HANDBOOK ON
IRRIGATION SYSTEM OPERATION PRACTICES

WATER RESOURCES MANAGEMENT AND
TRAINING PROJECT

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Irrigation Research and Management Improvement Organization
Central Water Commission

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HANDBOOK ON

IRRIGATION SYSTEM OPERATION PRACTICES

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FOREWORD

This Handbook on 'Irrigation System Operation Practices' has been developed on behalf of the Irrigation Research and Management Improvement Organization, Central Water Commission, Govt of India and the United States Agency for International Development under the Irrigation Management and Training Program of the Water Resources Management and Training Project (WRM&TP) No.386-0484.

The WRM&T Project is jointly sponsored by the Government of India and the United States Agency for International Development. At present eleven state governments and four universities are participating in the project. The goal of the project is to achieve increased production from irrigated agriculture through improved performance of irrigation systems. The primary means to be adopted are training, research, technology transfer, and organizational and procedural changes. The state governments have established Water and Land Management Institutes (WALMIs) or Irrigation Management and Training Institutes (IMTIs) for this purpose.

A major component of the project is development of interdisciplinary training and enhancement of management capabilities of in-service personnel. Curriculum development and preparation of training materials are important means for providing the required training. For this purpose, curriculum development workshops participated by faculty of various state training institutes and departmental officers are conducted on selected topics with the assistance of LBII/WAPCOS. Irrigation System Operation is one of the topics identified by the institutes for development of curriculum and training materials.

Water and Land Management Institute (WALMI) Uttar Pradesh came forward to organize this Workshop which was held from April 6-18, 1989 at Okhla. Faculty of various project institutions, including WALMI U.P., officers from U.P. Irrigation Department and LBII/WAPCOS consultants participated in the Workshop and in the curriculum development process. The WALMI UP Director, Mr. S.P. Jain, Associate Director, Dr. K.P. Jain and the faculty members who organized the Workshop and the faculty of different institutions who participated in the curriculum development efforts deserve a mention, their assistance is acknowledged.

It is hoped that this document will be useful to the faculty of STIs and the in-service professionals concerned with management and operation of irrigation systems. Suggestions and comments on this Handbook are most welcome and these will be suitably disseminated.

Executive Summary

This Handbook on 'Irrigation System Operation Practices' has been developed to bring in a scientific approach and homogeneity in the practices in the country. For increasing agricultural productivity from existing irrigation systems, improved operation of the systems has a major role to play coupled with timely maintenance of the systems. The handbook has been divided into nine chapters keeping in view the various aspects which will make an operation plan effective, efficient and acceptable. The aspect of Users Inputs and Needs has been given proper recognition in developing these chapters.

Chapter I describes the water-resource scenario of India, assessment of utilizable quantity of water by different authorities within the limitations of physiographic conditions, socio-political environment, legal and constitutional constraints and the technology so far used. While pointing out that increasing demands for other than irrigation may soon cause a strain on water resources it has been stressed that improvements in management for better agricultural yields with reducing quantity of water should be the course henceforth.

The utilizable quantity of water is estimated to be 700 km^3, the estimated ultimate irrigation potential is 113 mha from all sources. The irrigation potential created by systematic efforts is not being fully utilized and the gap is rather disturbingly increasing. The gap in 1985 was assessed to be 6.9 mha.

Several factors responsible for the increasing gap have been enunciated e.g. non-availability of water, lack of micro-network and land levelling/shaping, agronomical factors, etc. It has been emphasized that systematic and realistic planning and implementation and introducing better management practices are very vital to narrow down the gap.

Chapter II deals with irrigation system components, existing operation practices in Northern, Southern, Eastern and Central Zones. In Norther Zone - the operation is 'supply based' where canals are run on rotational basis according to predetermined schedules, while below the outlet 'Warabandi' system of water distribution is followed. On medium and minor projects, canal running schedules for each crop season are decided by Water Distribution Committees.

In Central Zone - 'Rigid Shejpali' system is followed where applications are invited from the farmers and the Canal Advisory Committee decides the total area to be allowed water. Farmers' applications are sanctioned either to irrigate the full or reduced area as per availability. Schedule of operation is prepared and publicized indicating the channel flows in the weeks of the season.

In Southern Zone - The District Collector convenes a meeting of the Irrigation Engineer, Agriculture Officer and prominent farmers to decide the opening date of irrigation system and its running program. On bigger systems, this exercise is done at Government level. The systems are opened for the season after due publicity. Continuous flow is maintained in channels specially for paddy (rice) - during its puddling and transplantation period, subsequent supplies are made by turns till maturity. For irrigated dry crops, supply is intermittent - generally 10 days 'on' and 10 days 'off'.

Below the outlets, there is no established Warabandi system like Northern Zone but a notional distribution practice by turns among various holdings is prevalent. Disputes are settled mutually by the farmers with the help of social pressures.

On tank systems - there exist formal or informal committees at village level to manage operation. An irrigator-agreeable to all - called 'Neerkatti' is engaged by the beneficiaries to distribute water to various holdings.

In Eastern Zone - The practice of submitting applications by the farmers for supply of water for short/long-term lease exists. Junior Engineers check them for 'earthen bund' around fields to check wastage of water and that 85 per cent of farmers in the block have applied for water. The Junior Engineer recommends them to Sub-Divisional Officer for sanction. Divisional Canal Officer sanctions the long-term lease for water. The agency of 'Lambardar' or 'Sattedar', a representative of group of farmers in the Chak or a block of Chaks, exists who assists in getting applications, measurement of irrigated areas, reporting misuse of water, distribution of demand slips among farmers and in investigation of complaints, etc.

In Bihar, 'Tateel' system of water distribution is followed. In this the opening and closing time of the system is decided by the Superintending Engineer Incharge or the Executive Engineer and notified through pamphlets. 'On' and 'off' periods on channels vary from system to system as per judgement and past experience of Superintending Engineer/ Executive Engineer regarding availability of water. Most of the big irrigation systems in the state are 'run-of-the river' (diversion) systems and water availability is fluctuating.

In this chapter, the objectives enshrined in the National Water Policy-1987 relevant to system operation, reproduced below have also been highlighted.

i) water allocation to be with due regard to equity and social justice,

ii) reduction in gap between potential created and utilized, and

iii) involving farmers in various aspects of water management.

The options for approach to preparation of improved operation plan have been described to focus 'site specific' plans for each system under 'scientific approach'.

The variety of operation methods in vogue in the country are also contained in this chapter e.g.

i) running the canal system continuously for the designed base period,

ii) running and closing the entire system for 7, 14 or 21 days alternately till the storage lasts.

iii) running the main canal full or partial and running the distributaries and minor full by rotation,

iv) dividing the command into zones and supplying water to separate zones by turns,

v) supplying water to the whole command with less depth of waterings,

vi) by reducing flow period in mains by increasing in their discharge capacity,

vii) volumetric method.

Chapter III deals about the knowledge and background information which the System Manager should gather for preparing a realistic operation plan, like physical and technical details of the system, climate, topography and soils. River basin development, availability of surface flow, status of ground water, drainage status, crops and cropping activity, design principles of canals, maintenance needs and implementation, feedback from farmers, status of communication, statutory provisions and responsibilities of various functionaries regarding operation of a system have been also described.

Chapter IV highlights the various field and hydraulic surveys required for an improved operation strategy. Use and maintenance of flow control structures on the system for operation control have been stressed. Measurement of channel losses periodically (either by inflow-outflow method or ponding method) has been emphasized. Unless discharges are regularly measured and data on seepage losses gathered, realistic operation plan may not be possible. Emphasis has also been given for seeking farmer's input in system operation.

Chapter V deals with the Preparation of Operation Plan, the need, objectives and types of operation plans. The steps required to be adopted have been listed viz:

i) assessment of water availability, and

ii) assessment of demand for irrigation and for other purposes. Interaction with farmers and agriculture experts on demand have been highlighted.

iii) matching supply and demand with an eye on the crop-water need and measures

iv) preparing the plan, rotation, grouping, running schedules, etc.

For assessing the demands, as stated the need of interaction with farmers and seeking their active participation for realistic appreciation has been emphasized. Their preparedness and capability to use water and commitment to follow the proposed operation program has been suggested.

Various options for preparing an operation plan have been described - major ones being - projected cropping pattern based, crop growth stage based and crop-water requirement (or evapo-transpiration depth) based.

The chapter further deals with matching the supply and demand when supply is more or equal to demand, when it is moderately less than demand or when it is much less than the demand. Rotational operation of channels and grouping of channels and their operation in rotation have been described.

One solved example on preparation of operation plan (North-Rotation) has been given to illustrate the steps involved. Typical example each of North, South, East and Central Regions of operation plan has also been given.

Chapter VI deals with the important aspect of dissemination of operation plan amongst irrigation staff and beneficiaries for taking decisions about crops, irrigated area, sowing times, winning confidence, increasing responsive attitude and acceptability. That the O&M staff should know broad assumptions, methodology, procedures, quantity of water planned, periods of supply to have better understanding, taking action in time has been highlighted.

The chapter suggests the information to be disseminated, the delivery schedules, time and periods of supply, opening and closing dates of canals. Methods to be adopted for dissemination including notices, newspapers, mass media like All-India Radio, Door Darshan (TV) for reaching remotest places have also been described.

The need for discussions with farmers to be organized in groups or through users associations, consultative committees, etc., has been discussed. The need for contingent plans in case of less water in monsoon has been stressed. Farmers to be apprised of maintenance of micro-network, preparing fields, adopting improved irrigation methods for water saving/conservation have also been mentioned.

The need for the allocation of duties and responsibilities to be proper and clear for various functionaries for successful implementation along with illustration for gauge reader have been given. Likewise the interaction and linkage with supervisory functionaries such as Mistry/Mate and operating staff has been explained. The need of clear instructions about actions to be taken in maintenance, emergency situations such as breach in canal has been given. Volume control concept to reduce response time and saving water is recommended for operating long canals.

The need for feedback from field, feedback information from command - rainfall, actual deliveries, crops, cropped area, cropping activities, critical growth stages, irrigation system efficiency has been given in some details. Flow diagram depicting dissemination and feedback procedure has been enclosed for ready reference.

Various possible eventualities within the irrigation scenario like (i) more rainfall in catchment and command, (ii) more rainfall in command and less in catchment, (iii) less rainfall in command and catchment have been described. Possible revisions in operation plan according to the different methods of distribution of water in the Northern, Central, Southern and Eastern Regions are suggested. There are four appendices on (i) assignment of duties during implementation with illustration, (ii) activitywise responsibility of various officers for feedback information, (iii) role and responsibility of project management indicating the roles of different officers starting from the Chief Engineer upto tertiary level, duties, functions and responsibilities, and (iv) preparation of a comprehensive annual administrative report about the performance of the project by the project management. The expected contents of the reports, information needed, analysis and findings are explained in detail.

Chapter VII stresses the need for a reliable and fast communication network which is very important in irrigation management. Precise and accurate planning, implementation, monitoring of water deliveries involves collection of meteorological data, weather forecast, information about crops, irrigated area, sowing times and critical growth stages. Various types of modes like messengers, telegraph, telephone systems in vogue, the drawbacks vis-a-vis present day fast communication have been given. Latest innovations of high frequency, very high frequency, ultra frequency wireless systems have been given. In the present conditions, VHF is most suited for irrigation management and has therefore been recommended. Need of providing wireless sets for all officers at the controlling points has been emphasized. The methodology for network where 8 to 10 stations can communicate efficiently has been given.

Different networks that could be organized on area sharing/time sharing basis to reduce the frequencies needed for smooth working/clear audibility have also been brought out. Suggestions for a phased program for installation of VHF system by continuing existing systems has been recommended.

The need to prepare a wireless manual for all irrigation projects to cover installation stations, officers authorized, rules of operation, frequencies allotted, priorities, etc. for the use of operating staff has also been explained.

Some information and hints for preparing manual - like establishing control stations, traffic rules, priorities of different massages, abbreviations, code words, standard messages, timings for essential water management messages, writing messages, duties and responsibilities of operation staff are indicated. Ways and means to minimize operating cost, number of operators needed for different networks has been illustrated. Advance technology including telemetry, computer controlled systems, written communication facilities, extension of telephonic transmissions are also indicated.

Sample standard message - daily gauge report, VHF networks proposed in Upper Krishna Project, Karnataka have been given for guidance purposes.

Chapter VIII deals with need for monitoring, objectives of monitoring, existing monitoring procedures and improvements required have been described.

Regular monitoring of physical constituents of the infrastructure, climatological data, water availability, water releases in canals, ground water, crops - their patterns and delta of water applied, yields, and farmers' response to water distribution has been emphasized for evaluation of the project's performance. The formats needed for reporting each of the above parameters have been appended. It also gives as to what permanent, seasonal and regular reports are to be prepared and record maintained.

The chapter also includes guidelines and proforma for preparing water account to work out the conveyance efficiency of the system, application efficiency in field and working out the delta; and duty of water to enable the system manager to analyze the causes of low efficiencies or low duty or high delta for taking suitable measures to improve.

Chapter IX, the last chapter in this Handbook is on training and emphasizes the need for a more comprehensive understanding of Irrigation Management and its prerequisites like precise water control, reliability of supply, increased availability of water to farmers, equity in distribution. Some of the topics for training of various field staff have been identified along with a broad approach for designing the training program by laying down the job requirements and then working out the training topics. Likewise the need to train farmers in the field has been emphasized. It has been suggested that training activity need not be centralized for all levels, rather field (on-site) training has been stressed.

CHAPTER I

Introduction

1.1 Water Resources of India

Water, the most essential input for agriculture is becoming scarce. The demands on water for non-agricultural purposes like industries, municipal, fishing, recreation and navigation are continuously increasing resulting further strain on water availability for irrigation.

The average annual precipitation in India is estimated at 4000 km^3 (kilometer^3) from rain and snowfall. Out of this, the seasonal rainfall is of the order of 3000 km^3. After allowing for evaporation and other losses the country's estimated water potential from surface flow is estimated to be 1800 km^3 (180 m ham i.e. million hectare meter).

The water availability varies in time and space and is not uniformly distributed.

The utilizable quantity of water, within the limitations of physiographic conditions, socio-political environment, legal and constitutional constraints and the technology so far used, has been assessed by different authorities as under:

i. Irrigation Commission of India-1972 assessed it to be 666 km^3 or 38% of total surface water.

ii. Dr. K.L. Rao an eminent engineer and later Minister of Irrigation and Power suggested it as 50% of water potential equal to 900 km^3.

iii. National Commission on Agriculture-1976 estimated the quantity as 700 km^3.

The utilizable quantity may be considered 700 km^3 (70 mham). The ultimate irrigation potential of India is estimated at 113 mha (million hectare) comprising 58 mha from major and medium projects and 55 mha from minor projects which includes 40 mha from ground water. Presently committed water utilization is estimated as 420 km^3 out of total annual utilizable resource of about 700 km^3.

1.2 Land use pattern

The total geographical area of the country is 329 mha. The land use is broadly 67.34 mha under forest, 40.35 mha not available for cultivation, 30.91 mha other uncultivated land comprising of pastures, tree crops, culturable waste and 22.87 mha for current and other than current fallows. The net area sown is about 143 mha while the gross cropped area is about 180 mha.

1.3 Climate

India has diverse and varied climate, from Himalayas in the North to Indian Ocean in the South. The annual rainfall varies from 2500 mm along West Coast and Western Ghats to 150 mm in Western region. The climate, sunshine, temperature is favourable for cultivation except the snow clad, steeply sloping, hilly and rocky areas. The monsoon is generally regular, South West monsoon comes between June to September in the country, in Tamilnadu it is North East Monsoon during October to November. The rainfall in most of the areas except North Eastern and Coastal regions is erratic with occasional long dry spells turning the agriculture into a gamble. Supplementary irrigation is therefore essential even for Kharif while for Rabi a substantial supply is needed for assured and higher production, use of ground water can be helpful in areas where it is available.

1.4 Growth of Irrigation - Reasons for shortfalls:

The irrigation tradition in India is as old as civilization. Considerable efforts were made in ancient/historic periods in harnessing surface and ground water for irrigation by diverting the river/stream flows and excavating wells/tanks.

Some major irrigation projects were taken up in pre-Independence period in drought prone or water short areas, some major diversion works were also constructed on perennial rivers in Northern, Eastern and Southern parts of the country. However, the process of systematic planning for sustained supply of water and land use through irrigation in all the regions only began after Independence. Massive investments have since been made in this Sector through successive Five Year Plans creating a potential of 67.5 mha (end of VI Plan) against the pre-plan figure of 22.40 mha, before Independence. The pace has been as under:

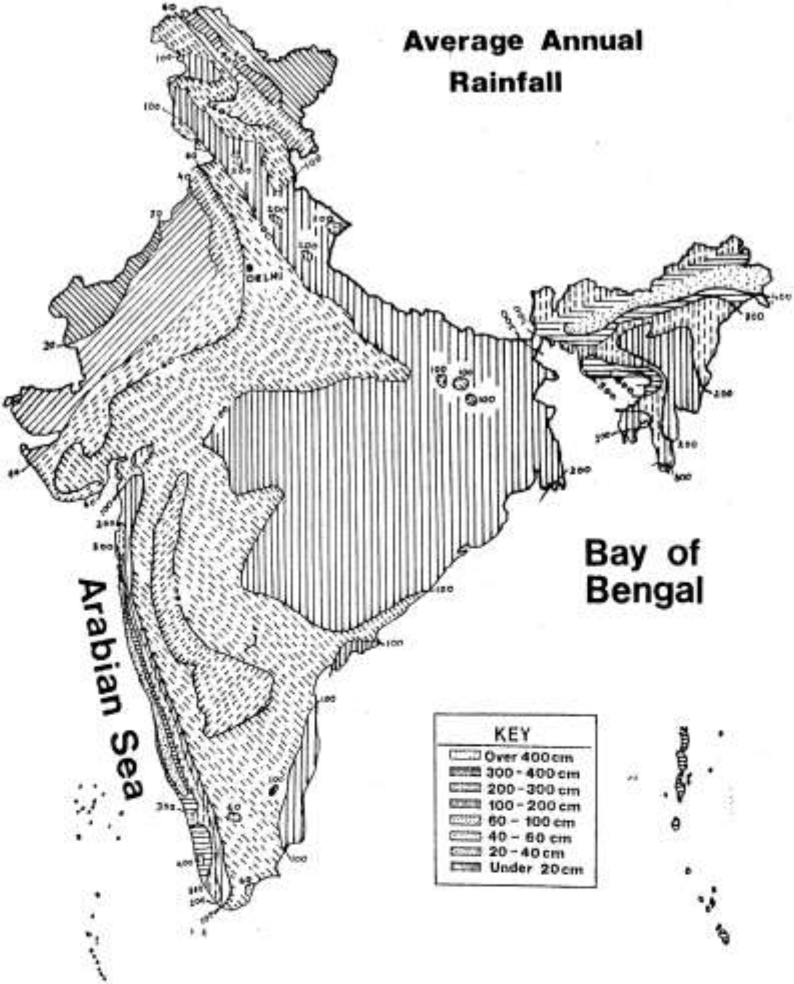
Cumulative Irrigation Potential Created

Unit - million ha (mha)

	Major & Medium Irrigation	Minor Irrigation	Total
Pre-plan benefits	9.7	12.70	22.40
First plan	12.26	14.00	26.26
Second plan	14.30	14.79	29.09
Third Plan	16.60	17.01	33.61
Fourth plan 1974	20.70	23.50	44.20
Fifth plan 1978	24.82	27.30	52.12
Sixth plan 1985	30.01	37.52	67.53
Seventh plan anticipated (June 1990)	33.01	45.96	78.97 Say 79 mha

MAP OF INDIA

Average Annual Rainfall



All these years emphasis has been laid on creation of additional irrigation potential to attain self sufficiency in production of food and fibre. But during this process, the utilization of the created irrigation potential, however has not been able to keep pace as shown below:

Year end	Potential created mha	Potential utilized mha	Gap mha
1951	22.4	22.4	X
1956	26.3	25.2	1.2
1961	29.00	27.8	1.4
1966	33.60	32.2	1.4
1969	37.1	35.8	1.3
1974	44.2	42.2	2.0
1978	52.1	48.5	3.6
1980	56.6	52.7	3.9
1985	67.5	60.6	6.9

The gap is rather fastly increasing particularly on the major and medium irrigation projects by and large managed by the irrigation departments of the states. There are several factors responsible for this lag although some of them may be beyond the control of the project management. A few of more dominant factors are discussed below.

1.4.1 Availability of water

On some of the projects the availability of water for irrigation anticipated at the project formulation stage has been decreasing, perhaps due to (i) changes in the rainfall pattern (ii) over-estimation of runoff at the planning stage (iii) installing additional works upstream (iv) construction of large number of minor irrigation tanks, percolation tanks, nala bunding/diversions or lift irrigation schemes in the upstream reach. Thus, it is always useful to assess the actual yield in the rivers and properly evaluate the potential at intervals.

1.4.2 Micro network

The micro-network is constituted by field channels, irrigation ditches, turnouts and related structures. Earlier the outlet/chak size was usually large while farmers were expected to construct field channels for conveyance of water from the outlets to the fields. The field channels constructed by the farmers in an unplanned manner led to excessive loss of water in transit and excessive use of water in the upper reaches, thus impairing water availability at the field, ultimately resulting in less than planned coverage by irrigation.

1.4.3 Land levelling/shaping

The absence of proper grading of fields subjected to irrigation reduces the application efficiency leading to less coverage and utilization.

1.4.4 Agronomical factors

In the absence of knowledge of suitable crop varieties responsive to irrigation for higher yields and profits, the farmers grow whatever crops they know, which may even be high water consuming crops like paddy (rice) in kharif or rabi followed by summer crops in coastal region, which affects both the coverage and thereby the utilization. The farmers in Maharashtra, Gujarat, Karnataka have switched on to sugarcane, banana crops which are although pest resistant and have assured market profits but consume more water rather than seasonal crops.

There is still a need for evolving crops giving good yields, pest resistant, low water consuming and responsive to irrigation in critical periods e.g. oilseeds, pulses to cover large areas with the available water. The country is also short in the production of these crops.

1.4.5 Farmers Response

The farmers response in improving water management at micro level and field level has not been very encouraging. There is no collective thinking and planning due to absence of well organized farmers associations. There is hardly any responsibility or incentive for water saving. Night irrigation is not practised uniformly.

1.4.6 Management practices

Although in the recent years several steps have been taken to narrow down the physical infrastructural and institutional gaps, but major delay is in introducing better management practices through systematic and realistic planning and implementation.

The demand for water from non-irrigation sectors is on the increase, perhaps being essential for improving the quality of life which too cannot be underrated, even though these do reduce the availability of water for irrigation purpose. The irrigation sector, to meet the challenge must plan covering larger areas even with diminishing water resources to not only maintain but also increase the production of food and fibre. This certainly warrants improvements in storing, handling and delivering water as per requirements of plants for increasing the production per unit volume of water.

Effective and improved water management is therefore a need of the day. The effort needs organized training of project personnel particularly middle and tertiary levels through state level training institutes, WALMIs, exposing them to better operational and implementation practices.

This Handbook on 'System Operation Practices' is thus an effort to address the issue of improving system operation practices, which, it is hoped will be helpful in imparting training to the project personnel and to the practicing professionals at large.

Chapter II

II. System Operation - Components, Objectives and Options

2.0 Most countries around the world have invested large sums of money to create infrastructure for development of irrigation potential. Emphasis on utilisation of the potential is obviously a concern. A major step to focus on this aspect is improving management practices to increase crop production. Deteriorating irrigation network and inadequate operating procedures often preclude any significant improvement.

An important strategy for improving the management for increased agricultural productivity is, first of all, to identify the maintenance deficiencies in the system and to remedy them particularly those interfering with the proper operation of the system. Second step would be to resort to improved operation practices that deliver reliable, predictable and equitable water. Once the operation practices have been improved, technical assistance should be provided to the farmers so that they also improve their water use practices and management of tertiary system.

2.1 Irrigation system - constituents:

It may be appropriate to recall the importance of the constituents of the system & role they play in the system operation.

Primary constituents of a Irrigation System are:

1. Water Source - reservoir/river-diversion
2. Water diversion and conveyance system
3. Delivery Sub-system:
   Distributaries/minors/outlets.
4. Command area or Farm Sub-system water courses/field channels & allied farm structures.
5. Drainage Sub-system for removal of excess water from the command area

The farm sub-system is considered to be the "heart" of any irrigation system performing the primary function of crop production. The water delivery and water removal sub-systems support the farm sub-system.

2.1.1 Source:

Source of water supply to any irrigation system may be, a River where water diversion structure, a weir or barrage or regulator may have been constructed to direct river water into main canal(s) on the flanks for irrigation. Availability of water for irrigation on such a system is dependent on the flow in the river and may fluctuate as per discharge flowing/passing in the river. Regulation of water for delivery to each of its sub-systems as per crop water requirement is therefore not possible on such a source of water. In case it is a dam on river for storage of water, regular and timely release of water is possible from the reservoir and irrigation operation can be better planned on them.

2.1.2 Conveyance and Delivery System:

The conveyance system is one which conveys water from the source to other distributing channels. Important features of this are;

Head Regulator - A structure at the uppermost point to release regulated supplies, constituting the first and main flow control structure on the system.

Main Canal or a feeder canal is the principal artery of the conveyance system. It is mostly a contour canal, with a flat bed gradient varying from 1/7000 to 1/15,000 commensurate with the topography of land to serve maximum possible area.

Branch canal: Branch canals take off from the main canal running usually on ridge lines to facilitate irrigation. Commonly no direct outlets are allowed from the Main canal or Branch canal. These constitute the Primary system of the net work.

Distributaries These are the channels which off take from Main/ Branch canals running mostly on ridges. Bed gradient follows the the natural ground.

Minors: Minors take off from distributaries, with carrying capacity varying from 5 to 25 cusecs. If the capacity is less, they are called sub-minors. Outlets for delivering water to water course are provided on minors, outlet is the last government control point.

The distributaries and minors form Secondary system net work.

Tertiary/Micro system: Below the outlets are the water courses & field channels which feed the area under command, called tertiary or micro system of the net work built, maintained and controlled by the farmers them-selves. Lately under new directions of GOI they are constructed by government upto 5-8 Ha block to be maintained by the farmers.

Control Structures: Control structures regulate the supplies for all channels. Head regulator is most important structure provided at the head and regulates supplies to suit the plan of operation or for closure for routine maintenance. Another important structure is cross-regulator, located on the downstream of take-off point, to maintain water level needed for releasing water into the off-take even if the main canal is run at lesser discharge. It is helpful in rotational running and closure of channels. One important control structure is Escape. Escape with regulating gates is helpful in meeting emergencies, for quick reductions in flow in the reaches located at long distance from the main canal, it is in reality a safety valve to prevent damage to the system.

Command area: The area irrigated by gravity flow from the outlets is the command area. It is divided into a number of blocks called chaks. Area under by one outlet is called a 'Chak' and may vary from 20 ha to 60 ha. Sometimes the area can be even up to 400 ha as in Northern Zone. Large size chak calls for a longer length as well as larger carrying capacity of water course which the farmers may feel difficult to manage. The number of beneficiaries also becomes large and sometimes the farmers may not join together to construct and maintain the water course and field channels. On new projects, the Government of India have issued directions to divide the chak into 5-8 ha sub-chaks and government channels to be constructed up to these 5-8 ha blocks. The number of land holders in this sub-chak is thus reduced to a manageable size. The length of field channel also gets reduced.

2.1.5 Drainage: Irrigation and Drainage go together. If surplus water is not quickly drained out it would affect the fertility of soil and the crop yield. The rain water too needs removal in time to enable timely sowing. Under the concept of command area development, every field is provided with a field drain along the field valley line to carry water to another drain (lateral drain), which collect water of all adjoining fields and take it to Main or Main sub-drain, flowing into the nearby natural drain or river. In case each of the fields cannot be provided separate field drains, it should be ensured that at least a group of them have at least area drainage facility. Natural depressions or borrow areas can be linked for field to field drainage. Drains are designed not only to cater to excess irrigation water but also for rain water from the fields and have to be regularly maintained like canal system.

Besides the surface drainage, there are other methods also e.g; (i) providing sub-surface drains (horizontal drainage) (ii) a series of tube wells (vertical drainage) & (iii) growing a large number of plants (like eucalyptus) termed biological drainage. For sub-surface drainage, perforated pipes are laid below the ground to collect excess water. This method is costly but may, sometime be needed if sufficient land for surface drains is not available or the cost is prohibitive.

2.2 Existing Operation Practices:

India also has a variety of operation practices, evolved over a long period to suit the water availability, topography, agro-climate and socio-economic conditions of different regions.

The country could be divided in four distinct regions namely i) the Northern - Haryana, Punjab, Uttar Pradesh and Rajasthan 2) the Central - Madhya Pradesh, Gujarat and Maharashtra, 3) the Southern - Tamil Nadu, Andhra Pradesh, Karnataka and Kerala and 4) the Eastern - Orissa, Bihar, Assam & West Bengal. Some distinct inter-region similarities in operational practices are noticeable.

1) Northern Region - The operation of the systems is generally "Supply Based". Distribution of water is done according to predetermined running schedules at varying capacity factors and rotational operation. The distribution below the outlet is also on prefixed sharing of flow-time pro-rata to individual farm holdings. The procedure of water distribution below the outlet is called 'Warabandi'.

In Northern region, the states draw allocated share of water from various rivers. Even the river systems are inter-linked to lend an integrated multi-benefit character and help basin-wise development. Inter-basin transfer of water is also followed. The storage works are designed for mean flows for more capacity and advantage of carry over for utilization in lean years. The water flows are primarily regulated for power, keeping, of course, in view the irrigation requirements as well.

For other major, medium and minor irrigation works, the 'Water Distribution Committees' at various levels have been constituted. The committee decides the running programme of various channels for the crop season. Agriculture officer advises the suitability of crops to be grown for the given availability of water.

There are State Level Advisory committees also which meet under the chairmanship of the Irrigation minister of the state and take policy decision relating to supply of water.

During running periods,, the distributaries/minors are run at full supply for the outlets to draw their stipulated share of water. No distributory/minor operates for all the days during the crop period, they follow a rotational programme, this prevents the land from becoming saline and minimise conveyance losses. The absence of manual control at outlets makes the distribution fool-proof. The water supply below the outlet is managed by the beneficiary farmers by their collective wisdom and commonsense.

Most irrigation schemes in the Northern region command areas much larger than can be actualy irrigated and thus water deficit occurs. Distribution of water in water deficients system is done by following methods;

i) Canal rotation with full supply : The distributaries are run full, by rotation. Farmer takes water in field when there is water in the channel.

ii) Rotational system: The channels run in proportion to the availability would result in running at lower levels than full supply which in turn would cause silting as also shortage of water at tails. The channels therefore are run full by turns after grouping them as per exigencies of supply.

iii) Warabandi: The system of warabandi (by turns) below the outlets is followed and farmers follow the system mutually. The system has some proven advantages which greatly promote better water use avoiding wastage as well as conveyance losses. It is practiced as most organized and orderly method of water distribution.

One weakness in the system of Warabandi is that it can not accommodate water demand of crops with highly variable water requirements. This has to be taken care by supplementation from ground water, wherever possible.

2) Central Region - System of supply of Irrigation water followed in the states of Gujarat, Maharashtra and Madhya Pradesh is by inviting and sanctioning applications (demand) known as "Shejpali", now being revised to "Rigid Shejpali". The water distribution is based on application by farmers and sanction by Irrigation Department. The applications indicate both the area and crop(s) to be grown.

Irrigation programme is fixed for each outlet command (20 to 60 Ha) for each rotation period. The dates when water would be delivered and closed are fixed and the farmers are informed by notice. The duration for delivery to individual farmers is not fixed. The irrigation starts from tail to head except where field channels are not in good condition or when intensive demands occur. During the peak demand periods, the tail end farmers suffer. The head reach farmers take more water thus depriving the tail enders of water. The system is now being revised by fixing the date and time termed as `Rigid Shejpali'.

The applications are received, the volume of water required at various points in the system (outlet, minor head or the distributary head etc) is worked out in cusec days. The total area to be allowed water is decided generally after convening the meeting of canal advisory committee at the beginning of the season. The canal advisory committee meeting at Executive

Engineer's level consists of officers of Agriculture and other departments and leading users. Farmers get sanction to the applications (within the limit) from the ID, to irrigate the applied area or reduced area. A reduction can be made if the demand exceeds the availability. A schedule of operation is prepared (based on the area applied/sanctioned) and publicized, indicating the flow periods in weeks of the season. Schedule of distribution at the farm level is drawn up indicating the order in which the farmers should draw water within the chak. Areas sanctioned for the crops are supplied water up to maturity. Irrigation department is responsible for operating the system as per the schedule and ensure that the flow (generally/day cusec) is constant at the outlets (generally serving about 40 ha). Farmers take water by turns within the sanctioned area. When the farmers of a chak have taken water for the sanctioned area, the outlets are closed until next flow period. All outlets have gates which can be locked.

This existing system has several shortcomings to make it an efficient system. These are:

i) Outlets are gated pipes drawing about 1 cfs. even when the parent channel runs with half depth. Most of the outlet gates are broken and are opened or closed using mud or vegetation to plug the pipe. This leads to over-drawals in head reaches and undependable supply at tails.

ii) The time taken to irrigate the sanctioned area may vary significantly due to variation in flow rate, nature of soil and the degree of levelness of fields.

iii) Farmers are liable to not use their turn or choose not to irrigate at night, and the department tries to make up the lost turn.

iv) Filing of applications is irregular/delayed, and goes on till middle of Kharif season. The farmers intentionally delay applying, hoping for the rainfall. Once the application is sanctioned, the farmer has to pay the charges irrespective of the fact whether there is water or not. Any delay in Kharif crops leads to delay in Rabi and even loss in production.

These factors undermine the schedule of operation causing unreliability of flow at the outlet (in time, quantity and duration) which further results in lack of discipline. Farmers tend to over irrigate whenever water is available. The system deficiencies and unreliable water supply especially to the tail enders are among the primary reasons for low utilization of irrigation potential.

3) Southern Region: The basic design, layout, construction, as also the system operation of the irrigation systems in Tamil Nadu, Andhra Pradesh, Karnataka and Kerala is almost similar except for minor variation within these states.

In Southern region, the right to use irigation water is attached to the land. When a new irrigation project is implemented and the canal net-work comes on the ground, all the land to be served is identified and listed with respect to land settlement survey numbers and notified converting these lands based on soil characterstics from 'dry' to 'wet'. The Culturable Command Area (CCA) and the irrigated area are generally the same. The rate of revenue is revised to a higher level. The water cess component is neither separately shown nor it is known. The land cess thus collected is relevant to the type of land and not the crops grown or water used. Once the land is classified as 'wet', the new cess becomes effective whether the farmer(s) take water or not. The land cess is collected by Revenue Department and Irrigation Department has nothing to do with either the assessment or the collection. The Irrigation Department functions as Service Department to make irrigation water available for the crops grown, this system is noticed to function.

The irrigation system (headworks, canal network and the outlets) is designed to ensure supply to the entire command on 75% dependability, as per cropping pattern and crop period as assumed. Regulating and flow control structures are provided on the canal net work for distribution of water in all the limbs of the system.

At the beginning of the irrigation season, the District Collector, calls a meeting of the Irrigation Engineer, the Agriculture Officer and a few prominent farmers to decide the dates on which the system(s) in the district could be thrown open. The irrigation engineer gives details of the water availability, the in-flow anticipated, the behaviour of monsoon etc., the agriculture officer is to advise the timings and kinds of crops and other agricultural packages. For bigger systems, the exercise is done at Govt. level by the Agriculture Production Commissioner who calls for proposals from the Chief Engineer Irrigation and the Director of Agriculture.

The system is opened for the season after due publicity through radio, press and notification clearly giving duration for which the system would be open. Irrigation Engineers keep on releasing water as per needs and/or the demand of the farmers in different limbs of the system. Thereafter, a continuous flow is maintained. This can be varied in different branches depending on needs, atleast in the rice growing areas. The demand is maximum during puddling and transplantation periods when flow is maintained continuously. Subsequently the supply is made by turns. For irrigated dry crops, the supply is intermittent, generally ten days 'off' and ten days 'on', the interval can vary from system to system and crop to crop.

Operation practices followed below the outlet are as under:

a) When the main system is 'on' continuously and supply is normal, the farmer turns are observed by following a sequence mutually arrived at and tradition-ally practiced. Though there is no established warabandi system like Northern Zone, there is a notional distribution among the holdings by days, part of the day or even by hours depending on the holding. Any dispute arising over this is settled mutually amongst the farmers using social pressures. Very rarely this assume is found to severe proportions requiring interference of the officials, the revenue official is empowered to intervene.

b) After transplantation is over, supportive irrigation is maintained, by adopting a turn key system at the minor level. The minors are kept open or shut while the distributaries are run at half supply level for proper feeding of the outlets. The farmers' turns, within the chak, continue when the minor is on.

In some systems in South India, certain segments of the command are eligible for two crops, rest being eligible for one crop only. Water supply can be denied to the later for the second crop.

Storage System Operation:

Storage reservoirs (tanks) are operated by the beneficiaries irrespective of the size, the number of outlet sluices or channels taking off. Most of the tank systems do have formal or informal committees at the village level to manage the operation. In large tanks where Irrigation Department staff is available, the sluices are operated by them according to the decision of the committee. In small tanks, the village headman gets it done. Maintenance of large tanks (more than 40 Ha in T.N.) rests with the Irrigation Department and that of small tanks with the 'panchayats'. Water distribution is by the beneficiaries. An irrigator agreeable to all, called "Neerkatti" is engaged by the beneficiaries to distribute the water to various holdings according to a traditional procedure of 'by turns', and is paid in kind at the time of harvesting by all the beneficiaries.

Deltaic Area:

The deltaic area of the rivers like Mahanadi, Godavari, Krishna & Cauvery, constitutes a substantial part of the total irrigated area of the states. The management is complicated and difficult owing to drainage problems. In case of intensive rainfall which is common often in the coastal zone, the run off from the uplands rushes down the delta, but the mild land-slopes considerably reduce the velocity causing silting which raises the general levels of land, the ground water level also rises and when the drains overflow they cause flooding in the area. The sea at the same time is rough giving rise to high waves which practically prohibits the drains from flowing into the sea, thus causing stagnation and flooding of inland. Sand bars get formed at the mouth of drains, adversely affecting functioning. Large pockets of low lying areas become water logged owing to poor drainage and damage the crops. While there may hardly be any feasibility for storage due to mild slopes, irrigation system operating as a flood removal system earlier, can at best function as a direct flow system. The tidal influx extends quite far into the inland spreading salinity. Though river flows do periodically flush the silt, the saline intrusion does take place. The soils in delta region are semi previous loamy - alluvial, capable of intensive cropping as agro-climatic conditions favour raising of wet crops. Continuous vigil is required to utilize the river flows, the area being prone to heavy precipitation and flows in the rivers, to eliminate inundation or water-logging.

Rules of Regulation:

Rules of Regulation approved by competent authority are available for each of the systems. These are at best only a guide, with directions for operation in normal times. They dwell more upon the precautions to be taken and for actions in dealing with the floods.

When irrigation is 'on' in a system, the day-to-day schedule of releases caters to the requirement projected at the section level. Looking to the area under the crop, and its stage of growth, the Section Officer intimates the water requirements for compilation at the sub-divisional level and further transmission to the Executive Engineer, who is the key person in the management. He uses his foresight, considers the water availability and other relevant factors and approves the schedule of release of water in different sub divisions and for sections.

4. Eastern Region:

Most of the Irrigation systems in Eastern Region comprising of Bihar, Orrisa, Assam and West Bengal are river diversion works. These states have normally good rainfall and water is in abundance in the rivers during monsoon. Due to this availability and its reliability, Paddy is mainly grown in Kharif in large areas, almost covering 100% of the culturable commanded areas. Supporting irrigation in Kharif is provided whenever there is a long gap in rains while the crop requires water. Due to shortage or unreliability of water in winter, Rabi is grown in a comparatively much less area, i.e. about 30% or less.

Since water from the run of the river is directly diverted into the irrigation channels, there is a problem of sedimentation in the canals. Maintenance grants are being inadequate, due to which the canals are seldom maintained causing serious reduction in the carrying capacities of canals. On the other hand new techniques of agriculture under the Intensive Agriculture Programme and new methods of agriculture are being practiced, while using high yielding variety seeds and fertilizers. This has increased the demand of water, while canals have proved to be inadequate to meet these needs. In general, the canal systems have many deficiencies like lack of field channels below the outlets, lack of control structures, gates etc. resulting in considerable wastage of water and low field application efficiency.

In Bihar, 'Tateel' system of water distribution is followed. The opening and closing time of the system is decided by the Superintending Engineer incharge and or the Executive Engineer and notified through pamphlets to farmers. Water is supplied for irrigation during Kharif season also. To illustrate the point a mention may be made of one Paligaon distributory which is usually open for ten days and closed for five days and so on. The period of 'ON' and 'OFF' varies from system to system, according to the judgement of the S.E/E.E. coupled with availability of water and past experience.

Under the Bengal Irrigation Act 1876 and canal rules applicable to 'Son' Champaren-Saran-Kala, there is a provision for submition of application by the farmers for supply of water on long term lease (7 to 10 years), lease for Kharif season, Rabi season, hot weather season or even for a single watering during Kharif crops. One or more waterings during hot weather season & water required for village tank(s) are also covered by these rules. The applications are made on prescribed forms, the junior engineer checks the possibility of irrigating the area in question, whether a small earthen bund exists around the field to prevent wastage of water and that 85% of the farmers in that block have applied for water. If satisfied, he recommends the application to the SDO (Assistant Engineer). Except the long term lease usually sanctioned by the Divisional Canal Officer (Executive Engineer), other applications are sanctioned by the SDO and conveyed to the farmers through the Jen & Lambardar. These rules provide for appointment of a 'Lambardar' or 'Sattedar', a representative of a group of users in a chak or a block (group(s) of chaks). 'Lambardar' is appointed by the SDO in consultation with the users. The Divisional Canal Officer can also make the appointment. A Lambardar must have an interest in the land use, his functions are:

i) To obtain signed application for water and certify the correctness of signatures of the applicant.

ii) To assist officials in measuring the irrigated area or the area proposed to be irrigated & record the same in 'Sudhkar' registers.

iii) To give timely information to the canal officer of the irrigation requirements.

iv) Supervise distribution of water within the outlet command and report misuse or wastage of water.

v) To attend investigations by the Divisional Canal Officer.

vi) To receive and distribute the demand slips among the concerned farmers.

vii) To verify the gauge readings at site recorded by the gauge reader.

Rules also provide for payment of Lambardar fees, in proportion to the water cess assessed. Rates vary from Rs.1.56 to Rs.3/ per Rs. 100/- of assessed water cess, the average is about 2%. The rules also prescribe water rates, procedure of water cess assessment, collection, remissions etc.

The 'Lambardar' system abandoned in 1974, has now been revived in 1988. The farmers apply water to fields according to convenience, from field to field, starting from head. They sometime irrigate higher lands also by obstructiing flow in the canal for raising water level. Due to which the lower portion of command are deprived of water and may go unirrigated. Farmers are also not united & have no collective control on the system. They are not certain of the availability and its duration. The communication system on the canals is lacking. Lambardar does not interfere with water distribution below the outlet although disputes are resolved by the cultivators mutually.

Efforts are now being made to form "Adhoc" farmers association on pilot basis to awaken and discipline the farmers as a group, and ultimately hand over responsibility to them along with statutory measures/powers.

A chart showing summary of existing operation practices in various zones is enclosed at pages 19 to 23.

2.3 Improving System Operation - objectives:

The National Water Policy - 1987 besides other things lays down that:

i) The irrigation intensity should be such as to extend the benefits of irrigation to as large a number of farm families as possible, keeping in view the need to maximise production.

ii) Water allocation in an irrigation system should be done with due regard to equity and social justice. Disparities in the availability of water between large and small farms should be obviated by adoption of a rotational water distribution system and supply of water on a volumatric basis subject to certain ceilings.

iii) Concerted efforts should be made to ensure that the irrigation potential created is fully utilized and the gap between the potential created and utilization is removed. For this purpose the command area development approach should be adopted in all irrigation projects.

iv) Participation of Farmers: Efforts should be made to involve farmers progressively in various aspects of management of Irrigation systems, particularly in water distribution and collection of water rates. Assistance of voluntary agencies should be enlisted in educating the farmers in efficient water use and water management.

V) Improved Management: A perspective plan for standardized training should form an integeral part of water resource development. It should cover training in system operation, physical infrastructure and the management of water distribution system. The training should extend to all the categories of personnel involved in these activities as well as the farmers.

EXISTING OPERATION PRACTICES

INDIA

North Zone	Central Zone	Eastern Zone	Southern Zone
Supply based	Supply based (to meet the predetermined demands through sanctions of crop and area to each cultivator)	Supply based	Supply based

METHODS OF OPERATION

ABOVE THE OUTLET

North Zone	Central Zone	Eastern Zone	Southern Zone
Distribution of water according to a predetermined canal running schedule by rotation. Canal scheduling decided by water distribution Committee for each system as per availability of water	Schedule of operation is prepared based on the area sanctioned to be irrigated on each channel. Canal Advisory Committee decides the area to be sanctioned for irrigation on each project as per water availability.	"Tatael" system of distribution i.e. "on" and "off" pattern for various channels. Program of channel running is finalized by the Superintending Engineer and Executive Engineer after judging the "flow" available in the river.	Localization system of irrigation Land to receive water identified and classification as I.D./wet is followed. Wet crops are given continuous water supply while irrigated dry crops are given 'off' and 'on' supply. Program of running is finalized by Collector assisted by Irrigation and Agriculture Departments and for major projects by the Government.

contd.....

BELOW THE OUTLET

Through Warabandi or Osrabandi	As per water required on each outlet by turns (Shejpali). As per pre-determined time on each outlet by turns (rigid Shejpali)	Outlets get water in turn when the channels run. No Warabandi like Northern Zone is followed. "Sattedar" or "Lambardar" assists in water distribution.	No Warabandi followed but cultivators manage it mutually through "Neerkatti".
Outlets are open pipes or APMs	Outlets are generally gated	Outlets are open pipes	Outlets are open pipes

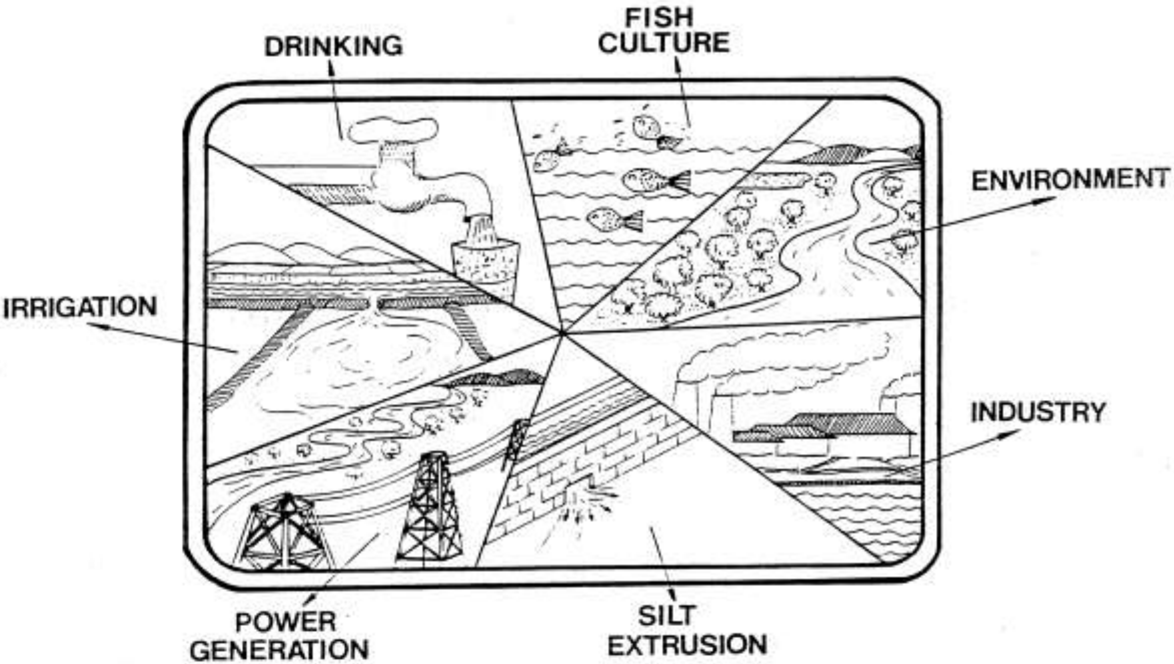
PLANNING OF OPERATION

Depending on the estimates for supply, groups are formed and priority running periods worked out. The details are perused by the water distribution committee and dates of running and closure are decided. Program is prepared and then printed for general information. Running schedules are sent to ID personnel for strict adherence.	Application for crop to be grown and area to be irrigated are invited, verified, compiled and decisions for allocation are taken depending on supply available/anticipated. The period of running and closure are decided by the Canal Advisory Committee. The applications are sanctioned and "passes" are issued. A plan (PIP) is prepared.	System of application is followed on some systems. On others "off"and "on" is practised. The applications are sanctioned by EE/AE. Program is finalized by SE/EE based on their skill and experience.	Areas are identified for supply of water Wet/ID and rotation for ID crops is planned. Supply schedules for continuous or "off" and "on" are decided. Dates of opening and closing are decided in consultation with Agr. depth by Collector.

contd....

