CHAPTER - 3

BASE LINE PARAMETERS OF UGC & THEIR EFFECT ON WATER USE EFFICIENCY

3.1 WATER USE EFFICIENCY

Water Use Efficiency is an index of percentage gainful performance of irrigation water releases. It indicates how efficiently the available water supply is being used; based on various methods of evaluation. Design of Irrigation system, degree of land preparation and skill and care of irrigation practices are principal factors influencing irrigation efficiency or water use efficiency and losses occur in the conveyance system in non-uniform distribution on field; and percolation below root zone.

Water use efficiency can also be reflected directly by produce per unit volume or ratio of crop yield to amount of water depleted by crop in process of evaporation. Where as economical irrigation efficiency is the ratio of total production attained with operational system and the expected indicated target.

All these various criteria can be applied in evaluation of an irrigation project. Actual irrigation achieved in acreage of farm land and the water delivery made in cusec days; have also been collected for a number of channels to depict relative delta on various system.

3.1.1. Crop Water Requirement (WR)

Crop water requirement is defined as the quantity of water, regardless of its source, required by a crop or diversified pattern of crops; in a given period of time for its normal growth under field conditions at a place.

Water requirement includes the amount of evapotranspiration (ET) or consumptive use (Cu) plus the loss during the application of irrigation water (unavoidable losses) and the quantity of water required for special operations such as land preparation, transplanting, leaching etc. It may thus be formulated as,

WR = ET or C_u + application losses + special needs.

Water requirement is, a `demand' and the supply would consist of contributions from any of the sources of water, the major source being the irrigation water (IR), effective rainfall (ER) and soil profile contributions (S) including that from shallow water tables. Numerically therefore, water requirement is given as :

$$WR = IR+ER+S$$

The field irrigation requirement of a crop, therefore, refers to the water requirement of crops, exclusive of effective rainfall and contribution from soil profile, and it may be given as

$$\mathrm{IR = WR - (ER+S)}$$

The farm irrigation requirement depends on the irrigation needs of individual crops, their area and the losses in the farm water distribution system, mainly by way of seepage. The irrigation requirement of an outlet command area includes the irrigation requirement of individual farm holdings and the losses in the conveyance and distribution system.

The water balance of a field is an itemized statement of all gains, losses, and changes of storage of water occurring in a given field within specified boundaries during a specified period of time. The task of monitoring and controlling the field water balance is vital to the efficient management of water and soil. A knowledge of the water balance is necessary to evaluate the possible methods to minimize loss and to maximize gain and utilization of water which is so often the limiting factor in crop production.

Gain of water in the field are generally due to precipitation and irrigation. Occasionally, there may be gains due to accumulation of runoff from higher tracts of land, or to capillary rise from below (especially where a water table is present at some shallow depth). Losses of water include surface runoff from the field, deep percolation out of the root zone (drainage), evaporation from the soil surface, and transpiration from the crop canopy. The change in storage of water in the field can occur in the soil as well as in the plants. The total change in storage must equal the difference between the sum of all gains and the sum of all losses.

(Gains) - (Losses) = (Change in storage)

$(P+I)-(R+D+E+T)=(\supseteq S+\supseteq V)$

in which, P is precipitation, I irrigation, R runoff from the field, D downward drainage out of the root zone, E evaporation from the soil, T transpiration by the crop canopy, $\supseteq S$ the change in soil water content of the root zone, and $\supseteq V$ the change in plant water content. All of these quantities are usually expressed in terms of water depth per unit of area (ha-cm) or units of depth (cm).

The gross Irrigation requirement (IR) at the field head; can be worked out

$IR = DN / E$

Where IR = seasonal gross Irrigation requirement at the head of field (Cm)

D = net amount of water to be applied at each watering (Cm)

E = water application efficiency

N = no. of irrigations in a crop

Despite adoption of best farm practices ; never would all the water applied for Irrigation enter the soil & help in root zone. Losses are unavoidable as caused due to seepage, some leakage in the conveyance; non-uniform application on farm or field; percolation below crop root zone & wastage due to surface runoff at the extremity of furrows or borders. In case of Irrigation by Sprinklers; losses occur also due to evaporation from spray and by retention of drops on the foliage.

3.1.2 Watering or Frequency of Irrigation

The depth of each watering and frequency of such watering depends on the consumptive use rate of individual crop root zone. It is a function of crop, soil and climate. Crops grown in sandy tract would require more frequent watering than crops in fine textured deep soils, Moisture use rate also increases as the crop grows and days become longer and hotter. Irrigation; generally should commence when 50% and not over 60% of the available moisture has been used from the zone in which most of the roots are concentrated. The stage of growth of crop with reference to the critical periods of growth is also kept in view while working out irrigation frequency.

