comprehensive. During Phase III, relations will be sought among the many variables affecting performance so that the level of M&E can be minimized. In this manner, there will be a greater likelihood of sustaining a Performance Assessment Program after the termination of loan funds.

5. ORGANIZATION

For this project, the organizational arrangement for IIMI staff is shown in Figure 4. The Project Leader is assisted by an Irrigation Engineer/Associate Expert, who in turn is assisted by a Civil Engineer specializing in hydraulics, who is doing similar work with the Punjab Department of Irrigation and Power on the Fordwah and Eastern Sadiqia canals and their branch canals.

There are three organizations involved as consultants: (1) CEMAGREF, which is the French national research organization for agriculture, water and forests; (2) International Sedimentation Research Institute, Pakistan (ISRIP), which is a research unit of the federal Water and Power Development Authority (WAPDA); and Delft Hydraulics in The Netherlands. These consultants are all involved in Phase III, Field Operations. CEMAGREF is the developer of the SIC model and they are continually upgrading the capability of this model, so they will advise on any modifications to SIC based on the particular conditions being encountered in the USC-PHLC system. Delft Hydraulics will advise on matters related to the combination of hydraulics and sediment transport. ISRIP is involved with investigating sediment deposition and movement in Tarbela Reservoir, so they will advise on future trends in sediment concentrations, as well as participate in the deliberations regarding the combination of unsteady flow hydraulics and sediment transport.

The left column in Figure 4 under the heading, "Model Development", is involved with all three phases of this project, particularly the Systems Analyst, while the Computer Specialist is involved with Phases I and III. The Student Support will occur during Phase II, while the GIS-Remote Sensing occurs during Phase III (Year 6) in preparing maps using satellite imagery that provide the cultivated area for each distributary in the PHLC project area.

ANNEX 4: DOCUMENTS COLLECTED FOR OUR FIELD VISIT.

On the following pages are:

1. the visit schedule
2. layout, warabandi rotations and organizational chart of Chistian Sub-division
3. layout, administrative control and communication system of Malik Branch.

FIELD VISIT ON 24/06/96

09:30 Well come to Cyril and Antorine at Field Station Bahawalnagar.

09:40 Tea.

10:00 Briefing about the system (Chishtian/Malik Subdivision), field program and theoretical background of today field activities.

10:15 Visit from RD-199812 to tail RD-371650 of Fordwah Branch and explanation about:

a- Outlets (different kinds)

b- Broken outlets

c- X-regulators

d- Disty, minor

Discussion with farmers/Gauge readers during visit.

14:00 Discussion with SDO Chishtian (subject to availability) and see his office.

14:30 Back to Station.

FIELD VISIT ON 25/06/96

08:00 Departure for SDO office Malik Subdivision Bahawalnagar.

08:15 Discussion with SDO Malik Subdivision at ID office Bahawalnagar (subject to availability).

09:30 Visit Malik Branch, Gajjiani, Sirajwah disty,to see gated structure at RD-86000 of Malik Branch and outlets of influential farmers. Discussion with farmers/gauge readers.

13:30 Back to Station.

Attached:

(1) Layout of Chishtian Subdivision.

(2) Warabandi Program of Fordwah Division.

(3) Organizational chart of Chishtian Subdivision.

(4) Layout of Malik Branch.