IMPLEMENTATION			
The dates of running, closing, priority are disseminated and dates for releases as per schedules are strictly followed. The distributaries and minors are run full.	The whole plan is disseminated and channels are run or closed as per predetermined dates which are strictly adhered to. In case of rainfall, some channels can be closed as per approval of XE for use in subsequent crop season.	Running or closure of canals is done as per approved program.	Running/closing is done as per program decided.
MONITORING			
Actual deliveries and irrigation done are monitored. The gauge discharge formats are used. System of water account for each channel exists although not strictly followed. Actual areas irrigated and cropping pattern is also monitored. Monitoring of climate is not much prevalent. Precise monitoring of losses in channels is not in vogue.	Actual deliveries are monitored. System of annual performance report in terms of AIDC is in vogue but not strictly adhered to. Emphasis on monitoring of climate and inflows is better. Mid-term revisions become possible. Area irrigated is also monitored. Precise monitoring of losses in channels is not in vogue.	The degree of monitoring of actual deliveries somewhat lags behind. There is no water accounting. Area irrigated is monitored. Losses are not monitored.	There is no monitoring of actual deliveries. Area irrigated is not monitored by irrigation department and there is no system of water accounting. Losses in channels or at application are not monitored.
Monitoring of tertiary system is not done.	Monitoring of tertiary system is not done.	Tertiary system is not monitored.	Monitoring of tertiary system is not done.
EVALUATION OF PERFORMANCE			
Not done	Partly done	Not done	Not done

USES OF WATER



In view of the vital importance of water for human and animal life and considering its increasing scarcity, the planning and management of this resource and its optimal and equitable use has become a matter of utmost urgency. There is thus a need to look into and analyse the deficiencies in the systems and improve the actual operation and management.

2.4 Conceptual approach

Conceptual approach to an ideal operation programme would be (i) to corrctly assess the availability of water for distribution in the Command, (ii) to correctly assess the water demand of crops, (iii) draw the operation plan as per water availability, (iv) seek input of the users, (v) implement the plan publicised publicity, (vi) have proper feedback and interaction, (vii) monitor the deliveries through regular and continuous feedback from field, (viii) revise/improve the plan with knowledge gained, and (ix) evaluate the performance. The aim should be to extend irrigation benefits to as large a number of farm families as possible keeping equality and social justice in view.

2.5 Scientific approach:

Different irrigation systems would have different 'site specific' problems. An effective approach would be 'process-oriented' rather than prescriptive. Prescriptive approach lists step by step procedure to be followed and is perhaps preferred by many system managers but it does not result in optimal result and the field staff do not learn how to accommodate the site characteristics to improve the performance. A scientific approach, 'site specific', is therefore necessary. This process emphasizes;

a) attaining more detailed physical knowledge about changes within the system.
b) documenting maintenance needs for system improvement
c) using existing flow control structures for water measurements
d) increasing conscious approach for operating the system to meet the user needs.
e) awareness of crop-water needs and farmer responses

Steps required for improving the system operation plan:

(A) Know the system - Problem Identification

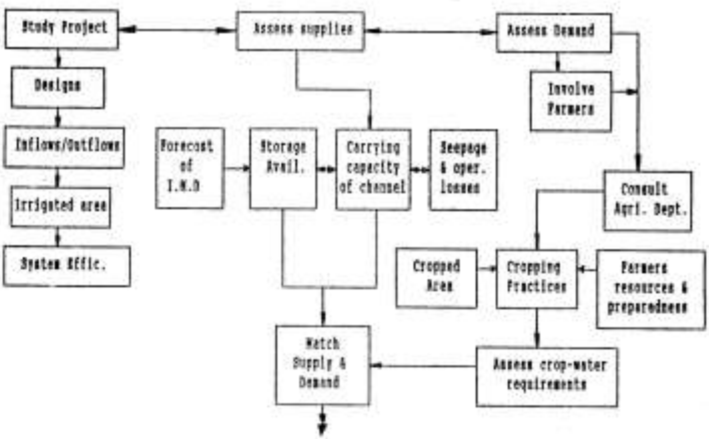
i) Study maps, old record and information about crops grown & cropping activity.
ii) Seek input from farmers
iii) Examine water availability Scenario.
iv) Conduct hydraulic survey and mapping

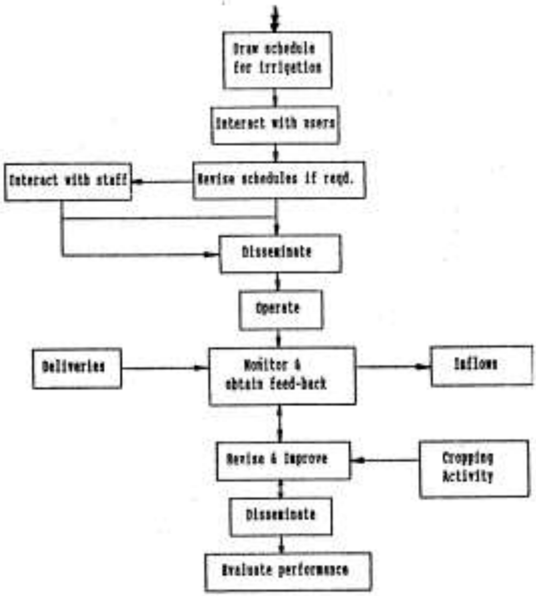
v) Oversee the outlet designs, location, sizes & alignments
vi) Identify flow control structures for flow measurement
vii) Conduct operation control survey
  - Check discharge ratings
  - Measure channel losses.
viii) Examine flow control at Tails (Tail clusters)

(B) Implementation of Solution
  i) Implement proper channel maintenance programme and maintenance plan for structures.
  ii) Implement improvements in water delivery. Also oversee the outlets.
  (iii) Continue improving water delivery schedules.

(C) Development and Testing of solutions
  i) Develop operation plan. Ensure releases to meet the crop requirements at critical stages of growth.
  ii) Check discharge ratings.
  iii) Obtain information on cropping activity.
  iv) Mid term review/revision of operation plan.
  v) Monitor and obtain feedback.
  vi) Further refine the system operation plan.

CONCEPTUAL APPROACH




Draw schedule for irrigation
Interact with users
Interact with staff
Revise schedules if reqd.
Disseminate
Operate
Deliveries
Monitor & obtain feed-back
Inflows
Revise & Improve
Cropping Activity
Disseminate
Evaluate performance

a) Overseeing the outlets - numbers, sizes and locations:

Problem of unauthorized additional or oversized outlets exists on most of the old projects as well as on the newly built ones. In early stages phases of construction and for a quick development of irrigation the managers themselves encourage/allow fixing of these outlets. When the farmers get used to them and start growing high yielding crops after making investments on land, seeds and fertilizers, they are likely to resist removal of these outlets at completion phase. The axe falls on the tail-ends where even subsistence irrigation is not available. These practices upset the whole operation planning procedure and should thus be arrested, if equitable distribution is to be ensured. The case for a change in the size or location should be examined on technical merits. Extra outlets should be removed. There is likely to be a severe resentment by big/influential farmers to such a step and here the rapport and credibility of the manager will come to rescue. If needed, recourse to the provisions in the Irrigation Act should be taken, taking care that link water course/field channel for the new (authorized) position is made on the ground before hand.

b) Direct outlets from main canal/branch canal:

When the availability is more than demand, the system could run full & may not cause difficulties even if outlets from the main or branch canal are given. But such a situation would seldom occur, as efforts to irrigate more area than permissible are bound to cause shortage of water. In order to meet the situation the distributaries and minors have to be put on rotation on 'ON' and 'OFF' basis, and the main canal/branch canal run full or partial for all the days. The direct outlets given on the main canal/branch canal would continue drawing water for all the days, unless gated and secured by locks which would warrant avoidable man power, supervision and control. As a principle no direct outlets from the main/branch canal should be given. The areas possible by only main/branch canal can be grouped together and a separate sub-minor built taking off from a regulator and grouped with other channels for rotational running.

This is an important aspect of planning the system operation and, funds if required for the needed interventions should be found.

c) Small chaks - stream size:

The last Govt controlled structure on a system is the outlet for about 40 Ha to allow nearly 1 cfs. discharge. Although the size would normally depend on the 'duty' adopted. The command area is divided in a number of chaks to be served by outlets provided. It is kept in view that the length is not unduly large, a length of 1 to 1.5 km being preferred. Since the water course follows the ridge. The size and extent of chak is mainly dependent on geographical features. For chaks of size 40 Ha and above, the discharge of a water course at the outlet may be 1 cfs based on the water allowance. For smaller chaks, the discharge may work out to be less than 1 cfs. To illustrate, if the area of a chak is 10 Ha, the allowable quantity would be only 0.25 cfs. If the length of the water course is 1 km incurring a seepage loss of 3% to 4% per 100m length, it will mean loss of 30 to 40% of the discharge. The stream flow through the water course would be dwindling and may not be able to cover the area in the allotted time. The chance is that the tail area may not get any water at all. So it is essential that a minimum stream size depending on the type of soil and length of water course may have to be fixed.

Such situations can be met with by grouping of smaller chaks into one or two so as to make a viable size. They can be considered to be grouped with the adjoining large chak(s). For doing so, the water course of one chak will have to be linked with the other by either providing a syphon through the chak boundary (generally a valley) or across the minor or even distributory.

Such review of blocks ('chakbandi'), while preparing the operation plan would be helpful in optimising the use of irrigation water and at the same time ensuring a proper stream size.

2.6 Options for Operation:

There can be a variety of options in planning system operation. They largely depend on the water dependability, physical system (storage or river diversion), topography, cropping pattern, cropping practices, rainfall - intensity frequency, maintenance of the infrastructure, control structures, socio-economic conditions of the farmer, user-groups in the command and farmer's know how on maintenance & distribution of water. The practices may vary from system to system, region to region and state to state.

A variety of operation methods are in vogue. Below the outlet, the farmers manage water distribution mutually or at places through some sort of formal or informal societies. It is either 'warabandi' in the North, the mutual understanding in east or south and the 'Shejpali' in central region. The person supervising distribution of water below the outlet is called 'Miraab' (North). 'Sattedar' or 'Lambardar' (east) & 'Neerkatti' in South. The options in any of these methods, can be:

i) Running the main canal & system continuously for designed base period of the crop. Closing the entire system for 7 or 14 days and again running it till the storage lasts or crop matures, whichever is earlier.

ii) Running the main canal with full or partial supply for designed base period and run the distributaries and minors full by rotation.

iii) Dividing the command in zones and supplying water to separate zones in turn (if water is insufficient) each year.

iv) supplying water to the whole command with less number of waterings and adjusting the cropping pattern.

v) By reducing flow period & increasing discharge of minors is another method of operation prevalent in Maharashtra and on many minor irrigation projects in Rajasthan. It calls for a design of the Distributory/ minors and the outlets for a (flow) period of 15 days while the main canal/ branch canals are designed for the peak require-ments of one month of the crop season (based on monthly crop water requirements). So by running these minors for 15 days with double the discharge, the required quantum of water required for crops is possible to be supplied in half the month. This results in a bigger stream size and faster application of water to fields, thereby minimizing conveyance and field losses. These channels remain closed for 15 days to give enough time for carrying out maintenance work if necessary. Farmers appear generally happy and satisfied with this method of operation.

vi) Volumetric method of supply:

Supply of water for irrigation on volumetric basis is very much desirable looking to the present day high cost of project. It will promote a judicious and optimum use of water by the farmer as he has to pay for it on volume basis. It would reduce wastage of water, thereby providing an ideal water management and maximum productivity. But it is not practically feasible in Indian conditions because of heavy cost in installation of meters and arrangements required for maintaining and reading of large number of meters installed. Also fool-proof meters to operate in field conditions are difficult to maintain.

To promote volumetric use of water, Govt. of Maharashtra in their Irrigation Act 1976 as section 60 have made a provision that in case 51% of the occupiers of land on a distributary command area agree, water can be supplied in bulk at the head of distributary on volumetric basis at promotional water rates, the internal distribution being left to an association of the concerned beneficiaries.

The methods i), ii), & v) above are "supply-based" while (iv) and (vi) are 'crop water need based'. Farmers adopt a cropping pattern based on past availability of water and economic scenario. Requirement of water varies from crop to crop as per their critical stages of growth which too vary from crop to crop. In the event of rainfall in a part of command there may be need to curtail supply to them but due to lack of communication, such regulation is either not possible or delayed, thereby affecting the crop.

"Demand-Based" system of operation perhaps the most desirable, is not very much in practice. 'Shejapali' system in central region, and localisation system in Southern region attempt to do so but there are many drawbacks. For demand based operation, a lot of automation, excellent communication system and abundant water is necessary.

vii) <u>Delta region</u>:

The finer position of silt in the rivers gets deposited near the outfall into the sea due to flat grade while the coarse grained silt gets deposited in upper reaches. The river bed thus rises. During floods, canal banks overflow and may even breach causing the water flow into depressions. Thus the rivers (drains) serve as irrigation channels in the head reaches and drainages at the end. The flat topography may not permit any storage reservoir or tank meaning that only "run of the river" systems are suitable for deltaic region.

In Plain or Plateau areas, we have generally a storage reservoir or a tank with a network of canals irrigating the commanded area. Run of the river systems are also feasible/ existing. In diversion system the flow is not always uniform. There are fluctuations in flow which may be more & sometimes less than required. For operation of such systems, a historical flow data of the river at the weir location will be helpful in predicting the flows for planning purposes. Upstream flow measurements and effective communication system is likely to make the situation easy for anticipating the availability of water at the weir/barrage. The system manager is required to be alert to divert & utilize all the available flow through the canal in a rational manner.

A schematic plan for various options of operational methods-both supply based and crop based for Plain/pleatau and Delta regions is shown below:

GENERAL OPTIONS OF OPERATION

Irrigation System

Case	Sub-system	Flow condition	Releases	Remarks
Case (i)				
Continuous Running	Primary Secondary Tertiary	continuous flow continuous flow continuous flow	Full Full Full	
Case (ii)				
Rotation Below distributary	Primary Secondary Tertiary	continuous flow intermittent flow intermittent flow	Partial Full Full	
Case (iii)				
All by rotation	Primary Secondary Tertiary	intermittent flow intermittent flow intermittent flow	Full Full Full	

Volumatric (on demand)	All Sub-system	By Volume	By Volume	Needs measuring device at farm gates and crop water know-how by farmers

Minor work	Primary Secondary Tertiary	continuous 15 days 'on' & 15 days 'off'	Full	Twice of authorized(Channel design is done accordingly)

PREPARATION OF O-PLAN
Distribution of water

- OBJECTIVES :
  - Equality -- per unit area
  - Timeliness
  - Predictability
  - Acceptability by farmers & involvement
  - Punctual & prompt attention by ID personnel

Chapter III

Knowing the System

It is essential for the system operator to first acquaint himself with the system for which the operation plan is to be prepared. The manager has to study all the components of the system and other socio-economic aspects having direct relation with the system operation for effectivity and efficiency. The object of knowing the system would require the following steps:

3.0 KNOWING THE SYSTEM

- Study of physical, technical, historical and socio-economic details of the system.
- Climate, topography and soils.
- River basin, its development, rainfall, location of rain gauge stations, and catchment area.
- Surface flow and Ground water
- Drainage, water logged and salt affected areas.
- Cropping pattern and related activity.
- Water requirement on the system
- Canal net work - design principles, fixation of carrying capacity, flow control points and delivery of water to farms.
- Maintenance needs and implementation
- Operation information from farmers.
- Organisation, responsibilities and functions, system of approval.
- Status of communication - feed back and monitoring.
- Statutory provisions and rules related to operation of system.

3.01 Study of physical, technical and historical details of the system

The first step to "know the system" is to collect and study the relevant and available data on the physical, technical and historical aspects of the system. The Survey of India maps showing the location of the dam, catchment area and command area of the project need a careful perusal. Similarly the design, plans like the longitudinal sections, X-sections of the dam and canals, layout plans of canal system, soil characteristics, geological features etc. should be studied for improving operational efficiency. Reports and technical studies or economic evaluations carried out should also be obtained. There should be registers listing various activities, noticeable channel reaches in the system and history of changes which the system might have undergone over the length of time are likely to provide the required insight into the system and need to be studied. Information regarding standing orders issued for effect operation and maintenance from time to time should also be looked into. It will be most valuable in providing background of the system and assist in formulation of workable improved operation plan.

3.02 Climate, Topography and Soils

Besides rainfall, other climatic factors like temperature and humidity occupy an important place in assessing the net requirement of water for'irrigation. High temperatures cause evaporation of water from the free surface of reservoir/ canals, as well as from vegetation/crops - called evapo-transpiration which too is quite significant. Therefore, data on evaporation losses based on 'pan evaporimeters' observations or that for evapo-transpiration based on instrument observations should be known to arrive at correct hydrologic balance and water requirements.

Shape, size and gradient of the catchment area and soil types available are important factors, as they very much affect the net available surface flow or run-off from the catchment. The flowing water is liable to carry lot of sediment, rolling or suspended and settling in the reservoir bed, to adversely affect the live capacity of reservoir.

Likewise details of topography, land-slopes, in particular, soil types in the command area are also essential to facilitate decisions on measures to minimise seepage losses and/or erosion of banks and for enhancing the efficiency in implementation.

3.03 River basin, its development, rainfall, rain gauge stations and gauge discharge observation sites

Correct realistic assessment of water availability in the reservoir is the most important step to enable preparation of a realistic and effective operation plan. A careful study of the complete river basin, dependable minimum and maximum flows, soil conditions and climatic aspects is necessary for assesing the hydrological behaviour of the catchment area. The run off intercepted by other storages upstream has to be properly accounted for. Commitment on the downstream spills has also to be kept in view for reservoir operation. Details of such dams have therefore to be known. The information would also be needed for assessing the peak flood discharge and effect the operation at the spill-way/ waste weir. Location and type of rain-gauge stations in the catchment area with complete record of rainfall, peak intensities on some particular days in preceeding years should be studied to determine the yields from the catchment. If river discharge observation sites exist in the basin, the discharge data available, along with the cross-sections and longitudinal sections at these sites should be obtained to recheck and verify the water availability by establishing proper rainfall-runoff relationship wherever necessary.

3.04 Surface flow & Ground-water

Surface flow and ground water are integral and inseparable components of the hydrological cycle. As a natural corollary, their utilisation should also be inter-dependent and conjunctive.

The actual maximum and minimum yields at the dam site for a number of past years for which rainfall/ discharge data may be available, should be made use of and dependable yield at 50%, 75%, 90% and 100% span of time be ascertained. The gross and utilisable storages provided at the time of formulation should be analysed. Details of quality of water regarding salinity, pH value (acidic or alkaline) etc for suitability for irrigation and drinking should be collected. The existing sources for irrigation other than canal within the command area, the cropping practices followed and status of land use for irrigation should be also ascertained.

Similarly, status of use of ground water, availability, quality, depth from the ground, seasonal variations, present extent of exploitation and future prospects should be weighed. Ground water table observations taken both in pre-monsoon and post-monsoon, for at least three years should be examined.

This information would enable identifcation of areas where conjunctive use of surface and ground water is possible or where only ground water use is possible for irrigation in areas within the command. This would also reveal dependence on canal water to enable a decision for release of water for consumptive use or less and if the water can be spread over larger area by supplying water at critical growth periods during shortages.

3.05 Drainage - water logged areas/salt affected area:

For planning the operation, it is essential to have information about important characterstics, e.g type of soils, soil cover, gradient, means of drainage, general topography (undulating - mild slopes-plain), areas water logged or salt affected. Special information regarding water logged or salt effected area is necessary. The system Manager may have to, at some stage, be called upon to exclude the water logged area from surface irrigation. If necessary a plan for providing a series of (tube) wells in the area for conjunctive supply of water to adjoining lands should be considered. This would not only help in reclamation of the water logged areas but would also create a second source of irrigation. There may also be a requirement of extra water for leaching of the salts to be taken into account and if conditions permit, the plan should meet these special requirements. If, however, water for leaching is not available, salt affected areas could as well be excluded from irrigation programme. Irrigation without drainage leads to many problems and it has to be ensured that the fields have proper drainage. It is likely that these were provided for each field while reshaping the land, or there could be field to field drainage or some natural drains may be around to take care. Unless there are appropriate means to drain excess water, salt incrustations are likely to occur and harm the fields, for which, the irrigation manager may consider minimum number of waterings.

3.06 Cropping pattern & Farming activities

It will be desirable to find out the cropping pattern followed in the area for past years and comparing it with the project cropping pattern, alongwith the cropping methods and timings of the activities. The delta (water depth applied) for each crop and actual duty (area per unit volume of water) should also be assessed. Besides, it may be useful to assess the users crop preferences to arrive at an acceptable cropping pattern to optimise the use of irrigation water. It is generally not easy to exercise a control over the cropping pattern but some consensus can be arrived at depending on the mutual dialogue and trust.

3.07 Water Requirement on the System:

After knowing the areas irrigated and the cropping pattern on the system, assessment of duty of water and system efficiency, approximate requirement of water for irrigation in that area and crops could be easily estimated. This would also warrant a close examination of all relevant documents which might have been prepared in past. It should also be co-related with other agriculture inputs, soil types and practices.

3.08 Canal network design principles

For improving the system operation practices it is essential to have a complete study of the canal network, design principles, existing carrying capacities, location of various control points on the net work and the method of water delivery to the farms. Design principles adopted for the canal system should be studied. The bed width, side slopes, Coefficients of roughness (rugosity), silt factors etc. adopted in the design should be looked into. This knowledge would enable the system operator to find out whether the channel sections are appropriate or they need special attention. It is likely that original design of existing canal structures was based on the traditions of old irrigation systems. Some changes, on the old practices over the time may have taken place due to better know-how now available, while the canal structures may be required to conform to the latest principles.

- Carrying capacities:

  The carrying capacity of any canal is fixed on an assumed cropping pattern taking into consideration the climatic conditions, cropping intensities and crop water requirements envisaged at the time of formulation. Conveyance and other losses are also taken into consideration in the design. Normally the peak water requirement occurs during pre-sowing stage of one crop and flowering stage of the previous crop. The project water requirements for the given cropping pattern are worked out for each month of the crop season.

  A change in the crop pattern commensurate with social/community demands in future cannot be be ruled out. The design discharge can be marginally increased to take care of such requirements. It is also likely that the capacity may even now be suitable even for the existing cropping pattern. An analysis of the situation will enable the manager in taking appropriate action.

- Flow Control points :

  Knowledge of all control points on the canal net work is necessary to prepare and implement the system operation plan. If adequate number of control points do not exist, they will have to be suitably provided/identified. The important points of flow control can be head regulators, main canal, branches, distributaries and minors, cross regulators, escapes, tail clusters and the outlets.

At the off-take point of each branch, distributary or minor, a head regulator is provided for regulating or closing the supplies as per operation schedule or routine seasonal maintenance. Cross regulators on the canals on the downstream of take-off points are so located that they are able to raise up water level to fully feed the off-taking channels. Providing adequate number of cross regulators and head regulators for operation purposes is not only of utmost utility in control over canal flows but also due to the fact that these structures also provide a lot of flexibility in operating the irrigation system under all eventualities. Escapes with regulation device are also essential on large canal systems for emergency use. They are helpful in quick reduction in flow in the system located at long distance from the main canal. The escapes are safety valves for avoiding damage to entire system.

Tail cluster is an important structure at the tail of a minor, where there may be 2 or more outlets. The outlets can be open type, gated or fixed orifice or modules which can also serve as flow control points (Fig. 3.1). It has to be seen that they are properly fixed with gauge strips provided on their cills to measure available working head on each of them. It has to be ensured that outlets get their designed operating head to pass the required stream flow on to the fields. It would be proper to lay down guidelines on 'outletting' for homogenity.

3.09 Determination of maintenance needs and implementation:

Adequate and timely maintenance of an irrigation system is vital for proper irrigation water management. This management can be effectively possible only when the infrastructure for water conveyance is in a fairly good condition. For increasing productivity, evaluation of maintenance deficiencies and their rectification coupled with improved operational practices providing more reliable and predictable water deliveries are most essential. There is a need to conduct engineering survey of the system for determining the maintenance needs conducive to implementation. As certaining the quantum of desilting required restoration of the gradients to design and the quantum of earthwork to be

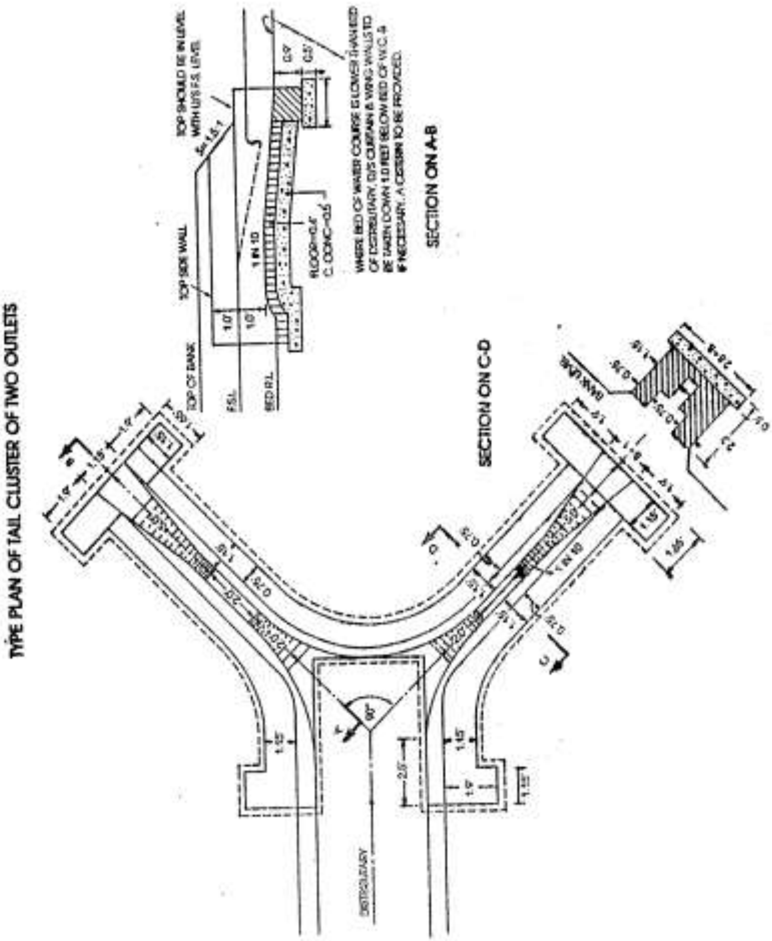

TYPE PLAN OF TAIL CLUSTER OF TWO OUTLETS
SECTION ON A-B
SECTION ON C-D
DISTRIBUTARY

Fig. 3.1

filled in the eroded banks or bed for proper slope and shape is essential for restoring conveyance efficiency.

In order to improve water distribution in the command, a study on the quantum of seepage losses from the canal is essential. This would help in identifying the reaches where proper measures may have to be taken to save the losses.

Water can be effectively managed only if it can be accurately measured. Some important structures on the system can be identified as flow control structure and calibrated to measure the discharge. It is thus necessary to properly identify and repair such flow control structures so that they can dependably serve both as flow control and flow measurement structures.

A diagnostic `Walk-Thru' maintenance survey is necessary for a precise and documented projection of maintenance needs. An important source for ascertaining these needs is to involve the user farmers. They would provide many clues to maintenance and operation problems in the system which may not otherwise be possible to be identified by the System Manager.

Some social causes may also be responsible for giving rise to maintenance needs e.g cutting of banks, putting obstructions or unauthorized/ oversized outlets or tampering with the fixtures, warranting the manager to understand the causes to develop proper solutions and take remedial measures so that appropriate maintenance plan(s) can then be prepared and implemented.

3.10 Farmers' Input for Operation Plan

Before embarking upon preparation of the system operation plan it is necessary to have a dialogue with a few knowledgeable farmers of the command in its head, middle and tail reaches and have a feel of their capacity, resources, and preparedness to respond to the situation when water has reached their outlet as well as problems regarding maintenance and operation and their crop preferences, dates when water is required along with choices of intervals of waterings. A manager who can establish a rapport with the users will be wining half of the operation battle. The operation plan, infact, has to meet the needs & expectations of the users.

3.11 Organization - responsibilities and functions

For planning the system operation, it is necessary to know the organization on the ground, their functions and responsibilities. Maintenance is an inseparable part of operation & so one has to know the functions and duties of the various functionaries. The Executive Engineer, Assistant Engineer. Junior Engineer and the work charged staff, telephone operator, gauge reader, dak-runner and beldar, each has specified duties to perform in the operation or maintenance of the system. Their points of location, times of duties etc. should be clearly known. The Manager has also to know, whether any formal or informal group/committee or association of farmers below the outlet exists to take care of maintenance of water courses/field channels and distribution of water in 'chaks' and organise other on-farm activities.

Knowledge of important provisions in the Irrigation Act & Rules of the state, statutory powers of each of the engineering officers vested by the rules is necessary. The financial powers to sanction budget and programmes should also be known.

3.12 Status of communication : Feed back & monitoring

This is yet another important aspect needing attention for organising efficient irrigation system operation. It enables good and effective monitoring, and issue of instructions. Successful implementation of water delivery schedules will greatly depend on the reliability and efficiency of the communication net work. Joint decision by senior engineers are possible only when important feed back from the field is available to them. The system manager has thus to ensure that the speed is maintained.

3.13 Statutory Provisions and Rules of system operation

It is important to have a knowledge of the statutory provisions in the act and rules framed thereunder for operation/water distribution in the system.

An example of the Northern zone may be quoted, after annexing the province of Punjab in 1849, the Britishers acquired full control of the Indo- Gangetic plains of Northern - India and set up a network of canal off-taking from the rivers - Ganges, Yamuna, Ravi, Beas etc. For necessary control and development of canal irrigation, an act called the Northern India canal and Drainage Act was enacted in 1873. After independence and reorganization of Punjab, this act with minor modifications is still prevalent in Northern States viz Haryana, Punjab, Utterpradesh and Rajasthan. Each state has adopted the act and issued a set of rules or other executive orders to be followed in respect of management of irrigation water.

In Rajasthan, Rajasthan Irrigation and Drainage Act 1954 and Rajasthan Irrigation & Drainage Rules 1955 are applicable. In Gujarat, the Bombay Irrigation act has been slightly modified and is called Gujarat Irrigation act and rules thereof are called Gujarat canal rules. In Maharashtra, Maharashtra Irrigation Act, 1976 and Bombay canal rules are applicable.

Historically the, management of the Irrigation systems largely rested with the beneficiaries. The village panchayat left it to a group of farmers to maintain, operate and manage these in the best mutual interest. In most cases, commands were within the limits of a single village. If benefits extended to more than one village, there was an informal arrangement for consultations between the groups in respective villages in the allocation, distribution and operation of storage reservoir or the main system. Disputes, if any, were settled by the village panchayat. Although the rulers believed in more and more centralisation, still they retained the village as unit. The first civilian department of importance they created was the `Marommat' department to repair and maintain the numerous small systems of irrigation. These departments over a long time grew into the present Irrigation/P.W.D. while Centralisation of administration with the department led to enactment of various acts. A few of them relating with water management are still in use in regions e.g.

- The Madras compulsory Labour Act 1850.
- The Madras Irrigation Act 1865
- The Madras River Conservancy Act 1885
- The Madras Land Encroachment Act 1905

In Eastern Region, the following Acts and Rules are applicable;

- The Bengal Canal Act V 1864
- The Bengal Embankment Act VI 1873
- The Bengal Irrigation Act III 1876
- The Bengal Drainage Act VI 1880
- The Bengal Embankment Act II 1882

The state of Bihar have also framed & promulgated various Rules under the above acts as below;

- The Drainage Rules
- The Navigation Rules 1893
- The Embankment Rules 1916
- Sone, Champaran, Saran, Kamla Canals Irrigation Rules
- The Bihar Public Irrigation & Drainage works rules 1949
- The Sakri Canals Irrigation Rules 1952
- The Damodar Valley Corporation Rules.

In various canal acts provisions do exist to deal with all day to day problems. Some of the provisions in Northern region are illustrated below:

i) The divisional canal officer may demand by issue of an order to the beneficiaries using a water course to construct suitable bridge, culvert or other works for smooth and efficient passage of water in such water course.

ii) The Divisional canal officer can issue directions to provide for any of the components indicated below and get the same implemented through an order;

   a) Construction, alteration, extension and alignment of any water course or realignment of any existing water course.

   b) Addition of any new areas to a water course and increase its capacity or reallotment of areas served by one water course to another or exclusion of areas from one outlet to another.

   c) Lining of any water course or any other work to avoid wastage/loss of water.

   d) Occupation of land for depositing the soil available from water course clearance.

   e) Any other matter which is necessary for proper maintenance and distribution of supply of water from a water course.

iii) The Divisional canal officer can acquire any land required for implementation of a scheme. He can direct the beneficiaries to take over and maintain the water courses and on their failure to comply with directions, he can make arrangements for maintenance of water courses at the beneficiaries' cost in proportion to the culturable commanded areas.

iv) If a person demolishes, alters, enlarges or obstructs or causes any other damage to the water course, the person affected can apply to the sub-divisional officer for issue of directions for restoration of the same to its original condition. If water supplied through a canal is used in an unauthorized manner, and if a person by whose act or neglect such use has occurred cannot be identified, the person who has derived or may derive benefit therefrom, is liable to the charges prescribed for such use.

v) Distribution of water and settlement of differences is done by the Deputy collector (canal) under relevant section of the act. Disobedience of orders under the section is punishable under the act.

vi) A Divisional Irrigation officer with prior approval of Supertending Engineer can prohibit the use of canal water

a) To any field which can be irrigated from any other permanent or reliable source

b) For irrigation of Kharif crop, if land to be irrigated is situated within one and half kilometers from the outer most houses in any town

c) If land has not been prepared properly with plots (Kyaries)

d) If the cultivator has not paid irrigation dues

e) If the cultivator does not adhere to 'Warabandi'

f) To any cultivator where water courses are not in proper condition

g) To any cultivator who does not take water during night

h) To any cultivator who obstructs the flow of water in the water course passing through his field for supply to other cultivators on the same outlet.

Some states have constituted Water Distibution Committees for deciding the water distributionion programme and cropping pattern for the particular season. The committee is headed by the Executive Engineer Irrigation and represented by representatives of Agriculture and Revenue departments, Pramukh of Zila Parishad, Pradhans and Sarpanchs and few farmers of the command area. This committee decides the programme of opening and closing of various channels.

Water Distribution committee meets twice a year i.e. prior to Rabi & Kharif on major projects. Complete programme of running of main canals, distributaries and minors is settled in consultations with Agriculture department experts and the users. Agriculture department officer also advises suitable cropping pattern and/or the number of waterings possible from the available water.

Chapter IV

Hydraulic and Field Surveys for System Operation

4.0 Hydraulic/field survey of the system components is necessary for arriving at the M&O needs for improving the operational efficiency and thereby the responsiveness of the operation plan.

4.1 Survey of system

4.1.1 Approach to field work:

If there are more than one main canal, the canal serving the larger area will of-course be of primary importance, but to begin with, the smaller one may be taken up. The work will be completed sooner to give a feeling of accomplishment . Mistakes, if any, committed on smaller system would provide valuable insights.

The field work on the smallest distributary or minor should be undertaken first. After completing the field work on the smaller distributaries and minors, begin field work on the smaller branch canal and proceed to the main canal viz the principle of part to whole should be followed.

Since many of the structures on the system may be similar or of standard design, it is advisable to calibrate identical structures first. See if results are compatible. If not, reasons should be investigated by checking dimensions and elevations and accuracy of the discharge measurements during calibration.

4.1.2 Bench Mark Survey:

For arriving at the maintenance needs of earthen channels & structures, and developing a maintenance plan and system operation plan, bench mark survey is necessary. Elevation Benchmarks have first to be fixed. A net work of bench marks may already exist on the system. If these were fixed long back, it would be advisable to recheck/refix the same for authenticity. The bench-mark elevations should be true elevations above MSL (Mean Sea Level) & not arbitrary. It is important that the circuit of elevation level survey terminates at the starting point to be sure that elevations are accurate. Whenever any system is closed (in rotation), elevation values for all sill/crest of flow control structures, a fall or escape, or of outlet structure should be assigned. If strip/depth gauges have been provided at the flow control structures, their elevations corresponding to the zero reading on each should be marked.

4.1.3 Hydraulic Survey of Channels:

For assessing the hydraulic status of any channel(s), hydraulic survey is required to be done at least once in two years to ascertain the depth of silt to be removed, restore bed gradient as per design/regime section (a non-silting and non-scouring section) and the quantity of earth required to be filled in the eroded bank or bed. Survey for Longitudinal section of the channel is undertaken and plotted on graph sheet. The designed longitudinal section of the channel is superimposed and areas of silting or erosion worked out for removal or filling. For bank(s) also the designed cross-sections are superimposed. The study of behavior of a canal for some time, may warrant change in parameters in some reaches so that channel attains the regime section. In cases of channels where regime is yet to be attained a regular and periodic watch is needed. This can be accomplished only by conducting regular hydraulic surveys at regular intervals.

4.1.4 Flow control structures:

i) Identification

For efficient water management, accurate measurement of water flowing in the channels and delivered at the outlet is very essential. It is therefore necessary to identify such flow control structures in the system which can be calibrated to measure the discharge. Ideally, the discharge should be measured at every division in the irrigation system but in most projects discharges are measured at the head works of the canals only. The technology for measuring irrigation water is a simple one, but yet it is not included in the routine operation practices on many irrigation systems.

A variety of structures can be calibrated to measure water. The most common are canal sluices (regulators), open channel measuring flumes and outlets etc. The outlet structures are generally uncontrolled, mostly free flow structures, or pipe outlets, or open channel flumes.

ii) Maintenance needs

During channel operation, each structure should be inspected for visible damage and leakage. Most of the flow control structures on major channels would be gate structures. It should be seen that there are no difficulties in operation and there is no leakage. As regards other structures such as falls, escapes, check structures, it should be seen that their crests are intact. If damaged, they should be repaired. Similarly, the outlets should be checked to see that they are of desired sizes and at desired levels. The canal structures have to function both as flow control and flow measurement structures. For operation control, some of them would need to be calibrated for discharge measurements and therefore it is essential to have these structures in good condition.

The canal system should be inspected by the Assistant Engineer by a 'Walk-Thru' survey and maintenance needs for structures listed in a register.

During canal running, the structures should be inspected for visible damage or leakage. For example checking operation of the gates of regulators for repairs that may be needed to check the leakages or for proper lowering and lifting. Fixing of staff strip gauges, bench-mark on suitable locations could be done while canals run to facilitate measurement of water levels later when developing the discharge ratings.

During canal closure, each structure should be inspected. The gates, gate frames and gate structures should also be carefully checked. Falls, escapes and check structures should be carefully verified for crest elevation. Crests should be repaired and levels assigned.

The location and size of the outlets should be checked, and cross-sectional area ascertained to compare with the sanctioned numbers and sizes.

4.2 Calibration of flow control structures:

(i) Discharge calibration:

Calibration is the process by which depth-discharge relationship is established. Standardized flow measurement devices like sharp crested weirs, cut throat or parshall flumes previously calibrated in a hydraulic laboratory can be installed. When doing field calibration on any control structure, water discharge rates corresponding to one or two flow depths are recorded. To ensure correctness, a minimum of four to five readings are necessary. Each reading will contain appropriate upstream and downstream depth measurements and corresponding flow rate. When appropriate data has been collected, a graphical presentation is done for establishing the gauge-discharge relationship, a rating table thus prepared is kept in a plastic case located on the structure. Classifications of control structures depend on their functions and operational nature. Some may be either modular or free flow structures while some may be non-modular or submerged flow structures. The terms modular flow, free flow and critical depth flow have identical meaning wherein a change in the downstream flow depth does not affect the upstream flow depth because the critical depth occurs in the vicinity of the constriction. Likewise the non-modular, submerged and drowned flow have identical meanings. A non-modular flow condition exists when the down stream flow depth is raised to the extent that flow velocity at every point through a constriction becomes less than the critical value so that an increase in the downstream flow depth results in an increase in the upstream flow depths. Control structures designed to operate under modular flow conditions sometimes become non-modular on account of unusual operating conditions like accumulation of aquatic weeds or vegetative growth down stream. Care should be taken to observe the operating conditions of the control structure in order to determine which flow rating should be used. In modular flow condition a reading taken at each upstream gauge depth must have a corresponding flow rate measurement. In a non-modular flow condition, two readings, one upstream and one down- stream are required for each discharge measurement.

4.3 Flow Measurements:

Methods

There are a number of methods to measure discharge. A current meter is generally used for discharges greater than 500 liters per second. When discharges are less than say 300 liters per second, flow measuring flumes like `parshall' or `cutthroat' flumes are used by installing them in the channel. To measure, very small discharge even a plastic bag can be used for collecting the water and repeatedly poured into a graduated volumatric container to find the total volume of water. This is a very helpful method for measuring leakage from closed gate structures.

A. Gauge (stage) measurement:

A staff gauge is placed against the wall of an irrigation structure or on a post located in the middle of an irrigation channel. For modular flow, the staff is located on upstream while for non-modular flow, two staves, one upstream and one downstream are placed. A mark can also be drawn on or top of the wall of the irrigation structure and reading is taken by using a tape to find the distance from the mark to the water surface. This mark establishes a reference point for future readings. When water surface is turbulent, use of piezometer is helpful. A piezometer pipe is placed through the wall of an irrigation structure connected to a stilling well on the channel (Fig. 4.1).

B. Orifice:

Any opening where upstream water level is higher than the top of opening is referred to as an orifice. If upstream water level is below the top of the opening, the opening is hydraulically functioning as weir structure. LBII/WAPCOS technical report 19-A can be made use of for modular/non-modular flow measurements, formulae and methods for calculations.

Head regulators of main canal, branch canal, distributaries are gated orifice structures. Outlets on minors feeding the tertiary system are also uncontrolled orifices. They mostly act as modular orifices but sometimes as non-modular also.

C. Culvert and Inverted Syphon:

Culverts can serve as a combination of open channel and closed conduit flow measurement structures depending on the type of flow conditions. For culverts placed in irrigation conveyance channel, free surface flow occurs in the culvert. In addition, downstream conditions will likely control the depth of flow in the culvert. For this particular condition of free surface sub-critical culvert flow analysis for non-modular (submerged) open channel constriction would apply.

D. Overflow structures:

The most common overflow structure used for discharge measurement is weir. Whereas flume is open channel structure with flow constricted from sides, weir is open channel structure with flow constricted from the floor.

Another common type of overflow structure is a drop structure with curvilinear crest, inclined drop or vertical drop. Over them the flow passes through a critical depth in the vicinity of the crest, so it is modular.

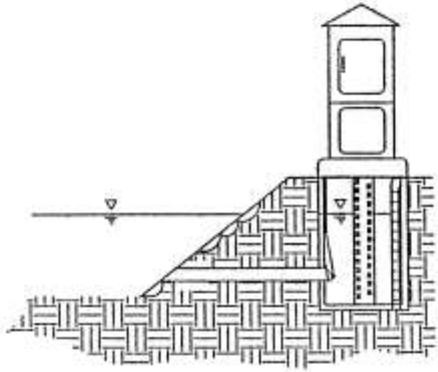
General form of the modular flow equation for an overflow structure are described in LBII/WAPCOS Technical report 19-A which can be referred to.

E. Outlets

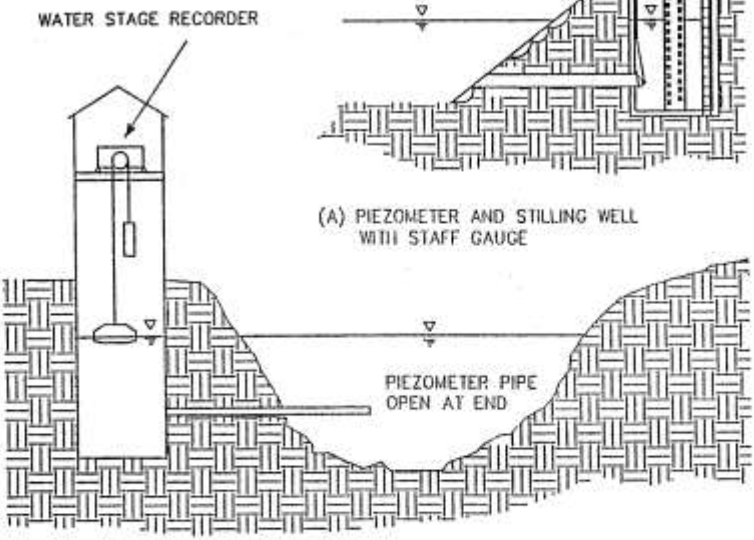
These are structures on the minors to convey water to the tertiary system. They are very large in number and carry a small discharge varying from 0.5 to 3 cusecs. For this, flow range, portable flumes are usually most convenient device for measuring discharge. Either a trapezoidal flume or parshall flume or cutthroat flume could be installed on the downstream of the outlet for measurement.

Following types of canal outlets may exist on a system

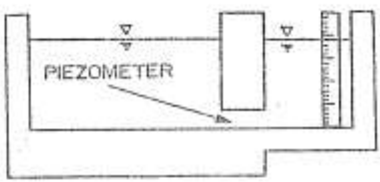
(i) Flume outlets
(ii)Fixed orifice outlets
(iii)Open pipe outlets
(iv) Gated orifice outlets.



(A) PIEZOMETER AND STILLING WELL
WITH STAFF GAUGE



(B) PIEZOMETER AND STILLING WELL WITH WATER STAGE RECORDER



(C) IRRIGATION STRUCTURE WITH ADJOINING STILLING WELL

Fig. 4.1

i) Flume outlets:

A flume outlet is open channel constriction which can operate both under modular flow condition or non-modular flow.

ii) Fixed orifice outlets:

In a fixed orifice outlet, the discharge rate is a function of the canal water level to the exponent of 1/2. Thus the discharge rate increases with increasing water levels in the canal. For a fixed orifice outlet, the free flow discharge rating is drawn with the help of standard formulae. In northern region fixed orifice outlets are provided (Fig. 4.2).

iii) Open pipe outlets:

These outlets are simplest of all so far as fabrication and installation is concerned but are most complex hydraulically. Their discharge rate will, in most cases, be a function of water depth in the canal, hu to the exponent 1/2 or the square root of the difference in water levels between the canal and the tertiary channel.

iv) Gated Orifice Outlets:

Procedure for these outlets is identical to those of orifice structures described above.

4.4 Measuring Channel losses - inflow-outflow and Ponding Methods:

Seepage losses from canals and tertiary channels are a significant problem on many irrigation systems in India. With the increasing emphasis upon improved irrigation water management practices, accounting for movement of water through a system including seepage losses also becomes increasingly important. In order to distribute water in an irrigation system, a knowledge of variation in seepage losses throughout the system is required.

Seepage losses on channels can be measured by inflow-outflow method or by ponding method. Seepage loss can be expressed either in litre per second per 100 meter length of channel or in percentage per 100 meter length or in cubic meter per unit of wetted area.

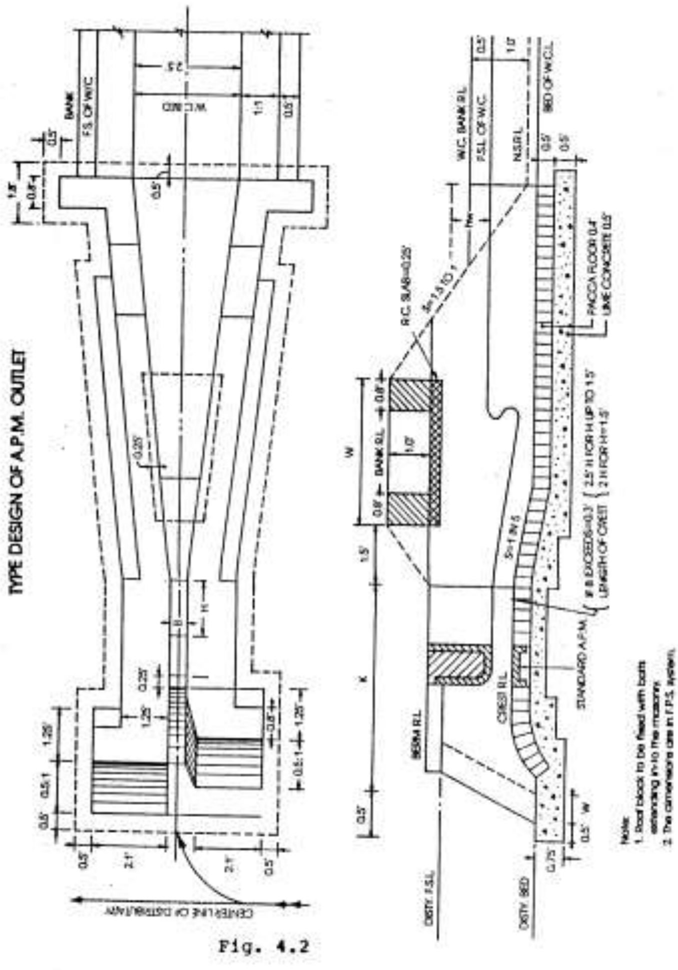

TYPE DESIGN OF A.P.M. OUTLET
BANK
F.S. OF W/C
W/C BED
CENTER LINE OF DISTRIBUTARY
R.C. SLAB=0.25'
W/C BANK R.L.
F.S.L. OF W/C
N.S.R.L.
BED OF W/C L
BANK R.L.
BERM R.L.
CREST R.L.
STANDARD A.P.M.
PACCA FLOOR 0.4'
LIME CONCRETE 0.5'
DISTY. F.S.L.
DISTY. BED
Note:
1. Roof block to be fixed with bars extending in-to the masonry.
2. The dimensions are in F.P.S. system.

Fig. 4.2

Determining canal losses

- INFLOW OUTFLOW METHOD
- PONDING METHOD

- Factors causing seepage
  - Permeability
  - Depth
  - Wetted area
  - Slope
  - Watertable
  - Soil - water temperatures
  - Porosity
  - Soil - water chemistry

A. Inflow - outflow method

In the inflow-outflow method, the existing irrigation structures are used for discharge measurements. The structures for which discharge rating are developed are used for the purpose. Seepage loss rate can be evaluated for each reach between two structures and added up covering the complete canal to evaluate total seepage loss. A series of discharge readings at various times in irrigation season could be taken to assess the variation in seepage loss rates. Installing temporary flow measuring devices such as V-notch or cut-throat or parshall flumes on small tertiary channels can also be helpful in these observations.

Current meter can also be used for inflow-outflow method on large canals, the difficulty with the use of current meter is that the seepage losses need to be much greater than the possible error in observations. If seepage loss rate is low, a very long reach has to be selected for measurements.

B. Ponding method:

Reaches with minimum number of canal outlets are preferred for the test. During seepage loss measurements, the outlets have to be plugged so that there is no leakage. If it is not possible then the discharge through each of them has to be accurately measured. The length of pond depends on the bed slopes of the channel. For flatter slopes in channels, longer ponds will be required. The actual method is described in details in technical report no. 19-A brought out by LBII/WAPCOS which can be referred to.

4.5 Seeking farmer's input for system operation:

Involving the farmers in the maintenance and operation of the system is not only essential but very useful too. An inbuilt system should therefore be introduced on a project which would enable the departmental hierarchy to have regular contact with the beneficiaries to "listen" to them. Sometimes they would know the problems as also their solutions in operation and maintenance of the system better than the field officers. Some finer issues which may not come to notice during hydraulic surveys can sometimes be identified through farmers. It is therefore adviseable to form "Irrigation Committee" at each sub- divisional level for the irrigation works in a sub-division. The committee may consist of the concerned Assistant Engineer as its convener, the concerned junior engineer of the section and the farmers. The supervisor of that section should also attend the meetings.

The meeting of committee should be convened every week during the crop season on fixed dates, at fixed place and fixed time, notified in advance. Stations could be fixed in the sub-divisional jurisdiction to hold these meetings. Place of meeting should be such that farmers do not have to walk more than say 3 km to attend the meeting. All problems/suggestions put forth by the farmers during the meeting should be recorded in a register and entries should be again made as soon as each problem is redressed or action taken. Efforts should be made to mitigate the problems say within a month i.e. by the time next meeting is held at the same place.

An Irrigation Assessment and Action programme on the Periyar Vaigai Irrigation system has been launched in Tamil Nadu to enhance communication between the Irrigation Department and the farmers. Each section officer is required to be in his office every Monday at 4 p.m. during irrigation season to meet the farmers, when both operation and maintenance problems are discussed. Such committees would be highly helpful in seeking farmers' advice and their involvement in maintenance programme. This would also create in them a sense of ownership of the system and a confidence in the department. It will also enhance credibility.

4.6 Diagnostic "Walk-thru" survey - objectives and procedure.

Some times the field surveys may not provide minor details of the needs. So a 'walk-thru' survey is necessary to have detailed insight of the problems. This also helps in proper diagnosis of the causes aad possible remedies. Such 'Walk-thru' survey provide the field personnel greater understanding and sensitivity.

Before the Diagnostic 'Walk-thru' survey, four major activities pertaining to the (i) Hydraulic Survey of channels, (ii), Calibrating the flow control structures, (iii) Measuring Irrigation channel losses and (iv) Input by farmers should have already been accomplished.

The primary information obtained from the Hydraulic Survey of channels, viz the quantities of sediment to be removed from various reaches and the locations where either the banks or bed require earth fill can be verified during the walk-thru survey. Causes of scour or sedimentation can also be diagnosed on the spot.

Similarly the correctness of the discharge ratings on flow control structures can be tested by comparing the actuals with the design discharges.

Information obtained during channel loss measurements would identify reaches of high, intermediate and low water losses.

During walk-thru survey, a study of high & low water loss reaches could be done and it may be possible to diagonise the causes of such high or low water losses by on the spot study of the physical conditions and environment like soil type, cut and fill reaches, biological activity in the embankment or depth of the ground water in adjoining area.

This survey requires two or three individuals such as Assistant Engineer, junior engineer and his supervisor walking along each irrigation channels and taking notes on each O&M need. While `driving-thru' may highlight only the major problems, walk-thru would allow observation of minor maintenance and operation problems which can be readily corrected at less cost before they become expensive major problems.

Chapter V

PREPARATION OF IRRIGATION SYSTEM OPERATION PLAN

5.0 Irrigation System Management

Preparation of an irrigation system operation plan is an important activity of the management which can induce discipline in the operators and gain credibility with the users. It warrants the use of professional skills of the manager and good inter-active rapport with the users. The manager has to know the system, its capabilities and the degree to which it can respond to the farmer needs. The object is to get better farm yields with the same volume of water. The system manager has to be on the vigil, using administrative discipline to enforce equality.

5.1 Irrigation Systems Operation Plan - Need for

The river and stream flows are community assets. When water is stored/diverted by building a dam or a weir, the allocation for different uses will depend on the priorities e.g. water for drinking purposes, bulk of which is used for agricultural purposes. For delivering this water to the fields, a network of channels (main canal, branches, distributaries, minors and water courses) is constructed with large investments. Efficient utilization of available water depends on the efficiency of the system operation plan.

The delivery system should be capable of providing uniform quantities of water on the principles of equality and predictability. The ideal object would be supplying the right quantity of water at the right time. But several physical factors may prevent achieving this objective. Thus the least acceptable would be adequacy and predictability. This means that a plan to operate the channels is carefully drawn up. The farmers are involved in decision making for this activity of water management. Various pre-requisites for arriving at the plan of system operation are;

* Inflows into the reservoir are determined realistically.

* The channels (whether lined or unlined) have a fairly physical status (conveyance efficiency).

* Operational losses in the system are properly determined.

* The actual deliveries are well monitored and there is an effective feed-back system.

* All the individual functionaries clearly understand and perform their duties in an appropriate manner..

* The rapport and continuous interaction between the system managers and farmers is maintained.

Adequate maintenance of the channels together with properly designed outlets will further improve the system performance. The identification of deficiencies in the system and solutions have already been discussed. Corrective measures to ensure adequate functioning of the delivery system have to be taken to sustain capability and credibility. For improving an operation plan, the following steps are necessary:

i. Estimation of water supply available.

ii. Estimation of water demands.

iii. Matching of supply and demand.

iv. Evolving schedules and/or measures to meet the situation.

v. Preparing schedule of releases.

vi. Inter-action with users.

5.2 Objectives of a System-Operation Plan

Water releases into the irrigation system during the season should match the demands of the farmers who follow a cropping pattern most appropriate for them. It is the responsibility of the system manager to keep this priority in mind while distributing water. The water distribution to farm lands is to be achieved through a conveyance network system which should:

i. Be flexible enough to carry peak/partial flows at constant water levels.

ii. Deliver a predictable quantity of water at predetermined times.

iii. Deliver water to the service areas identified in accordance with the policies of the Govt. for the region/scheme/area.

iv. Entail minimum channel losses.

v. Provide accurate flow control and measurement

vi. Meet the expectations of the farmers.

5.3 Types of System Operation Plans

At the formulation stage of any irrigation system, water requirements are worked out on an assumed cropping pattern, for each month of the crop season. The channel design is arrived at giving due weight to the climatic conditions and watering depths for those crops. These computations are listed in terms of percentage of the peak requirement termed capacity factors. The capacity factors form the yardstick to run the channels. The variable is the duration of running time. Due to these capacity factors the canal rotation becomes essential. The channels during flow should attain governing levels and head of water over the outlets, which can draw their share of water only when the designed head of water exists.

The first step for the system operator is to find the water available for agricultural use. The following situations can arise which will determine the type of 'Operation Plan' for the system;

1. Supply is equal to or more than demand.

2. Supply is moderately less than demand.

3. Supply is much less than demand.

4. Supply is far less than demand, calling for emergency measures.

5.4 Steps for Preparation of Irrigation System Operation Plan

The preparation of an irrigation system operation plan is an exercise in which the manager uses his professional skill giving due consideration to the various concerned issues. To properly understand the system capabilities and to rectify gaps the following steps are followed:

Step I. Know the System

- System components
- Design parameters
- Objectives implemented
- Farmer interaction/participation
- Cropping pattern and activity related
- System of water distribution

- Channel and operational losses
- System efficiency
- Monitoring & communication practices

Step II. Field Survey Requirements (discovering the gaps)

- Hydraulic and bench mark survey
- Identification of flow control structures
- Discharge measurements

    * Network
    * Outlets

- Channel loss measurements
- Calibration of structures
- Information from farmers
- Diagnostic 'Walk-Thru' survey
- Implementing solutions

Step III. Assessment of water availability

Step IV. Assessment of demand

Step V. Matching supply and demand

Step VI. Evaluate operational efficiency

Step VII. Evolve schedules or measures related with cropping activity.

The first two steps, 'Know the System' and 'Field Survey Requirements' for discovering the gaps have already been discussed in preceding chapters. It shall therefore be appropriate to now proceed with the remaining steps on preparation of an operation plan.

5.5 Assessment of Water Availability

The assessment of water available from the source is based on a number of physical factors, such as soil conditions and climatological factors. It has to be realistic, for calculating the water availability, the hydrology of the area has to be properly analyzed to arrive at a reliable estimate.

The use of hydrology is made to predict floods, their extent & magnitude. The discharging capacities of surplussing arrangements on the storage dam are fixed after carrying out hydrological studies. Analysis in terms of time & frequency is carried out to predict the maximum flood, full tank level (FTL) and maximum water level (MWL) of a dam are fixed for storage, flood protection, flood routing etc.

Text books on Engineering Hydrology can be referred to for the purpose of detailed procedures. However, for medium & minor irrigation systems, in India, empirical formulae are still in use. For major storage schemes or diversion works hydrological studies are carried out to support the formulation. Medium & minor works are taken up on smaller streams and flow-discharge data are often not available or scanty and empirical formulae with proper values for characteristic coefficients are chosen. Maximum flood values are also determined with the help of empirical formulae for the region. It is, however, better that rain gauge and discharge observation sites are fixed in representative sub-water sheds to arrive at rainfall and runoff relationships for all time use. This could be done or started even during operation phase of the project.

It may, however, be appropriate to recall briefly the definition of run-off and other terms used in hydrology, factors governing run-off, characteristics of catchment and other considerations.

5.5.1 Approach for determining Water Availability

The assessment of water availability is carried out with the help of a number of data from various sources. It is processed in the formats and then analyzed as per established practices. Various steps are;

a. Collection of stream flow gauge data, if available. Collection of rainfall data from properly located rain gauges, river or stream, cross sections, long sections, & other characteristic details.
b. Correlation of stream flow & rainfall to arrive at a relationship equation/curve
c. If data is not available, statistical methods are to be followed.
d. Obtaining isohyetal maps & using empirical formulae
e. Determining losses in the stream, reservoir & the system.
f. Assessing sediment behavior.

5.5.2 Factors affecting the availability:

The factors affecting the flow likely to be available (run-off) from a catchment are:

i) Precipitation characteristics: Such as types of storms, extent, duration and intensity. Distribution and direction of storm intensity with time, effects of proximity of water bodies, and types of precipitation, (such as snow melting) causes a direct impact on the run-off.

ii) Geological features of the catchment

(a) Type of surface soil and sub-soil and the permeability characteristics.

(b) Location of the point of discharge.

The forces which produce physical features may be internal, such as Earth movements or external forces like forest denudation & deposition.

iii) Topography

The degree of ground inclination is a very important factor related to infiltration capacity, time of overland flow and concentration of rainfall in stream channels. The slope is of direct importance in relation to flood magnitude, other factors are (i) orientation of the basin (ii) Altitude of the basin & (iii) Physical character of the basin.

iv) Size and shape of the catchment

Between the catchment areas of two individual streams an area of higher land separates the surface water flow to either side. These may be major 'divides', between two complete river basins or minor 'divides' between tributaries. The catchment area is bounded by the topographic water shed and contribution to run-off is characterized by the following generalizations:

* Usually intense rainfall is over a small area i.e. the larger the catchment area, the smaller is the average intensity of rainfall.

* The peak flow often decreases as the area of the basin increases.

* Large basins give a more constant minimum flow than smaller ones.

* Fan shaped catchments give greater runoff.

v) Meteorological conditions

Temperatures, annual and seasonal, variations and duration, timings of extreme low and high temperatures, all affect the run-off.

vi) Catchment pattern

There are two kinds of patterns. Autogenic: Which are inherent in the river regime and involve channel migration, cut-offs, crevassing, avulsion etc. Secondly which occur in response to system changes like, climatic fluctuations or altered sediment load or discharges, perhaps a result of human activity.

The pattern or arrangement of the natural stream channels developed by nature is also known as 'drainage net'. If the basin is well drained, the length of overland flow is short, the flood peaks are high and the minimum flow is correspondingly low. The more efficient the drainage, the more flashy is the stream flow and vice versa.

5.5.3 Estimation of run-off

Runoff is estimated by various methods:

a. Empirical formulae and tables

b. Estimating losses

c. Infiltration method

d. Rational method

e. Unit hydrograph method, and

f. Synthetic unit hydrograph method,

Methods a to d above are mostly used for computing surface run-off. The other two (e & f) are used in flood forecasting and/or routing. If stream flow and rainfall data are available, the co-relation should be established for finding run-off yields. These exercises are carried out for major systems. For small schemes adoption of empirical formulae and tables are of ready help taking care in selection of the coefficients.

5.5.4 Empirical formulae and tables

There are a few formulae and tables prepared by eminent engineers in the country after lot of observations and analysis. The run-off is calculated on the basis of catchment area, rainfall and geological characteristics of the catchment. These researchers determined values of the characteristic coefficients and even percentages of the total precipitation expected at any location in the river or stream. Different values have been assigned for urban, forest, commercial and industrial areas, parks, farms, pastures, pavements, clayey soil, sandy soils, black cotton soils, flat and cultivated, partly cultivated, hilly, steep, without cultivation areas, etc. The catchments have also been defined as 'good', 'bad', 'average', 'dry', 'damp' or 'wet' etc. The incidence of rainfalls has also been variously distinguished like, light rain, continuous down pour, heavy down pour, intermittent pours etc. These have also been defined as 'negligible', 'light', 'medium' or heavy falls. The commonly used formulae are:

i. Binnie's percentages	(Madhya Pradesh)
ii. Barlow's tables	(UP)
iii. Strange's tables	(Maharashtra)
iv. Inglis & de-souza formulae	(Maharashtra)

Strange's tables have been used in the example of Rajasthan. Reference to text books for further details is advised.

The annual/seasonal yield can be worked out with the help of the formulae for the data of rainfall for a number of years. These computations can be arranged in descending order to verify the dependability quotient for the reservoir contents (90 or 75%). When rainfalls are erratic the commonly adopted design criteria is based on mean flows (50%) for better carry-over of water for lean years.

For computation of surface run-off by (i) Estimating losses (ii) Infiltration method and (iii) rational method, a reference to the text books is advised. Determination of run-off on large catchments has to be supported by data of actual & reliable observations.

5.6 Assessment of Demands:

After arriving at a reliable estimate of water likely to be available, the next step in preparing the system operation plan is assessment of demands. It is necessary to seek farmer participation and inter-act with them to arrive at an acceptable and implementable plan. It is essential to develop a rapport with the farmers and to become familiar with their capabilities & resources.

There are practices in some states where beneficiaries are to apply for water indicating are and crops proposed. These applications are scrutinised by the management and sanctioned in accordance with the overall policies. There is also the practice of executing 'contracts' for longer periods. These practices exist in particular areas and have been practiced over a long period of time. The principles governing releases of water however remain the same either under these practices (shejpali) or others.

5.6.1 Farmer participation/interaction

Holding of meetings with farmers of the area and deciding the duration and quantum of water supply is one of the important step for preparing a system operation plan. The beneficiary knows the cropping practices comprehensively. His involvement in the preparation of the plan is essential. Including farmers in drawing up the policies for preparation of the system operation plan and at various other stages of irrigation system operation is bound to induce the spirit of ownership and commitment to the plan. While preparing the plan, their needs, expectations and capabilities should be taken into account to increase their commitment for successful implementation.

Farmers decide their crop preferences, achieve capabilities and preparedness. Therefore, this interaction & involvement is bound to give good results and an effective plan. The farmers also play a very important role in attaining equitable water distribution and maintaining field channels in good operating condition. The objective for the manager should be to:

i. Know their need and crop preferences.

ii. Know their capabilities and preparedness

iii. Ensure farmers' commitment and acceptance

iv. Earn credibility with them.

Any deficiency in performance should be attended to with promptness and commitment. Successful farmer participation will thus lead to:

- Elimination of inequitable distribution of water

- Development of good social practices by farmers enhancing the utility

- Prompt & efficient use of water on the farm by way of construction and maintenance of field channels and adoption of improved practices.

- A sense of system ownership by farmers.

- More effective implementation of distribution policies.

- An atmosphere of coordination, confidence & credibility.

5.6.2 Steps for assessment of water demands.

The assessment of water demands needs careful appraisal. Various types of demands can be:

* Drinking purposes
* Industrial
* Pisciculture
* Power generation
* Environmental
* Silt extrusion
* Agriculture
* Flood moderation

These requirements have therefore to be accounted for in order of priority to determine the quantity available for irrigation purposes.

5.6.3 Consideration of Soils:

There are bound to be different types of soils (Fig. 5.1) in the command ranging from pervious to impervious. Pervious soils would need more frequent irrigations than impervious ones. So, to decide the frequency of irrigation, soils should be got tested for their water retentivity.

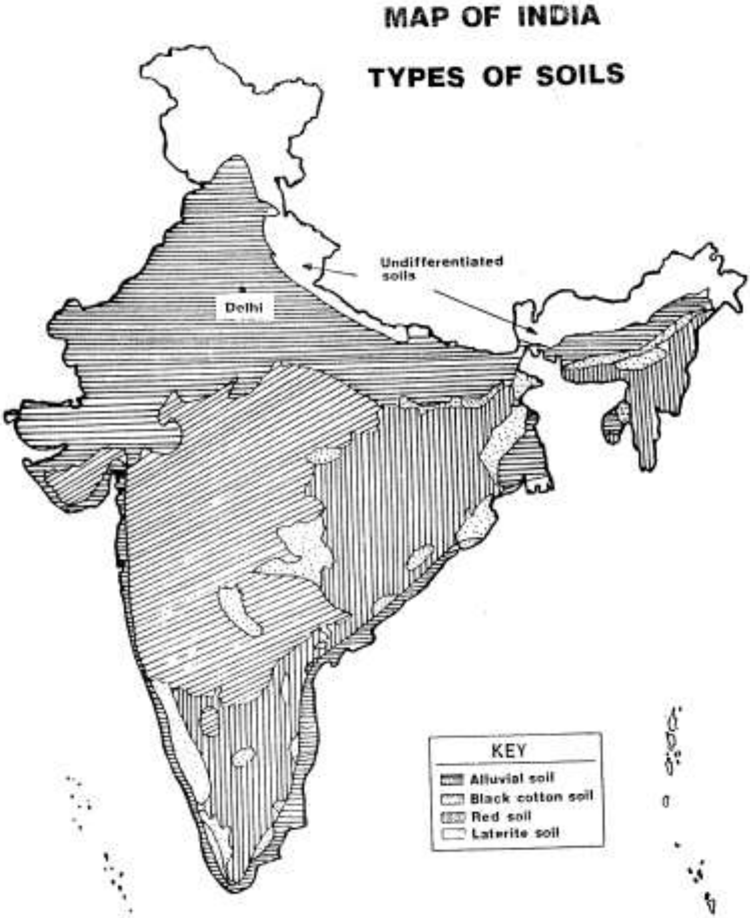

MAP OF INDIA
TYPES OF SOILS
Undifferentiated soils
Delhi
KEY
Alluvial soil
Black cotton soil
Red soil
Laterite soil

Fig. 5.1

5.6.4 Water Demand for irrigation purposes:

The demand for irrigation is linked with the soil and land, which is fixed. It is also linked with the cropping pattern which is a dynamic process and on which the irrigation manager has little control. Care should be taken to plan releases of water according to the demands which can be worked out on the following options:

* Cropping pattern based (conventional - projected)

* Crop-water (growth-stages) depth methods

* Evapo-transpiration depth method.
  The most common procedure practised by most irrigation managers in the country is original system design cropping pattern based. This means supplying water as per parameters adopted at the time of installation of the system. Although this may be in variance with realities.

(i) Based on projected cropping pattern:

The difficulty of foreseeing the expected cropping pattern varies according to the degree of freedom allowed to farmers in choice of crops and the timing of their cultivation activities. It is easy on land settlement projects with an integrated management. The government, through the operating agency, controls the cropping pattern (and, often the timing of cultivation activities). Demand can also be controlled by control over the water supply (permitting highly water-consuming crops in some areas which receive sufficient water). Legal limits can be placed on the areas to be covered by certain crops.

Free choice of crops depends on market demand which will be the determining factor. The farmers are permitted choice on the cropping pattern for better returns. This makes the task of the irrigation manager more difficult. To overcome the complexity, inter-action with the farmers will provide the manager with insight to plan the releases. Although the network may have been designed for an anticipated cropping pattern, channel capacities must still meet the requirements of an altered cropping pattern. There is thus a need for the manager to work out the demands accurately to see that the system can respond to the changed circumstances as well as possible.

In irrigation schemes where management can exercise authority over the cropping pattern the balance between the cropping pattern desired by the farmers and the management can be by approval or rejection of application forms. The farmer's proposal is examined by the management and is informed whether his form is rejected, approved or modified. If rejected, the farmer must propose another cropping pattern. This procedure will prove fruitful if the farmers are knowledgeable enough to select crops suitable to the soils, climatological characteristics and water availability constraints.

If the management has no authority over the cropping pattern, it is necessary to study the trends in relation to different crops. This should be done in the operation manager's office, although mostly it is collected by other government offices.

For accurate calculations of monthly water requirements, information is needed on the expected cropping pattern and the actual water requirements (stages of crop growth) under different soil conditions. Thus there is a need for a small planning unit in managers office - at least in a large project, where such data can be collected and analysed.

The requirements thus known, the calculation of the monthly crop water requirements can be made. A variety of well known formulae exist to undertake this exercise. (Irrigation and Drainage Paper No. 24 FAO 1977)

(ii) <u>Based on crop-water need (critical stages of crop-growth)</u>:

The requirement of water is worked out to meet the water deficit at the stages of growth broadly identified by research (Annexure I). For example for wheat crop the stages have been identified as:

Growth stage for wheat	No. of days after sowing
a. Crown root initiation (core watering)	20-25
b. Tillering	40-45
c. Jointing	55-60
d. Flowering	85-90
e. Milk Formation	100-105
f. Dough	115-120

Depth of water required for each of these stages is worked out in light of climatic conditions viz. temperature(s), moisture, wind velocity, rainfall, etc.

Such periods of growth for various crops in the country have been identified by the research organisations and can be used to work out seasonal/monthly/fortnightly demands to schedule the releases into canals accordingly.

The term water requirement of crops implies the total water required at the field head to mature the crop and does not include transit losses. The term consumptive use (CU) means the water loss due to Evapo-transpiration (ET) plus that used in the plant metabolism. Since the water used in metabolism is negligible, the two terms are synonymous.

The amount of water required to replenish the soil moisture deficit back to field capacity for the entire crop growth period is stated as the total water requirement. Water is also needed for special purposes like leaching excess salt(s), puddling, pre-planting irrigation (palewa) etc. The water requirement (WR) of crops may be expressed as

WR = ET or CU + Application loss + special needs

Water requirement of crops (WR) can be expressed in terms of source of water from which these demands are met, as:

WR = IR + ER +S.

The IR is the irrigation requirement of crops at field head. It is the gross amount of water applied through irrigation. ER is effective rainfall i.e. the total or fraction of rainfall that forms part of consumptive use (CU). The S is the amount of moisture contributed to CU from the soil profile either as stored moisture in the root zone and/or that contributed from the shallow ground water table.

The IR can best be determined directly by conducting field experiments based on the modern concept of soil water or plant water requirement. Field equipment of appropriate size and kind can give more talented parameters like IR, ER, S, runoff, percolation losses, etc. But these facilities not being available for estimating WR it is necessary to measure ET which can be measured directly by soil moisture depletion studies in the field. In the absence of such facilities, ET can be estimated indirectly. For Pan Evapotranspiration (PET) values calculated by using evaporimeters such as the 'WEMB' standard open pan or by using various empirical formulae. Or one can base calculations on thermodynamic principles, using climate parameters like temperatures, wind velocity, relative humidity and solar radiation. It may be mentioned that "Hybrid" crops are more sensitive and vulnerable to "crop-stress" and need more frequent waterings. Thus it would also be necessary that the incidence of "Hybrid" crops is kept in mind while determining the requirements.

(iii) **Based on crop water requirement (Evapo-transpiration):**

This method is based on the depth of water needed to meet the water loss through evapo-transpiration of a disease free crop, growing in large fields under non restricting conditions including soil, water and fertility and achieving full production potential under the given growing environment. The general equation used for working out the requirement is;

$$E_T\,crop = K_C \times E_T O$$

Where E_T crop = Evapo-transpiration depth required (mm)

K_C = Effects of crop characteristics on crop water requirement called crop coefficient

$E_T O$ = Rate of evapo-transpiration (Reference evapotranspiration) from an extensive surface of 8-15 cm tall, green cover of uniform height actively growing completely shading the ground & not short of water. (FAO Irrg. & Drainage paper 24)

The value of K_c varies from crop to crop, critical stages of crop growth & prevailing climatic conditions.

The value of $E\,T_o$ (mm per day) can be determined by any of the 4 methods prevalent at present. It can vary from year to year depending on the climatic scenario.

a. Blaney - criddle method
b. Radiation method
c. Modified Penman method
d. Pan evaporation method

5.6.5 A sample case study on crop water requirements (Inder Mohan March'89 - CBIP) shows requirements by the Modified Penman method (Annexure II). The study for Bhakra System, evaluates existing scheduling of irrigation for Rabi crop only where the water allowance is 2.75 cusecs per thousand acres of CCA. Other features considered were :

a. The canal system was partially lined.
b. The system has been in operation for a long time.
c. The tendency of the farmers was to spread the available limited water over a relatively larger area.
d. The efficiencies were adopted as below;

Conveyance efficiency	75%
Field Channel efficiency (outlet to field gate)	85%
Field application efficiency	80%
Overall project efficiency	0.75x0.85x0.80: 0.51 or 51%.

e. The cropping pattern (Rabi):

Wheat	22.8%	
Gram	7.6%	
		Total 40.3%
Oilseed	7.6%	
Fodder	2.3%	

f. Cultivable commanded area: 11,66,000 Ha
g. The depth & frequency of waterings were based on suggestions of the Haryana Agriculture Department and Haryana Agriculture University.

The findings are summarised below:

(a) Requirements per ha by modified penman method were 3942 CuM (field)

(b) Requirements per Ha by stages of crop growth were 3080 CuM (field)

(c) Supplies actually made in 10 years period (@ 2.75 cusecs per 000 acres) were 2796 CuM(field)

In this case, if water was available, it would be desirable to meet the crop-water based on modified Penman method. In scarcity, a judicious decision to meet the demand based on crop growth stages, duly supplemented with ground water will be necessary so that crop yields do not suffer.

5.6.6 Irrigation system efficiencies

After calculation of the demand, the efficiency of the water distribution system and application efficiency must be known. This usually is the weakest point in estimating the demand. Such evaluations are rarely made in the field because they are time consuming. These functions could be integrated within the irrigation managers service office. The important thing is that they are carried out by someone. A good irrigation system incurs minimum operation losses. Main system losses include losses in the main canal, branches, distributaries & minors upto the outlet heads. For calculation of overall system efficiency the losses in water courses and field applications also play a part.

5.7 Matching Supply and Demand

There can be situations when water is released from head works also for non consumptive use e.g. power generation, flood moderation, silt extrusion or environmental requirements. The water demand as worked out above will hold good, but appropriate scheduling to use the available water will have to be done. The resulting effect on matching the demand & supply can be;

(a) Supply may be more or equal to the demand: a situation which will pose minimum problems in distribution.

(b) Supply may be moderately less than the demand: a situation calling for appropriate scheduling/ rotation of canals.

(c) Supply may be much less than the demand: a situation when mandatory canal scheduling/ rotation may have to be resorted to.

If supply is far less than the demand, it would require canal scheduling known as "Distress-Regulation" or "Crisis Management".

After the water availability and water demands are known, the system manager has to match them and evolve a manner of releases which would correspond to the crop needs and farmer-expectation and thus the need to establish a rapport with farmers.

The most skillful part of the exercise begins in deciding the water distribution practices or resorting to other measures to achieve the closest possible matching of supply & demand.

The possible situations for matching supply and demand can be any of the three above (a,b, or c). The considerations in evolving the schedule may be;

i) Systems where water supply is more or equal to the demand.

This is the most favorable situation from management point of view. The systems with sufficient water are easier to operate, but are likely to be less efficient in terms of returns per unit of water than systems with some degree of scarcity. This kind of situation may exist during the construction period or on incomplete schemes and in initial years of irrigation development in a command, when demand is lower than supply.

In technically well designed schemes, supply and demand should match fairly. It is not only important to check the seasonal volumes needed but also if the demand in the peak month can be met. When the supply is lesser than the peak month demand, a corrective measure can be to advance the planting dates of some crops to avoid coincidence of peak demands.

ii) Systems with a moderate water deficit

A moderate water shortage (10-20% of the design), is often encountered in irrigation schemes. This can also be a periodic situation only in "dry" years. In the first case, it is normally an accepted risk in the design of an irrigation scheme, while in the latter it may be attributed to designed intensity of irrigation for larger social spread. Although other factors like changes in cropping pattern, over estimation of water supply, technical deficiencies of the system, etc. may also lead to this situation. Whichever the case, these systems offer the best return from water.

Suitable water distribution practices combined with some of the measures discussed later can be useful in matching supply and demand. Most of the irrigation systems in India face moderate deficits from year to year, thus requiring the manager to exercise his skill and judgement in evolving a schedule of releases of water.

iii) Systems where supply is much less than demand:

There are many irrigation schemes, which command much larger area than can ideally be irrigated. The water shortage may be greater than 50 percent. These schemes may not have been designed to irrigate whole of the command area or may be to irrigate (area) less than 100 percent for benefitting as many people as possible. Some can be a result of under-evaluation of crop water requirements. These projects gave yields lower than expected.

5.7.1 Measures to match supply and demand

Several measures and water distribution practices can be used to reduce the gap between supply and demand, applicable mostly to situations described under (ii)and (iii) above.

The measures to reduce the gap between supply and demand are related to:

a) Cropping pattern

b) Water distribution practices

c) Water fees.

(i) Measures related to the cropping pattern

There are three crop related measures which can be applied to reduce water demand: (a) changing the planting time; (b) changing the existing crops for others with lower water requirements; and (c) reducing the irrigation area. These are the most effective to reduce water demand but they are also the most difficult to implement, requiring authority to introduce changes in the cropping pattern. A long dialogue between the management and the farmers is needed to convince them of the necessity for these measures. They are effective in the following ways:

a. Shifting or alternating planting dates to reduce peak demand. For instance, water supplies can be carefully varied according to the stage of crop growth and farmers made to know that to get enough water at periods of peak requirements (for land preparation, etc.) they must keep to a pre-planned time table. Careful scheduling of this kind allows controlled staggering of cultivation activities between different sections of the system.

b. Changing the existing crops for others is another effective measure to reduce demand, but the condition being that the two crops have similar benefits for farmers, that is domestic requirements, financial returns, labor requirements, risk, input investments and by-produts, (fuel, fodder, etc). The possibilities of applying this measure are therefore limited.

c. Reducing the irrigated area is the most expedient way of reducing the demand, but difficult to implement. Rather than reducing the irrigated area, the usual is to reduce the water allocation which should mean reduction in the area. Some methods of reducing the cropped area are:

- eliminating the areas farthest from the distribution point (quite common in small tank schemes in South India where the farmers may have fragmented holdings, some near the tank, others farther away).

- giving water to certain sections of the command area only, with the sections rotated from season to season. This is feasible only where irrigation is supplementary and other sections are able to grow rainfed crops in the season concerned. It is also only possible if good farmer participation and cooperation exists.

ii) <u>Measures related to water distribution practices</u>

There are only two water distribution measures that can be used to manage a water deficit:

- reducing the water allocation but keeping the same distribution method;

- changing the water distribution method to a more efficient one.

a. Reducing the water allocation can be effected in different ways:

1. Allocating water to preferential crops: This can be practiced where high value crops (fruit trees, nursery produce, vegetables) are grown. The valuable crops receive the necessary allocation and whatever is left is utilized for the other crops. This is easy to implement if goals of the farmers and the management are the same.

ii. Decreasing the amount of water per irrigation: This can be done in proportion to the deficit without regard to the crop yield or, by trying to decrease water in a way that the effect on crop production is minimized. The first alternative is commonly adopted because of its simplicity, the second offers a much better possibility but requires a thorough understanding of the critical growth periods of the crops concerned. Its effectiveness decreases with the number of crops grown because the intervals and critical growth periods for some may not fit the others.

With measures like these, the reduction expected is moderate. Large reductions in flow will often hamper the operation of canals.

iii. Extending the intervals between irrigation is a measure commonly used to meet water shortages. If in one given year the system is able to provide 6 waterings, the following year the supply may be only half and the system may deliver 3 waterings at double intervals of time. This measure is most common, but efforts should be made for giving the 3 irrigations at times when the crop can make the best use (growth stages). The effectiveness of the method is also influenced by the number of crops grown.

b. Changing the water distribution method: Among the different distribution methods, some may be more efficient (assuming comparable situations of management and technical design) than others. The possibilities of changing, distribution method are limited because of it's link with a specific technical design. Changing the method may also require changing the physical system. Even if there is no need to alter the physical system, a switch is difficult because farmers get used to a particular system. Such changes if intended, should be tried in pilot areas and then extended to other areas if positive attributes of the new method have been demonstrated.

iii Adjusting water fee policies:

Increases in the water fees tend to decrease the amount of water used. This measure should be exercised with great care and only where the preconditions for its use exist, the system must be equipped with measuring devices at the farm level, and supply is on the basis of volume. This can either be considered at Minor Level (Farmer Organization) or at the outlet point. Another requirement is that the farmer must have understanding of soil-plant-water relationships, otherwise he will continue to use the same amount of water as before and simply pay more for it. This method can hardly be adopted in a foreseeable future, and may not even prove equitable.

5.7.2 Canal Scheduling for Water Distribution

Canal scheduling is done for distribution of available water in an organized & equitable manner. When water is run in the channels continuously, i.e. for paddy areas, it generally does not prompt optimum use. Water losses in the channels as well as in the field are significant. This can lead to an inequitable situation, the head-reach farmers thriving at the cost of tail-enders.

5.7.3 Objectives for canal (rotational) water distribution

The rotational system of water distribution in the event of shortage of water can infuse a sense of equality (in joy or sorrow) amongst the farmers. The objectives should be;

i) Allocation of Water for social justice and equality.

ii) Predictability

 (a) In time & duration
 (b) In quantity

iii)Equality from head to tail.

iv) Orderly distribution.

v) Punctual running of the channels as per predetermined programme.

vi) Maximizing benefits.

Each of these objectives (and advantages) are important:

i) Allocation of water for social justice and equality: In case of shortage/fluctuations in water supply, the distribution should be based on social justice and equality. While various measures to overcome situations of shortage have been explained, the basic object of designing a system to irrigate less than 100% of CCA is to spread the benefit to as large number of farmers as possible. The system manager should also likewise choose a rotation which supplies water to all the traditionally irrigated area rather than a reduced or restricted area. This may not enable ideal crop yields, but will infuse a sense of equality, either supply water at long intervals or for lesser depths in the field to all the area, 'head to tail' of every distributary/minor.

ii) Predictability in time, duration and quantity: The rotational plan for channels should ensure running of the distributing channels at their authorised full supply levels at prefixed timings, so that the canal outlets have their designed head of water and draw their share of water. It is equally essential that farmers are aware of the program in order to anticipate the arrival of water and to make preparations. The rapport of the manager with the farmers again will be of immense use, the farmers can be prompted to form a group to distribute water amongst themselves.

iii) Equality from head to tail: The system manager should ensure that designed full supply levels and 'working head' are kept on all the outlets from head to tail, that each outlet gets its due share, and that there is no over drawal. Vigilance by the system personnel is needed as some of the farmers adopting un-social means can not be ruled out. It has also be ensured that the data of 'Tail-gauge' is particularly communicated to the manager in preference to other gauges to properly monitor distribution.

iv) Orderly distribution: Any socially good system undoubtedly demands discipline. The beneficiary involvement in operation policy management by way of group formation for each outlet command with due weightage to 'Tail' should be attempted. Water should be regulated properly to enable every farm, its due share. Taking water by 'Time-turns (Warabandi)' is a sturdy tool for ushering self discipline.

v) Punctual running of the channels per predetermined program: The rotational running of channels is meant for the farmers and they must know of the releases and closures in very certain terms. Once the program has been well disseminated, the management should see that the running of channels proceeds according to the given program, and that there is no laxity.

vi) Maximizing benefits: The goal of a rotational running program is based on social justice for benefit to the maximum possible. The ideal object would be to supply water as required in the entire command area, but when that is not possible, the next best option is to make do with whatever is available to reach as close to the goal of maximization of benefit as possible.

Most of the Indian systems are water-constrained systems and the rotational running of channels is likely to provide benefits to the largest number of farmers. The managerial instinct has thus to be effective, to win the confidence of the beneficiaries. The Water-short systems prompt a better return from water per unit volume.

5.7.4 Critical stages of crop growth based example of preparing a system operation plan for Rabi Crop (Oct. to March) season (Major crop - Wheat)

Example Exercise : Prepare an operation plan for a storage irrigation (medium size) system with the below mentioned salient features.

1.	Description:	A medium sized (more than 2000 Ha) irrigation reservoir system having a gross capacity of 94.43M³, the dead storage being 1.98 MM³.	
2.	Catchment area:	Gross area	744.96 sq. km.
		Free area (unintercepted)	744.96 sq. km.
	Type of Catchment:	'Average'(Strange's classification)	
3.	Average annual monsoon rainfall (50 yrs):		700 mm (27.56 Inches)
4.	Expected monsoon yield:		96.51 MM³ (3450 m. cft)
5.	Gross Command area:		17,523 ha
	Cultivable command: area		10,860 Ha
6.	Intensity of irrg.:	85% Rabi 13.5% Kharif 98.5% Total	

Anticipated annual irrigation: 10,705 ha

7. Supply sluice cill level: EL 295.42 m.
Top of Dam (Earthen): EL 309.14 m.
Full Tank Level: EL 305.94 m.

8. Network system: Two main canals (unlined), trapezoidal, Left Main and Right Main & minors with the following particulars:

		RMC	LMC
CCA (Ha.)	:	7334	3526
Length (Km)	:	28.4	26.2
Full Supply Discharge (cusecs)	:	249	119

9. Climatic conditions: Sub-tropical with 3 distinct seasons

Kharif (Mid June-Sept),
Rabi (Oct-Mid March) and
'Ziad' (Mid March-Mid June)
Maximum temperature 47°C
Minimum temperature 1°C
Rain - erratic, mostly occurs from July to Mid September, yearly data reproduced below for years 1968-86.

	mm
1968-69	713.10
69-70	663.26
70-71	446.50
71-72	869.70
72-73	490.30
73-74	967.12
74-75	636.25
75-76	826.15
76-77	926.16
77-78	654.40
78-79	614.13
79-80	974.32
80-81	561.35
81-82	419.12
82-83	731.34
83-84	506.18
84-85	458.00
85-86	689.70

10.	Topography	Altitude	260 m to 305 m
		Average Slope	0.2% West to East
11.	Cropping Pattern	Crop	Percentage
		Kharif	19.64
		Rabi	59.21
		Total for the Year	78.85

12. Losses: Conveyance Network Losses = 50%

Tank Losses:	Summer	9%
	Others	6%
	Total	15% (over ten months)

13.	Designed discharge capacity	LMC	119 cs
		RMC	249 cs
			368 cs

Exercise Requirements: Please evolve the following:

i) A system operation plan for the Rabi crop season
ii) A canal rotational plan, if required.

A line diagram of the system is given Annexure III.

Note:

i) Presume the year to be a normal year for purposes of rainfall precipitation.

ii) The agriculture experts advise that a 10 cm depth for pre-sowing and 7.5 cm depth of water should be provided for every subsequent irrigation in the field. The dominant crop is wheat, releases should be planned for the main crop.

iii) The number of waterings and depth may be as below:

I turn pre-sowing	(Field)	10 cm
II & subsequent	(Field)	7.5 cm each

Crop Growth Stages (Wheat)

Stage	Days from sowing
Sowing	0
Crown root initiation (CRI core)	20-25
Late Tillering	40-45
Late Jointing	55-60
Flowering	85-90
Milk Formation	100-105
Dough	115-120

Solution to the example:

Step No. 1: To determine availability of water

a) Catchment Area — Gross 744.96 sq. km.; Free 744.96 sq. km.

b) Rainfall — 50 years; Average rainfall = 700 mm (27.56 inches)

c) Since no observations of river discharges are available, empirical formula will have to be used for determining the run-off. In this case, at the time of formulation of the project Strange's coefficients and table had been used. A reference to Strange's table, which gives the runoff in Million cuft per sq. mile is also made now. For a yearly rainfall of 700 mm (27.56") and classification of the catchment area as 'average' the runoff is 4.63 M. cft per Sq km. Thus the monsoon yield @4.63 M. cft per sq. km. is adopted.

	MM^3
Total yield	96.51 (3450 M.cft)
Gross storage capacity	94.43 (3375 M.cft)
Dead storage	1.96 (70 M. cft)
Live Storage (Net)	92.47
Reserved for drinking purposes	1.81
Deduct reservoir losses @ 15% per annum (10 months)	14.02
Net available for irrigation use	76.83
Water available for the two crops: (in reservoir)	
Rabi Crop	66.5
Kharif Crop	10.33

Note: The above allocations of water for the two crops have been arrived as per indication that the intensity of irrigation is 98.5% (85% in Rabi (winter crop) and 13.5% in Kharif (summer) crop).

Step No. 2

Conveyance Efficiency: It has been indicated in the example that the conveyance system efficiency is 50% ,that is 100 units of water released at head reduces to 50 units at the field. The physical status of the system thus cannot be rated to be satisfactory.

Step No. 3

In view of 50% conveyance efficiency it is clear that 66.5 MM^3 (allocated for Rabi) of water in the reservoir would mean delivery of 33.25 MM^3 in the field.

Step No. 4 Determination of requirement:

a) The cultivable commanded area : 10,860 Ha
Anticipated annual irrigated area : 10,705 Ha

Area to be irrigated	: i) Rabi 85%	:	9231 Ha
	: ii) Kharif 13.5%	:	1474 Ha

Thus water for Rabi is to be provided for 9231 Ha

b) To decide the number of waterings to be given we have to look at the past practices and the crop growth stages. The practice has been to provide one pre-sowing watering of 10 cm depth followed by waterings of 7.5 cm depth and releases made on cropping pattern basis.

As indicated in the problem, the critical crop growth stages for wheat are;

i. Crown root initiation (core)
ii. Tillering
iii. Jointing
iv. Flowering
v. Milk Formation
vi. Dough

c) The dominant Rabi crop in the command is wheat, so we shall confine the water releases to match the requirements of wheat. The crop-growth stages would necessitate one pre-sowing and 6 more waterings. Let us first see whether even the practice-based requirement can be met with (6 waterings). These requirements at field emerge as:

i) Field requirement for pre-sowing of 10cm $(9231 \times \frac{10}{100})$ = 923 Ham = 9.23 MM^3 -- (a)

ii) Field requirement for one watering of 7.5 cm depth $(9231 \times \frac{7.5}{100})$ = 692 Ham = 6.92MM^3 -- (b)

Total requirement on field (a +6+b) = 50.77 MM^3
Not withstanding the channel filling volume on each turn of flow.
Total requirement in reservoir with conveyance efficiency @50% = 101.54 MM^3.
Clearly it is seen that water available for Rabi in the reservoir is less than the amount needed (101.54 MM^3), and some thinking is required to plan the irrigation.