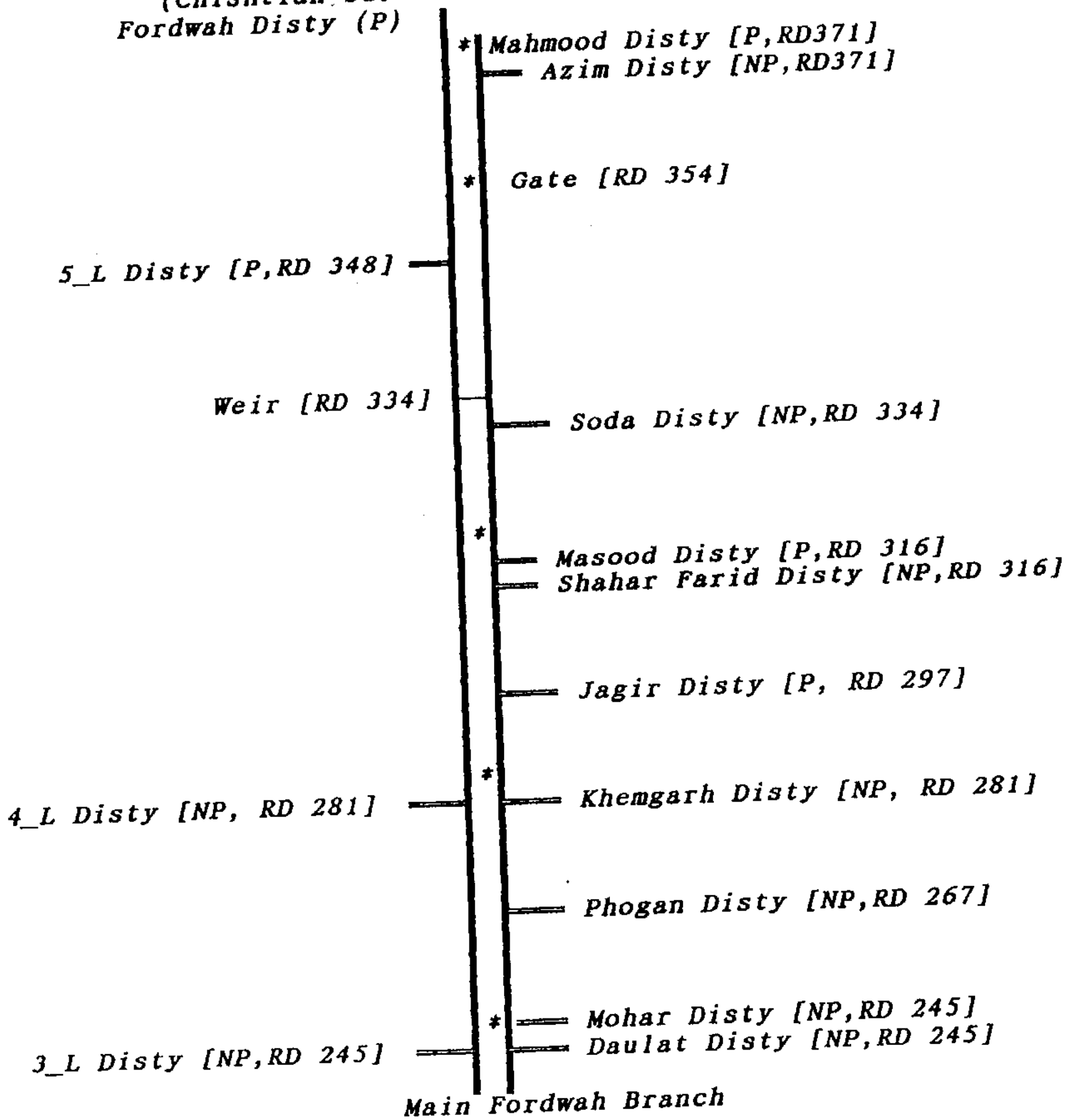
(5) Administrative chart of Sadiqia Division.

(6) Communication system of Malik Branch.

(Prepared By Anwar Iqbal F.A)

LAY-OUT FORDWAH BRANCH

(Chishtian sub division)



<u>Lagend:</u>
* = Gate structure
- = Weir
NP= Non perennial
P = Perennial

<u>Design discharge (Cusecs):</u>
Daulat=209,Mahar=38,3_L=18
Phogan=18,Khemgarh=30,4_L=16
Jagir=28,Sahar Farid=153
Masood=35,Soda=77,5_L=4,Mahmood=9
Fordwah disty=158,Azim=244
Total discharge=1033

WARABANDI PROGRAM FOR KHARIF,1995 FORDWAH DIVISION BAHAWALNAGAR

GroupA: BahawalDisty=117Ahmadpur =7, KhalsanaDisty=22, DarbaryDisty=270, MirzaDisty=41,BehkanDisty=31, DhuddiDisty=170, 1-L Disty=19, 2-L =23, BahawalnagaDisty=31, RojahanwalDisty=70, Sikandar=171.

A1:
BahawalDisty=117, Ahmadpur2Disty=7,KhalsanaDisty=22, DarbaryDisty= 270, TotalDischarge: 284 Cusecs.