The above would also show that we are proposing an over all (total water depth) delta of 55.0 cm (10 + 6 x 7.5)

This leads us to a situation:

a) Where we have to reduce the area under Rabi to 66.50/101.54 x 100 or 65.5% of 9231 Ha or 6046 Ha (adhering to 6 waterings) or

b) Where we may have to reduce the number of waterings and supply water at stages of critical growth when some stress can be borne by the crops.

iii. The agriculture experts advise that besides the pre-sowing, three more waterings are most essential for wheat at (a) CRI (b) Flowering & (c) Milk stage.

This would mean that the overall delta of 32.5 cm (10 + 3 x 7.5)) should at least be provided at the field. Water required will be (9.25+3x6.92) MM^3 or 30 MM^3. At the reservoir it will work out to be 60 MM^3 with the prevailing conveyance efficiency.

Step No. 5 Matching the requirements with availability

(a) With the objective to cover as much area as possible commensurate with the available supply avoid discontentment and to maintain social justice, the water requirement for the whole 9231 Ha area of rabi will be:
9.25 + 3 x 6.92 = 30.01 MM^3 at field or 60.32 MM^3 at reservoir plus channel Filling one day each on each release, 4 in all will make it 63.82 MM^3.

It is also seen that Water available for rabi is 66.5 MM3, while for pre-sowing and 3 waterings we need nearly 64 MM3. Therefore if we try another watering the requirement would rise beyond the permissible share of water for Rabi. Hence more than 3 waterings are not feasible.

Step No.6 Determination of canal running time:

(a) The total canal capacities are 249 + 119 = 368 cusecs, deliveries at 50% efficiency = 184 cusecs
(b) The canal running time to deliver these quantities at field will be: -
(1 Ham = 4.1 cusec days)
i. For presowing 923 x 4.1/184 = 20.65 or 21 days + 1 day for filling
ii. For each of the other waterings 692x4.1/184 = 15.48 days (say 2 weeks) + 1 day for channel filling

14 days (2 weeks) have been adopted to suit the time turns (Warabandi) system, which is a weekly cycle.

(c)	Total running days (effective) 21 + 3x14	= 63 days
(d)	Add channel filling time (1+3)	= 4 days
(e)	Total canal running time	= 67 days

Step No.7

Interacting with farmers by meeting and discussing with them revealed that in the eventuality of shortage of water and inability to supply water for 6 irrigations, the suggestion to give 3 waterings may be followed. Regarding sowing activity it was informed that they start sowing in November while some of them go upto mid December. Keeping this in view, the operation plan should provide for a canal flow scheduling accordingly. The farmers were advised to start preparation as per these discussions. The agriculture authorities were also requested to organize seed, fertilizer, and other inputs in accordance with these decisions.

Step No.8 Canal Scheduling

(a) Due to conveyance efficiency being 50%, a rotation by forming 3 groups of equal capacity to run two of them at a time can be attempted but due to location of minors and lengths involved it would perhaps result in additional absorption losses. Continuous running of both main canals for 120 days will not be possible/advisable and rotating the minors will also mean more losses. And the probability of 'head' farmers on the mains taking more and 'middle' or 'tail' farmers getting less and scope of other complications would also exist. Moreover continuous running is not possible because the total run is possible only for 67 days during the base period of the crop. Therefore we may only fix days for running of canals and closing them and run all the channels together as one single group.

(b) The practices in the area are that wheat is sown from the start of November upto Mid December. Thus we can fix the date of opening of the canals for pre-sowing with effect from 8.00 am of 24th October for 22 days to be effective from 25th October 8.00 a.m. which should be a Monday (In case 25th is not a Monday, a date falling on Monday will be fixed). All the canals will be opened at 8.00 am. Thus the schedule for releases of water for pre-sowing would be as under:

<u>Pre - sowing</u>

			(Run = 21 days)
24 Oct/25 Oct. Sunday/ Monday 8.00 am	1/11	8/11	15/11 Monday 8.00 Close

Out-lets to be opened from 25 Oct. Monday 8.00 a.m.

The running has been planned for whole weeks to enable enforcement of 'Warabandi' which must start on Monday only.

(c) For subsequent waterings channels are to be planned for 2 weeks running time for the same reasons.

The various stages of crop growth are given. Although the ideal pattern of irrigation will be to provide water at each stage of growth, because of the shortage, it has to be ascertained from crop-scientists as to when it is possible to skip. According to the findings available, water must be made available at "Crown Root Initiation" (CRI) stage which occurs after 20-25 days of sowing. As per prevailing system in the area (Northern Region) sowing of wheat is started in November and goes upto 15 December, it can be presumed that sowing will start from 10 November. Therefore water must be made available in the field from 29/11 (8.00 am - Monday) i.e 20-25 days after sowing and run upto 13th December (8.00 am, Monday) for CRI stage of growth. The canals would be opened on 28 Nov. at 8.00 a.m. to cover filling time of one day.

(d) Again according to Agriculture experts (to be interacted with farmers) water would be necessary at tillering and jointing stages, but we have no water for the two stages and the want can bear the stress also, therefore a closure be provided. Then, we see that after sowing, the 'flowering' stage will occur after 80-85 days i.e. somewhere in later fortnight of January, so the canals should be opened on 23rd, January at 8.00 am (Sunday) to be effective from 24th January, Monday 8.00 a.m. to be closed on 7th February (8.00 am, Monday).

(e) The third watering should then be provided at 'Milk' stage which occurs at 100 to 105 days from sowing. Thus 'Milk' stage will start appearing from end of February. The canal may therefore be opened on 27th February (Sunday - 8 a.m.) effective from 28th Feb. Monday 8.00 a.m. and closed on 14 March (8.00 a.m.-Monday).

(f) It has therefore become clear that there were two options for preparing the Operation Plan.

(i) Provide all the 6 stage waterings of 7.5 cm and one presowing irrigation of 10 cm but in that case the area covered will be smaller as shown above or.

(ii) Reduce number of waterings after expert advice and in consultation with farmers and maintain social parity for all the beneficiaries. It has been possible to provide water to all the Rabi area although with lesser number of waterings. Since the object is to provide the benefit to as much area as possible for social equity, we have chosen to provide the minimum 3 waterings besides the pre-sowing and cover the full targeted area of 9231 Ha even though the yields may be lower but this is the only option left so as to avoid discontentment and maintain parity.

<u>Step No.9</u> <u>Operation Plan - Preparation</u>

The eventuality of reduction in waterings could have been avoided, had corrective measures to the effect of conveyance system losses were taken in time. We see from part I of the solution that water for Rabi in reservoir is 66.50 MM3 but it becomes 33.25 MM3 owing to 50% conveyance system losses. The operation plan emerging from the above given solution can be figuratively expressed as a chart attached (Annexure IV).

Step No.10 Preparation of Reservoir Operation Plan

Commensurate with the above pattern of releases, it is necessary to prepare an operation plan for the reservoir operation. The availability for each month has to be worked out and then the losses are computed. Since the canals may also be running during the month, releases into them are also worked out.

As per capacity chart of the reservoir the water levels and dates are indicated and the 'operation-instructions' for the operator are also recorded in the statement given below.

Operation plan for Kharif Crop with Sugar Cane as the main crop (11%) can be prepared. Water requirement for other crops would be much lesser than sugar cane and some adjustment in terms of areas or releases would be possible.

The above would depict the method of preparing a system operation plan. At the time of preparing the same in different projects/cases, actual practices of the area will have full bearing on the exercise.

Note: Canals to open at 8.00 a.m. on Sunday & outlets opened on Monday falling nearest as suitable to your calender and to be closed on Monday 8.00 a.m to facilitate adoption of Warabandi turn system.

Reservoir Operation Plan Computation

Calculations for reservoir depletion
(Figures in MM^3)

Month	Quantity on 1st day of month	Losses at 1.5%	Releases during the month
October	94.43	1.46	8.55
Nov.	84.42	1.31	18.40
Dec.	64.71	1.03	13.12
Jan.	50.56	0.82	9.65
Feb.	40.09	0.67	8.55
March	30.87	0.27	14.20
13th March	16.40	0.58	-

Reservoir Operation Schedule

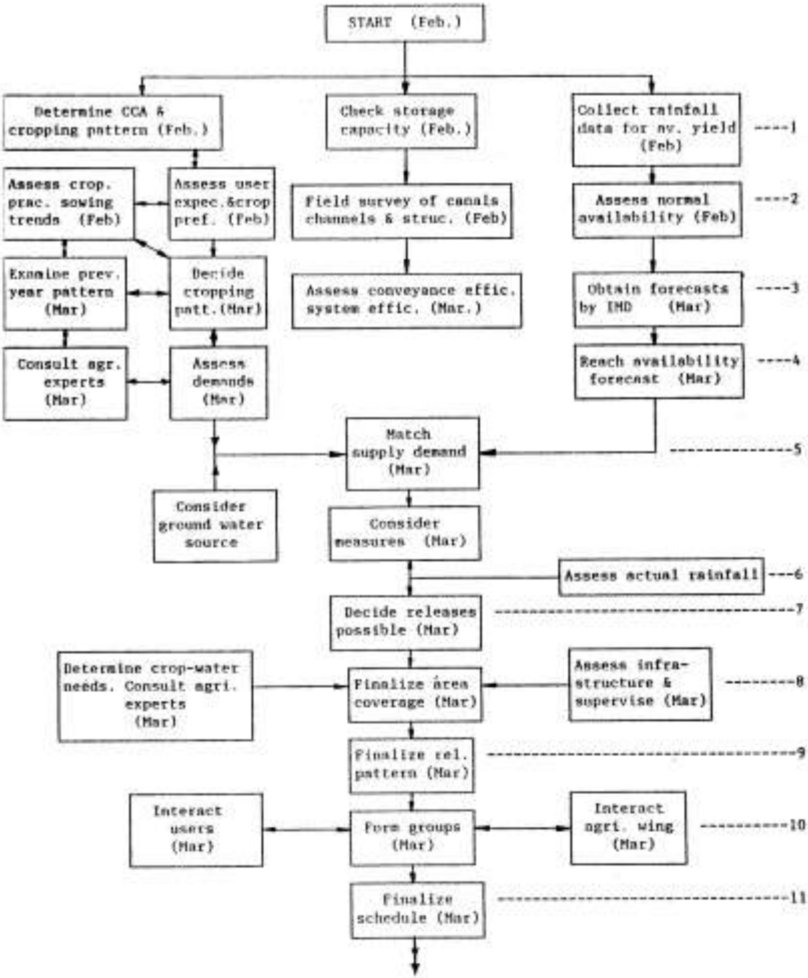
Date of Operation	Water level (m)		
24 Oct.	305.18	Open	FTL 305.94
15 Nov.	303.96	Close	
28 Nov.	303.94	Open	
13 Dec.	302.85	Close	
23 Jan.	302.74	Open	
27 Feb.	301.67	Close	
28 Feb.	301.61	Open	
14 March	299.84	Close	Sluice Cill Level: 295.42

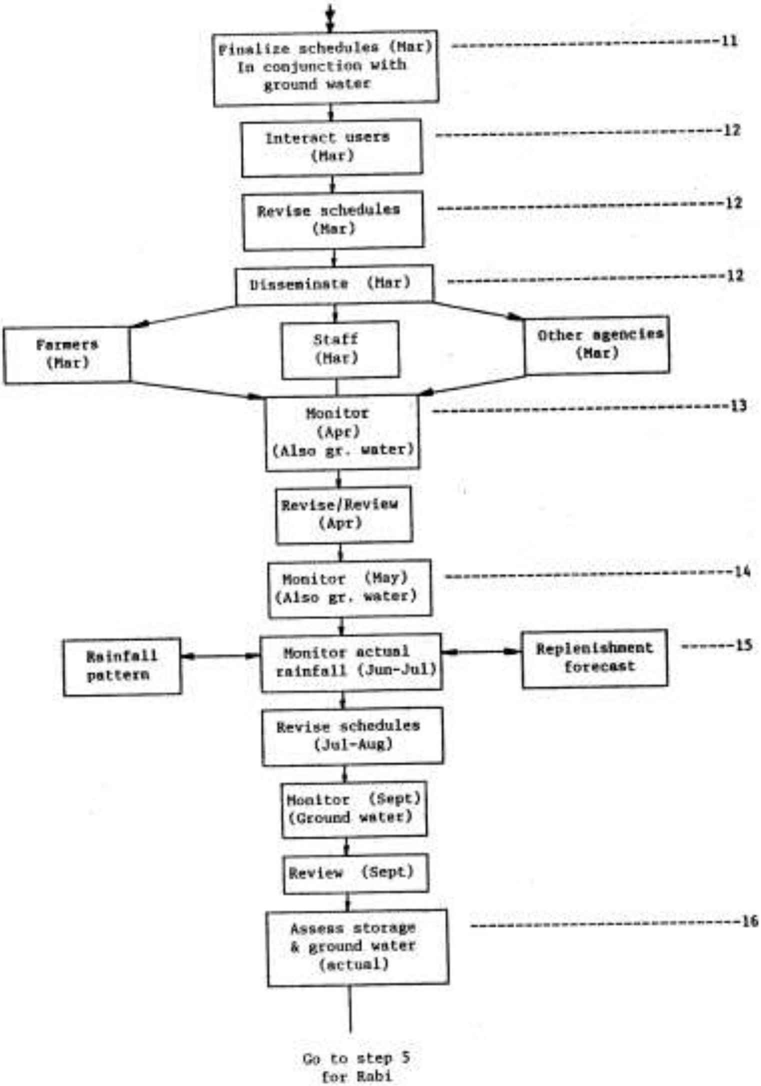
Canal rotation - allocation of water:

Allocation of water in the canals in years of good rainfall may not pose much problem, although, care is needed for optimum use of water. It should not go waste or used for over irrigation. When the availability of water is less, utmost care is required for fair distribution of water.

In case of supplies, one alternative is to run all the canals at a time, with less than full supply discharge, proportionate to the available supplies. It is however not conducive to delivery of water at the tails of channels. Lower water levels in the canal will not be able to feed the share of outlets, farmers may resort to putting obstructions in channels to raise water levels to feed outlets while some may draw more at the cost of others lower down . People may even resort to cutting of banks of canals to irrigate fields instead of taking water in an orderly

ACTIVITY FLOW CHART
PREPARATION OF YEARLY OPERATION PLAN




Finalize schedules (Mar) In conjunction with ground water
11
Interact users (Mar)
12
Revise schedules (Mar)
12
Disseminate (Mar)
12
Farmers (Mar)
Staff (Mar)
Other agencies (Mar)
Monitor (Apr) (Also gr. water)
13
Revise/Review (Apr)
Monitor (May) (Also gr. water)
14
Rainfall pattern
Monitor actual rainfall (Jun-Jul)
Replenishment forecast
15
Revise schedules (Jul-Aug)
Monitor (Sept) (Ground water)
Review (Sept)
Assess storage & ground water (actual)
16
Go to step 5 for Rabi

and organised manner. It may lead to chain reactions difficult to check or control. If a channel is run with less than full supply discharge for a longer period, it would cause silting and form additional berms on sides thereby affecting the carrying capacity. Similarly, overfeeding (more than full supply) endangers the structures, bed & banks of channels. Thus, keeping the designed flow regime of channels is very important, whenever any distributary/minor is run it must run to its full designed capacity.

5.7.6 Rotational Operation of Channels

The Other alternative is the method of rotational operation of canals. This method is followed in large irrigation projects or multi-purpose hydro-electric projects, where canal network comprises of significant lengths, and supplies are inadequate and/or fluctuating. This system may not find favour in the medium/minor irrigation tank projects. In medium and minor irrigation projects, assessment of the available storage is done and the decision regarding allocation of water for a crop season is taken in advance and releases decided upon, keeping in view the crop calender - sowing period and various stages of crop growth.

In the rotational system, the canals are run in turns with full supply discharge and the duration of flow is regulated. Water flows in the canals as per predetermined schedule round the clock.

This system has been practised in North-Western States of India for decades and is acclaimed to be a successful method of Irrigation Management. The water managers and farmers have developed satisfaction in these allocation and distribution practices. Farmers participate freely and actively in these practices as these are based on the principle of fairness. This system has been devised;

- To allocate available water keeping in view social justice and equality.
- To ensure equitable distribution of water from head to tail.
- To arrange orderly distribution of water in canals.

- To extend benefits of irrigation to as large a number of farmer families as possible keeping in view the need to maximize production by timely availability of water.

- To run the channels as per predetermined program, the regulation schedule of running of channels having been made known to the farmers in advance.

- To maintain operational efficiency of system by obviating any tendency on the part of Government official to increase or decrease discharge or duration of flow of canals, as also, to obviate any temptation of farmers to interfere with the flow of water in the channels.

- To maintain canals in regime so that they draw their authorized full supply discharge at the designed full supply levels from head to tail.

5.7.7 Grouping of Channels

Water from source, a reservoir or diversion barrage, etc. is fed into the main canal(s). The main canals may feed 2 or 3 branch canals, which in turn supply water to a number of distributaries/minor through control structures. Distributary/minor is the channel which supplies water to water courses through various outlets (see Annexure V).

Keeping in view the principle that whenever a distributary is run in rotation, it runs with full supply discharge, the formation of groups of canals is decided. Other deciding factors are, location of control points, losses in the feeding channels and other priority requirements, if any.

If the availability of water at the head is equivalent to the total authorized capacity of entire distribution net- work, all the channels can be run at a time with their full authorized discharges as "One Group".

In cases of inadequate or fluctuating or unpredictable supplies, the system of 'Rotational Operation' of canals is resorted to for distribution of available water in the entire command. The entire net work of canal system is divided into Groups for rotational running.
Following types of groupings have been in practice in NW-India for the purpose.

- Two group system

  If the expected supply is in the range of 50% of total capacity of channels, then the channels are divided into two groups of nearly equal capacity.

- Three group system

  If the available supply is in the range of 33% or 67% of total capacity of channels, then channels are divided into three groups of nearly equal capacity.

- Various combinations of groups/subgroups can be formulated for other ranges of supplies, depending upon the control points.

5.7.8 Rotational Running Period

Rotational running period of a group of channels is dependent upon the proposed running period of outlets.

In the 'Warabandi' system of distribution of water below an outlet, a water course runs on a seven day cycle according to a predetermined roster. In order to feed all the outlets from head to tail of distributary, a certain travel time is required for the water to reach the tail of distributary and attain its full supply level. The running time of distributary is therefore bound to be more than seven days. This travel time can be calculated by actual observation from time to time. However, in actual practice for easy operation, the distributaries are run on multiple of 8 days cycle basis to ensure minimum of seven days of full supply discharge to outlets.

5.7.9 Operation of Channel Groups in Rotation

In actual practice, the predetermined schedule clearly depicts the details of groupings of every channel. The groups are allotted 'Preferential Orders' (PO I, PO II, PO III, etc.) of running, and decided period of running of each group throughout the crop season is also given. Whenever any group runs, all the group channels are run with their full supply discharges. The groups are run as per their preferential orders and rotated.

Two group system

In this system, when PO I group is running for eight days period, then PO II group remains closed. After completion of 8 days cycle, the supplies to the PO I group are switched off and allocated to PO II group for 8 days running. The groups keep rotating after 8 days cycle. In case the supply is more than the total capacity of PO I group, then the additional supply is diverted to the PO II group. The PO II group is then called as running in "balance" without affecting its preferential order. Though the capacity of groups, is very carefully fixed in the beginning keeping in view the lowest possible expected supply, but due to certain exigency circumstances beyond control like breach of upper feeding canal or heavy fluctuations from above, such situation can not be ruled out. The sufferance so caused can be compensated not during the flow-period of these being prefixed. It could be possible to do so only during "Balance" phase.

Two groups can be rotated in another fashion also. In this, one group runs for 15 days and the second group remains closed for 15 days. The groups are rotated after 15 days cycle. "on" and "off" period of 15 days (instead of 16 days) is adopted because one extra day for filling the system upto designed full supply level is required only once at the opening of the channels and it is not required for the second consecutive week when the channels are already running full.

In this system, the farmer in each group gets his turn after every seven days in the first running period of 15 days. But when this group is rotated for second run, then the farmer will get his next turn of water after 23 days.

A sample of "Two Group" formation indicating name of each channel in the group, their authorized discharge, losses in between in the main and branch canals, and regulation timing of each head regulator, is given (see Annexure II).

A sample of Rotational Program of "Two Group System" for 8 days cycle, their preferential orders and predetermined dates of running is also given (see Annexure II).

<u>Three group system</u>

When the lowest expected supply is in the range of 33%, then each group runs for 8 days and remains closed for 16 days. The groups are run and rotated as per their preferential orders.

The farmer gets his turn of water after 24 days.

If the expected supply is in the range of 67%, then two groups can be run simultaneously for 15 or 16 days and the third group remains closed for 8 days.

The farmer in each group gets his turn of water after seven days in the first "on" period of 16 days. In the next rotation, he will get his next turn after 16 days.

If the supply is more than 33% or 67%, then additional supply is fed to the next PO Group (balance group).

Samples of three group formation with 33% availability of water and rotational running are available at the end of the Chapter (case example no. 3).

The system of dealing with fluctuations in supplies and balance running of groups is the same as that described in two group system above.

Rotational operation at a glance

The following table gives a typical rotational operation at a glance, for a canal system of 1000 cusecs for different water availability situations:

Sl. No.	Avail-ability.	No.of groups	Running days	Closing days	Interval between two consecutive waterings
1.	67%	3 Groups (330,340,330 cs. each)	16	8	7 days in every Running Period. Next turn 16 days.
2.	50%	2 Groups (500 cs.each)	8	8	16 days.
			16	16	7 days in every running period. Next turn 24 days.
3.	33%	3 Groups (330,340,330 cs. each).	8	16	24 days.

5.7.10 <u>Case study on Rotation of Canals</u>

A case example of Gang canal system (Rajasthan) on two groups as well as three groups methods is appended at the end of this chapter (Annexure V(1) to V(7)). This is a system which receives water under an inter-state agreement. The grouping is done to cope-up with anticipated deficit in supply. In the event of full supply being available, all the channels can run as one group. The destributaries and minors are always run full to ensure designed working head and share of water to each outlet.

Salient events of the study are summed up below:

A. Two group method

i. Two groups formation has been done by mentioning the discharging capacity of each channel of the group which is more or less equal.

ii. Absorption losses from one control structure to the next one have been worked out and given.

iii. Travelling time for water to reach various control structures has been determined and given.

iv. Crop status, dates of opening & closing cycle prescribed and priority have been indicated.

B. Three group method

i. In this case also the groups have been formed which add up to more or less equal discharges following the same procedure as for two groups.

ii. Other data e.g. losses, travel time and priorities have been given.

iii. The procedure for dealing with fluctuations, running with balance is same as for two groups.

5.7.11 Case Study on 'Shejpali' system of water distribution (Central)

A sample of 'Preliminary Irrigation Program - PIP' as prepared for Mula irrigation project, Maharashtra for Rabi & hot weather (details at Annexure VI) depicts the procedure followed generally in central region. This plan is based on following principle:

i) The anticipated availability is worked out. (Annexure VI(1) to VI(4)) (carryover, evaporation losses and river gains are taken into consideration).

ii) Demands for non-irrigation purposes is accounted for besides the earmarking for lift scheme from the reservoir. Net availability is therefore known for the crop (Rabi & Hot weather).

iii) Based on last years' performance in area as well as crops and future trends, requirement of water for Rabi is worked on 'duty' basis. The exercise is repeated while working out availability for hot-weather (end of Rabi). PIP indicates areas, crops and number of irrigation planned for the variety of crops. (Annexure V(12)).

iv) Program in detail for every rotation is prepared based on (a) Sanctioned area, (b) Crop-wise sown area, (c) Area irrigated by day cusec as observed. Preparation of this program is done from lowest functionary (Canal Inspector) upto project level. (Annexure VI(5) to VI(9)).

v) Schedules for water deliveries allocating water to each farmer (below the outlet) is also prepared by the Canal Inspector and publicized (Annexure VI(10)).

vi) The canal inspector also prepares statement showing opening and closing time for each outlet on the minor. The Jr. Engineer prepares this for his jurisdiction. The Sub-division/Division then prepare the program for distributary branch canal and main canal is prepared. (Annexure VI(11)).

vii) After each rotation, the quantity of water delivered vis-a-vis area irrigated is reported for each outlet/ minor/disty and main canal in terms of AIDC.

However, to improve upon the present procedure the following suggesti ons are made, an improved format is also given at Annexure VI(12) based on NIR (Net irigation requirement for different crops).

1. The canal losses should be considered as per actual experimental observations, minors, distributaries, main canal and actual conveyance efficiency worked out for each season.

2. Water requirements may be worked out with climatological approach and net irrigation requirements worked out after considering average effective rainfall for preparing PIP instead of adopting duty concept.

3. The water delivery schedules for allocating time for individual farmers may be prepared on the basis of consumptive use of different crops after deducting effective rainfall during the period as shown in Annexure .

4. To reduce repetative calculations and labour required at present in preparing individual outlet water delivery schedules, cut of statement of outlets on minors and subsequently minors on distributaries etc. for each rotation, computers may be used for which softwares are already developed by WALMI, Aurangabad.

5.7.12 Case Study on 'Localization' system of water distribution (South)

The operation plan in southern region is prepared by taking the 'Wet' & 'Dry' areas into consideration on the following principles:

i. Water requirements are worked out on the basis of crops sown and delta observed. These requirements are at the 'major' (main distributary) head to which the losses in the main canal are added subsequently at circle level.

ii. The requirements are shown in M.cft and converted into cusecs.

iii. The capacity of the 'major' is indicated in the plan and the required flow in cusecs is worked out. If the required flow is more than carrying capacity, the free-board is encroached.

iv. The plan stipulates running at partial discharge.

To improve the system operation practices, the following suggestions are made;

i. The water requirement should be worked out, after taking the effective rainfall into account rather than 'delta' basis.

ii. Actual losses in the conveyance system should be observed to ensure efficiency.

iii. In the event of requirement of partial flow, the canal should be run with full supply and closed after the volume has been delivered.

iv. Losses in the main canal (actual) should be reflected in the plan to find out total flow.

v. Individual channel (farmer) allocation and period of running should be worked out to arrive at 'ON' & 'OFF' periods.

A sample 'plan' prepared for a system in Andhra Pradesh is given at Annexure VII.

5.7.13 Practices in Eastern Region

The operation plan depicting the areas, crops and requirement for each fortnight/month should be prepared. A sample notification at Annexure VIII issued for Patna canal indicates that after receipt/ sanction of application the running/closure program is issued and notified for implementation. The canals are run as per this notification to their full capacity. The following suggestion would improve the 'system operation' practices.

i. Detailed calculations for field requirement and at outlet/minor/disty./main canal should be carried out.

ii. Losses should be observed and taken into account for arriving at the flow required at 'head'.

iii. A scientific method needs to be laid down to ensure proper water management.

iv. Individual channel/farmer allocation should be given and then rotation should be devised.

GROWTH PERIODS (IN DAYS AFTER SOWING) OF TYPICAL CROPS

Crop	Stage	Days After Sowing
Wheat	Crown root initiation	20 - 25
	Tillering	40 - 45
	Jointing	55 - 60
	Flowering	85 - 90
	Milk	100 - 105
	Dough	115 - 120
Maize	Seeding	10 - 15
	Tasselling	95 - 100
	Silking	115 - 125
Sorghum	Seeding	15 - 25
	Preflowering	95 - 110
	Grain Formation	115 - 120
Barley	Tillering	30
	Jointing	60
	Milk	90
Gram	Preflowering	45 - 70
Soyabean	Vegetative	30 - 45
	Flowering	45 - 70
	Grain Filling	80 - 110
Groundnut (Kharif)	Flowering	35 - 45
	Pegging	50 - 60
	Fruiting	70 - 75
Mustard	4"-6" Leaf Stage	20 - 30
	Flowering	80 - 90
Cotton	Vegetative	0 - 45
	Reproductive	45 - 90
	Boll Bursting	90 - 120
Potato	Stolonization	20 - 50
	Tuberization	50 - 80
	Maturation	90 - 120
Rice	Early (100-110 days)	
	Seeding	20
	Maximum Tillering	30 - 35
	Panicle Initiation	40
	Flowering	75
	Maturing	100 - 110

Medium (120-140 days)	
Seeding	20
Maximum Tillering	35 - 40
Panicle Initiation	55 - 60
Flowering	90 - 100
Maturing	120 - 140
Late (150-170 days)	
Seeding	20
Maximum Tillering	40
Panicle Initiation	85 - 90
Flowering	125 - 135
Maturing	150 - 170

Annexure II(1)
(Refer to para 5.7.5)

Scheduling Based on the Water Requirements as Computed by Modified Penman Method (FAO-24)

Crop water requirement is expressed by the rate of maximum evapotranspiration (ETm), considered as the field water supply level for the maximum yield. The ETm of each crop is worked out by the following three steps.

i. Reference evapotranspiration (ETo) - This is calculated by Modified Penman equation set out in FAO Irrigation and Drainage Paper No. 24 (1977).

ii. Crop coefficient (kc) - This is determined on the basis of growing period and length of developmental activities during each growing period.

iii. Maximum Evapotranspiration (ETm) is then calculated by relationship.

$$ETm = kc \times ETo$$

On the basis of the values of consumptive use as computed above, net irrigation requirements at the field level are calculated keeping in view other parameters such as effective rainfall, percolation losses and special needs of certain crops.

The computations for fortnightly water requirements in a typical study case are given at Statement - 1.1. Only Rabi Season is taken up for analysis as an example. These have been calculated using, 'A Guide for Estimating Irrigation Water Requirements' by R.S. Saksena --, Inder Mohan et al, published by the Ministry of Irrigation, Government of India.

The cropping pattern and intensity of irrigation during Rabi season has been taken as follows:

S.No.	Crop intensity	Irrigation intensity as percentage of CCA	Cropping for one ha. of cropped area
1.	Wheat	20.5	0.43
2.	Oilseeds	12.0	0.25
3.	Isobgol/Cumin	13.0	0.28
4.	Veg/Potatoes	2.0	0.04
	Total	47.5	1.00

Crop water requirements for one hectare of composite cropped area are then calculated as given in the Statements 1.2 & 1.3.

Ref. Statement - 5.2

Average requirement from Nov. I to Dec. II	:	400 cubic metres per ha. for each fortnight
Average requirement from Jan. I to Feb. II	:	700 cubic metres per ha. for each fortnight
Canal Operations	:	

1. If Nov. I to Dec. II the canal is to run alternate week.

Discharge of outlet	:	$\frac{400 \times 1000}{7 \times 24 \times 3600}$ = 0.661 ltrs. /ha. for 7 days.
Consider Irrigation efficiency upto outlet	:	65%
Therefore discharge at outlet	:	$\frac{0.661}{0.65}$ = 1.016 litres/ sec. per ha.
Average CCA of an outlet	:	60 ha.
Intensity of Irrigation in Rabi	:	47.5%
Cropped Area	:	$\frac{60 \times 47.5}{100}$ = 28.5 ha.
		or 1.02 cusecs.

2. If from Jan. I to Feb. II, canal is to run every week, the requirement works out to 350 cubic metre/ha. for 7 days.

Discharge of outlet	:	$\frac{350 \times 1000}{7 \times 24 \times 3600}$ = 0.58 ltres/ Sec./ha. approx. same as discharge of 0.661 litres/sec./ha.

Thus, as per the requirements computed by Modified Penman Method the canal system should run alternate week during the period from November I to December II and every week from January I to February II. The discharge required at the outlet head is 1.016 litres per second per hectare.

The actual discharge being supplied at the outlet may then be compared with the above requirements for the assessment of extent of under or over irrigation.

STATEMENT 1.1

Water Requirement of Crops in Rabi Season*

in mm

S.No.	Description	October I	October II	November I	November II	December I	December II	January I	January II	February I	February II	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Wheat (120 days)											
	a) Crop factor (kc)				0.48	0.58	1.10	1.18	1.18	1.16	0.92	
	b) ETo crop				33.45	31.15	63.01	69.27	73.88	87.65	60.24	
	c) Effective Rainfall (mm)				-	-	-	-	-	-	-	
	d) NIR (mm)			76.00	33.45	31.15	63.01	69.27	73.88	87.65	60.24	494.65
2.	Oilseeds (110 days)											
	a) Crop factor (kc)			-	0.20	0.53	1.12	1.17	1.17	1.16	0.70	
	b) STo crop			-	13.93	28.46	64.17	68.73	73.25	87.64	45.83	
	c) Effective Rainfall (mm)			-	-	-	-	-	-	-	-	
	d) NIR (mm)			76.00	13.93	28.46	64.17	68.73	73.25	87.64	45.83	458.01
3.	Cumin & Isabgol (110 days)											
	a) Crop factor (kc)				0.23	0.31	0.65	0.53	0.57	0.82	0.43	
	b) ETo crop				16.02	16.65	37.24	54.58	60.72	61.95	28.15	
	c) Effective Rainfall (mm)			-	-	-	-	-	-	-	-	
	d) NIR (mm)			76.00	16.02	16.65	37.24	54.58	60.72	61.95	28.15	351.31
4.	Vegetable (Potato) (110 days)											
	a) Crop factor (kc)			0.37	0.42	0.90	1.05	1.12	1.08	0.74	0.70	
	b) ETo crop			28.08	23.32	43.02	53.54	59.80	60.48	48.55	9.18	
	c) Effective Rainfall (mm)			-	-	-	-	-	-	-	-	
	d) NIR (mm)		76.0	28.08	23.32	43.02	53.54	59.80	60.48	48.55	9.18	394.69

* Modernization of canals, Dantiwada, Medium Irrigation Project, Gujarat - Source: Central Water Commission, ND.

STATEMENT 1.2

Crop Water Requirements Per Ha. of Composite Cropped Area

In cum.

Rabi Crop	Cropped area	October II	November I	November II	December I	December II	January I	January II	February I	February II	March I	March II	Total
1 14	2		3	4	5	6	7	8	9	10	11	12	13
Wheat	0.215	-	163.4	71.8	67.0	135.5	148.9	158.8	188.5	129.5	-	-	1063.5
	0.215	-	-	163.4	71.8	67.0	135.5	148.9	158.8	188.5	129.5*		1063.5
Oilseeds	0.125	-	95.0	17.4	35.6	80.2	85.9	91.6	109.6	57.3	-	-	572.5
	0.125	-	-	95.0	17.4	35.6	80.2	85.9	91.6	109.6	57.3*		572.5
Isobagol	0.280	-	212.8	44.9	46.6	104.2	152.8	170.0	173.4	78.8	-	-	983.5
Potatos	0.040	30.4	8.3	9.3	17.2	21.4	23.9	24.2	19.4	3.7	-	-	157.8
Total	1.000	30.4	479.5	401.8	225.6	443.9	627.2	679.4	741.3	567.4	168.8		4413.3

Average requirement for each fortnight = 400 cubic metre per ha. per fortnight.

Average requirement for each fortnight = 700 cubic metre per ha. per fortnight.

* Last watering would depend upon the duration of crop variety so wn.

Annexure II(6)

STATEMENT

Cropped Area and Total Water Requirement in Rabi

Crop	Irrigation intensity as percentage of CCA	Cropping intensity for one hectare of cropped area	Crop Water requirements per ha. of each crop-depth (mm)	Water requirement for cropped (cum.)
1. Wheat	20.5	0.43	494.65	2127.0
2. Oilseeds	12.0	0.25	458.01	1145.0
3. Isobgol/cumin	13.0	0.28	351.31	983.5
4. Veg/Potatoes	2.0	0.04	394.69	157.8
Total	47.5	1.00		4413.3

Average requirement for one hectare of composite cropped area = 4413.3 cubic metres

Scheduling of Irrigation under Various Stages of Growth of Crop - A Case Study

For the evaluation of existing scheduling of Irrigation, Bhakra Canal System has been taken as a typical case. Only Rabi season has been analyzed.

i) Status of Existing Scheduling

The scheduling of irrigation at present in the above command is based on the water allowance of 2.75 cusecs per thousand acres of CCA at canal head. The intensity of irrigation being achieved in Rabi is 40.78%. The channels are run under preference orders, and shortages in any section are covered with the suitable balancing cycles already planned for the purpose. Ultimately balanced equitable distribution as per water allowance is maintained in the crop season.

The data of seasonal irrigation supplies at canal head and area irrigated thereof in 10 years period from 1969-70 to 1978-79 during Rabi season is given below:

Seasonal Irrigation Supplies*
(for Rabi Season)

CCA = 1166000 ha.

S.No.	Year	Irrigation supply at main canal head	Area Irrigated	Area Irrigated as %age of CCA	Gross supply per ha. of crop
		Mm^3	000 'ha	%	m^3
1.	1969-70	2857	478	40.99	5977
2.	1970-71	2290	448	38.42	5112
3.	1971-72	2693	486	41.68	5541
4.	1972-73	1996	470	40.31	4247
5.	1973-74	2717	477	40.91	5696
6.	1974-75	1766	398	34.13	4437
7.	1975-76	2961	494	42.37	5994
8.	1976-77	2655	475	40.74	5589
9.	1977-78	3135	493	42.28	6359
10.	1978-79	3152	536	45.97	5881
	Average	2622	476	40.78	5483

* Scurce : CBIP March, 1989

From the above data of seasonal irrigation supplies, average quantity of water delivered at canal head per ha. comes to 5483 cubic metres. In order to assess the water actually delivered at plant, conveyance losses in the system reckoning from the source to the field have been taken into account. The following value of conveyance efficiencies and field application efficiencies have been considered in the context that (i) the present system is partially lined, (ii) the system has been in operation for a long time, (iii) the tendency of the farmers is to spread the available limited water over relatively larger area.

- Conveyance efficiency (from canal head to outlet head) 75%
- Field channel efficiency (from outlet head to field gate) 85%
- Field application efficiency 80%
- Overall project efficiency = 0.75 x 0.85 x 0.80 : .51 say 51%

Thus the supply actually delivered to plant per ha. works out to 5483x0.51 = 2796 cum. As already mentioned equitable distribution of this water is maintained in the command area as per above mentioned water allowance.

The crop-wise intensities of irrigation as achieved are viz. wheat 22.8%, gram 7.6%, oilseeds 7.6%. In addition fodder is found to be 2-3%.

ii) **Irrigation Requirements Based on Stages of Crop Growth**

The intensities of irrigation and cropping have been taken same as envisaged in the system.

S.No.	Crop	Irrigation intensity as percentage of CCA	Cropping intensity for one ha. of Cropped Area
1.	Wheat	22.8	0.60
2.	Gram	7.6	0.20
3.	Oilseeds	7.6	0.20
	Total	38.0	1.00

Annexure II(9)

The data of stages of crop growth, irrigation depths, timings of sowing for various seed varieties etc. as recommended by Haryana Agriculture University and Agriculture Department has been adopted. This is as given below:

Crop	No. & depth of Irrigation in mm		Time of irrigation (days after sowing)	Stage of growth
Wheat	I	60		Pre-sowing
	II	60	22	Crowning
	III	60	45	Late tillering
	IV	60	65	Jointing
	V	60	85	Flowering
	VI	60	105	Milking
Gram	I	100		Pre-sowing
	II	80	60	Branching
	III	80	120	Pod-filling
Mustard	I	80		Pre-sowing
	II	60	50	Seedling
	III	60	110	Flowering

The crop seed varieties being used and their duration is as below:

Crop	Time of Sowing	Time of Harvesting	Crop duration (days)	Seed Variety
Wheat	1 Nov.- 25 Nov.	1 April- 15 April	135-150	WH 147, 283, HD 2009, Arjun, Sona etc.
	25 Nov.- 21 Dec.	15 April- 30 April	130-135	Sonalika, WH 291
Gram	10 Oct.- 30 Oct.	20 March- 10 April	160	H 208, C 214, C-24, Gaurav, C-235
Mustard	10 Oct.- 15 Oct.	10 March- 25 March	160	Raya, Parkash, RH 30, Varuna, T-59
	1 Sep.- 15 Sep.	20 Dec.- 5 Jan.	110	Toria, Sangam

Using the above date, the requirements as per crop growth stages have been computed. These are given in Statement - 1.5. The total requirement for one hectare of composite cropped area in Rabi works out to 3080 cubic metres. Little variations in flow are observed in each fortnight during the peak months of December, January and February. The overall extent of under-irrigation works out as under:

- Requirement of water as computed by the stages of crop growth : 3080 cum.
- Water actually delivered : 2796 cum.
- Percentage of water supplied : $\frac{2796}{3080} = 90\%$
- Percentage of under-irrigation : 10%

The deficiency of 10% could easily be covered by use of water from tubewells.

The average requirement for canal operations may be taken as about 350 cubic metre each fortnight during the months of December, January and February. If during these months canals area to run alternate week, the discharge of outlet would be

$$= \frac{350 \times 1000}{7 \times 24 \times 3600} = 0.58 \text{ litres/sec per ha.}$$

Knowing the discharge of the outlet per hectare of cropped area, as computed above, the discharge required at the outlet head to cover entire CCA of outlet and corresponding discharge and running period of distributary, can be assessed and compared with the existing scheduling.

STATEMENT 1.5

Crop Water Requirements per hectare of Composite Cropped Area
(Bhakra Canal Irrigation Pattern)

Rabi Total	Composite Cropped	Septemeber				October				November				December				January				February				March				April		area
		I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	
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	32	33
Wheat (Nov.1-25)	0.15	-	-	-	-	-	-	-	-	I 90	-	-	II 90	-	-	III 90	-	-	IV 90	-	-	V 90	-	-	VI 90	-	-	-	-	-	-	540
	0.15	-	-	-	-	-	-	-	-	-	I 90	-	-	II 90	-	-	III 90	-	-	IV 90	-	-	V 90	-	-	VI 90	-	-	-	-	-	540
	0.15	-	-	-	-	-	-	-	-	-	-	I 90	-	-	II 90	-	-	III 90	-	-	IV 90	-	-	V 90	-	-	VI 90	-	-	-	-	540
Nov.25-	.075	-	-	-	-	-	-	-	-	-	-	-	-	I 50	-	-	II 50	-	-	III 50	-	-	IV 50	-	-	V 50	-	-	VI 50	-	-	300
	.075	-	-	-	-	-	-	-	-	-	-	-	-	-	I 40	-	-	II 40	-	-	III 40	-	-	IV 40	-	-	V 40	-	-	VI 40	-	240
Gram	0.10	-	-	-	-	-	-	I 100	-	-	-	-	-	-	-	-	II 80	-	-	-	-	-	III 80	-	-	-	-	-	-	-	-	260
	0.10	-	-	-	-	-	-	-	I 100	-	-	-	-	-	-	-	-	II 80	-	-	-	-	-	III 80	-	-	-	-	-	-	-	260
Oilseeds	0.10	-	I 80	-	-	-	-	-	-	II 60	-	-	-	-	III 60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200
	0.10	-	-	-	-	-	I 80	-	-	-	-	-	-	-	-	II 60	-	-	-	-	-	III 60	-	-	-	-	-	-	-	-	-	200
Total	1.00		80				80		200		240		180	330			370	300			270		370	300		270				50	40	3080

Comparison of Irrigation Requirements Based on Crop Growth Stages and Modified Penman Method - A Case Study Relating to Bhakra Canal Command

Irrigation requirements based on crop growth stages have been computed vide Enclosure 5.2 (ii). The total requirements during Rabi season workout to 3080 cubic metres for one hectare of composite cropped area. The month-wise breakup of this requirement is given at Statement - 1.7.

Irrigation Requirements Based on Modified Penman Method

For computation of irrigation water requirements of Bhakra Canal Command by Modified Penman Method, the basic meteorological data has been extracted from climatological tables of Hisar observatory, which provided 30 years average of temperature, rainfall, humidity, wind velocity and sunshine hours. For such of those crops whose planting dates are spread over a period of one month, average values have been taken.

The intensity of irrigation, cropping pattern, planting, harvesting dates of crops and their durations have been taken to be the same as adopted while computing the requirements based on crop growth stages. The requirements computed for each crop are given in Statement - 1.8.

The water requirement per hectare of composite cropped area are given in Statement - 5.6. These work out to 3935 cubic metres per hectare.

The results of the two observations are tabulated below:

Comparison of Crop Water Requirements (for one hectare of composite cropped area)

(in cubic metres)

Crops	Requirements as computed by Modified Penman Method	Requirements as per stages of growth	Remarks
Wheat	2658.6	2160	Month-wise breakup is
Oilseeds	523.8	320	given at
Statement			
Grams	752.8	520	5.6
Total	3935.2	3080	

The data indicated that the requirement as worked out by Modified Penman Method are about 28% more as compared to requirements under stages of crop growth.

STATEMENT 1.7

Crop Water Requirement by Modified Penman Method in Rabi***
(Haryana - Hissar)

Depth in mm.