A2:
Mirzadisty=41,Behkandisty=31,Dhuddidisty=170,1-L disty=19,
2-L disty=23,Totaldischarge=28 Cusecs.

A3:
Bahawalnagadisty=31,Rojhanwala= 70, Sikandardisty=171,
TotalDischarge=272Cusecs.

GroupB:
Daulatdisty=209,Mohardisty=38, 3_L disty=23, Phogandidty=
18, Khemgarh=30, 4-L disty=16, Jagirdisty= 28, Masooddisty=
35, ShaharFariddisty=153,Sodadisty=70, 5-L disty=5, Fordwahdisty=
160, Azim disty=244, Mahmooddisty= 9.

B1:
Daulatdisty=209,Mohardisty= 38, 3_L disty= 23 , Phogan didty = 18,
Khengarh= 30 , 4-L disty= 16 , Total discharge= 334 Cusecs.

B2:
Jagir disty = 28 , Masood disty =35 , Shahar Farid disty=153, Soda disty=
70, Total discharge= 286 Cusecs.

B3:
5-L disty= 5, Fordwah disty =160, Azim disty= 244, Mahmood disty = 9.
Total discharge= 418 Cusecs.

Note:
Sadhu disty, Dona disty, Noshera disty, Bonga disty, 2-L disty
These disties will not included in the warabandi shedule because of there crest level are higher.

1. At the tail of Fordwah canal, Head haddi wala water will be destributed between Fordwah branch and Meaklodgung branch in ratio of 87:13.

2. When Makleodgung branch at full supply from head then at tail of Makleodgung branch water will destributed to bearwala and Meard at the ratio of 62:38. But water will less then 50% then one disty will be at full supply for ten days and then other for next ten days. S.D.O. Minchnabad will responsible for this.

3. Executive Engineer will be Incharge of warabandi.
In case exces or less of water warabandi program will changed with the permission of S.E.Bahawalnagar.

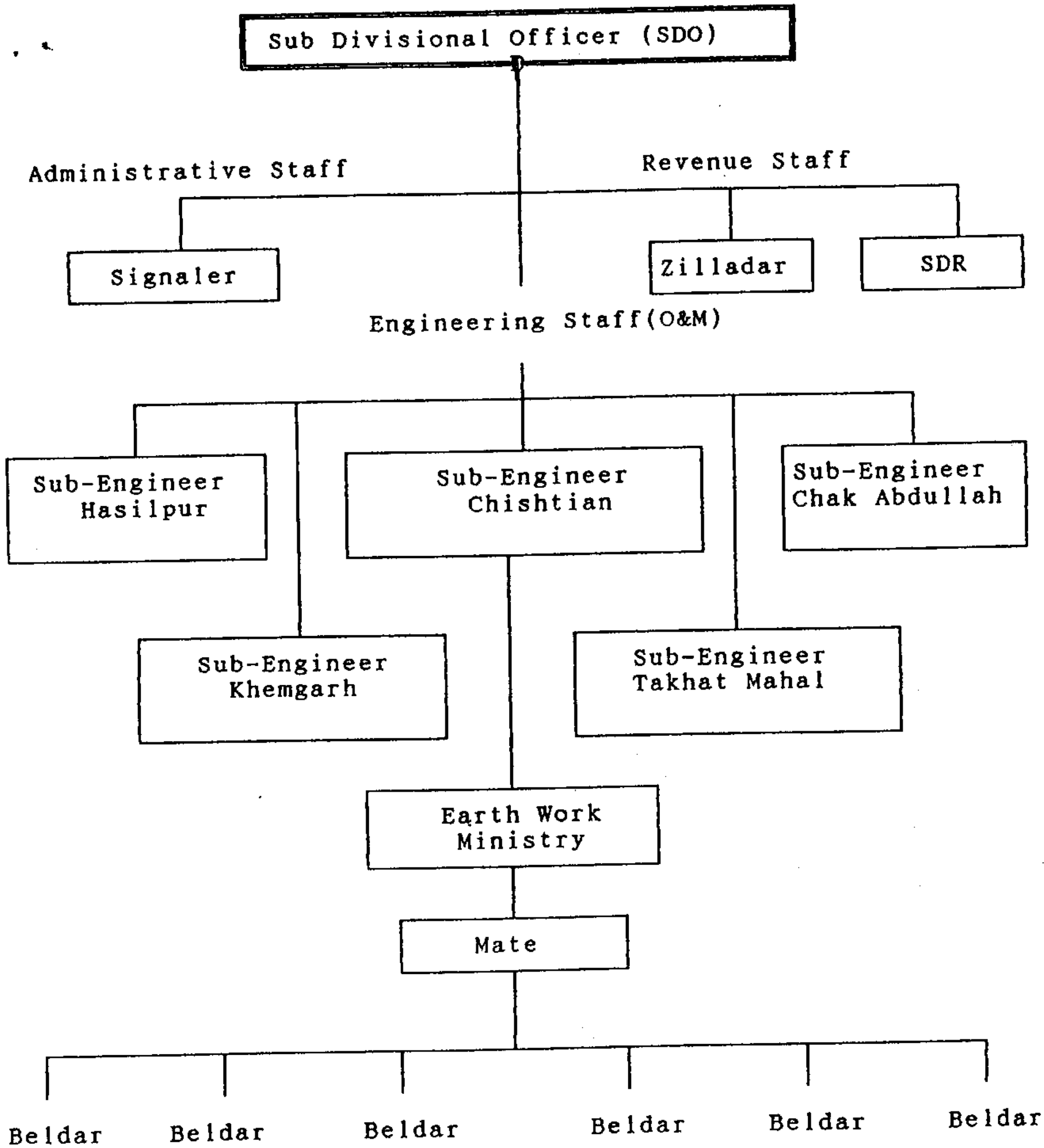
4. In group "B" when water will less, then disties will be closed from left to right. For example, when group "B" will second on dated on 16-4-95 to 25-4-95 and then in case of shortage of water in group "B3" first 5-L then Mahmood then Azim then at the last Fordwah disty will closed.

5. In the dates when Darbari disty will closed, At that time the Karries will not be used in Fordwah Br. at R.D. 77500.

6. Water should not be heading up unnecessary.

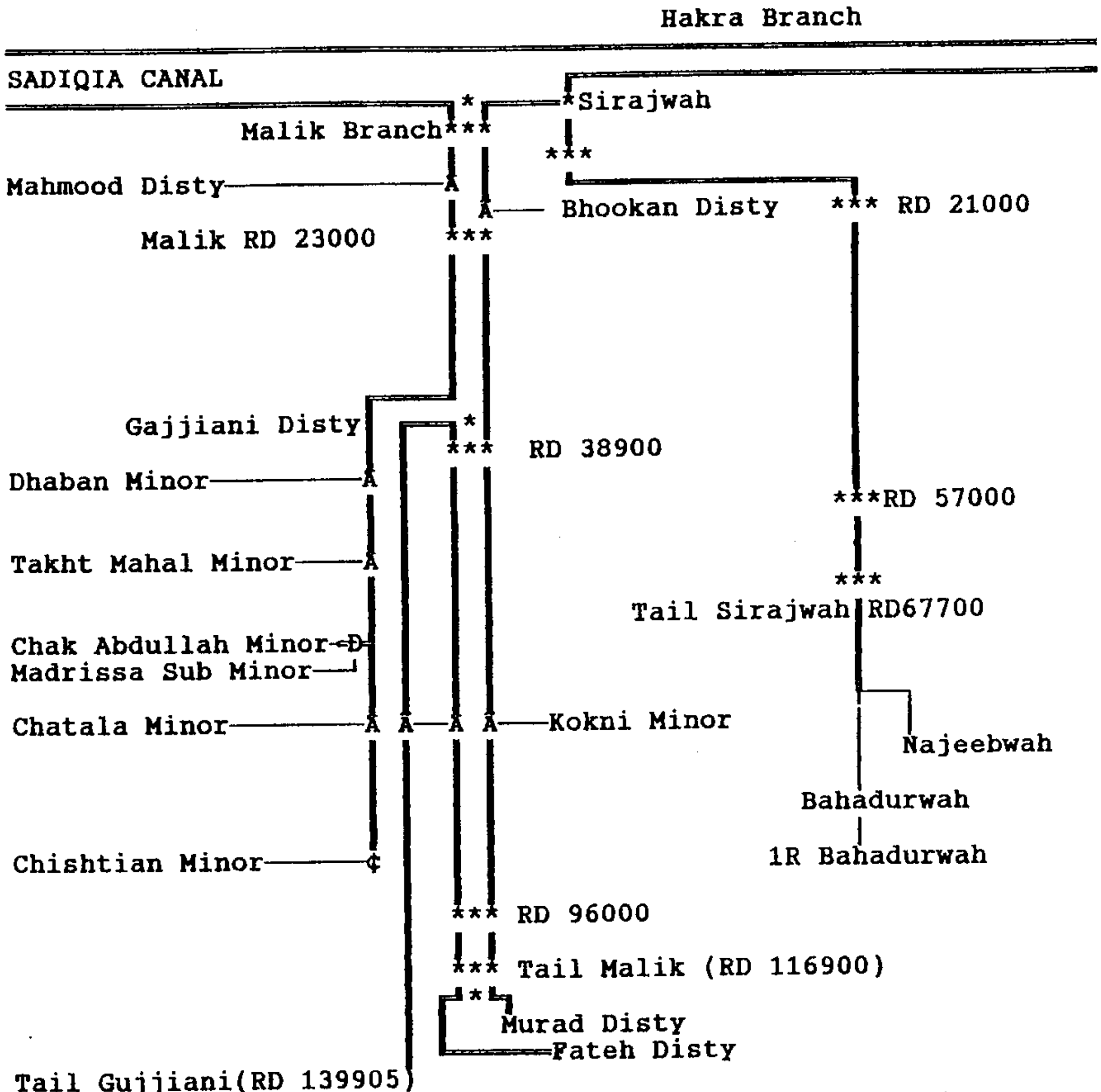
16-4-95	25-4-95	A	B	B1	B2	B3
26-4-95	5-5-95	B	A	A1	A2	A3
6-5-95	15-5-95	A	B	B2	B3	B1
16-5-95	25-5-95	B	A	A2	A3	A1
26-5-95	4-6-95	A	B	B3	B1	B2
5-6-95	14-6-95	B	A	A3	A1	A2
15-6-95	24-6-95	A	B	B1	B2	B3
25-6-95	4-7-95	B	A	A1	A2	A3
5-7-95	14-7-95	A	B	B2	B3	B1
15-7-95	24-7-95	B	A	A2	A3	A1
25-7-95	3-8-95	A	B	B3	B1	B2
4-8-95	13-8-95	B	A	A3	A1	A2
14-8-95	23-8--95	A	B	B1	B2	B3
24-8-95	2-9-95	B	A	A1	A2	A3
3-9-95	12-9-95	A	B	B2	B3	B1
13-9-95	22-9-95	B	A	A2	A3	A1
23-9-95	2-10-95	A	B	B3	B1	B2
3-10-95	12-10-95	B	A	A3	A1	A2
13-10-95	22-10-95	A	B	B1	B2	B3

Organizational Chart Of Chishtian Sub Division



SDR = Sub Divisional Reader
Note: The values for Beldars can be different for different sections, and Mate too.