Crop	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	Total NIR
WHEAT								
ETo	158	106	80	82	105	174	226 (1/2)	
Kc		0.3	0.7	1.05	0.85	0.7	0.25	
Consumptive Use ETc.		31.8	56	86.1	89.25	121.8	28.2	
Presowing requirement		30.0	-	-	-	-	-	
Effective rainfall		-	-	-	-	-	-	
NIR		61.8	56	86.1	89.25	121.8	28.2	443.1
OILSEEDS								
ETo (mm)	158	106	80	82	105	174 (1/3)	226	
Kc		0.3	0.7	1.05	0.7	0.25		
ETc		31.8	56	86.1	73.5	14.5		
Effective rainfall		-	-	-	-	-		
NIR		31.8	56	86.1	73.5	14.5		261.9
GRAM								
ETO (mm)	158(2/3)	106	80	82	105	174	226	
Kc	0.3	0.7	1.05	0.85	0.7	0.25		
ETc	31.5	74.2	84.0	69.7	73.5	43.5		
Effective rainfall	-	-	-	-	-	-		
NIR	31.5	74.2	84.0	69.7	73.5	43.5		376.4

* Source: Central Water Commission

STATEMENT 1.8

Crop Water Requirements Per Hect. of Composite Cropped Area in Rabi

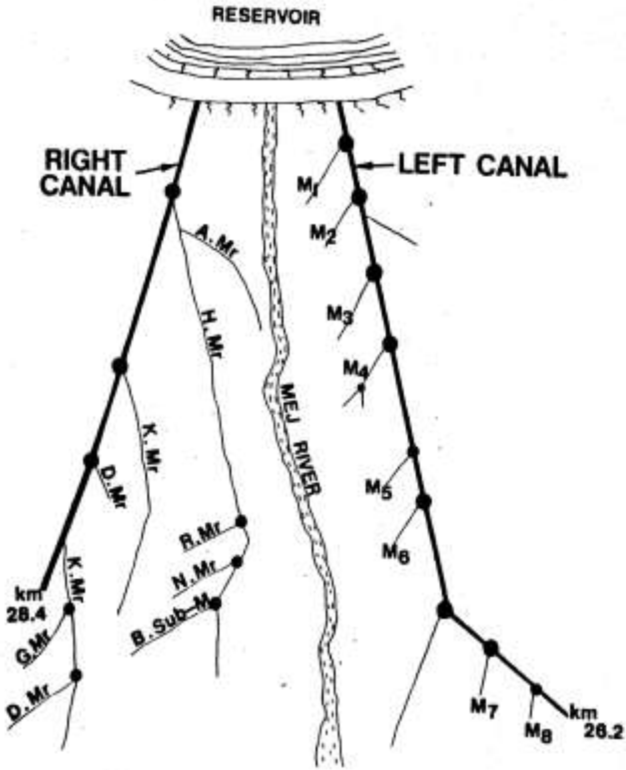
(A) As per Modified Penman Method (in cubic metres)

S.No.	Rabi Crop	Cropped Area in hectare	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	Total
1.	Wheat	0.6	-	-	370.8	336	516.6	535.2	730.8	169.2	2658.6
2.	Oilseeds (Sarsoan)	0.2	-	-	63.6	112	172.2	147	29	-	523.8
3.	Gram	0.2	-	63	148.4	168	139.4	147	87	-	752.8
				63	582.8	616	828.2	829.2	846.8	169.2	3935.2

(B) As per Stages of Growth of Crops

S.No.	Rabi Crop	Cropped Area in hectare	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	Total
1.	Wheat	0.6	-	-	360	500	490	450	320	40	2160
2.	Oilseeds	0.2	80	80	60	120	-	60	-	-	400
3.	Gram	0.2	-	200	-	80	80	160	-	-	520
			80	280	420	700	570	670	320	40	3080

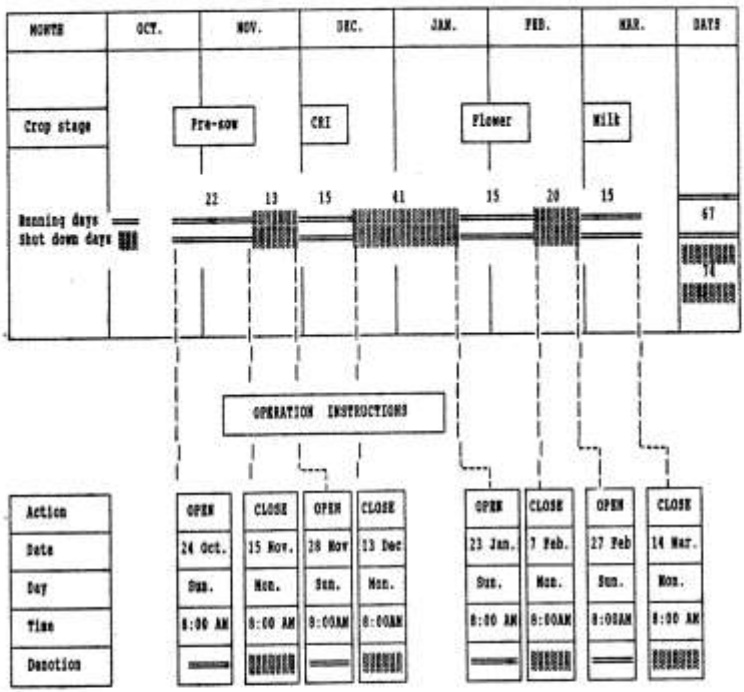
SCHEMATIC LINE DIAGRAM OF THE SYSTEM



● Flow Control Structures
(vertical gates)

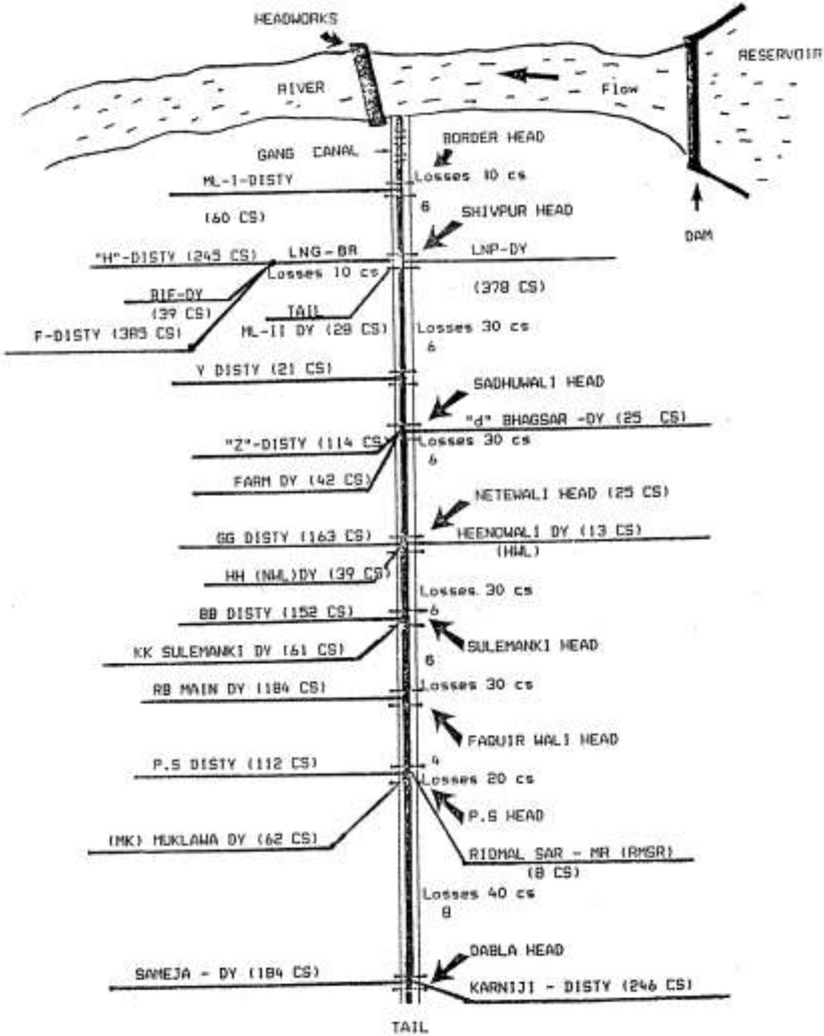
GRAPHICAL REPRESENTATION OF
OPERATION PLAN

WHEAT--Rabi Crop



Annexure V(1)

LINE DIAGRAM OF GANG CANAL SYSTEM



ROTATIONAL PROGRAM OF GANG CANAL SYSTEM
FOR THE PERIOD TO YEAR
GROUPING OF CHANNELS)
(TWO GROUPS)

Group A

	Name of canal	Discharge(C.S)
1.	ML I	60
2.	H	245
3.	BIF	39
4.	F	385
5.	ML II	28
6.	LNP	378
7.	Z	114
8.	Y	21
9.	Farm	42
10.	D-Bhagsar	25

		1337
	Add. Losses from Border head to Sadhuwali Head & in LNJ Br.	50

		1387

Group (B)

	Name of canal	Discharge (C.S)
1.	GG I	163
2.	HH-NWL	39
3.	HWL	13
4.	BB	152
5.	KK-SLMK	61
6.	RB	184
7.	PS	112
8.	MK	63
9.	RMSR	8
10.	Sameja	184
11.	Knji	246

		1225
	Add. Losses from Border head to Dabla head.	190

		1415

Absorption Losses:

1.	Border head to Shivpur head	10
2.	Shivpur head to Bifurcation head	30
3.	Shivpur head to Sdhuwali head	30
4.	Sadhuwali head to Netawali head	30
5.	Netawali head to Sulemanki head	30
6.	Sulemanki head to Faquirwali head	30
7.	Faquirwali head to P.S. head	20
8.	P.S. head to Dabla head	40

Regulation Time

1.	Border head	03 Hrs.
2.	Shivpur head	06 Hrs.
3.	Bifurcation head Sadhuwali head	09 Hrs.
4.	Netawali head	12 Hrs.
5.	Sulamanki head	15 Hrs.
6.	Faquirwali head	18 Hrs.
7.	P.S. Head	20 Hrs.
8.	Dabla Head	24 Hrs.

Approved by
Executive Engineer

ROTATIONAL PROGRAM OF CANAL SYSTEM FOR THE PERIOD 7TH OCTOBER TO 17TH APRIL YEAR AND PRIORITY OF GROUPS

(Two Groups)

PERIOD	DATES		CYCLE	PREFERENTIAL ORDER OF GROUPS	
SOWING				I	II
	07/10	15/10	1	A	B
	15/10	23/10	2	B	A
	23/10	31/10	3	A	B
	31/10	08/11	4	B	A
	09/11	16/11	5	A	B
	16/11	24/11	6	B	A
	24/11	02/12	7	A	B
	02/12	10/12	8	B	A
GROWING					
	10/12	18/12	9	A	B
	18/12	26/12	10	B	A
	26/12	03/01	11	A	B
	03/01	11/01	12	B	A
	11/01	19/01	13	A	B
	19/01	27/01	14	B	A
	27/01	04/02	15	A	B
	04/02	12/02	16	B	A
MATURING					
	12/02	20/02	17	A	B
	20/02	28/02	18	B	A
	28/02	08/03	19	A	B
	09/03	16/03	20	B	A
	16/03	24/03	21	A	B
	24/03	01/04	22	B	A
	01/04	09/04	23	A	B
	09/04	17/04	24	B	A

Note: Commencement and closing dates of Rotational Program of Canal system for different crops seasons shall be in accordance with the crop calendars based on agro-climatic conditions of individual Irrigation System.

Annexure V(4)

<u>Abstract of number of cycles and running days of each group under I and II preferential orders</u>

I			II		
Group	Cycles	Running Days	Group	Cycles	Running Days
A	12	96	A	12	96
B	12	96	B	12	96
Total	24	192		24	192

Note : 1. Each group will run in I preferential order after 8 days.

2. Running days for each group in each preferential order are almost equal.

ROTATIONAL PROGRAM OF GANG CANAL SYSTEM
FOR THE PERIOD TO YEAR
GROUPING OF CHANNELS)
(THREE GROUPS)

Group A		Group (B)		Group (C)	
Name of canal	Discharge (C.S)	Name of canal	Discharge (C.S)	Name of canal	Discharge (C.S)
1. ML I	60	1. ML II	28	1. RB	184
2. GH	245	2. LNP	378	2. PS	112
3. BIF	39	3. Y	21	3. MK	63
4. F	385	4. GGI	163	4. RMSR	8
5. Z	114	5. HH-NWL	39	5. Sameja	184
6. Farm	42	6. HWL	13	6. KNJI	246
7. d-Bhagsr	25	7. BB	152		
		8. KKSLMK	61		
	910		855		797
Add. Losses from Border head to Sadhuwali Head & in LNJ Br.	50	Add. Losses from Border head to Sulemanki head		Add. Losses from Border head to Dabla head.	190
	1387				1415

Absorption Losses:

1.	Border head to Shivpur head	10
2.	Shivpur head to Bifurcation head	30
3.	Shivpur head to Sdhuwali head	30
4.	Sadhuwali head to Netawali head	30
5.	Netawali head to Sulemanki head	30
6.	Sulemanki head to Faquirwali head	30
7.	Faquirwali head to P.S. head	20
8.	P.S. head to Dabla head	40

Regulation Time

1.	Border head	03 Hrs.
2.	Shivpur head	06 Hrs.
3.	Bifurcation head Sadhuwali head	09 Hrs.
4.	Netawali head	12 Hrs.
5.	Sulamanki head	15 Hrs.
6.	Faquirwali head	18 Hrs.
7.	P.S. Head	20 Hrs.
8.	Dabla Head	24 Hrs.

Approved by
Executive Engineer

Annexure V(6)

ROTATIONAL PROGRAM OF CANAL SYSTEM
FOR THE PERIOD 7TH OCTOBER TO 17TH APRIL
YEAR AND PRIORITY OF GROUPS

(THREE GROUPS)

PERIOD	DATES	CYCLE	PREFERENTIAL ORDERS OF GROUPS		
SOWING			I	II	III
07/10	15/10	1	B	A	C
15/10	23/10	2	C	B	A
23/10	31/10	3	A	C	B
31/10	08/11	4	B	A	C
08/11	16/11	5	C	B	A
16/11	24/11	6	A	C	B
24/11	02/12	7	B	A	C
02/12	10/12	8	C	B	A
GROWING					
10/12	18/12	9	A	C	B
18/12	26/12	10	B	A	C
26/12	03/01	11	C	B	A
03/01	11/01	12	A	C	B
11/01	19/01	13	B	A	C
19/01	27/01	14	C	B	A
27/01	04/02	15	A	C	B
04/02	12/02	16	B	A	C
MATURING					
12/02	20/12	17	C	B	A
20/12	28/02	18	A	C	B
28/02	08/03	19	B	A	C
08/03	16/03	20	C	B	A
16/03	24/03	21	A	C	B
24/03	01/04	22	B	A	C
01/04	09/04	23	C	B	A
09/04	17/04	24	A	C	B

Note: Commencement and closing dates of Rotational Program of Canal system for different crops seasons shall be in accordance with the crop calendars based on agro-climatic conditions of individual Irrigation System.

Annexure V(7)

Abstract of cycles & Running days of each group under I, II and IIIrd Preferential orders

I			II			III		
Group	Cycles	Running Days	Group	Cycles	Running Days	Group	Cycles	Running Days
A	8	64	A	8	64	A	8	64
B	8	64	B	8	64	B	8	64
C	8	64	C	8	64	C	8	64
Total	24	192		24	192		24	192

Note:

1. Every group will run in I preferential order after 16 days.
2. The running days for each group in each preferential order are almost equal.

Preliminary Irrigation Program (PIP) for Rabi-Hot weather

MULA Project Ahmednagar, Maharashtra (comprising of two canals - MLBC and MRBC)

	Expected balance Gross in Mula Reservoir as on 15th October		26500 Mcft.
I	**Deductions**		
1.	Dead Storage	4500 Mcft.	
2.	Carryover	1000 Mcft.	
3.	Evaporation losses in reservoir at 6 Mcft/day for 137 days 6x137	822 Mcft.	
		6322	6322
	Net storage available		20178 Mcft.
	Expected river gains/post monsoon flow		561 Mcft.
	Water available for utilization		20739 Mcft.

II Requirement of water for urban and domestic purposes:

		Mcft.	
1.	MPHV Agricultural University (Agriculture use)	270	
2.	Ahmednagar Municipality	77	
3.	MPHV (Drinking water)	13	
4.	Wambori village	6	
5.	Rahuri Sugar Factory	2	
6.	Mula Sugar Factory	2	
7.	Dyneshwar Sugar Factory	8	
8.	Jogeshwar tilt irrigation	10	
9.	MIDC Ahmednagar (Indl.)	100	
		488 Mcft.	500
	Net water available for Rabi/Hot weather irrigation		20239 Mcft.

III Requirement of Rabi irrigation as per program approved in CADA Executive Committee on the basis of cropping pattern as developed and future trends in demand in consultation with agriculture department and farmers' representatives.

Mula Right Bank Canal (CCA 80000 Ha)

S.No.	Crop	Area in Acres	Conversion factor	Equivalent areas on S.cane basis (Acres)
1.	S. Cane	4000	1.00	4000
2.	Wheat	30000	0.67	20100
3.	Jwar local	21000	0.33	6930
4.	Vegetable	3000	0.33	1000
5.	Other seasonal crops, gram, sunflower	9000	0.33	2970
		67000		35000

Base period 15 October to 28 February = 137 days
Canal losses 30% and duty 70 on cane basis

Water required for Rabi:

$$\frac{30980 \times 137 \times 1.3}{11.87 \times 70} = 7520 \text{ Mcft.}$$

where:

11.87 cusec days constitute 1 Mcft.

Mula Left Bank Canal including Pravore Right bank tail area - CCA 10000 Ha

S.No.	Crop	Area in Acres	Conversion factor	Equivalent areas on S.cane basis (Acres)
1.	S. Cane	1000	1.0	1000
2.	Wheat	6000	0.67	4000
3.	Jwar local	6000	0.33	2000
4.	Vegetable	900	0.33	300
5.	Others	600	0.33	200
		14500		7500

Water required for Rabi, canal losses 25%

$$\frac{7500 \times 137 \times 1.25}{11.87 \times 70} = 1582 \text{ Mcft}$$

Total water required for Rabi = 7500 + 1582 Mcft.
= 9102 Mcft.

Expected Balance in Reservoir as on 28 Feb. 1982

20239 - 9102 = 11137 Mcft.

Hot weather 1981-82
- From 1 March to 30 Jan 1982 = 122 days

1. Deductions for evaporation in Reservoir at 8 Mcft/day for 122 days:

   8 x 122 = 976 Mcft.

2. Requirement of water for Urban and other uses as per Rabi 488 Mcft.

3. One watering for Kharif seasonal crops 1982-83 for early sowing:

   873 Mcft.
   2337 — 2337

Net quantity of water available for Hot weather season — 8800 Mcft.

Water requirements as per program for Hot Weather:

Mula Right bank canal

S.No.	Crop	Area in Acres	Conversion factor	Equivalent areas on cane basis (Acres)
1.	Sugar canal including cane on wells as per demand of farmers	8000	1.0	8000
2.	Ground nut	30000	0.67	19100
				27100

Water requirement for 122 days considering canal losses 40% and duty 50 Acres of Sugarcane

$$Q = \frac{27100 \times 122 \times 1.4}{11.57 \times 50} = 7859 \text{ Mcft.}$$

Mula Left bank canal including Pravare Right bank canal tail area

S.No.	Crop	Area in Acres	Conversion factor	Equivalent areas on cane basis (Acres)
1.	Sugar cane	1000	1.00	1000
2.	Seasonal crops	3500	0.67	2345
				3345

Quantity of water required:

$$\frac{3345 \times 122 \times 1.3}{11.57 \times 50} = 900.7 \text{ Mcft.}$$

Total water required for Hot weather:

$$7859 + 900.7 = 8759.7 \text{ Mcft.}$$

Expected balance in reservoir on 30 June:

$$8800 - 8759.7 = 20.3 \text{ Mcft.}$$

Illustrative Water Demand Statement for a Rotation of Kharif
(Prepared by Canal Inspector for his beat for each rotation)

Offtake	Demand (ha)					AI/DC (ha)	Q.reqd. (day cusec)
	Cane	Gr.Nut	Kharif Bhusar	Other	Total		
Direct Minor 3							
1. Tail	-	1.00	3.10	-	4.10	2.5	1.5
2. OR-2	-	2.00	2.00	-	4.00	2.5	1.5
3. OR-1	-	2.00	2.80	-	4.80	2.5	2.0
Total	-	5.00	8.00	-	13.00	2.5	5.0
Direct Minor 4							
1. Tail	0.20	-	0.40	-	0.60	2.5	0.25
2. OL-5	0.20	1.00	1.80	-	3.00	2.5	1.00
3. OL-4	-	-	-	-	-	-	-
4. OL-3	0.40	1.40	2.00	-	3.80	2.5	1.00
5. OR-3	-	-	2.00	-	2.00	2.5	0.75
6. OL-2	-	1.00	1.00	-	2.00	2.5	0.75
7. OR-2	-	-	2.20	-	2.20	2.5	0.75
8. OL-1	0.40	1.00	0.80	-	2.20	2.5	0.75
9. OR-1	-	-	-	-	-	-	-
D.M. 4/1							
10.Tail	-	1.00	3.80	-	4.80	2.5	2.00
11.OL-4	-	1.40	6.20	-	7.60	2.5	3.00
12.OL-3	0.60	1.00	7.40	-	9.00	2.5	3.75
13.OR-3	0.80	1.00	5.60	-	7.40	2.5	3.00
14.OL-2	-	3.80	15.80	0.30	19.90	2.5	8.00
15.OR-2	1.00	2.40	5.80	0.30	9.50	2.5	4.00
16.OL-1	0.80	2.60	6.60	-	10.00	2.5	4.00
17.OR-1	-	0.40	3.60	-	4.00	2.5	2.00
Total	4.40	18.00	15.00	0.60	88.00	2.5	35.00
Direct Outlet No. 23	0.40	2.00	8.00	0.20	10.60	*3.0	4.0
G.Total	4.80	25.00	81.00	0.80	111.60	-	44.00

Average AI/DC = 2.54 ha.

* AI/DC = 3.0 is considered for direct outlets on distributary as losses are less compared to outlets on minors.

Illustrative Water Demand for a rotation of Kharif
(Prepared by Sectional Officer for each rotation)

S.No.	Particulars	Demand (Ha)					AI/ DC	Qty. reqd.
		Cane	G.Nut	Kharif Bhusar	Other	Total		
	DM-3	-	5.00	8.00	-	13.00	2.5	5.00
1.	DM-4	4.4	18.00	65.00	0.60	88.00	2.5	35.00
	DO-23	0.4	2.00	8.00	0.20	10.60	3.00	4.00
	Total	4.8	25.00	81.00	0.80	111.60	-	44.00
	DO-21	2.00	3.40	16.00	-	21.40	3.00	7.00
2.	DO-22	1.00	7.00	19.00	0.20	27.20	3.00	9.00
	MI.DY-4	8.20	13.00	65.00	8.40	94.60	2.00	47.00
	Total	11.20	23.40	100.00	8.60	143.20	-	63.00
3.	DY-4	23.60	50.40	162.00	7.20	243.20	2.00	121.00
4.	MINOR-5	7.60	33.00	72.00	27.50	140.10	2.00	70.00
Grand Total		47.20	131.80	415.00	44.10	638.10	-	298.00

Day Cusec

Average AI/DC = 2.14

Illustrative Water Demand Statement for a rotation of Kharif
(Prepared by Sub-divisional Officer for each rotation)

Kukana Sub-Division

S.No.	Name of Section	Demand (Ha)					AI/DC (DT. head)	Qty. reqd. Cusecs
		Cane	H.W.	Kharif	Other	Total		
1.	Kukana Section 1	48.00	136.80	327.35	28.40	542.55	216.00/3.0	72.0
							97.00/2.5	39.0
							229.25/2	115.0
								226.0
2.	Kukana Section 2	47.20	131.80	415.00	44.10	638.10	59.20/3.0	19.0
							101.00/2.5	40.0
							477.90/2.0	239.0
								298.0
3.	Sirasgaon Section 1	54.40	80.20	371.80	12.60	519.00	519.00/2.0	259.0
4.	Sirasgaon Section 2	82.60	38.20	381.40	60.20	562.40	562.40/2.0	281.0
5.	Dahigaon Section	58.20	140.00	564.80	187.40	942.40	44.00/2.5	18.0
							898.40/2.0	449.0
								467.0
6.	R.W.S. Minor	0.40	5.40	28.00	-	33.80	33.80/2.5	13.0
	GRAND TOTAL	274.80	532.40	2098.35	332.70	3238.25		1544 Day Cusecs

Average AI/DC = 2.1 Ha

Transit losses per day in mile 0 to 22 = 70 Cusecs
Flow Period = 7 days.
Total losses= 70 x 7 = 490 Day Cusecs.
Total Qty. Required for Sub-division = 1544 + 490 = 2034 Day Cusecs.
Daily rate of discharge = 290 Cusecs for 7 days.

MULA IRRIGATION DIVISION, AHMEDNAGAR
ILLUSTRATIVE ROTATION PROGRAM FOR A ROTATION OF KHARIF SEASON
(Prepared by the Project Management for each rotation)

Area in ha.
Q in Cusecs day

S.No.	Particulars	Rahuri Sub-Dn.		Ghodegaon Sub-Dn.		Newasa Sub-Dn.		Kukana Sub-Dn.		Amarpur Sub-Dn. Tail Dy.		Amarpur Sub-Dn. Pathardi Br.		Total	
1.	Cane on P.No.7	224.4		235.9		332.6		274.8		65.0		-		1132.7	
2.	Gr. Nut	489.0		413.9		605.0		532.4		173.0		106.1		2319.4	
3.	Kharif Bhusar	1022.0		376.8		1085.9		2098.3		590.0		500.0		6220.3	
4.	Others	88.9		244.3		243.2		332.7		26.4		26.0		914.2	
		1824.30		1770.9		2266.7		3238.2		854.4		632.10		10586.5	
		A	Q	A	Q	A	Q	A	Q	A	Q	A	Q	A	Q
5.	Q required for direct outlet with AI/DC=3ha	145.9	49	267.8	89	276.2	89	275.2	92	-	-	-	-	-	-
6.	Q required for minors & small Dys.with AI/DC = 2.5 ha	1008.4	403	937.1	375	665.4	266	275.8	110	-	-	-	-	-	-
7.	Q required for major Dys.with AI/DC=2 ha.	670	335	566.0	283	1334.1	667	2687.2	1344	854	427	632.1	316		
		1824.3	787	1770.9	747	2266.7	1022	3238.2	1546	854	427	632.1	316	10586.6	4845

MULA PROJECT, AHMEDNAGAR

ILLUSTRATIVE CANAL OPERATION SCHEDULE FOR A ROTATION OF KHARIF
(Prepared by Project management for each rotation)

Discharge in Cusecs.

S.No.	Date	Amarapur Sub-Dn. Tail Dy.	Amarapur Sub-Dn. Pathardi Br.	Kukana Sub-Dn (Br.2)	Newasa Sub-Dn (Br.1)	Mile 38	Ghodegaon Sub-Dn	Mile 23	Ghodegaon Sub-Dn (Sonai Dy.)	Rahuri Sub-Dn	Head
1.	31-7-82	100	79	290	216	685	149	834	73	360	1267.00
2.	1-8-82	100	79	290	216	685	149	834	73	360	1267.00
3.	2-8-82	100	79	290	216	685	149	834	73	360	1267.00
4.	3-8-82	100	79	290	216	685	149	834	73	360	1267.00
5.	4-8-82	100	-	290	216	606	149	755	-	360	1115.00
6.	5-8-82	-	-	290	216	506	149	655	-	360	1015.00
7.	6-8-82	-	-	190	216	506	70	576	-	229	805.00
TOTAL CUSECS DAYS		500	316	2030	1512	4358	964	5322	292	2389	8003.00

Annexure VI (10)

Illustrative RWS schedule on the basis of AI/DC Outlet No.-OR 6
Distance of Tail End Farm Outlet = 700 m. Capacity of Outlet-30 lit/sec (1 cusecs) Losses in F.C. in 700 m length - 20% Correction Factor will increase from 1 to 1.25 in 700 m length i.e. 0.0036 per 10 m length

(Prepared by Canal Inspector for each rotation)

SR. NO.	SURVEY NO.	NAME OF FARMER	DIST. FROM OUTLET m.	AREA TO BE IRRIGATED (HA.)	TIME ON THE BASIS OF AI/DC = 6 (i.e. 10 hrs ha) hrs.	CORRECTION FACTOR	CORRECTED TIME hrs	CORRECTED TIME min	SUPPLY FROM	SUPPLY TO
1	3	Ganesh Patil	700	0.5	5.0	1.25	6	15	Mon 08-00	Mon 14-15
2.	8	Shriram Patil	600	1.4	14.0	1.22	17	05	Mon 14-15	Tue 07-20
3.	6	Nathu Kabra	600	1.1	11.0	1.22	13	25	Tue 07-20	Tue 20-45
4.	26	Vikas Mantri	450	0.8	8.0	1.16	9	17	Tue 20-45	Wed 06-02
5.	13	Vishnu Patil	450	0.7	7.0	1.16	8	08	Wed 06-02	Wed 14-10
6.	14	Hari Markhede	250	1.7	17.0	1.09	18	32	Wed 14-10	Thu 08-42
7.	18	V.M. Patil	150	0.8	8.0	1.05	8	24	Thu 08-42	Thu 17-06
8.	19	Keshav Mahajan	100	0.6	6.0	1.04	6	15	Thu 17-06	Thu 23-21
9.	20	Shankar Patil	-	1.7	17.0	1.0	17	0	Thu 23-21	Fri 16
				9.3 ha						

104.35 hrs i.e. 4.34 days

over all AI/DC at outlet head = $\frac{23}{4.34}$ = 5.3 acres

Rotating outlets on minor cutoff schedule
(to be prepared by Canal Inspector for each rotation)

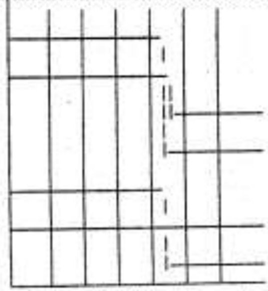
Minor No...........
Dy. No. ....
Branch No..........
Mula Right Bank Canal

Capacity of minor 135 lts/sec
No. of outlets that can be run at a time with 30 lts/sec = 4 m
Total No. of outlets = 7

S.No.	Outlet	Total CCA ha	Area to be irrigated during the rotation ha	Total time required hrs/day
1.	Tail	24.3	9.3	104.35/4.34
2.	OR_4	22.0	10.0	110.00/4.58
3.	OL_4	21.25	5.0	54.00/2.25
4.	OR_3	16.50	6.0	64.00/2.67
5.	OL_3	23.00	9.50	102.30/4.26
6.	OL_1	28.00	15.00	162.30/6.76
7.	OR_1	18.00	5.00	65.76/2.74

DAYS

1	2	3	4	5	6	7



No of outlets running at a time

4	4	4	4	4	4	4

RWS Schedule on the basis of ET Requirement of Crops Outlet No.OR 6 Rotation No. 4 (Jan 1 to 14) Capacity of Outlet 30 lit/sec Losses in F.C. - 20% in 700 m Length

SR. NO.	SURVEY NO.	NAME OF FARMER	DIST. FROM OUTLET m.	DEMAND CROP	DEMAND AREA (HA.)	NIR FOR 14 DAYS (mm/ha)	TOTAL NIR ha-mm		FIR (NIR /0.7) ha/mm	TIME IN min	CORRECTED TIME hrs - min		SUPPLY FROM	SUPPLY TO
1.	3	Ganesh Patil	700	Wheat Jowar	0.3 0.2	85 75	25 15	40	57	317	1.25	6-40	Mon 08-00	Mon 14-40
2.	8	Shriram Patil	600	Wheat Jowar	0.4	85 75	34 75	109	156	867	1.22	17-40	Mon 14-40	Tue 08-20
3.	6	Nathu Kabra	600	Wheat Gram Jowar S. Cane	0.4 0.3 0.2 0.2	85 75 75 125	34 22 15 25	96	137	762	1.22	15-30	Tue 08-20	Tue 23-50
4.	26	Vikas Mantri	450	Wheat Jowar	0.4 0.4	85 75	34 30	64	91	506	1.16	9-50	Tue 23-50	Wed 09-40
5.	13	Vishnu Patil	450	Wheat S. Cane	0.3 0.4	85 125	24 50	74	106	590	1.16	11-25	Wed 09-40	Wed 21-05
6.	14	Hari Markhede	250	Wheat Jowar	1.0 0.7	85 75	85 52	137	196	1090	1.09	19-50	Wed 21-05	Thu 16-55
7.	18	V.M. Patil	150	S. Cane	0.8	125	100		143	795	1.05	14-00	Thu 16-55	Fri 06-55
8.	19	Keshav Mahajan	100	Wheat	0.6	85	51		73	406	1.04	7-00	Fri 06-55	Fri 13-55
9.	20	Shankar Patil	0	Wheat	1.0 1.7	85 125	85 88	173	247	1373	1.0	23-00	Thu 13-55	Sat 12-55

NAGARJUNA SAGAR LEFT CANALS - WATER BUDGET FOR KHARIF

Block I & II

S. No.	Block Nos.	Name of the major	Localised ayacut (in hect.)		Ayacut by Kharif (in hect)		Designed carrying capacity	Water requirement Mcft. for Kharif																	
								June		July		August		September		October		November		Dec.		Jan.		Feb.	
			Wet	ID	Wet	ID	Cs.	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
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
Zone I N.S.C. O&M Division Miryalguda																									
1.	I	Rajawaram Major	3623	-	3623	-	156.25	MCFT	83	58	175	250	200	100	100	200	200	100	-	-	-	-	-	-	-
		(-) Sugarcane	931	-	931	-	C/s	C/s	64	39	135	193	155	77	77	155	155	77	-	-	-	-	-	-	-
		Total	2792	-	2792	-	Total		64	39	135	193	155	77	77	155	155	77	-	-	-	-	-	-	-
2.	I	D.T.D. Km. 14.53	202	-	202			MCFT	6	4	13	18	16	7	7	14	14	7	-	-	-	-	-	-	-
								C/s	5	3	10	14	11	6	6	11	11	6	-	-	-	-	-	-	-
								Total	5	3	10	14	11	6	6	11	11	6	-	-	-	-	-	-	-
3.	I	Peruru Major	669	-	669	-	32.27	MCFT	17	10	37	53	42	21	21	42	42	21	-	-	-	-	-	-	-
		(-) Sugarcane	81	-	81	-		C/s	13	8	28	41	33	16	16	33	33	16	-	-	-	-	-	-	-
		Total	588	-	588	-	Total		13	8	28	41	33	16	16	33	33	16	-	-	-	-	-	-	-
4.	II	D.T.D. Km. 19.30	125	-	125			MCFT	4	2	8	11	9	4	4	9	9	4	-	-	-	-	-	-	-
								C/s	3	2	6	8	7	3	3	7	7	3	-	-	-	-	-	-	-
								Total	3	2	6	8	7	3	3	7	7	3	-	-	-	-	-	-	-
5.	II	Surepally Major	1968	-	1968		80.27	MCFT	58	35	123	176	141	70	70	141	141	70	-	-	-	-	-	-	-
								C/s	45	27	95	136	108	54	54	108	108	54	-	-	-	-	-	-	-
								Total	45	27	95	136	108	54	54	108	108	54	-	-	-	-	-	-	-
6.	II	Bantapur Major	192	-	192		7.66	MCFT	6	3	12	17	14	7	7	14	14	7	-	-	-	-	-	-	-
								C/s	4	3	9	13	11	5	5	11	11	5	-	-	-	-	-	-	-
								Total	4	3	9	13	11	5	5	11	11	5	-	-	-	-	-	-	-
7.	II	Nidamanoor Major	131	-	131		5.5	MCFT	4	2	8	12	9	5	5	9	9	5	-	-	-	-	-	-	-
								C/s	3	2	6	9	7	4	4	7	7	4	-	-	-	-	-	-	-
								Total	3	2	6	9	7	4	4	7	7	4	-	-	-	-	-	-	-

Sample order issued for operation of canals in Bihar

NOTICE

From Irrigation Department

Details for opening and closing of Patna Canal and its distribution system are given below according to which it is possible to supply canal water during Kharif of 1989-90.

S. No.	Name of Canal	Period of running	Period of closer
1.	R.P.Channel A(2) Tutarakhi R.P.Channel B. Teldihamahi (1st reach). Dewra. RP Channel C Anchha feeder. Patna Canal 3rd reach. Imamganj & RP Channel D. Maner. Patna Canal from Vikram to end of Patna Rajwaha Khajuri	20.6.89 to 29.6.89 5.7.89 to 14.7.89 20.7.89 to 29.7.89 4.8.89 to 13.8.89 19.8.89 to 28.8.89 3.9.89 to 12.9.89 18.9.69 to 27.9.89 3.10.89 to 17.10.89 18.10.89 to 27.10.89 1.11.89 to 10.11.89	30.6.89 to 4.7.89 15.7.89 to 19.7.89 30.7.89 to 3.8.89 14.8.89 to 18.8.89 29.8.89 to 2.9.89 13.9.89 to 17.9.89 28.9.89 to 2.10.89 13.10.89 to 17.10.89 28.10.89 to 1.11.89
2.	Patna Canal outlet 1st reach of Mali Canal. 2nd reach of Amra. Saidpur. Mohammadpur L.P. Channel. Belsar. Murra Nagwa. Paliganj. Bharatpura Chandos. R.P. 1Channel. G Patna Canal from Bikram to end Danapur. Majhauli of Rajbah. R.P. Channel. Kurkuri-Dariyapur.	20.6.89 to 24.6.89 30.6.89 to 9.7.89 15.7.89 to 24.7.89 30.7.89 to 8.8.89 14.8.89 to 23.8.89 29.8.89 to 7.9.89 13.9.89 to 22.9.89 28.9.89 to 7.10.89 13.10.89 to 22.10.89 28.10.89 to 6.11.89	25.6.89 to 29.6.89 10.7.89 to 14.7.89 25.7.89 to 29.7.89 9.8.89 to 13.8.89 24.8.89 to 28.8.89 8.9.89 to 12.9.89 23.9.89 to 27.9.89 8.10.89 to 12.10.89 23.10.89 to 27.10.89
3.	M.E. Canal & Manora Mali Ireach Koyasa. RP Canal E. Aiara Rampur Chauram. Parallel channel F. Patna Canal Outlet 1.2.3 RP Channel and Dokha Jaharpur. in between Arwal & Mahbalipur. Rewa. Adampur. RP channel 4. Dorwa Jalalpur.	25.6.89 to 4.7.89 10.7.89 to 19.7.89 25.7.89 to 3.8.89 9.8.89 to 18.8.89 24.8.89 to 2.9.89 8.9.89 to 17.9.89 23.9.89 to 2.10.89 8.10.89 to 17.10.89 23.10.89 to 1.11.89	20.6.89 to 24.6.89 5.7.89 to 9.7.89 20.7.89 to 24.7.89 4.8.89 to 8.8.89 19.8.89 to 23.8.89 3.9.89 to 7.9.89 18.9.89 to 22.9.89 3.10.89 to 7.10.89 18.1.89 to 22.10.89

Note:- 1. Cultivators are requested not to put any obstruction in distribution of water.

2. Any alteration needed during irrigation season is reserved with Executive Engineer.

3. There may be variation in supply due to fluctuation in supply from the same river.

4. The whole canal system will be closed when discharge in some river exceeds 4 lakhs cusecs.

5. The control on supply of water from head quarters from Barun Block to Biton Block and Paliganj district and irrigation will be looked after by E.E. Sone Modernization Div. Bikram. Division Khagol will look after irrigation from outlet. parallel channel. distribution and water courses from main canal.

CHAPTER VI

Implementation of Operation Plan

6.1 Dissemination of operation plan - Need :

The dissemination of operation plan amongst the irrigation staff and the beneficiaries is necessary for successful implementation and improvement in the system operation which would enable:

i) Farmers:

- Taking decisions about crops, area to be sown, its timing, the quantity of water to be made available and periods of supply.

- Wining the confidence of users and inducing a sense of ownership.

- Increasing responsive attitude and acceptability.

Likewise the O&M staff should also know the broad assumptions, projections made in preparing the plan so as to understand the limitations of the plan and suitable actions in implementation during excess/ average/scanty rainfall. They should know precisely:

- Methodology and procedures for operating the canal network.

- Dates of opening/closing canals, time required for filling/emptying.

- Quantity of water planned to be supplied and period of supply.

ii) Staff:

- Better understanding of the plan by the operating staff.

- Understanding of the background of the plan particularly the water availability and steps necessary to take appropriate actions.

- Understanding about who is to do what and when, during implementation?

- Minimizing doubts, confusions or overlapping of actions at relevant time.

6.2 Information to be disseminated

Information about the irrigation operation plan, particularly the delivery schedules, time and periods of supply, crucial to the farmers in making decisions about crops, irrigation area, etc. should be furnished to the farmers as quickly as possible. Information about opening/closing dates of canals, changes in deliveries/closures of canals, restoration of supply etc. has to be given periodically.

Wide publicity is necessary to ensure that all concerned agencies, personnel and farmers get information in time. Various methods of disseminating information are described below:

Issuing Notices/Circulars

Conventional method of informing or drawing attention of large number of staff members and farmers is to issue notices and display on the notice boards.

Written notices give accurate message, can be patiently read and understood by the concerned personnel, and minimize distortions. Notices should be published in news papers, gazette and displayed at prominent places, offices, visited by the farmers.

- Irrigation offices such as circle, division, sub-division, section, CADA, T&V staff of agriculture extension services.
- Zila Parishad, Block/Tehsil, Panchayat, and Water Users Association (WUAS).
- Local bazaars, regular markets, credit societies, banks, sale/purchase agencies.

News Papers

News papers are likely to publish news of particular interests and may willingly take the news, bulletins or special articles describing the services provided and benefits of irrigation etc. The news or notices published give authentic information, that can be clearly understood by the farmers.

All India Radio (AIR) and Television (Doordarshan)

AIR and Doordarshan are the fastest and wide spread mass media reaching remotest places. The irrigation operation plans and information relevant to the farmers should be broadcast, telecast appropriately.

In addition, news bulletins and local announcements about water delivery schedules, crops to be taken to suit the planned frequencies of supply, appropriate dates for sowing should also be broadcast or telecast periodically.

The programs, plans to elaborate the services and benefits etc. could be organized to be discussed through interviews with the farmers on AIR/Doordarshan.

It is likely that the broadcast on AIR or displayed on TV screen may not be followed accurately. Hence, repetitions may be essential to attract attention of the listeners/viewers requesting them to obtain any further details from the irrigation officers.

6.3 Interaction - Need

Interaction with the operating staff and the beneficiaries would lead to valuable suggestions in respect of operation and use of water. These can be innovative and very useful in the mid term corrections in the water deliveries during the season, as well as in improving/preparing subsequent operation plans. Interaction would also establish healthy relations between the project managers and the users. Farmers would feel that they are consulted or involved in the planning/decision creating a feeling of ownership and promote judicious and economical use of water. Interaction and consultation with the supporting service agencies and operating staff helps in better understanding and emphasizing the importance of actions/efforts expected from them. Their suggestions may likewise indicate practical applicability of the process and improve the control/regulation of water.

(i) Interaction with the farmers

Organizing the farmers at various levels such as minors/ distributaries and seeking their participation in water distribution/management at micro level is a need which has even been initiated in many states. Outlet committees/panchayats, water users' Associations (WUA) at minor/distributary level or for the entire area covered in minor irrigation projects and systems based on wells are also being established. These WUAs should be able to undertake water distribution, resolving disputes in water sharing and maintenance of field channels/field drains in the initial stage. Later these can be involved in planning of crops, organizing inputs etc.

Canal consultative committees or canal advisory committees at the project level or at the irrigation division level should also be established, in fact these are existing in many states. It should be mandatory to organize meetings at fixed place(s) and time to redress the grievances of the farmers at least at sectional level. The officers too should also fix time and day for meeting farmers at their headquarters.

Discussions should be organized with such formal or informal committees/associations. The discussions could be held through specially organized meetings at villages/gram panchayats or block generally with groups to know their collective reaction/response. These discussions may cover following points:

- Opening/closing dates of canals - the basis adopted in evolving the plan, the water availability, actual or projected cropping pattern and suitable sowing dates. The crops planned, the sowing dates may be assessed from the farmers so as to match them with the program. The periods of critical stages of growth of various crops could be then assessed for mid-season corrections, later.

- Proper upkeep, maintenance and repairs of micro level network such as field channels, field drains. The importance of deweeding, desilting of field channels/drains for getting full quantity of allotted water and minimizing the seepage losses should be explained and the WUAs/ farmers advised to organize these in time, before the commencement of the season.

- Whereas water deliveries for Kharif season depend upon the replenishment in reservoirs or river flows and rainfall in the command, but knowing sowing dates of various crops, contingent plans for water deliveries in case of scanty rainfall and the possibility of skipping a rotation to conserve water for the most critical growth period can be discussed. Similarly possibilities of conserving water by decreasing the rotations (for storage based schemes) to be able to supply more water for the Rabi/Hot weather can be discussed.

- The major loss of water taking place in the field application and its importance should be brought home (even in well established canal systems field application efficiency is less than 70%). With proper training and educating the farmers, this can be improved to saving a large quantum of water.

- Improved methods of application like borders, furrows, etc. need to be introduced to the farmers. Large scale interaction to be followed by demonstrations of these methods, explanation on optimum lengths and widths of borders, furrows, stream size, cut off points should be given and later demonstrated on their fields. Irrigating alternate furrows to save water under conditions of scarcity or giving light dose by increasing stream size could also be explained. The extension wing of Agriculture Dept. may be requrested to provide the input.

- For paddy irrigation, the latest finding of Agricultural Research is that, it is not necessary to maintain high depths of water (5 to 10 cms) all the time. The yields do not reduce, even if there is no water on the surface for one day. This can be an important factor for extending irrigation to other areas by economizing/conserving water and improving irrigation efficiency. The extension wing can be requested to intervene.

- Film/slide shows, Video Cassettes may be extensively used for quickly educating/assisting the farmers in the command in large number.

(ii) <u>Interaction with Staff & Other Agencies</u>

Interaction with staff should cover all operational details and delineation of various tasks to be performed by the field staff. It may also include ascertaining/ processing or obtaining necessary approvals, sanctions as per statutes. Suggestions on duty allocations are given in Appendix I.

The allocation of duties and timely actions to be taken, is an important aspect of successful implementation. In addition, instructions for respond to various situations arising in supply of water through large networks are also required to be circulated and discussed. Illustration on duty allotment for one category of the field functionary is given below;

<u>Gauge reader:</u>

- Fix exact time of reading the gauges.

- Procedure for reading the gauge accurately, eliminating parallax.

- Recording in register clearly in an unambiguous manner.

- Reading the corresponding discharge from discharge rating curves/graphs/statements.

- Reporting gauges & discharges in standard units prescribed, whether in lit/sec or cumecs and gauge in cms or meters up to second or third decimal points.

- Action to be taken if gauge decreases/ increases such as;

  i) If the gauge of main canal/branch increases beyond danger line, encroaching the free board; open the escape and intimate sectional officer.

  ii) If the gauge of distributary/minor increases beyond the specified level, operate the gate and adjust the gauge/ discharge to the level permitted and intimate the sectional officer.

  iii) If the gauge in main canal is less than planned, intimate the sectional officer.

  iv) In the event of breach in main/branch canal, take following actions:

     a. Close the cross regulator on upstream side
     b. Open escape to release excess water
     c. Simultaneously report immediately the sectional officer and the sub-divisional officer.

(iii) <u>Interaction & linkage with Supervisory functionaries such as mistry/mate</u>

The sectional officer is the last rung of control on operation and maintenance of the network. The functions are divided below this level. The mistry/mate/gangman are responsible for maintenance, and the mistry/canal inspectors are responsible for operation and supplying water. A close linkage is essential for smooth and timely operations and maintenance.

The Mistry/mate should know the program of works to be carried out inside the channels during closure period. In case of breach, the gauge reader/ ziledar/patwari, canal inspector on getting information should take immediate action to close upstream CR, open escape and intimate mistry/mates to take up repairs if the breach is of small magnitudes.

Leakages through gates of HRs of distributaries/ minors, jamming of gates, bending of stem rods, wearing out of seals of gates, leakages through structures like pipe/ masonry aqueducts, damage to lining noticed should be promptly reported to mistries, and the sectional officer, for taking up repairs.

(iv) There should be standing instructions to the operating staff on the actions to be taken in emergent circumstances. Emergency situation may crop up during implementation due to i)Earthquakes ii)floods iii) breaches in canals iv)Heavy down pours.

In case of damages due to rainfall and earthquakes, following actions are advisable.

Assess damage, if it poses a threat to the safety-reduce discharge or close the channels and report to sectional officer for immediate inspection and repairs. Breaches are common in a large network due to piping, failure of structure, or over-topping. Major breach particularly in Main canal/branches affect the rotation program and may lead to submergence of fields nearby, besides the loss of production as it may involve stoppage of supply. Prompt and action is necessary to minimize the damages. The important actions required on occurrence of breach, are described below:

- If the breach is liable to erode the channel section, close up-stream regulator completely or reduce the discharge to the extent that can safely pass.

- Open the escape up-stream and release excess water.

- Assess the discharge required for the upstream off-takes and reduce discharge in the main canal to meet that requirement.

- Intimate the occurrence of breach on priority message 'CRASH' to the next higher officer and all other officers in the command.

- Sectional officer/SDO should inspect the breach and take actions such as;

  Assess (i) extent of damage (ii) labor, material and equipment needed for repairs (iii) approximate time required for the repairs (iv) labor, material & equipment with them to start repairs and (v) expected time to start work of closing.

- Organize procuring labor, material, equipment from other units;

- Intimate the farmers on AIR/TV and wireless network through bulletins, the location of breach, probable time of starting the repair work, expected time and date of completing repairs as well as likely time for release of water. A diagram showing the flow of such a situation is given at Appendix I.

- Start the repairs immediately simultaneously preparing working estimates/obtaining approval, sanctions.

- The SDO/SO should workout the travel time of water to downstream and intimate the farmers about the exact time, they would get water.

- Standard message should be used for reporting breaches suggesting actions to be taken in the situation

6.4 Feedback from Field::

For quick communication and relay of reports/ instructions the system needs a reliable communication network. For the system to work properly and efficiently, the need is for a dependable communication network to quickly disseminate information pass important messages and convey instructions.

It is used for conveying day to day information relevant to implementation.

(a) Reporting of gauges

i) The reporting of gauges and discharges to higher levels affords monitoring of the canal flows and should be arranged to be done promptly.

ii) All information about the gauges/discharges within the jurisdiction of sections, sub-divisions, division should be reported at one time in one message every morning and evening.

iii) In order to minimize time in transmission, the message should be very brief. Standard form of messages called "Situation reports" (SITREPS) for rain gauges and discharge `sitrep RGD' should be used for this purpose.

The names of distributaries CRs, HRs could be printed so that only the figures of gauge readings and discharges need be filled in while reporting which can be used by the receiving side also saving considerable time.

Suggestions on assignment of duties for improving implementation process for other categories are given in Appendix II.

(b) <u>Other Information</u>

Most of the information is available/collected at the field and transmitted regularly to the project level as feed back. The information or feed back which is required daily or frequently -

i) Precipitation rain/snow fall
in catchment area
in command area

ii) Floods or inflow in the reservoir.

iii) Run off, river gains.

iv) Annual yield of the river.

v) Contents in the reservoir.

vi) Water released from the reservoir, spills diverted into the canals, evaporation.

vii) Water flows in canal at different points in the network.

viii) Area irrigated vis-a-vis water delivered.

River gains by regeneration from catchment are assessed presently on ad-hoc basis. However, exact measurements need to be taken by installing gauges on nallas joining upstream of the work.

(ii) <u>Actual Canal deliveries/gauges</u>

Measurement of discharge in open channels is important part in inplementation. They are classified two major categories:

a) Velocity type and

b) Head type

There are many types of standard measuring methods of which some are good and dependable to suit the water head available and accuracy desired.

<u>Points of measurements</u>

Measuring and reporting of water discharges at the HRs/CRs/escapes of canal, branches, distributaries, provide a feedback on releasing water in various networks as per schedules in respect of time and quantity. It also provide information about equity in water deliveries in various sub commands and that the flow in the main system is such that;

- the operational losses are minimum;
- there is no unauthorized diversion;
- there is no wastage of water in the system.
- to enable water flow upto tails of minors.

The discharge should therefore be measured at following points:

a) Main canal/branches - HRs, all CRs, escapes, bridges, flumed measuring devices. It is advantageous to have measuring devices at the beginning/end of each irrigation unit division/ sub-division.

b) Distributaries - All HRs & tails.

c) Minors Head & Tail ends

d) Outlet Head

(d) <u>Reporting of the data</u>:

	Observing & Recording by	Reporting by	Checking by
HRs Main/branch canal, distri-butaries and tail gauges	Gauge reader/ canal inspect-or/chowkidars/ wireless oper-ators	S.O.	S.D.O.
HR, Outlet	Patwari/canal inspector/ gauge reader	Ziledar/ S.O.	S.O.
CRs/Escape	Watchmen/ wireless operator	Wireless Operator/ Chowkidar	S.O./ S.D.O.

All the canal gauges should be reported twice a day i.e morning and evening at prefixed hours. Reporting at nearer intervals, may be come necessary during major changes in the flows.

The sectional officers and sub-divisional officers should report progressive as well as cumulative quantity of water delivered in the channels or part thereof lying in their jurisdiction weekly, fortnightly basis or as may be specified.

(e) <u>Feedback on cropping activities</u>

The actual crops sown, cropped areas, sowing dates for assessing critical growth stages may vary slightly or substantially from the adopted in the operation plan and therefore periodical feedback from farmers is necessary for reviewing and regulating water deliveries to meet the crop water needs during implementation of the plan.

The sowing/transplanting generally takes 2 to 4 weeks. The information need to be furnished weekly giving cumulative figures of cropped/irrigated areas of each major crop.

The information when received has to be arranged suitably as per canal sub-networks.

(f) Feed back on losses:

A feedback of losses and thereby the irrigation efficiency is a vital information about the performance of the system and water use. The efficiency can be judged quickly by two indices during the season.

- Losses in the canal system which indicate the conveyance and operational efficiency.
- Coverage by irrigation,an indication of water application/use efficiency.

The conveyance losses can be worked out by collecting information about quantity of water received and diverted in a specific reach of canal over a unit period.

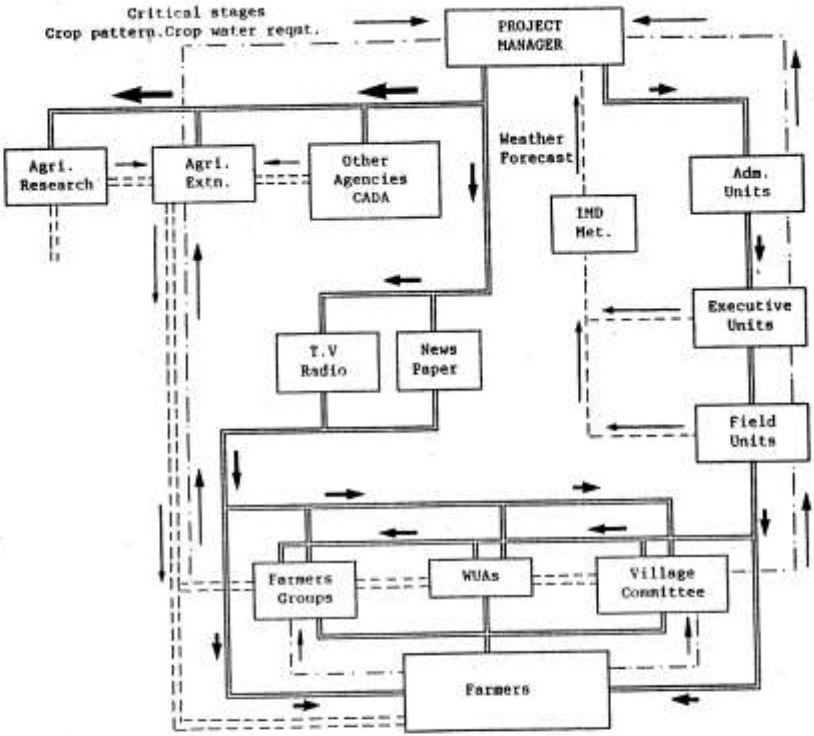
The reporting, computing and analysis can be done at the end of each rotation, season or the year.

The coverage by irrigation when related to the quantity of water delivered gives an indication of water use efficiency.

For assessing the irrigation efficiency and thereby the management efficiency, the area irrigated per unit volume of water supplied will have to be observed and recorded.

6.4.1 Responsibility for feed back: A precise system about collection & reporting of information has to be introduced by the system manager showing who is to collect data, the frequency of reporting etc. Some identification of such function has been done and is shown in Appdx.II.

Flow diagram depicting dissemination and feed back procedure



Information about water availability, opening/closing of canals period, frequency, field preparation, irrigation method.

Crops varieties, sowing time, package of practices, critical stages, assured pest control.

Actual sowing dates, cropped area, critical stages (actual).

Weather report by field office, forecast by IMD.

6.5 Review/Revision in response to feedback:

As the irrigation progresses in a season, more information about the crops, cropped areas etc. is available to the project management through periodical feedback. The actual precipitation/replenishment in the reservoir etc. is also known from time to time. This data is required to be processed, analyzed quickly to devise appropriate decisions to meet the actual conditions. If the area irrigated or the replenishments in the reservoir/river flows differ substantially i.e. about 20% from planned flows a revision of delivery schedules may be required to aim better utilization and yields. To facilitate compiling/processing/analysis/ retrival of voluminous data, it would be advisable to use desk calculators/computors. Every sub-division may be permitted a desk calculator and the division may have a micro-computor. Various likely situations are briefly illustrated below:

(a) Kharif

The water delivery schedules are mostly dependent on the monsoon and are thus flexible. The rainfall in the command and catchment monitored constantly, may necessitate revisions to meet the situations.

(b) Rabi and Hot Weather

The water availability is precisely known. The rainfall contribution assumed in the operation plan is generally small. There would be few occasions for revisions in delivery schedules. The rains in the catchment or command is helpful and conducive to saving/conservation of water which can enable increasing areas under hot weather season. There is thus a need for revision of schedules, even if the variations are of small magnitude.

There can be various eventualities within the irrigation scenario. The possible actions in respect of review/revision can be:

More rainfall both in catchment and command areas

There is no apparent need to save/conseve water, the demand is also small. If the variation in rains is small, no revision may be necessary. Distributaries receiving more rainfall can be closed and excess water diverted through escapes to avoid water logging/ flooding and damage to crops.

(i) If the rainfall in command is high, main canal system may need closure or reduction for the safety of the network and minimizing water logging/ flooding.

(ii) In the event of volume control for operation, if the network is small, and travel time does not exceed 1-2 days, the flow may be reduced or even stopped. In other cases, where response time is longer, main system may be run with less discharge and the distributaries closed. Excess water may be released through escapes.

- More rainfall in the command, less rainfall in the catchment or less river flow

  Such a situation warrants saving or conserving water to the extent possible. The water deliveries may be reduced in the affected areas so long it does not affect the crop yields. Canal networks, with constant volume control operation or projects with small networks can reduce or stop water flows as per requirement.

- Less rainfall in the command, with less rainfall/ replenishment, in the catchment is a problem which tests the skills of irrigation management. Due to different methods of water distribution, the approach has also to be different to meet the situation. The strategies may be:

(i) Northern Region

  The rostering & grouping of distributaries and according priorities for supply in different weeks as per availability and supply automatically provides in-built mechanism for effecting deliveries by field functionaries in different situations.

(ii) Central region

  One or two planned rotations in the non-critical stage growth periods can be skipped or deferred so as to suply during critical stages.

  In case of severe drought water saving measures like irrigating alternate furrows/borders, mulching may be advocated.

- One or two waterings can be skipped during non-critical stage growth periods.

- Supply in critical growth period of the principal crop should be maintained but adjusted as per sowing dates.

- Water should be conserved by closing the distributaries receiving rains.

If water receipts are noticable in October/November the actions can be:

- Revise the PIP to include additional area which can be sanctioned under late Rabi/Hot weather crops like ground nut, sunflower, hot weather green grass, fodder or suru sugarcane.

- Revise number of rotation for the remaining Rabi/ Hot weather seasons. Isuue fresh notice inviting applications for late crops.

(iii) <u>Southern Region</u>

The supply is generally with on & off running of distributaries.

(a) When water is more than anticipated which could be due to

- More post monsoon flow or late rains in catchment; or

- More rains in the command reducing irrigation needs.

(b) If water receipts are noticed earlier, say in October or November, revised operation plans may be considered.

- By reducing the 'off' period and increasing 'on' period and intimate farmers to enable them to sow additional area under different late rabi/Hot weather crops.

It may be advisable to conserve water for Rabi by closing the distributaries receiving rains. Even a small rain may be able to meet the consumptive requirement for a small period.

(c) If the availability of additional water is noticed late or there is late rainfall in December/January. Revision of schedules can be considered by:

- Supply of additional watering during critical growths.
- Conserve water in Rabi and increase the irrigation in Hot weather season.
- Reserve water for presoaking irrigation to the deep black cotton soil command areas, to enable farmers to take early kharif crops in the following year.

6.6 Suggestions for Improvements

6.6.1 The preparation and implementation of operation is dynamic to accommodate parameters e.g. rainfall, breaches in canals and crops. Computor use should be resorted for rescheduling daily/weekly deliveries. In Maharashtra, it has been started on pilot basis on minor works.

6.6.2 Volume control concept: The controlled volume concept for operating the gates and canals involves manipulation of the water levels between two cross regulators in such a way that the volume of water in the reach is kept practically same through many ranges of flow.

The water surface at zero velocity is maintained at FSD upstream of each CR and the volume of water stored in the compartment is worked out. While increasing the flow, the water surface is rotated at the mid point between the CRs by depressing the water level at the downstream CR and allowing it to rise due to back water effect upto the upstream CR. Care is taken to operate all CRs simultaneously at a predetermined time. The obvious advantages are:

- Canal storages are artificially built in compartments, between CRs, throughout the length.
- Changes in water surfaces, during fluctuations in the flow are minimum.
- Response time between demand and supply at any point i.e. head or tail is minimum, depending upon the rate of permissible depletion of water.

- In emergencies i.e. breaches or heavy rain fall in the command, it permits rapid shut down of the system to whatever extent necessary. As all the flow can be held, the loss or wastage of water can be significantly reduced.

6.6.3 Annual Performance Report: An annual completion report on the performance of the plan is necessary to evaluate the implementation. Broad outlines are shown in Appendix IV.

6.6.4 It is advisable that the head of the department should prescribe rules for system operation and circulate amongst the concerning staff. Suggestions are given in Appendix V.

Suggestions for regional improvements are given below:

Northern Region

1. Measurement and accounting of water in minor irrigation projects should be at par with major projects and reflected in Annual Performance Report.

2. Rostering distribution and according priorities in advance for supply of water during different weeks, eliminates arbitration/misunderstanding in supplying/receiving water by project field level functionaries and farmers. This also provides inbuilt mechanism in adjusting the deliveries automatically, in different situations of getting more/adequate/less water in main system.

   However, the farmers cannot get exact idea about the total quantum of water they are likely to receive, which is necessary for deciding crops, cropped area.

   Efforts should be made to intimate quantity and period of guaranteed supply during critical stages particularly in the storage based systems.

3. The revenue wing may be entrusted the responsibility of assessing the coverage of irrigation vis-a-vis water supplied and thereby improve the overall efficiency through regular monitoring and reporting the area irrigated/day cusecs or AI/DC by end of each rotation/season at outlet and minor level.

Central Region

Rigid Shejpali i.e. allocating precise time for each farmer should be adopted on all systems.

Applications and sanctions for water supply is a very elaborate process particularly when the farmers do not apply in time during Kharif. The water availability also cannot be predicted to plan water deliveries precisely in advance. In such uncertain situation, dispensing of applications for Kharif should be considered. Water can be supplied as per indents placed by Water users Associations (which are being formulated) indicating crops and areas.

In order to minimize effort involved in processing/ sanctioning applications for water; supply on volumetric basis at minor level to Water users Association could be encouraged. Computerization for preparing rigid Shejpali schedules assessing flows in main system may also be considered to bring preciseness/accuracy and speed during implementation.

Southern Region

Irrigation Water Tax is levied once the areas are notified under the project as a surcharge on land revenue. The project management has no obligation to measure irrigated area and prepare demands every season. However, this underscores the importance of measuring canal flows, end uses in utilization, ensuring equitability in supply and thereby evaluating performance efficiency.

Measurements of cropped (irrigated) area jointly by ID/Revenue staff should be introduced and reflected in annual Performance Report. The ID should compare water delivered against the area irrigated seasonally and should monitor number of waterings supplied at outlet level and farmer level on sample basis. Eventually measurements of water flows at different points would be obligatory for field staff.

The present practice of supply water to part command during shortages, may be reviewed from the point of view of equitable distribution and social justice. Attemps could be made to supply less number of waterings at critical stages to larger areas which would also promote substitution of light crops needing less water which can be sown on larger areas particularly during Rabi/Hot Summer.

Eastern Region

Extensive use of ground water potential, through conjunctive use or augmentation together with substitution of light crops needing less water may be considered particularly in Rabi/hot weather so as to increase cropping in these seasons and utilization of water on large areas to more number of farmers.

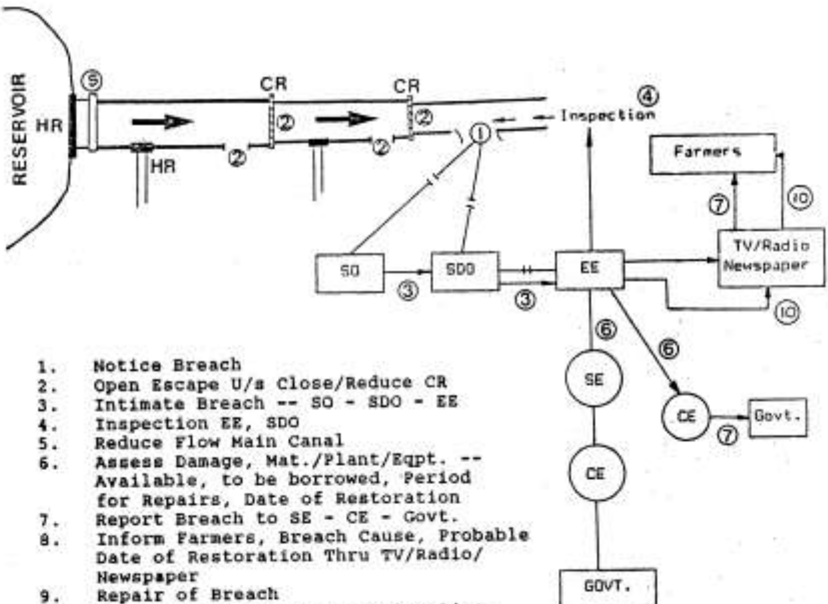
Planning operation of canals with 'ON' and 'OFF' system during Rabi/hot weather would be conducive to encourage light irrigated crops.

Measurements of irrigated crops and water flows need to be more systematic so as to get true picture of irrigation performance, equitable supply to all farmers.

6.7 Role and responsibility of project management

For improving practices of system operation and implementation, it is vital to allocate distinct role and responsibility for each of the functionary(s) precisely. The accountability to prompt discipline and promptness has to be also laid down. A few suggestions in this respect are given in Appendix VI.

Diagram showing the flow of feedback in case of a canal breach



1. Notice Breach
2. Open Escape U/s Close/Reduce CR
3. Intimate Breach -- SO - SDO - EE
4. Inspection EE, SDO
5. Reduce Flow Main Canal
6. Assess Damage, Mat./Plant/Eqpt. -- Available, to be borrowed, Period for Repairs, Date of Restoration
7. Report Breach to SE - CE - Govt.
8. Inform Farmers, Breach Cause, Probable Date of Restoration Thru TV/Radio/ Newspaper
9. Repair of Breach
10. Final Intimation about Restoration, Date of Water Release

1. Suggestions on Assignment of Duties - Implementation Process

The conveyance network constraints and the absence of clear guidelines for operating the system to deliver equitable, assured and timely supplies to all farmers have generally resulted in huge and avoidable waste of water. These have also resulted in appropriation of more water by the upstream farmers than their fair share at the cost of the tail enders, besides causing a negative impact on the economic performance of the irrigation project.

1.1 No matter how well a project is designed and constructed, an irrigation project fulfills its intended functions only when properly and judiciously operated and maintained. It is the general experience that water delivered equitably according to assured and timely schedules could raise production substantially and increase the net returns and incomes without appreciably increasing the operation costs.

1.2 A detailed note on duties of the O&M staff starting from gauge reader/sluice operator upto Executive Engineers, indicating the responsibility at each level, time of recording the gauges, reporting times etc. should be understood and adhered to. The following can be used as guidelines for duty allocation.

A. Gauge Readers

The gauges provide information for monitoring, accounting and later on auditing of water supplied and are therefore very important in irrigation management. The recording should be clean and unambiguous, showing actual gauges as read and the corresponding discharges as per the ready reckoner; supplied in the form of graphs or tables. The remarks column should invariably be filled in, showing possible reasons for departures from the schedules, e.g.

i) Fall in water levels in the parent channels,
ii) closing of off-takes due to rainfall in command and
iii) opening of distributaries due to prolonged dry spells.

The primary record should be with gauge readers, operators/chowkidars who may maintain one register for all the points in the beat.

Work Inspector/Mistry

He will receive & superwise the roster program, observe daily gauge and discharges at the head and tail of the minors, (morning and evening) with the help of the gangman, record the same in the register and report the same to the section office before 08-00 hours and 17-30 hrs every day. He will also monitor the gauges and discharges of the distributaries and report to higher authorities for corrective action to maintain the authorized discharge.

Wireless Operator Cum Watchman at the Cross Regulator

He will have stage-discharge tables for different openings of gates at different operating heads. He will receive advance intimation from S.D.O. about setting of gates and maintaining the gauges upstream and downstream gauges and the gate openings and the corresponding discharge at 07-00 hrs and 17-30 hrs and transmit the same immediately to the S.D.O. under intimation to Section Officer.

Whenever there is an instruction to effect the changes in discharge, he will also record hourly/half hourly gauges, gate opening, as per instructions and give a final report at the end of the operation. He will have a standing instruction that in case the upstream gauge level crosses the danger mark, he should immediately open the escape and maintain the gauge level below the danger mark and report continuously to the S.D.O./S.O.

Sectional Officer

He will have the irrigation program, (annual and seasonal) rostering of distributaries, opening/closing times of main canal/ branches and distributaries in his jurisdiction. He should have ready information about gauge discharge tables for main canal, HRs of branches and distributaries and cross regulators in the jurisdiction.

He will receive the gauge/discharge reports from

i) gauge reader
ii) work inspector and
iii) watchman/wireless operator of cross regulators.

He will record this information including the daily rainfall data in the registers, verify the discharge as per tables and report the same to the S.D.O. between 08-30 to 9-00 hrs and 18-00 to 18-30 hrs, except the information of CRs which will have been already transmitted directly.

He should monitor the setting of gates of CRs through reports or personal inspection as per the program received from time to time.

He will also monitor regularly the gauge and discharges of the distributaries, minors and tail gauges during his inspections as also through daily reports.

Sub-divisional Officer

He will have the irrigation program (annual and seasonal) rostering of distributaries, opening/closing times of main canal, HRs of branches/HRs of distributaries in his jurisdiction. He should have also ready information about gauge, discharge, gate openings of HRs and CRs.

He will receive the daily gauge/discharges and rainfall dates from the Section Officers and wireless operators at CRs through the tertiary network. He will record the information in the registers maintained in his office. He will transmit the information to the Executive Engineer through the secondary network between 08-30 to 09-30 hrs and 18-30 to 19-00 hrs.

He will receive the instructions from the Executive Engineer about changes in the discharge to be made in main canal and branches and transmit the same to the wireless operators at CRs under intimation to the Section Officers.

He should monitor the operation frequently. He will also monitor the gauges/discharges of distributaries and laterals during his field inspections and through reports.

EXECUTIVE ENGINEER

He will have the irrigation program (annual/ and seasonal) rostering of distributaries, opening/closing times of main canal, HRs of branches/HRs of distributaries in his jurisdiction. He should have also ready information about gauge discharges, gates openings of HRs and CRs.
He will receive through secondary network daily gauge/ discharge and rainfall reports from sub-division officers, records the same in the registers maintained and transmit on the primary network the required information to the central irrigation operation control (C.I.O.C.) under intimation to the Superintending Engineer and the Chief Engineer O&M.

In case of heavy rainfall, he will instruct the S.D.O. to close the concerned distributary, letting out excess water through the escapes and report to the C.I.O.C. about the same and suggestions if any, for continuing the closure or not opening of the distributaries scheduled to be opened in the following period. On receipt of instructions from C.I.O.C., the E.E. will in turn pass on the instructions to S.D.O. to effect changes in discharge of main canal and branches and setting of gates.

APPENDIX III

Responsibility of various officers (activity wise)

Item	Responsible officers	Frequency of reporting
1. Water availability		
Rainfall in catchment and its distribution	SO/SDO/EE in charge of dam	Seasonal & annual
Rainfall/runoff relationship	- do -	annual
Yield of River	- do -	seasonal & annual
Storage, storage efficiency	- do -	seasonal & annual
Rainfall in Command	SO/SDO/EE in-charge of canals	seasonal & annual
Ground water availability	GWD/agri. dept.	annual
2. Status/condition of Project		
1) Total water supplied & efficiency of main canal/ branch	SDO/EE for their jurisdiction	seasonal/ annual
quantity of water released for escapes	Canal inspection in Central region	
2) Total water supplied & efficiency of disnet	SD/SDO for their jurisdiction EE to compile for his Division CE/SE to compile for Project	seasonal/ annual
3) Water released from outlets & efficiency	Patwari/Ziledar for their jurisdiction	

4) Water application efficiency	Patwari/Ziledar, canal inspector, section officer by conducting sample testing	seasonal/ annual
5) Overall project conveyance efficiency	EE/SE/CE in-charge of Project	annual

2. Utilization of water

1) Area irrigated cropwise/ seasonwise annual	Ziledar, Deputy Collector in Northern Region	seasonal & annual
2) Intensity of irrigation on canals	Canal Inspector, SO & SDO in Central region for their jurisdiction. EE to compile into for Div. SE/CE to compile for project Agriculture Deptt. in Northern/South Region	
3) Area irrigated by ground water a intensity	Canal inspector, so in Central region SDO to compile for sub-div. EE to compile for Div. SE/EE to compile for Project	seasonal & annual

3. Duties/Delta

1) Seasonal duty & delta of outlet/minor head & delta	Patwari/Ziledar in Northern Region. Canal inspector in Central Region	
2) Seasonal duty & delta of distributary head	Sectional officer/ Ziledar	
3) Seasonal duty of Main/ branch canal head	EDO/EE for Sub-div/div SE/CE to compile for project	

4. Cropping intensity

1) Total cropped area & cropping intensity	Rainfed area to be collected from Agri. deptt. or Director of station & compile for project. EE of Div. level SE/CE of Project level	seasonal/ annual

5. Health of soil/water

1) Area water logged/Prone to water logging/salt affected	Directorate of Irrigation Research or Drainage Div. in Central Region EE/SE for Northern/Southern Region	
2) Quality of soils, water	Director of Irrigation Research or Drainage Divn. in Central region; Agri. deptt. or GSDA in Northern & Southern Region.	Annual
3) Accidents/breach	Mistry/S.O. SDO for Sub-Div. EE for Div. SE/EE for Project	Annual

6. Costs

1) Expenditure on Regular & worked charged establishment	EE	
2) Expenditure on Casual labour	SDO/EE	
3) Expenditure on repairs/ other item	EE	
4) Assessment of cost per Ha. for O&M	EE for Div. SE/CE for Project	

APPENDIX IV

Annual Performance Report

A comprehensive annual administrative report about the performance of the project should be prepared by the project managers at the end of irrigation year i.e. 30 June. The report should be discussed in detail at the policy making level i.e. CADA board/canal consultative committee, canal advisory committee or various water management boards.

Purpose of the annual performance report

The annual report should be a concised record of the project performance giving details of natural resources as available, condition of the project components, management efficiencies, successes, failures in respect of achievement of end objectives such as utilization of available water, productivity and production. The report should also reflect the annual expenditures to judge the cost effectiveness of the project.

The report would indentify the weaknesses of the project personnel as well as farmers in utilizing the resources in optional manner.

The analysis of the report would provide useful information and guidance in improving the operation plans in subsequent years as well as in improving the implementation for achieving the planned/desired objectives.

Contents of the annual report

1. Availability of natural resources

    1. Weighted actual rainfall in the catchment against the anticipated/designed and rainfall/runoff relationship.
    2. Actual runoff of the river against anticipated/designed, number of rainy day, dry spells.
    3. Distribution of rainfall monthwise/ 10 days period vis-a-vis as per design
    4. Yield of the river in the year, vis-a-vis designed.
    5. Actual water stored vis-a-vis planned/designed.
    6. Actual water stored against maximum allowable storage to know storage efficiency.
    7. Quantity of water diverted from canals vis-a-vis planned/designed.
    8. Weighted actual rainfall in the command and its distribution/monthwise/10 days period against anticipated/designed.

9. Ground water potential in the command

Status and condition, performance of project components

1. Water released from HRs of distributaries against water released from HRs of main canal to know conveyance and operation efficiency of the main system.
2. Water released from HRs of minors/outlets against water released from HRs of distributaries to know conveyance efficiency of distribution network.
3. Water released from outlets against water released from HR of Minors as per sample tests to know conveyance efficiency of tertiary system.
4. Micro network conveyance efficiency as per sample testing of some outlets.
5. Application efficiency of the farmers fields as per sample testing.
6. Overall project application and conveyance efficiency.
7. Quantity of water released from escapes and leakages from various structures to know operation efficiency.
8. Farmers satisfaction on water availability as per program.

Utilization of water

1. Area irrigated cropwise, seasonwise and during the year from canal water vis-a-vis planned as per project report.
2. Area irrigated cropwise, seasonwise and during the year from ground water.
3. Irrigation intensity on canal water vis-a-vis planned and as per project report.
4. Gross irrigation intensity including irrigated area from ground water.

Duties, delta

1. Seasonal duty of irrigation in ha per cumecs at the head of outlet, minor, distributary, main canal. AI/DC in case of central region, vis-a-vis planned/as per project report.
2. Delta of Irrigation in mm/ha seasonal/annual of irrigated area at field, outlet, minor, distributary and main canal level -vis-a-vis planned as per project report.

Cropping intensity

1. Total cropped area cropwise, season wise, during the year.
2. Cropping intensity season wise, annual

Health of soil and water

1. Area water logged compared to previous year.
2. Area prone to water logging.
3. Saline area compared to previous year
4. Area prone to salinity
5. Quality of water from canals & ground water, PH, electrical conductivity, PPD,
6. Area damaged due to water logging/salinity and unfit for cultivation.

Other statistical information about performance

1. Number of breaches in Main/branch canal, period of closure, reduction in number of irrigation rotation.
2. Number of breaches in distribution network, period of closure area affected -
3. Number of accidents, during repairs.

Costs

1. Expenditure on Regular establishment allocated to the project
2. Expenditure on work charged establishment
3. Expenditure on casual labour
4. Expenditure on repairs
   i) Material
   ii) Contracts
5. Other expenditure
6. Total Assessment of revenue from irrigation, industrial and Municipal use of water
7. Total recoveries made during the year from irrigation, industrial, municipal use.
8. Cost of O&M per ha based on
   1. Actual expenditure on repairs
   2. Gross expenditure including establishment.

SUGGESTIONS FOR PREPARING RULES FOR OPERATING THE SYSTEM

Every project should have its rules of operation laying down briefly the policy in supply of water, and the rights/ responsibilities of the beneficiaries in using it. Such operating staff and made known to the beneficiaries also through booklets/pamphlets indicating the salient features of the projects, water availability, probabilities of replenishment in the reservoirs, storages, canal networks, control points and head regulators up to Distributary/Minor.

Some suggestions which could be helpful in preparing the operating rules are indicated below:

1. The control of the system up to outlets lies with the Irrigation Department. It is thus their responsibility that water reaches each outlet.

2. Wherever water Users Associations(WUA) exist and water is taken in bulk from Irrigation department for supply to the individual farmers, including the maintenance and repairs of minor; the control with ID will be to head regulator of minor. The department will however own the system below and exercise check and monitor equitable distribution of water to the farmers.

3. Water will be supplied to all farmers in the command for irrigation; (i) equitably proportional to their holdings subject to availability; (ii) on application filed by the farmers for the area to be sanctioned subject to the availability as well as to extend the irrigation to as large number of farmers as possible.

4. In case of WUAs taking water in bulk, the WUAs would be responsible to distribute the same equitably to all the member/non-member farmers.

5. Water will be delivered as per rotational water supply (RWS) through the canal net work amongst the groups of distributaries/minors and as per warabandi schedules or rigid shejpali schedules will be communicated to the farmers in advance.

6. Water will not be supplied to any land not included in the command.

7. Schedules for water supply will be prepared according to the general cropping pattern as established in the command in consultation with farmers.

The water release schedules will take into account:

1. Sowing dates and critical growth stages of principal crops grown;

2. Average probable effective rainfall in the command;

3. Period of maturity of principal crops.

8. Schedules shall be prepared and circulated before the crop season and rigidly followed and no one from the operating staff or the beneficiaries will be authorised to change, modify or alter except in case of heavy rains, the distributaries will be closed on request by the farmers, WUAs and for which no additional supply is liable to be made in the following `on' period.

9. During normal year, water will be supplied at days frequency.

10. Due to scarcity or less replenishment or other reasons during implementation, frequency of supply will be reduced and less number of turns will be made available in consultation with farmers and giving due publicity. However efforts will be made to supply water during critical stages of the principal crops.

11. In case of prolonged dry spells in the command, efforts will be made by the management to supply additional watering (if available) and such additional schedules will be communicated at least 48 hours in advance, preference being given to save standing crops rather than storing/preserving water for next (Rabi or Hot weather) seasons.

12. Unexpected/unforeseen interruption of service may occur due to many causes for which

i) the users will not be entitled to any compensation or

ii) remissions will be given in water charges.

13. Distributaries/minors will run for prescribed `on' days to ensure that every farmer gets at least one turn during each rotation.

14. Farmers should take water as per warabandi or rigid shejpali schedules. The schedules will be shifted by 12 hrs after one season/year so that some farmers may not have to continue to take water during night hours. If someone does not avail the night turn, this should not be made good later.

15. When water starts flowing into the outlets, the farmers will take the water by turns and time. They will start irrigation in sequential order from head to tail/tail to head as per schedules.

16. Farmers are authorised to

    i) grow any crop in any area within the command within the water allocated or

    ii) grow only those crops in that area as per sanctions accorded by the department.

17. Taking water unauthorisedly - out of turn, more in quantity by heading up the distributary/minor will be considered to be a legal offence and action will be taken by the department according to the provision in the Irrigation Act/Rules.

18. Additional outlets will be permitted only on written orders from executive/superintending engineer/chief engineer.

19. The farmers will have to maintain the field channels/ field drains for the length passing through their holdings.

    or

    The water users association (WUA) will have to maintain and repair the field channels/field drains/minor within their area of operation. The department may stop the supply of water if the field channels/drain are not repaired and water is likely to be wasted.

20. The beneficiaries will be responsible to pay the water charges levied by the department from time to time.

Role & Responsibility of Project Management

(General)

General

The principal objective of any irrigation system is to supply water to the farmers. The supporting agencies like agricultural extension (T&V), agriculture research, credit and input, stocking and supplying of seeds and CADA play a vital role in utilising the water resources quickly and in optimal manner. They help in converting the scarce water resource into production and wealth.

Effective management depends upon personnel-structure and ancillary services & equipment on the system like communication network, automation etc. In a multi disciplinery approach, different departments, organisations/ agencies are involved in management and, a clear understanding of functions of the individual discipline together with effective coordination and linkages with other disciplines at respective levels in day to day operation is most essential. It is proposed to limit the suggestion here to the role & responsibilities of the Irrigation department (ID) & its personnel.

Administrative Arrangements

The organisation of any major irrigation project or a group of medium or minor irrigation projects can be said to have four different components.

i) Policy making.
ii) Administration & decision making.
iii) Implementing or execution.
iv) Field operations (includes maintenance).

The typical organization set up on irrigation projects prevailing in most of the states is as under:

Types of Irrigation Projects

Units	Major	Medium	Minor
Policy making	State Govt. CADA canal Advisory Committee Canal Consultative Committee	State Govt. C.E. S.E. Canal Adv. Committee Consultative Committee	State Govt E.E.

Administration & decision making	C.E./S.E.	S.E.	E.E
Implementing execution	SE/EE.	E.E	S.D.O.
Field Operation	SDO/SO & Field Staff	SO & Field Staff	S.O. Canal-Inspector

The Executive Engineer of the major irrigation project or district, in case of medium/minor project prepares the annual/seasonal preliminary irrigation plans (PIP), which are approved by the SES. The crops, sanctionable area, rotation period, number of irrigation is described in the PIP.

The canal Advisory Committee comprising of MLAs, farmers' representatives, under the chairmanship of the Executive Engineer decides opening/closing of canals, rotations etc.

Canal Advisory Committee at sub-divisional levels are also organized for medium projects on similar lines to those for major projects at divisional level.

The Canal Advisory Committees are of advisory nature and help the respective officers in taking appropriate decisions in respect of planning/implementing and redressing grievences from the farmers.

Job Related Functions

The Irrigation officers have to perform several functions which can be classified in four major categories -

1. Administrative.
2. Operation and maintenance.
3. Implementation.
4. Monitoring & evaluation.

The administrative functions are generally in respect of controlling, directing and governing the work of the subordinate officer, and are specified in detail in the Irrigation Act, Rules, manuals, guidelines issued by the State Govt. from time to time. The Chief Engineer and Superintending Engineer have more administrative functions and are involved in decision making, directing, initiating certain activities, overseeing and monitoring. Coordinating with other departments, seeking approval of government in respect of issues, where powers are not delegated to them.

The Chief Engineers and the Superintending Engineers have more responsibilities in respect of policy making and planning. Their duties are generally similar in all the states and are governed by the administrative orders issued, provisions in the irrigation Acts/Rules of the respective states.

Function Related to System Operation Plan

Job related functions for operation/implementing/ execution of field officers vary considerably in different regions according to the methodology adopted in water distribution, assessment/recovery of irrigation changes and are therefore described in detail as under. However the job related function of CE and SE being administrative, are more or less similar and differ at the level of EE or down below.

Chief Engineer or Engineer-in-chief

As administrative and professional head of that branch wing of the department or of the region he is incharge and is the responsible professional advisor of government in all related matters. His main duties in respect of operation, implementation and monitoring are generally as under:

i) Reviewing water allowance and water allocations.
ii) Reviewing, monitoring and overseeing annual seasonal irrigation plan.
iii) Scrutinizing, reviewing performance of the projects and suggesting improvements in operation, services or work components.
iv) Guiding flood management.
v) Exercising full control over the water use for power generation, industrial and domestic use, exercising control over the execution of drainage schemes in the command.
vi) Initiating and incorporating latest and sophisticated technology in respect of equipment, methodology for better water conservation and control.
vii) Organizing periodical sedimentation surveys of the reservoirs.
viii) Coordinaton with concerned departments/agencies such as Agriculture Research, Extension, cooperative and revenue departments, India Meterological Dept. (IMD).
ix) Organizing suitable training program for all categories of staff for updating the knowledge in irrigation management.
x) Exercising administrative, budgetory control over all the officers under him.

xi) Issuing general or specific directors for uniformity in the system-operation. A sample of "Operating rules" is enclosed at Appdx I.

Superintending Engineer

i) He is the administrative unit of the department responsible to the Chief Engineer.
ii) He is responsible for all functions in respect of control, operation and maintenance of dams, reservoir, canals, supply of water in his jurisdiction.
iii) He should oversee and exercise control over the activities of the divisions under him.
iv) Coordination with other departments like Agriculture, extension, research, cooperation, revenue, Indian Meteorological dept.
v) Organizing periodical sedimentation survey of the reservoirs.
vi) Periodical inspection of irrigation works.
vii) Monitoring and evaluation of irrigation performance, irrigation efficiency and area irrigated per unit volume of water.

The roles below the rank of Superintending Engineer are distinguishable in various zones according to system of water distribution stated below:

Executive Engineer - Operation

A. Northern Region

i. Workout crop water requirements as per project cropping pattern or the crop pattern as developed in the command and identify critical growth stages.
ii. Workout water availability and furnish the same to the higher authorities in case of major projects.
iii. Supervise irrigation in the command as per schedules and turns.
iv. Observe crop condition in the command, coverage of irrigation and critical stage growths for releasing water as per crop needs.

B. Central Region

a. Planning of System Operation

1. To prepare program of irrigation of each season - Kharif, Rabi and Hot weather (P.P) as per water availability, forecasts and propose irrigation areas that could be considered for sanctions.

ii. Work out schedules for water supply along with periods of flow/closure and number of waterings for different crops.
iii. To check condition of the water conveyance system, distribution network and arrange necessary repairs.

b. Implementation of the plan

i. To release water from the system as per program.
ii. To sanction perennial, two seasonal, garden blocks for irrigation.
iii. To execute agreements with the villagers for supply of water.
iv. To check crop measurement of irrigated areas each season as prescribed by the government and observe recovery.
v. To ensure prompt payment of water charges by the users of canal water for non-agricultural purposes.
vi. To conduct surprise inspections periodically of the fields, the working of measuring devices, and controlling structures.

c. Monitoring

i. To keep constant vigilance over the gauges and/or other identified control points on larger systems.
ii. To ensure that irrigation 'passes' are issued and maintained properly and entries made punctually.
iii. To monitor progress of assessment and realization of the irrigation water charges and watch on recovery of arrears.
iv. To ensure that no unauthorized irrigation is done.

C. Southern Region

a. Operation

i. To furnish all details regarding water availability, inflow, river flows and anticipated behavior of monsoon to the collector during meeting for taking decision for the operation plan.

b. Implementation

i. To release water as per operation plan.
ii. To build up storages after allowing mandatory water releases for the downstream systems.
iii. To regulate water in the system as per plan and order changes in the 'on' periods as per water availability.

c. Monitoring

i. To watch canal gauges in the jurisdiction of the division and order corrections in distribution functions as per situation.

D. Eastern Zone

i) Invite water applications from farmers for supply of water.
ii) Sanction applications for long-term supply, 7 to 10 years and for perennial and hot weather crops.
iii) To release water as per operation plan.
iv) To regulate water in the system as per plan.
v) To investigate and redress complaints from farmers.

Sub-divisional Officer

A. Northern Region

a. Operation

i. To be in a position to allot available supply to various channels in proportion to various demands.
ii. Have a knowledge and information about agriculture conditions in the command.

b. Implementation

i. To inform farmers about state of supply of water and the rosters through ziledars/ patwari.
ii. Release water in the distributaries as per schedules and priorities and to see that all minor channels taking off from main system are fed with full authorized discharge.
iii. Checking crop measurements as per orders issued by the Government.

c. Monitoring

i. See the gauge register personally to see if channels are running according to orders and water is reaching tail ends.
ii. Undertaking field visits, inspecting irrigation and ensuring that every channel is properly maintained.
iii. Inspecting tail/head of each channel twice a year.
iv. Hearing complaints for irrigation and redressing grievances.
v. Ensuring maintenance of outlet registers showing changes in size, area etc.

B. Central region

a. Operation

i. To keep direct touch and control of field staff.
ii. To sanction water applications received for water supply in respect of seasonal crops on Form No. 7 and recommend other applications to Executive Engineer.
iii. To prepare irrigation schedules for each season and obtain approval of Executive Engineer.

b. Implementation

i. To ensure irrigation passes are delivered to the farmers in time.
ii. To release water in the canals network as per schedule.
iii. Ensure proper distribution of water and supply to all distributaries/minors. Investigate into the complaints received from farmers.
iv. To keep vigilant watch on gauges of water measurement i.e. storage, off-takes of canals, off-takes of major distributaries and regulate rotation and flow in the system.
v. Arrange measurements of irrigated crops through measures, check precribed percengages of the measurements of a season and prepare demand statements.
vi. To check that irrigation passes are properly up-to-date.

c. Monitoring

i. Check irrigation efficiency for every rotation and at the end of season and year through AI/DC and area irrigated per million cubic meter of water.

ii. Check 8% of the total number of Panchanamas in a season.

iii. Check the gauges and discharges reported by the S.O. and compare them with the planned discharges or order correction.

iv. Check unauthorized irrigation, wastage of water or excessive utilization is brought to books and panchanamas are framed in time.

Sectional Officer/Junior Engineer/Assistant Engineer

A. Northern Region

a. Operation

i. To keep all channels/structures in proper order and carry out repairs to see that the capacities of channels and control structure can serve to authorized discharge.

ii. Defects, major repairs to be reported to SDO.

iii. Take prompt action in closing minor breaches in canals.

iv. Remove unauthorized obstructions.

b. Implementation

i. To submit information in respect of
   - Status of irrigation demand.
   - Readings of all gauges head/tail in his section.
   - Observe discharge in the main channels at lease once a month by calibrating with current meter.
   - Checking measurements of crops.

c. Monitoring

i. Inspect all channels once a month and accompany higher officers for their field inspection.

ii. Inspection of all lined/unlined canals alongwith tube wells.

B. Central Region

a. <u>Operation</u>

i. To calibrate all gauges at control points before the start of kharif season and check them periodically.
ii. To inspect all irrigation/drainage and other structures before monsoon and after monsoon, report conditions to SDO and undertake necessary repairs.
iii. Demarcation and unitization of field boundaries.
iv. Checking condition of outer bunds to ensure that they do not leak.

b. <u>Implementation</u>

i. Prevent misuse of canal water.
ii. Receive applications from the farmers duly certified by the canal inspector/talathi and recommend them to SDO for sanction indicating past arrears of water revenue.
iii. Issuing passes to farmers after sanction by SDO/EE.
iv. Prepare delivery schedules and release water after approval by SDO/EE.
v. Reporting daily rain/canal gauges to SDO/EE and maintaining discharge registers.
vi. Preparing weekly or each rotation water account in prescribed forms and submit to higher officers.
vii. Checking measurements of irrigated crops and preparing demand statements.
viii. Recovery of irrigation water charges.
ix. Inspection of field irrigation in the beat frequently, checking panchanamas about unauthorized irrigation, wastage of water.

c. <u>Monitoring</u>

i. Checking and ensuring updating of irrigation passes.
ii. Checking wastage of water, unauthorized irrigation and booking offences under Irrigation Act.
iii. Collecting rain/canal gauges and periodically checking accuracy in gauge reading and recording.
iv. Checking seasonwise area under crops in a season as prescribed.

v. Observing area irrigated/day cusecs AI/DC at outlet, minor, distributing head and irrigation efficiency.

C. Southern Region

i) To release water as per operation plan in the distribution.
ii) To follow 'ON' and 'OFF' system for distribution in the remaining period upto maturity of crops.
iii) To maintain water levels in distributaries and effect continuous supply upto transplantation.

iv) To collect information about crop activities in the command.
v) To supervise working of Neer Katti.

D. Eastern Region

i) Scrutinize water applications, checking them with water availability and recommend them for sanctioning to SDO/Divisional Officer.
ii) Regulate flows in the distributaries as per rotation periods on instruction from SDO.
iii) To book irrigation offences, misuse of water.
iv) To perpare distribution slips for water.

Revenue Wing

A. Northern Region

In Northern region, the responsibility of water distribution below the outlet, measurement of irrigated crops, preparing demand statement etc. is handled by a separate Revenue unit under the control of Executive Engineer O&M. Deputy Collector is the head of this branch. The Deputy Collector is assisted by Ziledars and Patwars/Amins at field level. In Rajasthan the revenue branch is empowered to recover the irrigation water charge from the farmers.

The duties and responsibilities of Deputy Collector, Ziledars and Amins are:

a) Deputy Collector

For operation:

- To organize and supervise the program of irrigation measurements and assessment of canal revenue

- To prepare warabandi schedules on demand by farmers, hearing objections and recommend for sanction to E.E.

For Monitoring

- To check irrigation measurements recorded by the Patwari/Amin at site. The percentage checks prescribed are different in different states
- To inspect Patwari/Amin at field while the measurements are in progress and see that Ziledars are exercising prescribed checks.
- To enquire into the malpractices and recommending punitive rates.
- To assess compensation and remission for crops destroyed or injured by breaches, short supply of water or due to natural calamity such as hail, lockouts, pests etc.
- To see the correctness and completeness of shajra sheets of channels, Khasra bandobast and periodical revision
- To compile area statements for remodelling channels redistribution of outlets.
- To prepare demands of revenue of irrigation and submit them on due date to Divisional office.
- To recover the irrigation revenue (Rajasthan) or watch the recovery done by Tahsildar of Revenue department.

b) Ziledar

Ziledar has jurisdiction over 12000 to 18000 ha and 4 to 6 Patwari/Amins. His charge boundaries generally correspond with those of a sub-division. In Haryana Ziledar has independent office and reports directly to the Deputy Collector whereas in Rajasthan, the Ziledar reports to sub-divisional officer and works in his office. His duties are generally:

- To organize the irrigation measurement operations in consultation with the Deputy Collector and implement the same from Patwaris/Amins.
- Check crop measurements recorded by Patwaris/Amins as prescribed, preferably at least one village in each Patwari/Amins' beat, check every field and calculations of areas.

- To be in close touch with agricultural conditions i.e. state of crops, demand of water, and see that supplies are distributed to the best advantage as per predetermined schedules. He should report area irrigated daily to the division/sub-division/deputy Collector.
- To supervise checking of jamabandis
- To investigate promptly and carefully all complaints about irrigation and report to deputy Collector for orders
- To investigate all cases of unauthorised irrigation wastage of water, punitive rates, and offences under the Canal Act.
- To make thorough enquiry in case of a breach whether caused by cultivators or otherwise and initiate proceedings if the breach caused by cultivators or initiate proposals for compensation for damage to crops.
- To look into and report on all cases of water used for non-agriculture purposes and see that water rates are promptly levied
- To carry out sales of grass, fruits and other canal produce.
- Verify correctness of outlets.
- To prepare warabandi schedules on demand by farmers and as ordered by the Executive Engineer, after collecting data, verifying areas and titles of holdings from Revenue department and in consultation with farmers.

c) <u>Patwari/Amin</u>

Patwari/Amin is the lowest field man in the Revenue branch and controls irrigation. His duties are

- Maintain chak wise/village wise record of cultivable command area holding of each individual farmer as per revenue record
- Keep account of dates of sowing of each crop in consultation with farmers.
- Measure actual area irrigated under each crop by individual farmer for every crop season and submit to the Zilladars.
- Measure area of crop damaged under each type of crop for each individual farmer for every crop season and record reasons of crop damage.
- Prepare half yearly (crop season) returns indicating actual area irrigated, number of waterings applied, type of crop sowing, unauthorised irrigated area, times, amount of water charges etc.