LAY-OUT OF MALIK BRANCH



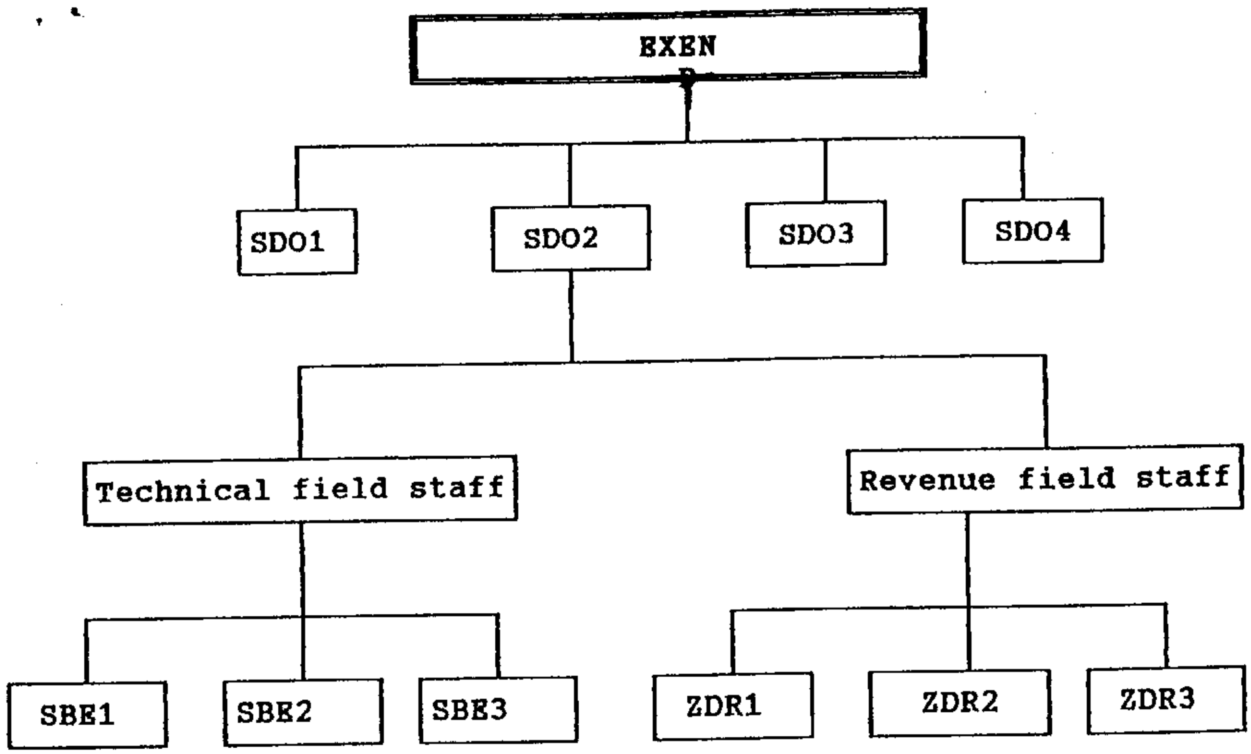
Lagend:

*= Cross Regulator
***= Fall

Design Discharge (Cusecs):

Malik Branch=1538,Sirajwah=189 Mahmood Disty=15.5,NajeebWah=39 BahadurWah=82,1R BahadurWah=4 Bhookan=13,Murad Disty=596,Fateh