- Prepare annual demand collection and balance (DCB) statement of each individual farmer and abstract and forward them to the Zilledar.
- Prepare/distribute water bills to each farmer in prescribed form, collect water charges and deposit in the treasury.
- Prepare monthly statement of irrigated area.
- Assist Zilledars for preparing warabandi proposed within outlet after in-depth discussions with them, observing filling/employing time of water course.
- Enforce approved warabandi.
- Solve routine disputes amongst farmers for enforcing warabandi as per roster.
- Keep up-to-date chak plans, shajras.
- Keep contact with farmers. Keep them posted with latest irrigation Act, Rules and apprise them with assessment of availability of water, Rotational running programs of canals, priorities etc.

B. <u>Central Region: Field Staff</u>

a) <u>Canal Inspector</u>

Canal Inspector is an important field functionary in the central region. He is in-charge of water releases and water distribution. His duties, mainly are implementation of irrigation plan and monitoring:

- To prepare a 'pali Patrak' for distribution of water below outlets to the individual farmers, for approval by the Sectional Officer. With rigid shejpali now being introduced, a detailed schedules indicating time allotted to each farmer, opening and closing of outlets, discharge required for the minor etc. is required to be prepared.
- Submit (at least 4 days in advance) the planned rotation, indent for supply of water in that rotation at the head of distributory channel in his beat to the sectional officer.
- Enter the next day turn on the irrigators water passes according to Pali Patrak. In rigid shejpali and outlet/minor panchayats or water user's associations being set up, the schedules are to be distributed to these units.
- To open the outlet gates of the channel at scheduled time, and close them as per schedules.

- Demarcation or unitization of the areas sanctioned under block system and preparing sketches thereof is also to be taken up if ordered by Sub-divisional/ Executive Engineer.
- He should keep record of areas irrigated under various crops, outletwise, minorwise, villagewise as per requirements.

CHAPTER VII

COMMUNICATION NETWORK

7.1 **Need**

For improving the management of an irrigation system, communication is one component which has to be established well so that everybody knows what is being said, done and implemented. Communication has various modes. On irrigation systems which are large enough, man to man communication would be a tall objective and therefore steps are necessary to have a communication system which is available to all the persons involved in maintenance, operation and monitoring of the activities. That these have to respond at all times need not be emphasized. The communication system should cater to the needs at any time of the day or night.

7.1.2 The Indian Meterological Department (IMD) is now able to provide forecasts for small area if climatological data from stations are furnished promptly and regularly to IMD.

Precise and accurate planning monitoring and regulation of water releases would warrant;

i) Collecting meterological data from additional stations in the command/catchment and transmitting the same to IMD.

ii) Collecting weather forecasts from IMD.

iii) Collecting information about crops, cropped area, sowing dates from command.

iv) Working out water availability.

v) Working out consumptive use of crops.

vi) Preparing delivery schedule and communicating them to the operating staff and beneficiaries.

vii) Releasing water as per schedule.

(viii) Knowing the happenings on the system related to water use.

(ix) Director/implementing reviewed instructions/ information

To achieve this precision in water management, a reliable and fast communication system is essential, to serve the following purposes;

a) Operation and maintenance of dams and canal networks.

b) Flood regulation and emergencies.

c) Warnings to flood prone areas and organizing rescue operations.

d) Organizing effective timely supporting services to help the farmers.

e) Other administrative requirements.

7.2 Types of Communication

7.2.1 Messenger Service

In ancient times, communication was possible only through messengers. Runners for carrying written/oral messages were used for transmitting information. After introduction of postal services, routine and ordinary messages are transmitted by Dak.

In some remote places, the canal and river gauges, are still communicated by hand or messengers called 'dak-runners'. The Dak runner system involves a large number of messengers. The communication is slow and takes long time in communicating for action and reporting compliance.

7.2.2 Telegraph/Telephone System

In India by about 1900 A.D., telegraphic communications or canal wires were introduced on some major and medium Irrigation Projects. Some of these are still in use efficiently. The telegraphy involves 'Morse' Code wherein messages are converted into sound strokes, transformed into electric circuit breakers through Morse Key and again transformed into sound strokes at the receiving end.

Later the telephones (magneto system) were introduced for better and quick communication through direct talk. The telegraph/telephone is under the Monopoly control of the Post & Telegraph (P&T) Department. The systems are installed by the P&T department as per specific indents of Irrigation department. The system is owned, maintained and repaired by P&T and leased out to the user department on yearly rent per km length of the lines installed, the operators are employed and paid by the user department.

Both, the telegraph/telephone are installed either with single wire-earth return or double wire systems. The annual rent per km for single wire-earth return system is less which works on 1.5 to 3 volts, the communication is weak and subject to interferences, distortions due to changes in weather, or influence of magnetic or electric circuits. In such case Morse Key transmission as a standbye for telephone system is essential. Double wire system is comparatively costly, but communication is better and not affected by climatological changes. The merits and demerits are given below:

Merits

i) Morse code transmission is unambiguous, clear and reduces errors.

ii) The P&T department carries out its maintenance and repairs.

iii) The lines available are for exclusive use of the department.

Demerits

i) The installation takes long time.

ii) The maintenance and repair service is not prompt and up-to-date. Batteries are not replaced promptly.

iii) The poles get uprooted/damaged and conductors snap frequently. Insulators are damaged by miscreants.

iv) The lines, when crossed by HT electrical transmission (11 KVA and above) induce A.C. hum affecting audibility or causes distortions in communication.

v) Audibility is poor when conductors are intercepted.

vi) The communication is possible between two stations only at a time or at the most 4 to 5 stations on the line. For long distances, the messages are required to be repeated involving more time.

vii) In the telegraph system, the messages have to be transmitted through trained operators and hence liable to distortion/misuse.

7.2.3 Wireless System

Wireless communication consists of short wave (SF), High frequency (HF), very high frequency (VHF) or Ultra high frequency (UHF) depending upon the wave length used. Wireless system eliminates physical structures like wires or poles in remote places and is thus free from a number of disruptions and damages. The installations can be done quickly. The operation/ maintenance cost is less than the rental charges of telephone/telegraph lines.

High Frequency Wireless (HF)

The frequencies are generally 10^6 to 10^7 Hz. The system can be installed and owned by the Irrigation department after necessary permission and licence to use frequency from the wireless Advisor, Ministry of Communication, GOI. The P&T Dept. also installs and leases out such network for exclusive use of the Irrigation department.

The HF wireless transmission propagates through space in omni directions, overcoming obstacles like high hills, earth's curvatures etc. and can cover longer distances. The power required is high and so the operating costs are also high. The HF system is susceptible to jamming or interference from other networks in the vicinity. The audibility is poor or weak during inclement weather high temperatures. There are periods when the communication can be totally blank particularly in summer during mid-days and mid-nights.

Very High Frequency Wireless Network (VHF)

The VHF works on very high frequency. The frequencies from 10^7 to 10^8 Hz. The transmission is in straight line like light ray beam which can be intercepted by an opaque body, structures or even the curvature of the earth. But, if the transmitters and receivers (through high antenna or higher altitude locations) are provided to avoid these obstructions, the reception is clear and audibility very good to excellent, not susceptible to weather or light temperatures or interference by other nearby wireless networks.

For large and extensive command areas intercepted by hills, auto repeator (transmitting/receiving) stations are required. The VHF transmitters/receivers work on relatively low power ranging from 2 to 20 watts, which reduces installation, maintenance and operation costs.

Ultra High Frequency Communication System (UHF)

Ultra high Frequency Network operate on frequencies 10^8 HZ to 10^9 HZ. The propagation pattern is that the electromagnetic waves travel straight and have lesser bending effect in comparison with the VHF. As a result it has less coverage of communication between two points in comparison with V.H.F, all the other factors such as out-put, terrain, aerial heights being similar this system gets restricted to purely line-of-sight communication due to earth's curvature. For a long distance communication UHF system will need more repeaters than VHF.

The most significant advantage over V.H.F. is that it has a multi-channel facility extending from 12 to 60 while the V.H.F. has only one channel facility. Better directive antennae can be designed. Although for taking advantage of multi channel facility it is necessary to have multi-plexing equipment in addition to wireless trans-receiver sets. The repeaters in U.H.F. are much less prone to noise and more number of repeaters in tandem can be possible. Although UHF has the advantage of multi channel facility the installation cost may be high but in the long run it proves economical. These systems are in use by Telephone Department, Defence, Railways, Civil Aviation and Police. Single channel U.H.F. is used by Civil Aviation and Navy for short distance communication with mobile sets and or hand held portable sets.

Ultra High frequencies however have a high potential use in remote measurements and control of water flows in the system. It may even become necessary when improved and sophisticated gates are installed on the systems in near future.

7.3 Locations, networks and sub-networks

7.3.1 Location:

In order to have smooth and fast flow of information/instructions to the operating personnel or strategic control points, the wireless stations need to be installed at the location of all key functionaries deployed on water/flood management, administrative hierarchy upto policy decision making level as suggested below:

1. Officers from Chief Engineer of the project (OCM) upto Junior Engineer (or Sectional officers).

2. Rain/River gauges in the catchment and all villages in the flood prone area on the downstream of the dams.

3. All control points such as Reservoir spillways, Head regulators, cross regulators, escapes on main and branch canals.

4. Offtakes of distributaries.

5. Meteorological observation stations in the commands.

6. Officers from supporting services like CADA, Agriculture Extension, Revenue & Police.

7. No station should be farther than say 8 km so that a man can walk down with the morning message and come back before evening.

7.3.2 Networks and Sub-networks

It is generally not necessary for all the stations to communicate with all other stations regularly. Generally about 8 to 10 stations can communicate efficiently on one network. The system should therefore be organized in suitable networks. A typical designed network system for primary, secondary and tertiary netorks (Annexures I and II) for an irrigation complex on Krishna river in Maharashtra have been shown to depict the use of same frequency on area sharing basis.

- Primary network

For administrative convenience, it may be necessary to have all important key officers from CE to EE under one primary network. This can also be used for water/flood management, rescue operations and emergencies. For large projects, auto-repeater stations may be necessary, for medium/minor projects such auto trans/receiving stations may not be needed. Appendix II depicts the manner in which primary and secondary networks can be laid out. Appendices III a, b and c show the various contact points in the primary or secondary networks on the same system as shown in Appendix I and II.

- Secondary networks

  The secondary networks should link the Divisions with sub-divisions and other important strategic control points, like dams, Cross regulators, Head regulators, main/branch canal or distributaries. The network should primarily be used for water management, it may be used for administrative messages in the remaining period. Each division and its sub-divisions can have independent network, as shown in appendices IIc & IId.

- Tertiary networks

  Under these networks, the sub-divisions can be the sections and important control points like HRs, CRs, escapes on main/branch canals, HRs of distributaries. These are to control water flows in the system and may need to work round the clock during irrigation seasons. Each sub-division and its sections should can have one independent network and all sub-networks of the project so grouped that places which are adjacent to each other on the same canal are able to inter-communicate. Appendix I shows an example of tertiary system also.

7.3.3 Frequency Requirements

The primary network may have two independent frequencies, one for water management and the other for flood management. For every autorepeater station in the command, two additional frequencies may be essential.

Providing independent frequencies for secondary and tertiary network may not be possible being limited the divisions/sub-divisions located at long distances, can use same frequencies on regional basis. If the traffic is less, adjacent divisions/sub-division can use the same frequency on time sharing basis.

Communication system is an important tool for management, and erection, installation alone may not ensure its effectiveness, it is the planning and orderly sustained operation and maintenance that may lead to better and efficient management. Preparing detailed, procedures for operations, manuals, traffic rules, assigning appropriate priorities for different messages, setting up time schedules for collecting important information, issuing instructions/executive orders higher authorities and periodical monitoring is another essential activity to ensure effectiveness in water management.

7.4 Combination of different communication systems

In most of the existing major/medium irrigation projects, some kind of communication system, telegraph (canal wire) or telephone is in existence and working satisfactorily. In the long run, the VHF wireless communication is suitable and economical for better water/flood management though immediate replacement may call for additional budgetary provisions. Since this may be difficult to obtain especially on complemented projects it may be advisable to continue the existing system and use it in combination with VHF wireless which may be installed on the missing links. Later when it is possible to get funds, same could be replaced by VHF network.

However, the preliminary/feasibility survey, GOI approval and allotment of frequencies should be organized for the complete network, as it would be difficult to later get adjacent frequencies.

7.4.1 Different situation may be prevailing in respect of communication systems in the commissioned projects. Where there may be telegraph system (canalwise) or telegraph/telephone or wireless sets on lease from police or P & T department, these may be used while improving the system.

The installation of VHF networks could be arranged in stages.

- Installation of VHF, secondary and primary networks in phase I, replacement of tertiary network in phase II.
- Installation of VHF tertiary network in phase I and secondary/primary in phase II,
- Installation of secondary/tertiary VHF wireless network in phase I and replacing HF network by VHF in phase II.

7.5 Wireless manual

A manual for the use of wireless communication may be prepared for all the irrigation projects in the state. The manual may cover -

i) Scope and objective of instsllation and use of the system, such as water mansyement, flood regulation, construction facilities, monitoring irrigation deliveries and health of soil and water in the command and collecting vital statistical information.

ii) Detailed methodology in carrying out preliminary survey, feasibility studies, obtaining approval, licence and allotment of frequencies from GOI.

iii) Types of wireless communications installed in the state viz. HF, VHF, UHF etc.

iv) Officers/field staff authorized to use the communication networks, and officers authorized to have direct Radio Transmission talk (RT Talk).

v) Qualifications for the operators of wireless sets, and radio technicians for repairs.

vi) Rules of operation and traffic discipline.

vii) Functions, duties and responsibilities of Central Control station (CCS) for the project and control stations (CS) of individual network.

viii) Method and language to be used in initiating/ writing messages, transmitting/receiving on wireless and forwarding the messages to the concerned officers.

ix) Priorities for different messages according to the purpose, contents and urgency.

x) Standard messages for common situations like flood warnings, breaches in canals, canal/river gauges, MET Reports.

xi) Monitoring of communication traffic by CSS & CS.

xii) Daily/Periodical maintenance, inspections of installations.

xiii) Officers authorized to use/operate 'mobile' 'Hand held' sets or sets installed in cars/jeeps.

xiv) Centralized training facilities, syllable for the operating staff and officers entitled to use the system.

Some useful information and hints are given in Appendix IV.

7.5.1 Priorities

Messages initiated for the operation and maintenance, flood management, administrative matters have different purposes and importance. Most of the messages in the O&M relate to water measurements i.e. gauges on canal/ rivers or discharges of water flow in the canal network. These information play vital role in regulation of water and therefore need to be given special status and specific time slots for transmitting/receiving. Few types of messages warrant suspension of all routine work, seeking immediate action by the receiving side. In order to understand the importance, urgency and purpose of various messages by the operators and the receiving officers, certain priorities need to be accorded.

Messages seeking prompt attention/action or compliance, such as unscheduled increases or decreases in the water flows, express reminders, indents for materials, equipment needed for urgent repairs or works and flood releases of higher magnitude, may be classified as 'Priority'.

Immediate/Most Immediate

Messages where the receiving side is expected to suspend their normal work and respond to the information/instructions of the calling side may be marked as immediate or Most immediate as per situation and urgency.

a. Breaches in distributaries/minors which are not likely to create panic, danger to human life or property but need immediate restoring.

b. Instructions/indents or movement of man material, equipment for restoring the damages from canal breaches.

c. Accidents.

d. Sudden decrease in canal discharges due to wide spread rainfall in the command warranting adjustments of gates of HRs, CRs and opening escapes gates.

e. Tour programs of VIPs.

f. High flood releases from reservoirs.

'Crash'

The messages, when the calling side expects suspension of all other works, requesting other wise for immediate action, prompt help or situations of alarming emergencies may be classified as crash.

a. Heavy flood warnings.

b. Release of heavy floods from dams expected to submerge villages on down stream, warranting immediate evacuation, rescue operation.

c. Earthquakes.

d. Major breaches in the main/branch canals likely to flood the area, damage the crops, structures, or cause danger to human/animal life and property.

e. Instructions regarding movement of men, material, equipment for restoring repairing the breaches.

f. Instructions/information about VIP programs.

Situation Reports (SITREPS)

i. Daily (morning/evening) gauges of canals/rivers, rainfall, MET observations like evaporation, temperature relation humidity, wind velocity, sunshine hours.

ii. Instructions for changing the discharges of canals, setting gate opening of CRS/HRS.

iii. Daily flood bulletins.

These messages, require exclusive and specific time slot for transmission as they play crucial role in water/flood management and monitoring. Sample sitrep at Appendix V.

Non Priority

- Reminders
  routine compliance of administrative orders, progress reports.

  Instructions regarding transport or movement of material/equipment.

7.5.2 Abbreviations Code Words

Communication on wireless involves transmitting message, repeating the same for correctness and copying & forwarding to the concerned officers. All these involve time and effort for writing and typing the message by the initiator. Considerable time can be saved in this process, if abbreviations, code words, or standard phrases are evolved and circulated among the concerned personnel/ officers. A few illustrations are given below:

Abbreviations - Terms

u/s - upstream
d/s - downstream
CR - cross regulator
HR - head regulator

Designation of various officers:

CE - Chief Engineer
EE - Executive Engineer
GR - Gauge reader

Code words:

Sitrep - Situation report
Sitrep DGR- Situation report daily gauge rainfall observations

7.5.3 Standard Phrases:

ETA - Expected time of arrival
ETC - Expected time of completion
PDC - Probable date of completion
WDS - Water delivery schedules

A few others in use are shown in Appendix VI.

7.5.4 Standard Messages

All sitreps in respect of climatological data, flood discharges, flood releases from the reservoirs, water releases from canal i.e. gauges and discharge at different points in the canal system, area irrigated, water accounts, etc. should be on standard message formats. These messages designed for specific situation can be printed and all the messages except the figures could be printed. This will reduce considerable time in transmission/receiving, writing, copying, besides increasing the efficiency of communication by way of handling more traffic or increasing the capacity of the system.

Special standard messages can be prepared for usual situations occurring in the irrigation projects like canal breaches, sudden increase/decrease in discharges etc. The standard message formats should indicate/hint all possible information desired to be reported by the concerned officer and also indicate further steps/ actions to be taken by them in such situations. **Typical message is enclosed [Appendix VII (1)&(2)].**

7.5.5 Meetings on wireless network

In case of emergencies or other important occasions like flood releases, rescue operations canal breaches etc. it may be necessary to have all concerned officers available for giving information, cross queries, confirmations or compliance. Radio Transmission meetings (RT meetings) can be convened on wireless networks, which will reduce the time, expenditure on travelling and further provide more time to attend urgent works. O&M officers like S.E.s may organize such meetings with E.E.s to know canal releases, action taken in adjusting discharge etc. Similarly E.E.s & A.E.E.s can organize meetings to discuss important matters.

Brief minutes of discussions should invariably be recorded and circulated by the control station organizing the meetings.

7.5.6 Procedure for operation

In order to maintain discipline and increase efficiency, the control station should steer the communications from the opening of the sets in the network;

1. The control station should give a netting call to all the outstations in a fixed serial order and the outstations should be requested to report back, to assess the audibility, strength of speech or identify break downs.

2. If the outstation is not audible or not found to be working, arrangements to substitute the set by replacing the standby set from the control station or the repairs of set may be initiated.

3. Urgent messages common to all or to the majority of the stations should be passed on by the control

station as per priorities, starting from "crash" up to "priority".

4. The control should receive priority messages from the outstations as per the order of priority and serial order of the stations.

5. The control should then allocate time for the outstations to transact any messages mutually between two or more but every time intervening and taking back the control after completion of the allocated time or completion of the communication.

6. Sitrep's should be transmitted/received during the specific time slots. Sitrep messages should be received from the outstations first in the serial order as decided and thereafter any instructions/orders to be issued by the control station should be transmitted. Normally ordinary traffic under 'non priority', 'priority' classification should not be entertained during the Sitrep time.

7. Before closing, the control should invariably remind the outstation, the time for opening for next transmission.

Considering the messages normally expected to be transmitted in the irrigation projects; specimen time schedule for communication is given below:

	Tertiary Water Management	Secondary	Primary	Time
Net call/testing Priority messages	0700-0830	0800-0830	0800-0830	
Sitreps	0830-0900	0830-0930	0900-1000	
Administrative messages	0900-1100	1000-1200	1000-1200	
Other messages about water management	1230-1300	1400-1600	1400-1500	
Administrative messages	1430-1700	1600-1800	1500-1800	
Sitreps	1800-1830	1800-1900	1900-1930	

7.5.7 Writing messages

Wireless transmission is on simplex which works on Press to talk switching (PTT). The operator on the transmitting side has to press the switch while talking and at the end of every sentence has to say `over'. The operator on the receiving side listens and writes the message simultaneously and says `Rodger' to intimate that the message or its part is received. After the message is transmitted, the receiving operator repeats it for confirmation. To facilitate communication certain methodology is required to be used in Writing message.

(i) Messages should be written in narrative form using small sentences separated by stops.

(ii) Long messages should be broken in paragraphs and sub-paragraphs which are denoted by firstly, secondly and sub-paras by alfa, bravo, charlie etc. This facilitates repetition or confirmation wherein the exact paras, sub-paras can be referred for confirmation, or correctness.

iii) Tabular information should be written in narrative continuous messages by indicating code for columns like alfa, bravo, charlie etc. (Appendix II)

iv) While writing message, subject should always be written first to draw the attention of the officer receiving the message.

v) Messages should be very brief and worded like telegraphs, decorative language should be avoided. Even some preposition, a, the, an, etc. and formal addressing phrases like `Sir', respected, kindly, please may be omitted to minimize errors, reduce time in transmission/receiving.

7.6 Duties and responsibilities of wireless operator

7.6.1 The wireless operators would be working at following places:

- Controlling stations of each network such as offices of Chief Engineer, Supt. Engineer, Executive Engineer or Sub-divisional officers.
- Sectional officers
- Along canal at head regulation/cross regulations or off-takes of major distributaries

- At spillway section, River sluices etc. of the dams

- At river gauge sites

- In the flood prone villages downstream of the dam

The operators posted at control station should be exclusively for communication i.e. controlling the traffic in the network, transmitting or receiving the messages.

The operators at sectional offices may have less work and can be entrusted with additional work of recording meteorological observations/ rain gauges for utilizing their services fully.

The operators along the canal or at dam sites or at the river gauging stations would have very light work in communication. Hence these operators can be entrusted with duties like watch & ward, reading gauges, operating gates etc. The duties and responsibilities of the wireless operators are described below:

7.6.2 General duties (Common to all categories)

i) Receive the written messages initiated by various officers in the station and acknowledge their recall promptly recording the date/time and signature.

ii) Open the wireless set on time as per schedule or as per instructions from the control station and check audibility and fine tune the set for better audibility.

iii) Transmit and receive messages distinctly and accurately. Repeating the messages for confirmation.

iv) Receive correctly the messages and regulation instructions and enter simultaneously in the receipt register.

v) In case of standard messages or sitreps the information received should be recorded in the printed formats and the original message pasted in the register.

vi) Despatch messages and regulation instructions and simultaneously enter in despatch register.

vii) Understand the `Priority' instructions on the message and transmit/receive them as per instructions.

viii) Mark time and date of transmitting/receiving on the messages.

ix) Pass on the copies of massages or gauge readings to the concerned officers.

x) Close the set on scheduled time or as per instructions from control.

7.6.3 (a) Operators in charge of control stations

i) Give net call to all the stations in the network and assess audibility.

ii) Take action for replacement of sets/repairs of the set not working of out station.

iii) Monitor and control the traffic throughout the working time of the network.

iv) Organize wireless meetings by intimating concerned officers as per instructions from the controlling officer.

(b) Operators at the sectional head quarters

(i) Record the meteorological observations such as Rain gauge, Maximum Minimum Temperature, Relative Humidity, Wind Velocity, Evaporemeter, sunshine recorded and enter into the registers.

(ii) Maintain the MET instruments, changing graph papers.

(iii) Transmit MET observation/data to the sub-divisional/Divisional officers as per instructions of the officer in-charge of station.

(c) Operators posted along the canal, reservoir, river

(i) Record the gauges and enter into the respective registers.

(ii) Operate the gates of CR, HR, escape as per instructions of Sectional officer/sub-divisional officer and check discharge as authorized.

(iii) Transmit the MET date, gauge reading, corresponding discharge from rating curves and operating of gates to the sectional officer/sub-divisional officer.

7.7 Manning Communication

Reliability of the communications depends on judicious use of the equipment, regular monitoring alongwith timely maintenance. The operating staff can be minimized by proper planning of job charts or assigning the duties proportionately to the effort required. The chowkidars/watchmen for CRs, escapes for the main/ branch canal and those for HRs of main canal, branches and distributaries, where wireless sets are installed could be trained to also carry out the functions.

7.8 Advance Technology

With a rapid advancement in electronics and electronically operated devices, there is a tremendous scope to use the wireless network for precision and accurate operating/controlling and monitoring water delivery or regulating floods. Some of them, expected to be used in near future are:

- Telemetry:
  Electronic devices are now available in market, which can continuously record the canal/river gauges at designed intervals. Equipment are also available which can record the gauges, installed at the measuring devices, and can transmit the same through auto transmitters periodically.

- Remote control:
  The gates of CR, MR, escape of canals or flood gates of the dam can be remotely operated from the control station, through servo motor operated hoists installed at the gates whose switch can be activated by wireless signals.

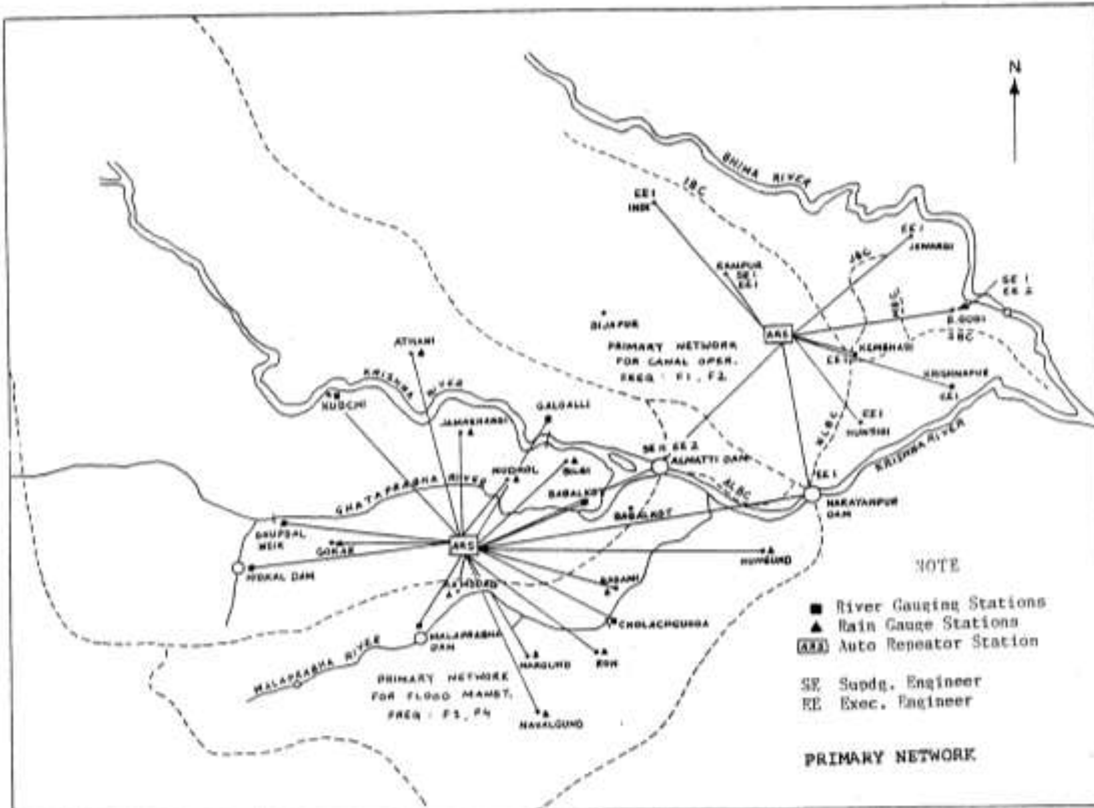
- Computer controlled information system:
  Computers can be used alongwith wireless network so to store information about crops, cropped area, climatological data required for working out crop water requirements. This can be brought on the computer screen, analyzed for taking appropriate decisions in releasing water.

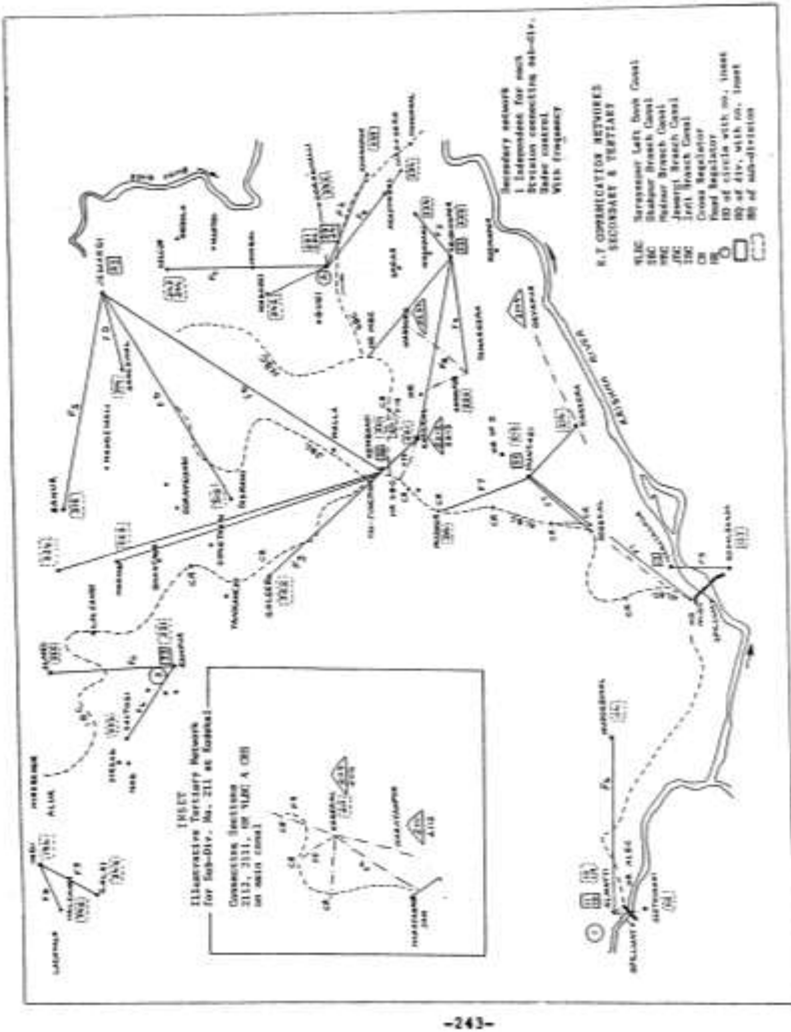
  Written communication facilities are also available. These devices can be attached to the wireless trans/ receiving sets. The messages can be transmitted through facsimile transmission accurately without mutilating the information with preambles such as time, date, message number to whom and by when initiated etc. Secrecy of the messages can be maintained since they are transmitted at a high speed in a digital communication code.

Extensions and telephonic transmissions:

In the present systems, the officers are required to go to the static wireless set installed at their location. Senior officer may not get time to go for transmitting/receiving messages. Similarly for urgent talks the conventional one way communication may be time consuming. Radio telephone exchange equipment working on duplex by Voice operated carrier system (VOX switching) in place of Press to Talk Switch (PTT) can be installed to facilitate senior officers like CE, SE and EEs who can then talk on VHF wireless similar to Telephone system.

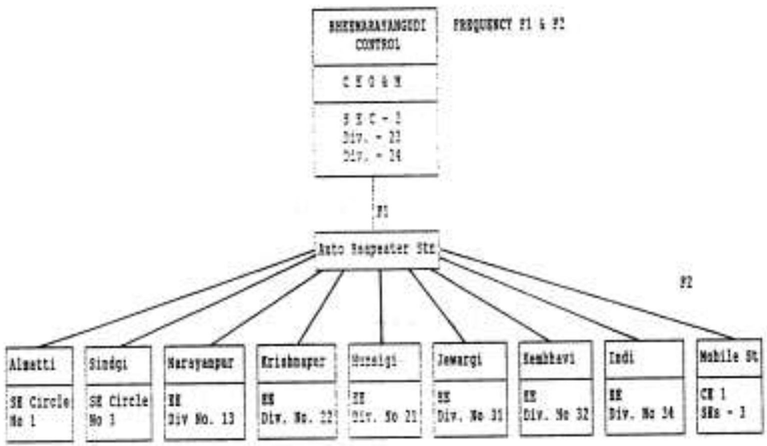
Appendix I


N
BHIMA RIVER
KRISHNA RIVER
GHATAPRABHA RIVER
MALAPRABHA RIVER
IBC
ALBC
ARS
BIJAPUR
ATHANI
KUDCHI
JAMAKHANDI
GALGALLI
BAGALKOT
ALMATTI DAM
NARAYANPUR DAM
HIDKAL DAM
MALAPRABHA DAM
GOKAK
HUNGUND
BADAMI
CHOLACHGUDDA
NARGUND
RON
NAVALGUND
KEMBHAVI
KRISHNAPUR
HUNSGI
JEWARGI
PRIMARY NETWORK FOR CANAL OPER.
FREQ : F1, F2
PRIMARY NETWORK FOR FLOOD MANGT.
FREQ : F1, F4
NOTE
River Gauging Stations
Rain Gauge Stations
Auto Repeator Station
SE Supdg. Engineer
EE Exec. Engineer
PRIMARY NETWORK

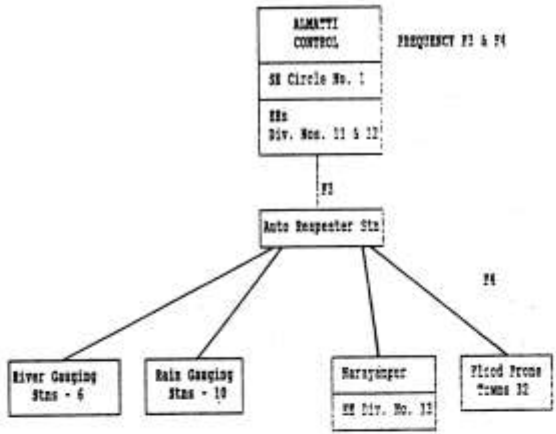


Appendix XII (a)

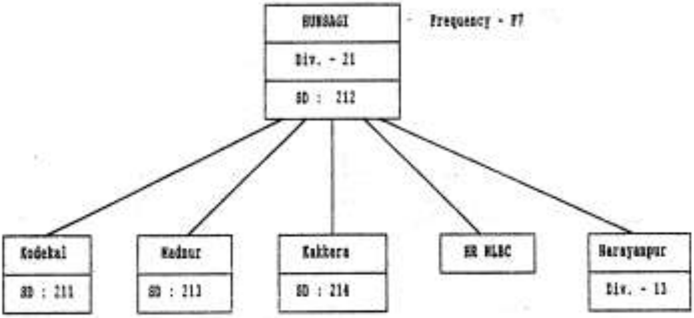
COMMUNICATION DIAGRAMS FOR
PROPOSED PRIMARY NETWORKS
IN U.K.P. AREA



COMMUNICATION DIAGRAMS FOR
PROPOSED PRIMARY NETWORKS
IN U.K.P. AREA



COMMUNICATION DIAGRAMS FOR PROPOSED SECONDARY NETWORKS IN UKP AREA



Some information and hints useful for preparing manual:

(a) Control stations

There may be 3 to 12 number wireless sets in one network. If all the transmitters or more than one transmitters are operated simultaneously or if more than one operator try to talk at a time, there would be confusion and interference. It is therefore necessary to designate one station in each net to control the traffic and regulate communication, direct opening/ closing of the sets at specific timings.

(b) Central Control Station (CCS)

There should be one Central Control Station in each project to regulate, & monitor the traffic of all the networks in the project area, under the control and guidance of the Chief Engineer Incharge of O&M. The Executive Engineer (EE)/Assistant Executive Engineer (AEE), could be designated as controlling officer of the CCS.

The CCS should prepare and issue detailed guidelines in respect of traffic rules and discipline, detailed procedure to be followed in transmitting/receiving. The CCS should also fix up timings for opening/closing of different networks, allot specific time for networks using same frequency on time sharing basis, and indicate specific time slots for transmitting/receiving situation reports (sitreps), or other messages of specific time importance. The CCS should prescribe duties and responsibilities for different persons/ officers entitled to use the communication networks. Similarly, Executive Engineer - O&M Division, could be designated as the controlling officer and the wireless set at the Division headquarters could function as control station for each respective secondary network.

The AEE O&M sub-divn. can be designated as controlling officer and the wireless set in the sub-division as control station for each respective Tertiary network under the sub-division.

(c) Traffic Rules - Discipline

i) Different networks should work strictly as per time allotted to them by CCS.

ii) Messages should only be initiated by the persons/ officers authorized to do so.

iii) The R.T. Communication (Radio-Talk) meetings on wireless shall be restricted only between the officers authorized specially.

iv) All messages should be on prescribed formats and signed by the persons/officers initiating the messages, duly according appropriate priorities.

v) All messages particularly in respect of flood/ water management should be logged in the registers maintained at each station and the operators should mark the time of

- receiving the message from the initiating officers.
- transmitting/receiving on wireless.
- delivering the message to the concerned officers.

vi) Operator receiving the message on wireless should repeat the same for confirmation and correctness.

vii) Messages should be brief, eliminating all unimportant words, phrases, propositions. The language should be similar to that used in telegrams.

viii) Only trained and authorized operators/radio-technicians, should be allowed to handle/operate the transmitters/receiving sets.

APPENDIX V

Sitrep No. 1

Daily gauge report

From : AEE, Sub Div 331

To : EE OCM Div 33

DGR Sitrep: Nov. 19 0830 hrs. Alfa. Main Canal HRG 5.50 m Q 230.31 comsec. Bravo. HR Dy 1. G 1.31 m. Q 1.31 cumsec. Charlie. HR Dy 2. G 0.91 m, Q 0.80 cumsec. Delta . HR branch . G 2.21 m, W 8165 cumsec. Echo. CR main canal km 13.41. G. 5.31 m. Q 200.18 cumsec go to openings 3 nos. 6.0 m x 0.81 m. Extort. Raingauge stn no 1 30 mm. Stn 2 41 mm. Stn 3 - 81 mm. Golf. MET Stn 1. Temp max 32.2°C mm 16.3°C. Day wind velocity 72 km. Evaporation 5.0 mm. Sunshine hrs 4.3. Hotel. Other information.

Note: For a given sub-division, initiating the sitrep to its controlling division, all the gauge points would have been already identified and known. The printed forms should have all the particulars regarding the locations of various control/gauge points units of measurement etc. Only the actual figures as per observations need to be inserted while initiating the message.

Abbreviations (in use):

AEE	Assistant Executive Engineer
EE O&M	Executive Engineer, Operation & Maintenance
Div	Division
Sub-div	Sub-division
Sitrep DGR	Situation report about daily canal gauges, rain etc.
HR	Head regulator
CR	Cross regulator
Dy	Distributary
MC	Main Canal
Br.	Branch
G	gauge reading
Q	discharge
MET	Meteorological Observation Station
Stn	Station

STANDARD MESSAGE

From : EE, Div. 21

To : SE, CR 1

Info : CE O&M, SEs (All), EE O&M (All)

SUBJECT: MAJOR BREACH IN MAIN CANAL Km 30

Firstly: Location and time. Breach occurred 1130 hrs Nov 18 on service road side at 29250 cm. Probable Cause. Piping. Extent of Damage. 150 m bank washed out upto CBC. Further erosion continues. Approximate E.W. damaged/washed out 5000 cum. P.C.C. slab lining 1500 sqm. washed off (stop)

Secondly: Action taken. CR Km 25 closed, escape km 24.99 opened. Discharge Q main canal reduced from 100 cumsec to 30 cumsec to cater irrigation damands u/s CR Km 25 (stop)

Thirdly: PDSR (Probable date of starting repairs). Water expected to deplete 1300 hrs. PDSR 1400 hrs (stop)

Fourthly: Equipment/manpower available. Tippers/trucks 4 nos. Labor 200 nos arranged Nov 18 1400 hrs. 400 m Nov 19 0800 hrs (stop)

Fifthly: Equipment/manpower needed. Additional requirement.

a) Tippers/trucks 15 nos.
b) Shovel/loader 1 no.
c) Road rollers 2 nos.

Request divert from other Divs./Circles (stop)

Sixthly: ETC (Expected Time of Completion. EW Nov 23 1800 hrs. Lining Nov 25. Irrigation expected to be restored Nov 27 0700 hrs (stop)

Seventhly: Request action to be taken your side. Broadcast info breach, interruption irrigation and expected restoration by Nov 27 0700 hrs on TV/AIR/NEWS PAPERS (stop)

s/d

EE Div 21

Message Received by ________ at _______ time _____ date.

Message Transmitted by ______ at _____ time _____ date.

Message delivered to ______ at _______ time _____ date.

Note

Standard message for breaches in main/branch canal should indicate the information expected to be furnished by the reporting officer and furthr should provide hints on actions to be taken by him in the circumstances.

The words and phrases underlined could be printed in the standard message with blank space for filling the information as per situation.

All messages should start with the subject to draw attention of the other side.

Time should be written as per railway time table and the first two digits indicate the date, such as Nov 18 0800 hrs means 8.00 am of Nov 18.

Chapter VIII

Monitoring & Evaluation

8.1 Need: Monitoring is just not collecting information from different sources. It should generate information and provoke thinking to improve the assumptions on various parameters that impinge on water delivery. It involves a sustained analysis of the information and keeping watch on the changes taking place in the physical condition of the components of the system. It is also for verifying whether the parameters adopted in formulation of operational plan of the system are actually realized during actual operation so that any modification necessary could be timely introduced. Monitoring and evaluation should lead to better design.

Currently the hydraulic performance of the system is not monitored to review and improve the assumptions made (rugosity coefficient, seepage losses, operational losses etc.). This causes serious effect on agriculture output on certain assumed supplies which in turn depend on assumptions made in the design. It needs a greater stress on monitoring of the system's hydraulic performance.

In absence of objective feedback from the field, new irrigation projects are being designed and operated on assumptions without taking their validity into account in actual performance. As a result of this gap between the field and design in communication, the planned objectives are not fulfilled. The presumptions regarding cropping pattern, duty of water, irrigation efficiency, canal losses etc. are not being met with. In order to continually improve the operation of an irrigation system, a fairly extensive monitoring data is required. When sufficient knowledge is gained about the hydraulic functioning of the system, the amount of monitoring data could be reduced.

8.2 Objectives:

Monitoring, evaluation & feed back for system operation of an irrigation system has the following objectives:

i) That all the constituents of the system are in a reasonably functioning condition for operational performance.

ii) To see if running of channels has been done as per programme.

iii) To see if distribution of water has been timely and equitably to the satisfaction of the farmers.

iv) To ensure that data on channel gauges and discharges, channel losses, cropping pattern and cropped area, soil test results of samples from the command, number of watering provided, weather (temperature, rainfall, evaporation) reports, discharge observing on the stream/river are being regularly collected and maintained season by season and year after year.

v) To ensure that the above data is evaluated and results applied for further improvements in the system for further improving the system.

vi) To ensure that proper water accounting is done after each cropping season with an object to assess and improve the irrigation efficiency year after year.

While items ii), iii), v), vi) above would require monitoring & evaluation by the operation wing, item i), & iv) will be required to be attended by the maintenance wing. Suitable simple formats to monitor i), ii), iii), & iv) during operation of the system will be required to be introduced so that the system of this data collection becomes an inbuilt practice for the O & M staff. Specimen formats for each item have been given in annexures.

8.3 Monitoring parameters:

Monitoring and evaluation of an operation plan would require a comprehensive data collection which can be grouped as below:

i) Physical infra-structure - Physical condition of the dam/weir, conveyance system and control structures is necessary to establish if the system would perform satisfactorily during operation.

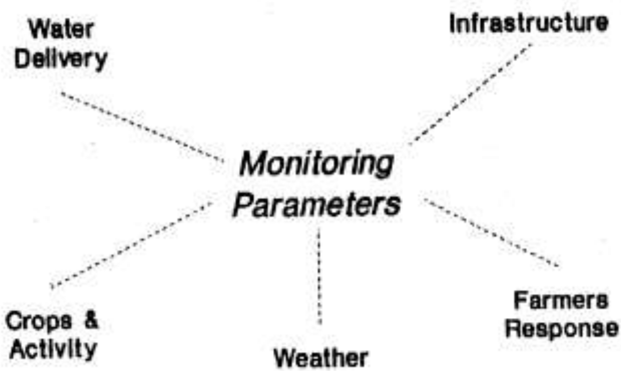
ii) Weather - rainfall, temperature, evaporation, humidity etc helps in evaluation of performance.

iii) Crops - cropping pattern, cropped areas, crop yields, their various growth stages, cropping activity and sequence of water delivery are essential to ensure that water delivery has been adequate and timely.

iv) Water delivery - Data on monitoring of inflows, outflows, and distribution as per programme is most important parameter. It would also include assessment of system losses, drainage flows, fluctuations in ground water levels etc. Deviation in the delivery from the planned programme or failures have to be specifically noted and evaluated.

v) Farmers response - Information on farmers' satisfaction or reactions about the system is important to judge whether the plan has been successful or require further improvements.

WHAT TO MONITOR ?



8.4 Existing Procedures:

Although water is such a precious and scare commodity for maximizing food production, yet no serious monitoring is done on its use on most of the irrigation systems. Leaving a few interstate multipurpose projects, where water accounting has to be compulsorily done to satisfy provisions in interstate agreements, no full scale monitoring covering all the parameters is done. On some major projects canal gauges are taken at some prefixed locations like head regulators of branch canal, distributaries or minors are recorded in a register but no efforts are made to further evaluate the discharges based on them or compare them with design/plan. Accuracy of the gauge data is doubtful as they are mostly taken by casual untrained gauge readers. Physical condition of the infrastructure is seldom monitored. Seepage losses, discharges measurements are rarely observed. The systems usually lack in adequate control structures and measuring structures. There are no tail gauges on the channels to ascertain the discharge reaching the tails of channels. Weather data like rainfall, temperatures, pan evaporimeter readings, etc. of course is maintained by the hydrology wing. But regular measurements of river discharges, sedimentation studies, soil and water tests are not done. Crop record is kept in some states where assessment and recovery of water charges is done by Irrigation Dept., but where it is done by Revenue Dept, no record of crops/irrigated area is kept. Once notified as command of the project, wet crop rates become leviable on the farmer under that project whether water is actually applied for irrigation or not. In such a case it is not possible to assess the water made available. On some projects, water has to be pushed to the tails of channels after great efforts. The management feels psychologically satisfied with this achievement but no effort is made by them to actually assess the discharge made available at the tails and whether it conforms to the design for the tail outlets. The system manager is thus always in dark about the quantum of water released and the quantum actually used on field and thus he can not have any estimation of the irrigation efficiency on the system. The procedure on multi-purpose major or medium projects is discussed below.

8.4.1 Physical condition of the infra-structure:

Many states have established dam safety cells for multipurpose projects to undertake monitoring the health of the dam. Periodical reports are obtained by this cell from the field giving the stress meter, strain-meter and deflectometer readings and analysed in consultation with the Designs Directorate. Visual inspections are also periodically carried out by the team of the safety cell in addition to the routine inspections by the maintenance staff. In case of medium and minor projects, only visual inspections are carried out by the officers at various levels and inspection notes sent to the next lower officer for guidance and necessary steps. The canals are also like-wise inspected and inspection notes sent, indicating steps required or repairs required to improve them. Certainly such visual inspections cannot be termed as monitoring as they no where come near to the pre-requisites of monitoring.