Disty=435,Gajjiani Disty=319,Dhaban Minor=17,Takht Mahal Minor=36 Madrissa Sub Minor=17,Chak Abdullah Minor=55.5,Chatala Minor=8,Chishtian Minor=23,Kokni Minor=13

Administrative control of Sadigia Division



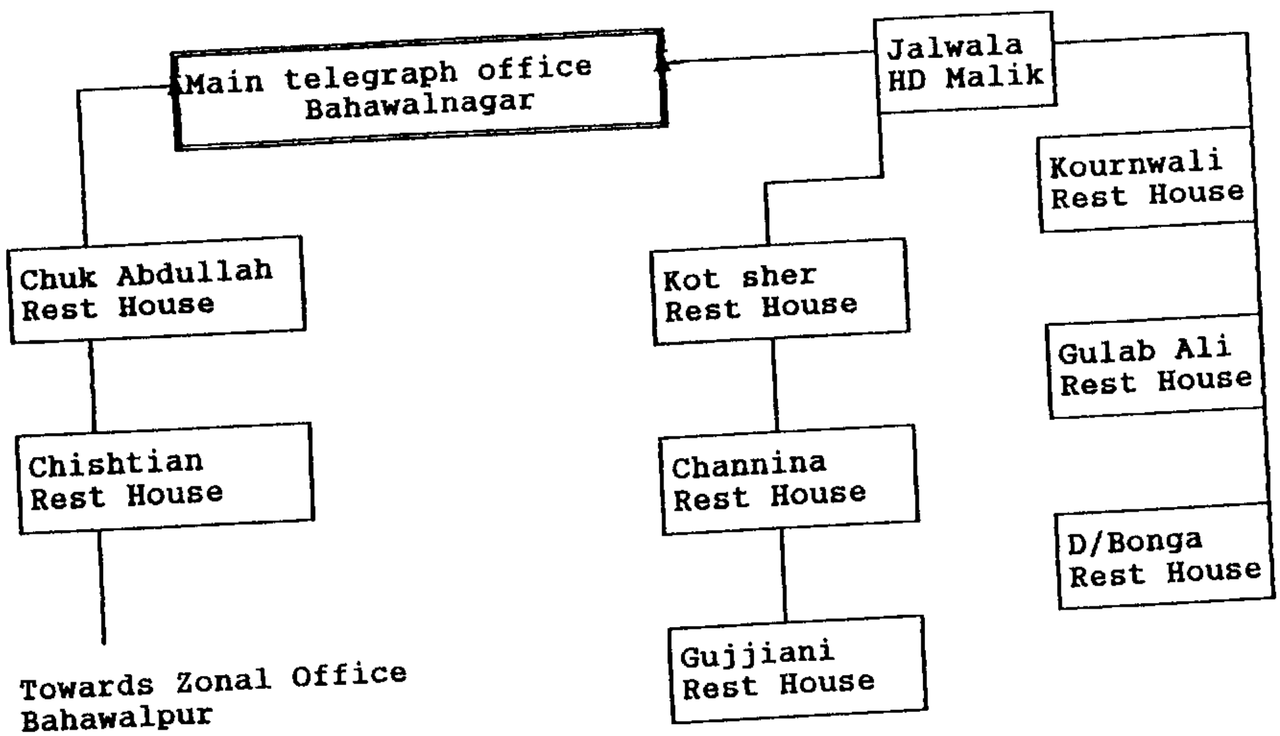
Lagend:

SDO1=Sub divisional canal officer Jalwala (HQ:Bahawalnagar)
SDO2=Sub divisional canal officer Malik (HQ:Bahawalnagar)
SDO3=Sub divisional canal officer Dahranwala (HQ:Dahranwala)
SDO3=Sub divisional officer Drainage Bahawalnagar (HQ:Bahawalnagar)

SBE1=Sub Engineer Kot sher Muhammad section
SBE2=Sub Engineer Sirajwah section
SBE3=Sub Engineer Gujjiani section

ZDR1=Zilladar Kot sher Muhammad section
ZDR2=Zilladar Donga Bonga section
ZDR3=Zilladar Gujjiani section

Communication system of Malik Branch



ANNEX 5: FORMS FOR LEVELS AND DISCHARGES COLLECTING.

On the following pages forms from:

1. Fordwah branch, Sutlej River, Punjab, Pakistan
2. Kirindi Oya Right Bank Main Canal, Sri Lanka

IIMI PAKISTAN MONTH........... YEAR...........

FORDWAH BRANCH RD 199

ALL VALUES IN IMPERIAL UNITS

		0 of gauge 513.060	0 of gauge 503.650	Crest level / Spindle Zero	512.975 / 3.37	513.006 / 3.28	513.018 / 3.60	513.018 / 3.25	512.996 / 3.40	513.012 / 3.34	
	R.L										
TE	TIME	ID GAUGE U/S	ID GAUGE D/S	DISCHARGE Q	GATE 1(L)	GATE 2	GATE 3	GATE 4	GATE 5	GATE 6(R)	REMARKS

දිනය: දත්ත සටහන් කලේ :

Off-takes/Gated Regulators	Time	Water Level (cm)		Head Over Weir (cm)	GATE – Sp Hts (cms)					Computed Discharge (cusecs)
		Up	Down		G1	G2	G3	G4	G5	
DC 01										
GR 5										
DC 02										
GR 6										
DC 03										
FC 34										
GR 7										
DC 04										
DC 05										
GR 8										
DC 06										
DC 07										
GR 9										
FC 68										
DC 08										
GR 10										
DC 09										

IIMI PAKISTAN

MONTH............ YEAR............

	SODA DISTY RD 334			WEIR	5-L DISTY RD 348			FORDWAH BRANCH RD 354				
		R.L WM 489.307	R.L WM 487.409	R.L WM		R.L WM 488.896	R.L WM 487.008		R.L WM 485.422	R.L WM 482.942	480.857 3.08	Crest level Spindle Zero
DATE	TIME	U/S	D/S	RD 334 D/S	TIME	U/S	D/S	TIME	U/S	D/S	GATE	REMARKS

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- Integrated research plan for Fordwah Eastern Sadiqia (South) Irrigation and Drainage project
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  A study case of the Kirindi Oya Right Bank Main Canal
  Jacques Rey & IIMI Colombo - 1991-92
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