8.4.2 Meteorological Parameters

Hydrology wing in the department generally maintains complete data on weather. It also maintains its own rain gauges and hydromet laboratories and collects data on rainfall, temperature, evaporation, humidity etc.

8.4.3 Water availability:

River gauging is carried out by the staff of the Hydrology wing in some states, in few, it is done by the headworks staff. Registers are maintained and water levels are recorded regularly. Measurements are frequent, sometime hourly during floods. Sedimentation studies are, however, not carried out on the reservoirs regularly. On interstate rivers, CWC maintains network of gauging stations. Both CWC and the States maintain flood warning system for major/main rivers.

8.4.4 Water releases in the canals:

A daily discharge register is maintained for each canal upto the head of minor, On minor projects, it is kept for the main canal/distributaries. Daily reports of gauges at important control points are sent to the Executive and/or Superintending Engineer Discharges are read from the gauge readings from rating curves. On very few projects, measuring devices are provided on the canal systems.

There is no regular practice to measure the canal discharges and assessing seepage losses. They are roughly assessed from the difference of discharges between two stations. Systematic estimation of seepage and other operational

Losses are undertaken only in context of a special programme for the purpose. Similarly, drainage flows are seldom measured except for special reasons like planning reuse or carrying out improvements in the drainage system.

8.4.5 Ground Water:

Prior and post monsoon ground water levels are usually recorded by the Ground Water Department of the state in order to monitor the rise or fall of ground water table. These observations are taken only in some of them by the Irrigation Departments also to monitor the ground water build up for which may threat water logging or salinity.

8.4.6 Crops, delta and yields:

In Northern States, the revenue wing of the Irrigation Dept maintains the record of crops, irrigated area, number of waterings etc. The Patwari records the irrigated area, and is checked by the Ziledar, SDO, Deputy Collector and Executive Engineer as prescribed. In Eastern Zone, record is maintained by the Patwari on deputation to Irrigation Dept from Revenue Dept. But in Southern region, recording of irrigated areas is done by the Revenue Dept. Total crop-wise irrigated area is worked out from the figures provided by the Patwaris to the SDO. and conveyed to the Executive Engineer SE & CE after the end of each crop season.

Crop yield estimation is done by the Revenue/Agriculture departments. In some states like Andhra Pradesh, it is done by the Bureau of Economics and Statistics. Crop yield data is obtained by Irrigation Dept. from the above deptts. whenever needed.

8.4.7 Farmers response:

At present, there is no systematic procedure or method to assess or understand the farmers' response to the water delivery system/methods. It is necessary to regularly monitor the farmers' satisfaction on water distribution at least twice during a crop season. They can give some very valuable suggestions to ensure equitable and timely supplies. Wherever pipe committees or farmers' association are in existence, some feedback regarding farmers reactions can be available through them.

8.5 <u>Suggestions for Improvement in Monitoring System:</u>

The present procedures only tantamount to some data collection, which can be termed to be just only a part of complete monitoring and this data collection is also not systematic and regular. It is seldom analysed or evaluated and used for further improvements. There is also a need to check the accuracy of the observations/measurements. Procedures for measurement of system losses and drainage flow needs to be introduced.

A more systematic approach to monitoring as per the parameters explained above is essential with particular emphasis on monitoring the physical fitness of the system, regulation of channel flows and timely & equitable distribution. The data like weather report, discharge measurements, seepage losses in channels, cropping pattern, and crop yields & farmers' response etc. could, however, be collected by the various agencies as a operational activity for further evaluating the efficiency of the system.
It will be desirable to have a monitoring system which is 'inbuilt' within the department and fully integrated with the management of the system, thereby minimizing dependence for collection on other departments. Sometimes, co-ordination is not well established with other dpartments and information obtained from them may not always be available in time or could even be questionable.

The monitoring should be capable of providing information required for day to day operation as well as for preparation and evaluation of the seasonal operation plan embracing both the water delivery and agriculture aspects. It should therefore aim at:

i) Consistency as far as possible with the existing data collection procedures and arrangements.

ii) Flexibility in application and adaptibility to the needs of scheme of different sizes and characteristics.

iii) Simpleness to adopt, relatively fool proof and capable of generating data of acceptable accuracy in reasonable time.

iv) Appropriateness for its purpose of the information to be kept at the level it is required and its reporting to those who need to know and act.

v) Capability for implementing by the existing staff or with some marginal incremental staff positions where such staff does not exist.

vi) Availability to each circle to evaluate the performance data, which can be done by an evaluation team or by the Technical assistant to Superintending engineer with one or two assistants under him.

There is no defined assistance to the system managers to carry out this important task of compiling, analysing, identifying areas for improvements and issuing directives. To strengthen the hands of managers the following steps would be helpful at various levels.

i) Sub-divisional level:

The information in specified formats is to be collected and transmitted by the Assistant Engineer who normally has 3 to 4 junior engineers, besides patwaries, mistries, gauge readers, signallers, dak runners etc. who may collect and furnish the same. Additional assistance of a junior engineer level person to be called 'Monitoring Assistant', may help coordinate and organise relevant information in time for transmitting to the Executive Engineer. At sub-divisional level too, record of rainfall, other climatological data, canal gauges and discharges, irrigated area and crop registers, unauthorized irrigation, lists of outlets, discharge and seepage register etc. will have to be maintained. The monitoring assistant may ensure that these are maintained properly.

ii) Divisional level

The data received in the division will need posting in separate registers. The important work with the divisions is to analyse and evaluate the data so received. In some States an Assistant Engineer termed technical assistant is provided to look after the work of checking of estimates, and other technical jobs but he is loaded with other administrative works that results in neglect of monitoring and analysing work. It would therefore be appropriate to put one more technical assistant in the O&M division of the level of Assistant Engineer to assist and ensure compilation, analysis, & evaluation.

iii) Circle level

In the circle (Superintending Engineer's office), reports are received from the Executive Engineers on reservoir operation, irrigation and cropped area, gauges/discharge of channels, seepage loss, seasonal/annual performance & evaluation of each system. These have to be compiled for the systems under control. The Superintending Engineer is supposed to analyse/evaluate and advise the Executive Engineers on important issues asking improvements. In some states the Superintending Engineer is assisted by a technical assistant of Executive Engineer level or a senior Assistant Engineer. It is felt that he should not be loaded with routine jobs but used for the important work of monitoring and evaluation.

iv) Chief Engineer's level:

Various reports on irrigation, cropped area, seasonal/annual performance reports, are received which need to be compiled and examined. At least the Superintending Engineer working as Technical Assistant to CE should exclusively look after this work and appraise the CE for induction of overall measures for improvements.

8.6 <u>Data collection & Reporting instruments</u>:
They can be categorized as under

- Permanent registers
- Regular reports - daily, weekly, fortnightly, monthly.
- Seasonal and annual reports.

A) Permanent Registers:

These are to be maintained for record of information collected on various parameters at definite and specific time intervals e.g.

(a) Rainfall and climatological data register to keep day to day record of rainfall, temperatures, humidity, evaporation etc. from observations taken at fixed timings in the field.

(b) Reservoir operation register to keep record of the daily water levels of reservoir based on observations taken daily at fixed hours.

(c) Instrumentation register - to keep periodical record of the observation from various instruments provided in the body of dam like, stress meter strain meters. piezometer, plumb hole etc.

(d) Gauge and discharge registers

(e) Irrigated area and crop register - channelwise and outlet wise

(f) Water charges - demand, collection & arrears register

(g) Land ownership/occupier register (where water billing and collection is done by Irrigation Department)

(B) Regular reports:

A few essential formats for communicating daily/seasonal/ yearly data regularly to higher offices are necessary for effective monitoring as indicated below:

Report	Periodicity/frequency	Initiating functionary	Destination
i) Rainfall report	Daily (observed at 8 A.M.)	Junior Engineer	E.E.
ii) Reservoir operation	daily (- do -)	- do -	A. En (AEn to EE weekly)
iii) Yield from the catchment	Yearly	Asst. Engr.	EE
iv) Canal Gauge & discharge (of each canal at head and tail and at other important control points)	Daily	-do-	AEn/EE
v) Channelwise water account	Monthly	Jr. Engr.	EE
vi) Chak area irrigated and water use	Monthly	Patwari	AEn/EE
vii) Drain discharge	Monthly	Jr. Engr.	-do-
viii) Channelwise irrigated area crop report	Seasonal	Assistant-Engineer	EE
ix) O.K. report for canal system & control structures (after essential maintenance)	Before start of irrigation in each season - say by 15th June for kharif & 15th Oct for Rabi.	Assistant Engineer	EE/SE
x) Discharge & seepage loss measurement (randomly selected outlets)	Once a year (31st Oct)	Jr. Engr.	Ae/EE
xi) Water logged and salt affected area	Yearly	-do-	-do-
xii) Breach report	Monthly	Asst. Engr.	EE/SE & CE
xiii) Farmer response	Once in a season	-do-	EE/SE

(C) Seasonal/Annual reports:

The evaluation team attached with the monitoring cell/unit in each division will prepare a seasonal/annual performance report of the system based on the above data and submit to the superintending engineer & Chief Engineer. This team will similarly prepare seasonal/yearly water account & submit to the above authorities. A sample for preparing water account is given in annexure 1.

Farmers Response survey report for each crop season will be prepared by the Assistant Engineer & sent to the Executive Engineer. Format for farmers response survey report given at annexure 14.

Farmer Response Survey at the end of each crop season will provide a clue on the implementation of operation plan and chak comparing performance in different sections of the command. It will provide useful data on farmers attitude to irrigation management, cropping preferences & yields.

8.7 Formats for Reporting

Well designed simple formats for monitoring of each parameter and for enabling a report is an integral part of monitoring. If the formats are correctly and timely prepared by the concerned functionary(s) involved in the system operation, assesment of performance of the same becomes easy and handy. Submission of these formats should be made compulsory for every functionary as one of his important duty(s). Unless submission of data is ensured the short-comings in a system will never come to light.

i) Climate data format: (Daily)

A typical format is given at annexure 2. Observations on rainfall, maximum and minimum temperatures, evaporation, wind volocity and humidity should be recorded daily for each station at a fixed time, mostly 8 a.m. The format can be used for reporting of daily rainfall by the junior engineers. Complete information for a month can be compiled from these in the register in the sub-division.

ii) Reservoir Operation Format: (Daily)

Format at annexure 3 is to be maintained for inflows outflows from the reservoir. Reservoir levels are to be observed at 6 a.m. Evaporation loss from the surface of reservoir can be directly taken from the suitably processed observations of open pan evaporimeter once in 24 hours. The releases by way of supplies to canals, river spillage for the past 24 hrs. have to be shown in the format. The evaporation losses besides others can thus be arrived at. This would give complete account of the water received from the catchment area of the dam. Format for conveying reservoir levels on regular basis is already in use but it needs to be upgraded to cover a few suggested factors. The above daily information will give total annual yield from the catchment of the reservoir/ system and should be worked out by the evaluation wing and compared with that adopted in design. Form 3 A gives the details to be worked out for assessing the annual yield.

iii) Canal & Distribution Gauge Format: (Daily)

Format at annexure 4 is meant for daily reporting of the canal gauges and discharges by the junior engineer. Gauges at head and tail of each channel along with other important structures located on the canal like falls, meter flume etc. has to be correctly recorded at a fixed time and transmitted to sub-division/division for keeping the record in a permanent register and further evaluation.

Based on daily discharges of each channel, overall performance report of the main/branch/distributary canal can be prepared. The channel losses worked out from this report could be confirmed/verified by actual measurements also.

iv) Chak Area Format (monthly)

Annexure 5 provides for the outlet/chak location, size, type, designed working head, designed discharge at the outlet and actual observed discharge (read from the rating table with respect to flow levels in the parent channel), area irrigated during the month and quantum of water issued to the chak. This also provides for the area, of unauthorised irrigation and water so used. This is new format and is rare in use pesently.

v) Drain Discharge Format

Excess water applied which the soil can not retain would flow down the drain. It may also flow from field to field till it meets the field drain or valley around the chak. If it flows from field to field, it can be measured for the group of fields in the chak by suitably installing a measuring device like V notch or parshall flume in the drain.

The format to be submitted monthly would give reference of the field drain, area draining into as also the location of V notch. From this it should be possible to work out the net water applied to the field during the month. Format is given at annexure 6.

vi) Channelwise Irrigated Area and Crop Report (Seasonal)

The Assistant Engineer would submit a report of the total villagewise irrigated area cropwise after every crop season, for each channel to his Ex. Engineer in the format at annexure 7. The revenue wing working under him would provide this data after actual measurements.

The Northern, Eastern and Central regions where irrigation is recorded by the revenue staff of the irrigation deptt., this is already being maintained. In Souther states, recording is done by the Revenue deptt. Information in this format may be obtained from the Revenue deptt. after each crop season. The concerned patwari of the area may directly submit it to the Asst. Engr. Strict directions by the Revenue deptt. would be necessary.

Agriculture deptt. carries out crop cutting experiments in the commands of irrigation projects as their routine exercise. From them, the average crop yield for each type of crop can be obtained and total crop production can be assessed to compare with this projected production. This can enable to determine monetary value also.

vii) OK report for canals and control structures (seasonal)

Unless water delivery system is in a reasonably good physical condition, timely and equitable distribution of water is extremely difficult. It has, therefore, to be ensured by the system manager that canal system is timely and properly maintained for satisfactory operational performance. To ensure this, the Superintending engineer should obtain a 'OK' report from his Executive Engineer(s) before starting irrigation in each season. Format for this 'OK' report is given at annexure 8 to cover essential activities of maintenance also. The replies should be given in yes/no. Introduction of such a format will eliminate overlooking importnat aspects in operation. Wherever the reply is 'No', the safe carrying capacity of the channel. The next higher officer will take note of this, inspect the site and record his own views on the corrective aspect of the situation.

This will be self revealing also, and induce the system manager to organise his work force, properly channelise the funds and use managerial skills to improve the performance. If some channels or group of them could not be attended to, the same should be truely reflected in the format for developing a proper improvement approach.

viii)Discharge measurement report

Discharge measurement on channels can be carried out throughout the year when channels are running with full supply. Some channels may have weed problem where it may be desirable to measure the discharges on to assess the effect of weed growth.

Discharge observation on bigger channels can be measured by current-meter while on smaller channels it can be done with the help of 'parshall' or cut-throat flumes. Measuring structures like standing wave flumes can be also used for the purpose. Format of discharge measurement report is to be sent by the Asst. Engr. to the Executive Engineer yearly for each channel in his charge as per Annexure 9.

ix) Seepage loss measurement report

It is very essential to regularly measure the seepage losses in a channel and to take it into account in preparing the operation plan. Proper checking of seepage loss would enable remedial steps and identification of problem reaches. Seepage loss should be determined at least once a year by the Asst. Engineer and reported to the Executive Engineers. Format for the seepage loss measurement report is given at annexure 10.

x) Discharge and seepage loss measurement report for Water Courses

The system manager should have knowledge about the condition of the tertiary system also as overall system efficiency would depend on the field channel and field application efficiencies. He may therefore, organise at least a random check on discharge and seepage losses in the water courses at the start of each crop season. Besides a few representative, some problematic water courses could be selected. This would help in bringing such cultivators into confidence who attempt to put oversized or extra/unauthorized outlets. Similarly field application efficiency should also be checked on random basis on some chaks. Annexure 11 gives the format for reporting water courses discharge measurement and seepage losses.

xi) Assessment of water-logged or Salinity effected areas

It is necessary for the manager to have an estimate of the water logged and salinity effected areas in the command. Even the areas prone to water logging (water table 1.5 m to 3 m below surface) should be estimated. Areas which are prone to water-logging have to be provided with restrictive irrigation. It may be advisable to leave out such areas to be irrigated by ground water only. Areas which are fully water logged or saline, have to be debarred from irrigation but if the requirement is for special purpose like leaching of salts etc. it should be accounted for, while planning operation. Format for the report (yearly) is given at Annexure 12.

xii) Report on breaches on canals

Monitoring of breaches if any, on the canal system is necessary. If any channel breaches often at the same location, some measures may be necessary. Similarly if the cause of breach on channels happens to be the similar a permanent solution is called for. Format for this monthly report to be furnished by the Asst. Engineer is given at Annexure 13.

xii) Farmer response survey

Every system manager may like to monitor the degree of satisfaction amongst the users. A questionnaire for conducting a survey is suggested who may like to carry it out from time to time for their own knowledge and evolving correct methodology, the format is given at Annexure IV.

Annexure 1

Water Accounting Procedure
(Some Suggestions)

1. At the close of each crop season, the System Manager should prepare a 'water account' on the basis of information collected through various formats/reports described below.

The total water stored/available in the reservoir can be known after deducting evaporation losses, seepage/ leakage at the dam and the dead storage. The carry over, if any in the dam is also be taken into account.

From the seepage loss measurements in main canal, branch canals, distributaries and minors up to the outlets, total losses in conveyance system can be worked out. Total water delivered to various outlets of the system divided by the total release from the head regulator of the dam would give the 'Conveyance Efficiency' of the system. Since the seepage losses depend on the degree of maintenance and upkeep the conveyance efficiency may vary from year to year commensurate with maintenance.
Below the outlets the watercourses carry water where sizeable seepage losses occur. Losses in a water courses, even if reasonably maintained, may be around 25 to 30%, or more, if not maintained. These losses, when reflected on added to conveyance efficiency, give the Irrigation Efficiency of the system. For project efficiency, losses in the reservoir by seepage or evaporation etc. are also added. The project efficiency would thus be less than irrigation efficiency. The water ultimately goes to the field channels and on to the fields, part of it as a surface flow goes into the drains, while some part goes to root zone of the crops or gets stored below the root zone or goes to the sub-soil aquifer. Knowing the irrigated area, the average depth of water applied can be determined. The average depth can be worked out for each watering, while the seasons total would give the 'Delta' of water for the crop.

If E_T for that particular crop is known, minimum depth of water stored in the root zone can also be known. Ratio of this minimum depth stored to the depth applied is called "Application Efficiency".

2. 'Duty' of Water: The total water released through minors to outlets is known. This divided by the area irrigated would give the 'Duty' at the outlet head. Duty of water at the minor head, distributary head and main canal should be similarly worked out by accounting for the total water releases. Water account can be prepared for each minor/distributary as per proforma 'A' and for each season annually in the proforma 'B'.

3. The accounting as above would give us the conveyance efficiency, application efficiency, overall irrigation efficiency, duty and delta achieved on the system. Thia would enable the system manager to analyse the causes of low efficiencies or low duty or high delta for taking suitable measures to improve. For example conveyance/irrigation efficiency could be improved by minimising the seepage losses from the channels and water courses. Application efficiency could be improved by reducing wastage through drains by manipulating just and adequate water to meet the field capacity of the soil as well as by resorting to proper field preparations.

Annexure 1 (A)
(water account)

Water Delivery Account

Name of the System

Sub-Division ____________ Return for the month ending ______________

Crop Season ____________

1. WATER ACCOUNT

DISTRIBUTARY NAME/NUMBER		WATER QUANTITIES (Cubic metres)		
	Planners Quantity	Actual issue	Devision from Plan	Reasons for deviation
Distributary1				
Distributary2				
Distributary3				
....				
....				
Total				

Annexure 1 (B)
(water account)

Annual Water Account

Sl. no.	Name of minor/ distributary	Authorized full supply discharge cusecs	Mean discharge Kh R Hw cusecs	Vol. of water applied Kh R Hw m^3	CCA ha	Designed Irrig^n intensity Kh R Hw	Irrigated area Kh R Hw
1	2	3	4	5	6	7	8

Irrga^n intensity achieved Kh R Hw	Duty at outlet or area irrigated per unit of water ha/cusec Kh R Hw	Total depth of water applied (cms) Kh R Hw	Volume of water drained from the command of minor m^3	Net Water used on field m^3 Kh R Hw	Average depth of water applied or delta(cms) Kh R Hw
9	10	11	12	13	14

Abbreviations used:

Kh - Kharif   R - Rabi Crop   Hw - Hot Weather Crop

Annexure 2

Climatic Data Format (Daily)

Station: ______________________

Month: ______________________

Date	Rainfall (mm)	Temperature c Max°	Min°	Evaporation (mm)	Wind Velocity km/Day	Humidity (relative) %	Sunshine (Hours)
1	2	3	4	5	6	7	8
1st Aug							
2nd Aug							
3rd Aug							
4th Aug							
and so on							
Total for one week (1st to 7th Aug)							
8th Aug							
9th Aug							
10th Aug							
and so on							
Total for 2nd week (8th to 14th Aug)							
....							
....							
....							
Total for the month of August							

(Total rainfall in the catchment & command can be separately worked out from this stationwise format)

Annexure 3

Reservoir Operation Format (daily)

Name of reservoir/system — Designed storage Mcm ______ division Mcm — Water depth on 1st July-----m — Storage on 1st July (carry over)-----mcm.

Date	Reservoir Water level 8 A.M.	Storage		Left Bank Canal discharge 8A.M. in past 24 hrs.	Right Bank Canal discharge 8A.M. in past 24 hrs.	Discharge through river sluices opened closed at at hrs. hrs.	Spillages in past 24 hrs.spillways/ water weir	Evaporation & other losses	Remarks
		Yesterday	Today						
1	2	3		4	5	6	7	8	9
	R.L.mts	mm³	mm³	cumec	cumec	cumec	cumec	cumec	

Note: River gains, if any, are reflected in column No. 3 in the above.

Annexure 3-A

Total yield format (annual)

Unit in mm³

Catchment area ----- Sq.Km. Designed yield -----Mcm.

Reservoir water level on 1st July (outgoing year	Storage (carry-over)	Water level on 1st July (current year)	Storage on 1st July (current year)	Difference (4-2)	Storage during the current year	Total spills during the year	Diversion to Canals Lmc Rmc total	Release through river sluices	Total evaporation and other losses	Total yield recd. ((5+6+7+8+9+10)
1	2	3	4	5	6	7	8	9	10	11

Annexure 4

Canal & Discharge Format (Daily)

System: ____________________

Month Date	Name of Channel	Full Supply discharge at head	Discharge planned as per programme	Gauge			Discharge		
				Hd.	Control Structure(s)	Tail	Hd.	Control Structures	Tail

Chak Area Format (monthly)

1. Name of System:
2. Name of Distributary/Minor:
3. Chak Location (R.D.)
4. Chak/Outlet No.:
5. Type of Outlet:
6. Size of Outlet:
7. Design Head at the Outlet:
8. Design Discharge of the Outlet:
9. Actual Discharge Carrying Capacity of the Watercourse (as checked at the beginning of irrigation season).
10. Area irrigated in the chak during the month:
11. Quantity of water supplied during the mongh (cusec x days)
12. Unauthorized irrigated area:
13. Water unauthorized used by:

Annexure 6

Drain Discharge Format (monthly)

Name of System:

Field Drain (chak no. to be given)number:

Area draining into the field drain:

Designed carrying capacity of the drain:

Actual carrying capacity of the drain
(to be measured in the middle of the crop season):

Discharge in the field drain

For areas without field drains:

Location of V.notch or Parshall flumes:

Area served (chak areas) by the V.notch:

Discharge at the V.notch/Parshall flume:
(to be measured once in a month)

Annexure 7

Irrigated Area Channel & Crop wise Report (Seasonal)

Name of System: **Year:**

Name of Channel:

Village(s) covered:

	Crops	Area Irrigated
Rabi	....	
Kharif	....	
	....	
	....	

Total Area for ....

FORMAT FOR OK REPORT FOR CANAL SYSTEM AND CONTROL STRUCTURE

Name of the Project
Name of Dn/Sub-Dn/Section
Period of Report

(A) Head Work:
Head Regulator:

	Yes	No
	☐	☐

a) Checked for smooth operation of gates
b) Leakage for gates
c) Gauge strips painted/marked
d) Discharge rating checked?
e) Approach to sluice cleared.

(B) Canal: (Write Yes/No/Part/Full

S.No.	Item of work	Main	Branch	Dist.					Minors			
				Name/Number					Name Number			
				1	2	3	4	..	1	2	3	..
i)	De-weeding/desilting bed-gradient restoration											
ii)	Bank. strengthening/ restoration											
iii)	Leakage/seepage attended to											
iv)	Service road repairs											
(C) Structures												
i)	Regulating gates checked for operation & leakage											
ii)	Gauge strips painted & Marked											
iii)	Head & tail gauges provided											
iv)	Cill levels of falls, regulators, measuring flume escapes restored											
v)	Discharge rating curves verified											
(D) Outlets												
vi)	Locations & discharge capacity as per design											
vii)	Leakage at gates, if any checked											

Discharge Measurement Format

i. Name of the System

ii. Name of the Channel

iii. Method of measurement

Current meter / measuring flume
Velocity-Area.

iv. Location of check-point

v. Cross-sectional area of flow at the point

vi. Time Start
End

vii. Velocity observations

viii. Discharge calculations

Annexure 10

Seepage Loss Report

Name of System
Name of channel
Whether lined or unlined
Canal section:

Date of measurement:
Location of reach - between RD - to RD

Length of reach

A. By inflow-outflow method:

Qu (Discharge at upper end of reach)
Qd (Discharge at downward end of reach)

Seepage loss - Qu-Qd

B. By Ponding Method:

Location of test spot
Length of the pond
Wetted Surface area of the pond

Time duration water was ponded

Initial reading
Final reading
Loss
Loss per sq.m of wetted area

Annexure 11

Discharge measurement report on outlets:(randomly selected)
Seepage loss measurement report on outlet:

Name of minor: Date of measurment:

Location of outlet: RD - - -

No. of outlet : (eg 6L or 6R)Length of water courses - - km.

Type and size of outlet - - - -
Area commanded by the outlet - Ha. - - - -

Designed discharge of the outlet at head:

Actual observed discharge at the outlet head:

Remarks - (Reasons of variation)

Seepage Loss:

Discharge in water courses at - - meters   cumecs (x)
Discharge in water courses at - - meters   cumecs (y)
. . Loss in - - meters = x-y

FORMAT FOR WATERLOGGED & SALINITY AFFECTED AREA ON PROJECT

Name of the project

Culturable commanded area of the project:

Name of the Division/Sub-Dn/Section
Period of report

Village	Name of the channel	CCA under the channel	Water logged area (water table between 0 to 1.5M) Ha	Area prone to water logging (water table between 1.5 & 3.0) Ha	salinity effected area Ha
		Total -------	Ha -------	Ha -------	Ha

FORMAT FOR BREACHES ON MAIN/BRANCH/DISTRIBUTARY/MINOR CANALS(MONTHLY)

Name of the Project
Period of report

Name of Division/Sub-Dn/Section

Date of breach	Name of the channel	Location of breach	Cause of breach	Extend of damage						Remarks (Preventive measures taken)
				E/w M^3	lining M3	structure	loss of water due to this breach	Area affected(crops)	Date of complete restoration	

Annexure 14

FARMER RESPONSE SURVEY QUESTIONNAIRE

Name of the System:

Date:

1.0 BASIC INFORMATION

1.1 Name/Number of — Distributary........
— Minor ....
— Outlet ....

1.2 Reach Distributory - Head / Middle / Tail
Minor - Head / Middle / Tail

1.3 Farmers Name:

1.4 Survey No. and Village

2.0 IRRIGATION MANAGEMENT

2.1 How much of land do you a) Own -------ha
b) Cultivate -------ha
c) Irrigate -------ha

2.2 How much of your irrigated land is in the scheme --------ha

2.3 When did the canal open?

2.4 When did water first reach your outlet?

2.5 How many waterings were given?

2.6 Was the water supplied through the canal adequate?

2.7 If not, did you obtain water from a well/tank/tube-well, or any other source to supplement canal supplies?

3.0 Crop Season: Kharif/Rabi
(The following questions apply only to farmer's irrigated land within the scheme)

3.1 For each crop you raised this season, when did you:

Name of the crop		Complete the operation	liked to have completed it
a)	Nursery		
	Land Preparation		
	Transplanting		
	Harvest		
b)	Sowing		
	Harvesting		
c)	Sowing		
	Harvesting		

3.2 Did any of your crops suffer from moisture stress?

If so, what crops ------ ------ ------

4.0 INPUT & PRODUCTION

4.1 For each crop you raised this season, what is

	Crop -----	-----	-----
a) The variety you used?			
b) The area planted (ha)?			
c) The type and quantity of fertiliser used (Kg/ha)	N ---- P ---- K ----	N ---- P ---- K ----	N ---- P ---- K ----
d) Your total production (kg)?	----	----	----

CHAPTER IX

TRAINING

9.1 Water Management - Pre-requisites:

There is still a need for an understanding of the meaning of irrigation water management. Irrigation water management has been defined differently but one view is that it is the process by which available water is manipulated and used for the production of food and fibre. It is not merely impounding water in the reservoirs, nor the conveyance through canal networks, nor the application at field level for crops in isolation. It is the way how best these processes, skills of the personnel, physical and biological factors, natural and social resources are utilized to convert the water as a means of production. Water management is the judicious conservation and optimum utilization of water in all spheres of its availability. It warrants the following pre-requisites for improvement and better performance:

i) Precise water control and reliability of supplies at the farm level.

ii) Increased availability of water to farms and farmers

iii) Equality in water distribution among all classes of farmers for social justice and maximizing production

iv) Sustained maintenance of environment, soils and system facilities

v) Increased participation of farmers in water distribution, and maintenance of micro level networks

vi) Precise cost effectiveness of the systems and services.

9.2 Need for training

There has been a growing awareness in recent years among the administrators, professionals and farmers that in order to make significant progress in fully utilizing the irrigation potential already created and increasing agricultural output, ways and means must be devised to increase the efficiency and productivity of irrigation water. Advancement in the agricultural research has provided a focus on:

i) evolving crop varieties having very high potential yields and response to irrigation

ii) accurate information about soils, crop-water-soil relationships

iii) water conserving and saving methods in respect of farm-water application and conrumptive water use.

The research in irrigation engineering has evolved precise controls through level controlled gates, remote or auto controlled gates, devices and methods of saving conveyance losses through lining, telemetry in water measurements, and improvements in control structures.

However, the irrigation engineers and field staff who are qualified primarily in Civil Engineering even now only concern themselves with water delivery system above the outlets. There is a tendency among them to think that water distribution is a routine activity. They do not feel concerned with crops or crop water requirements or demands of the farmers.

The agriculture extension agency who are giving technical advice to the farmers is likewise still concentrating only on the crop husbandry, farming practices, pest control, harvesting and post harvesting measures and storage etc. They do not have accurate information or knowledge about water availability in the system, constraints in supplying water through canal networks in public delivery system, soil-plant-water relationship, and optimal use of water for maximum production per unit volume of water. They appear to have an impression that water can be made available through the system to all farmers, whenever wanted or whenever crops need it and wherever wanted. The farmers feel that water should be supplied to individual farmers at the farm gates whenever they want and in full requirement. They usually feel that more the water more is the yield and therefore tend to over-irrigate the fields anticipating that if there is delay in ensuring supply (rotation) stored water in soils would be useful for the crops.

There is no overall endeavour yet to address on farm water management and water conservation and no one appears to be having any comprehensive idea or concern about the integrated water management.

The irrigation engineers and the operating staff have to face a number of problems/complaints or grievances raised by the farmers in the field. The problems in respect of water sharing, order of turns etc. can be minimized by introducing Warabandi, rigid shejpali but the complaints raised by them about the frequency of water deliveries, adequacy of water as per their expectations need authentic information on these subjects. The farmers in general expect and press for high water doses and that too with high frequency mainly because of the fear that the next rotation may not be available on time. Some perceptions of the farmers are described below as an illustration.

i) Shallow soils need more water and with high frequency.

ii) Deep black soils need very high dose particularly for pre-soaking irrigation as much as a delta at field level more than 20 cms.

iii) Paddy needs standing water in the field minimum 10 cms, during transplantation, flowering and continuous supply is preferable.

iv) Vegetable crops need water at 4 to 5 days interval.

v) High yielding wheat needs minimum 6 to 8 rotations.

vi) It is difficult to prepare fields for receiving irrigation in Kharif season and only flood irrigation is possible.

The thoughts prevailing amongst the farmers are not very true but irrigation engineers can convince them only if they have full knowledge and information on the findings of agricultural research.

The extension officers and field level workers advocate the water management practices based on research in Agriculture Universities or Research Centers which are oriented towards maximizing production per unit area of land. The water availability and the constraints in delivering water through the delivery system involving extensive canal networks as well as the concept of maximum production per unit volume of water is generally sidetracked. For uniformity in giving guidance on the water management, it is necessary that both the irrigation officers and extension officers, workers have some minimum basic working knowledge and information from either side.

The training effort is an effective means of apprising the personnel in respect of latest technology, precise meaning of comprehensive and integrated water management and thereby improving the capacity to manage water.

9.3 Objectives of Training

The objective of training should be to improve performance of the project by using the water resources for sustained increase in crop production, both in quantity and quality without detrimental effects on the enviornment and soils in particular. The training of project personnel should:

1. Induce in trainees, an appreciation of the benefits stemming from good and improved water use practices.

2. Provide the trainees with capacity to determine the existing deficiencies in the project facilities, operation, and to develop feasible, efficient as well as cost effective approaches to their removal/ reduction.

3. Provide the trainees, with discipline and team skills and approaches for regular on going monitoring and evaluation for further improvements in irrigation system operations.

4. Help professionals to understand the principles, processes and specific field problems.

5. Provide field training experience and knowledge for skills in monitoring methodologies and procedures in disciplinary and inter-disciplinary responsibilities and actions.

6. Understand the process and benefits of team work.

7. Help professionals to appreciate and adopt positive attitudes and behaviors related to involving farmers in decision making.

8. Prepare them for the role as project managers and not only administrators.

9.4 Training Topics for Field Functionaries:

Normally, the senior officers, during their field inspections are expected to train/guide the juniors working on the system, only an organized effort is required in this direction to improve the performance. As an illustration, an attempt to arrive at the training topics for a few field functionaries for such on-the-job training is given below:

9.4.1 Signallers:

Job requirements

- o Receive and transmit messages accurately and distinctly.

- o Control the stations in the network and regulate traffic.

- Know procedure, traffic rules.
- Keep instruments in order and maintain the same.
- Pass on the messages to concerned officers.
- Observe, record and pass on gauge of canal/ river/reservoir.

The above functions would warrant training on the following topics.

(a) Knowledge of the project organization/hierarchy

- The organization of the project, units like ChiefEngineer, S.E., EE, SDO, AE, their headquarters
- Hierarchy in reporting

(b) Information about the communication system installation;

- Networks and stations in each net, frequencies allotted.
- Overall State/Project wireless/telephone communication, manual/guidelines, rules, procedures.
- Control stations in each network, functions of the control.
- General time scheduling for the project.
- Other communication system, P&T, Trunk phone sets.
- Priorities of different messages.
- Standard messages.
- Net call in wireless communication, or Morning testing call in telegraph/Telephone systems. Procedure to be followed, order of communica-tion of different sets in the network.
- Closing the communication in the evening

(c) <u>Receive/Transmitting messages</u>

- Receiving messages from initiating officers recording time and date.

- Receiving/transmitting messages, procedures, paras, sub-paras, columns acknowledgement about 'properly heard', repeating for confirmation, recording time and date.

- Passing on messages to the concerned offices.

(d) Instrument handling/maintenance

- Handling the instruments with care.

- Daily/weekly maintenance of instrument and its accessories, like batteries, power packs, battery charger, antenna etc.

- Action to be taken if instrument is not working, reporting, replacing.

(e) Other functions:

- Observing the gauge correctly, removing parallax at scheduled intervals.

- Changing graphs for auto/self recording gauges.

- Reading discharge from depth/discharge rating cusecs/statements.

- Recording the gauge and discharge in the registers.

9.4.2 Gauge Reader

Job requirements:

- Reading the gauges accurately.

- Recording the gauge readings neatly in the register.

- Reporting to the sectional officer punctually.

- Adjustment of gates of control structures to allow authorised discharges in the off-takes.

- Reporting any variations of levels/discharges in main and/or off-taking channels to the sectional officer.

Topics for training

- o Various types of gauges, vertical, slanting with magnification, least counts etc.
- o Purpose of stilling wells for gauging to eliminate waves, keeping the inlet pipe clean.
- o Reading the gauge accurately eliminating the parallax.
- o Various registers prescribed for recording the gauges of outlets, minors, distributaries and main canals and accuracy needed in recording.
- o Physical phenomena of free flow and submerged flow in case of Parshall flumes, standing wave flumes, orifices and situations.
- o Reading the discharge on gauge/discharge rating curves/statements/graphs.
- o Time fixed for recording and reporting the gauges/discharges.
- o Standard formats for reporting.
- o Authorized discharges in different canals.
- o Setting of gates of Head regulators to allow authorized discharge.

9.4.3 Gate Operator

Job requirements:

- o To open and close the gates of canals as per program.
- o To adjust the gate openings for authorized discharge in the off-takes.
- o To watch water level in main canals/branches and ensure its regulation as per plan.
- o To open escapes if water level rises beyond danger mark, encroaching upon free boards.
- o To report variations in discharges to sectional officer.

Topics for training:

- Various type of gates installed worm/gear etc.
- Procedure of operating the gates, i.e. whether all gates to be operated sequence of operation etc.
- Action to be taken, if gates get jammed.
- Times fixed as per program for opening/closing different off-takes.
- Daily maintenance such as oiling, greasing etc.
- Reading the gauge of the off-taking channel to ensure authorized discharge and adjusting the gate opening.
- Danger level marks to be observed in the parent channel.
- Action to be taken if water level crosses danger mark, by opening escapes.
- Reporting formats, procedure of any abnormal conditions to sectional officer.

9.4.4 <u>Other field operating personnel</u>:

Likewise, topics for Canal Inspectors/Measurers/Ziledars/Patwaris could be identified as given below:

i) <u>Canal Inspectors (Central region)</u>

Job requirements (central region)

- Receiving water applications from the farmers, processing and forwarding to Section Officer.
- Issuing passes to the farmers.
- Maintain distributary/minor/outlet wise record of cultivable command area, individual farmers holding.
- Preparing water distribution schedules and inform farmers.
- Prepare and submit to Sectional Officer, indent for water supply.
- Resolve disputes of farmers in sharing water.

- o Open/close gates of HRs of minor/outlets and maintain authorized discharge.
- o Bring to book any unauthorized irrigation, wastage of water, preparing panchanama.
- o Keep water accounts and submit to Section Officer.
- o Demarcation and unitization of fields (Central region).
- o Measurement of Irrigated crop.
- o Keeping record of Irrigation by wells.
- o Prepare Warabandi schedules and enforcing the same.
- o Training and educating farmers in on farm water management, water application.
- o Seasonal, two seasonal, perennial, cane or garden blocks. Procedure to be followed in sanctioning blocks, delivering water.
- o Issuing irrigation passes to farmers.
- o Procedure to be followed in delivering water i.e. standard discharge at outlet (viz 30 lit/sec), supplying water from tail to head through authorized turnouts.
- o Distribute summons issued by higher authorities amongst farmers in cases of litigation under Irrigation Act and Rules.

<u>Topics for Training</u> (Canal inspector or equivalent)

- o Seasonal crop water requirements by growth stage and root zone depths for each irrigated crop.
- o How water below root zones is wasted?
- o Why are there variations in water requirements during the season?
- o When are the critical water requirements during the season?
- o Correct water depths to be maintained for paddy during various growing stages - depletion of water depth up to surface without affecting yields.

Basic understanding of differences in water holding capacities of various soil types and methods of irrigation.

- o Using feel or visual method to estimate soil/subsoil moisture.
- o Border, furrows, ring methods of field irrigation stream size, cut off points, optimum lengths.

- o How can farmers manage sandy/shallow soil fields?

Methods to improve accuracy in crop measuring and reporting procedures;

- o Measuring irregular shaped fields

- o How to use tables for conversion.

- o Preparing demand statements, cropwise, farmerwise, outlet/ minor wise, penal rates for irrigation offences and demands at penal rates.

Review of crop calendars and agronomic practices for crops grown in the area;

- o Common farming practices which affect irrigation scheduling

- o Recommended and actual sowing dates of different crops.

- o Number of watering required for different crops, most critical waterings and adjusting deliveries to coincide crop requirement as per availability.

- o Measures to be adopted by farmers in saving water by alternate border/furrow methods, matching.

Planning specific steps for securing better farmer participation in managing local irrigation system.

- o Organizing farmers, outlet committees, water users' associations, cooperation of department/ farmer public relations.

- o Farmers' roles in management and maintenance of the micro system i.e. field channels, field drains. setting disputes.

- Volumetric supply at minor head to the WUA, maintenance of water accounts, procedure and responsibilities of department and WUA in this respect.

- Dissemination of information about water supplies to farmers in time, holding farmers' meetings

- Leadership training

9.5 Engineering Personnel:

i) Sectional/sub-divisional officers

Job requirements:

- Maintenance of the canal network, ensure capacities of various channels as per design

- Distribute water among different distributaries/minors/ outlets as the operation plan

- Maintaining water levels and discharge in the main branch canal as per the irrigation plan/delivery schedules and controlling the flow in the system

- Reporting Meteorological data particularly rainfall, reservoir/canal gauges

- Routine and special inspections of dam/canal network structure, controlling structures, cross drainage works, head regulators, escapes and their gates and undertaking repairs

- Checking irrigated crop measurements (central)

- Initiating and submitting demand statement for collecting irrigation water charges and effecting recovery (Central region)

- Maintaining, recording and reporting information about quantity of water delivered at main (branch/ distributory/minor channels, rotation/season/year wise and comparing with area irrigated.

- Observing, assessing the system efficiencies i.e. storage, conveyance, operation, application.

- Reporting breaches/accidents in canal and undertaking/ organizing repair/restoration.

- Sanctioning water application for seasonal irrigation, preparing irrigation schedule, obtaining approval of Executive Engineer, preparing indents for water supply rotation wise (Central region).

- Keeping touch and control of field staff, informing farmers about state of water supply/rosters.

Training topics:

Review of field staff responsibilities and procedures in fulfilling and enforcing department rules and relevant portions of Irrigation Act, rules, manuals standing orders and their implications on farmers.

- Method adopted by the state in supplying water i.e. RWS (Predetermined schedules) and Warabandi, application system, continuous flow, on and off supply, localization, Rules and Act provisions and duties and responsibilities of the department and the farmers in supplying/ receiving water.

- Procedures for resolving common conflicts.

- Procedure for addressing rules violations.

- Various powers vested in the officers and limitations.

Knowing the system and project specifics

- Average Rainfall in the catchment, rainfall/ runoff relationship, distribution of rainfall, mean flow, yield of the river of dam/diversion as designed; probabilities of yields.

- Canal network, capacities of main/branch distribution, minors, size of outlets, water allowance.

- Intensity of Irrigation as planned and as per actuals.
- Ground water availability and utilisation.

- Project organization, communication system, location of telephone/wireless station, frequencies allotted.
- Hydraulic survey of structures and canals.
- Calibrating flow control structures and discharge measurements.
- Methodology of assessing conveyance losses.
- Project specific requirements of various components.
- Periodical inspections, recording observations and reporting.
- Preparing detailed estimates and annual plan for repairs.
- Dissemination of operation plan, issuing notices, interaction with farmers/field staff.
- Assessing demand for water supply and placing indents.
- Preparing detailed schedules for water distribution.
- Procedure in receiving/processing water application from farmers, obtaining sanctions and issuing passes to farmers (Central region).
- Procedure for resolving common conflicts amongst the farmers.
- Procedure for booking unauthorized irrigation misuse/ wastage of water, entries in Pahani Patrak, checking panchanama (Central region).
- Procedure for maintaining water levels/ controlling flows.

ii) Executive Engineers/Assistant Executive/Deputy Engineers in preparation and implementation of operation plan

In small projects EES/AEES/Dy ES are required to prepare and implement irrigation annual/seasonal plans. In the case of major projects they are expected to assist in preparing the plans for their jurisdiction and implement the same as finally approved by SE or CE as the case may be.

Job requirements:

(a) Collecting Information relevant to operation of the system that is reservoir details, status of command, trends in cropping pattern, crops, sowing dates, period of maturity. Crop water requirements, critical stages. Canal capacities, status of maintenance, hydraulic testing of canals seepage losses, conveyance efficiencies. Application efficiency from sample tests/ observations duties, delta of irrigation.

(b) <u>Interaction with other departments</u>

Trends in cropping pattern, new varieties expected for large scale sowing, crop water requirements sowing times from agriculture Extension and research and farmers. Requirements for leeching, requirements for hydel power generation, industrial/municipal use, and irrigation requirements for projects situated on downstream of river diversion/dam.

(c) <u>Interaction with farmers</u>

Interaction with farmers and establishing good rapport with them are the key factors for successful implementation of operation plan and high irrigation efficiency. The executive officers have to take a lead in organizing farmers, involving/seeking participation in preparing and implementing operation plan, for which they need training on approaching farmers, organizing them at outlet/minor level, addressing farmers' meetings, areas of involvement and participation, redressing their grievances.

Training topics

Operation plan: Procedure for -

- Assessing area which can be irrigated from available water after considering duties/ deltas canal efficiencies etc. in case of Central Region.
- Procedure for determining the number of irrigations that can be supplied as per water availability as per objectives set for distribution of water.
- Forming groups of distributaries/minors for rostering canals.

- o Fixing priority for supply of water in different groups in different weeks.

- o Determining opening/closing dates of canals after considering sowing times, period of maturity.

Dissemination of Operation Plan

- o Need for dissemination for better understanding among the staff and users Information to be disseminated, methodology of dissemination of operation plan.

9.6 Farmers Training

Farmers are the principal users of water. The overall irrigation efficiency depends largely on its use below outlets comprising of field channel efficiency and on-farm water application efficiency. The water use efficiency, however, depends on the appropriate irrigation doses at right time as per crop needs as well as moisture holding capacities of soils. Though individually the farmers know the 'Art' of Irrigation, they are required to be trained particularly on the community based approach, their responsibilities in the public delivery systems and the science of irrigation. Training should include importance of land levelling, operation and maintenance of micro network, correct sowing periods, crop water requirements, appropriate field layouts and advanced methods of irrigation.

Large number of farmers can be trained quickly, at low cost at field level. A team for training the farmers can be drawn even at a project level in coordination with Agriculture Department. High stress and emphasis should be given on demonstrations, audio visuals, slide/film shows, video cassets.

Training Topics:

(a) Land preparations

- o Advantages to the farmers individually and collectively

(b) Land levelling/shaping

- o Procedure for preparing land for irrigation and adopting modern on farm water application methods

- o Uniform application of water in the entire field.

- o Possibility of irrigating larger areas from available water per rotation

(c) Collective advantages by land levelling/shaping

- o Prevention of water logging/salinity as excess water can be drained off quickly.
- o Light irrigation possible and therefore possibility of getting higher frequency of supply.

(d) Improved methods of on farm water applications

- o Improved methods of irrigation, lengths/widths, stream size, cut off points.
- o Implements for preparing land, borders/furrows

(e) Crops, cropping pattern & sequence

- o Crops grown and that should be grown.
- o Need for a common and uniform cropping pattern. Sowing crops as per rotation of Irrigation to use water. Crop water needs/critical stages, disease control measures. Remunerative crops with available water, frequencies of watering. Crop water requirement of different crops.

(f) Distribution of water below outlet - maintenance of water courses, field channels, field drains

- o Distribution procedure e.g. Warabandi, rigid time based shejpali, continuous or intermittent.
- o Discipline to be followed by the farmers and penal action as per statutes for unauthorized irrigation, misuse/wastage of water or taking water out of turn. Rights and responsibilities of farmers in getting water, procedure for resolving disputes.

(g) Maintenance of water course field channels, field drains

- o Need for adopting participatory approach among the project managers and beneficiaries.
- o Organizing water users association/outlet committees.
- o Advantages to the farmers individually/ collectively.

Workshop on
Improved Irrigation System Operation Practices

WALMI Uttar Pradesh, Okhla

April 6-18, 1989

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