For the purposes of designing Irrigation network; the frequency of Irrigation to be used is the time (in days) between two irrigations in the period of highest consumptive use of crop growth. The frequency depends on how fast soil moisture is extracted when a crop is transpiring at its max^{m} rate. The irrigation system must have adequate capacity to supply water required during this period. The designed frequency of Irrigation can be computed as,

Designed frequency = Field capacity of the soil in the effective crop root zone available or residual moisture content at the time of starting irrigation
----
Peak period moisture use rate of crop

Irrigation Period

Irrigation period is the number of days that can be allowed for applying one Irrigation to a given designed area during the peak consumptive use period of the crop being irrigated. It is the basis for designing capacity of Irrigation system. The system needs to be so designed that the Irrigation period is not greater than the irrigation frequency.

Irrigation Period = Net amount of Moisture in soil between start of Irrigation and lower limit of moisture depletion
----
Peak Period Moisture Use rate of crop

Crop Response to water at various stages of growth

Water requirement varies with the stage of growth of crop. On the UGC system, the supplies during winter months is lean. Critical stages of crop growth with respect to moisture have in any case to be taken care of . This stage is most sensitive to shortage of water. Each crop has different critical stages at which shortage of moisture results in reduced yield unlike some of the system in southern & western part of country where demand slips are basis of releases from storages & where even cropping pattern is predetermined or possibly enforced. On UGC system like other northern canal network system; each farmers is at liberty to adopt any cropping pattern, change it from year to year or have mixed cropping at his pleasure. On any distributary or minor or even on an outlet as would

Table3.2 show for an example; different crops are grown and this leads to different periods of critical growth thus resulting in wastage of water when releases & availability conform to even max^{m} demand of one crop or acute shortage. That is why mere formation of water user's Associations at outlet level would serve practically no purpose. This is for the two-fold reason that the up canal act provides for upkeep of water course by the beneficiary & Osrabandi is enforced by the Deptt. It would be worth while only if Participatory Irrigation Management by formation of Water Users Association (WUA) is enforced voluntarily or by an act as done in Turkey; at the Minor or tertiary level by handing over the O&M and & administering of releases & charging them in bulk at head of channel. As done in the pioneer WUAs in Maharashtra; it was found more profitable for such WUAs to en-mass grow sugar cane on a single minor; synchronising of water releases to each of its field with almost identical time of sowing & critical growth which resulted in optimisation of irrigation water & maximisation of yield.

But keeping in view the existing scenario on UGC; supply needs to be made available at critical stages of growth. As separately tabulated; the critical growth period of different crops has been elaborated. The following terms are considered useful in identification of the growth & development stages of grain crop in relation to irrigation watering .

TABLE - 3.1

Stage	Details
Germination Tillering	The appearance of the radicle formation of tillers; branches produced from the base of stem stage
Jointing	when 2 nodes can be seen i.e. the beginning of shooting
Shooting	The stage of elongation of internodes.
Booting	The end of the shooting stage and just prior to the emergence of ears.

Stage	Details
Heading (earing)	The emergence of the ear from the tube formed by the leaf sheaths.
Flowering	The opening of the flower
Grain Formation	The period of grain development from fertilization until maturity This period is further sub-divided into 'Milk stage' – grain content has milky consistency 'Dough stage' – grain content has doughy consistency 'Waxy Ripe' – grain content has a waxy appearance. 'Full Ripe' – grain contents are hard `Dead Ripe' – grain ready for harvesting

TABLE - 3.2

IRRIGATION SCHEDULE FOR SOME COMMON CROPS

Crop	Time of Sowing	Number of watering	Water Requir--ement (cm)	Critical stages of crop Growth	Time of waterings days reckoned from date of sowing
Wheat (early sown	5th-15th Nov.	5 to 7	45	Crown root initiation jointing booking, flowering, Mill dough stage.	25, 45, 70, 90, 105, 125,140
Wheat (Late sown) & Tall Indigenous	15th-25th Nov. 1st week of Nov.	4 to 5	42 42	Ditto Boot stage, Dough stage	25, 45, 65, 80, 105, 125 30,55, 85,115
Barley	2nd or 3rd week of Nov.	3 to 4	30	Boot stage, Dough stage	30, 60, 85, 110
Peas	Last week of Oct.	1 to 2	15	Pre-bloom stage	55
Berseem	1st week of Oct.	15	90	After each cutting	At sowing 5, 20, 35, 50, 65, 80, 100, 115, 130, 145, 155, 165

Crop	Time of Sowing	Number of watering	Water Requir--ement (cm)	Critical stages of crop Growth	Time of waterings days reckoned from date of sowing
Potatoes	3rd week of Oct.	8 to 10	50	Tuber enlargement stage	1, 13, 25, 37, 49, 65, 80 97, 100
Radish	3rd week of Oct.	6 to 7	40	Root formation and bulking	1, 14, 27, 40, 53, 66, 79

Crop Characteristics : Crops with high water consumption create greater deficits of moisture in the soil. The effective rainfall is directly proportional to the rate of water intake by the plant. Crop characteristics influencing the rate of water uptake are the degree of ground cover, rooting depth and stage of growth. Soil moisture stored in deeper layers can be tapped only when roots penetrate to these depths. Deep rooted crops, therefore, increase the proportion of effective rainfall in a given area. Rainfall just before harvesting is ineffective for most crops.

Surface and sub-surface in and out flows : Computation of surface inflow normally does not apply, except for areas subject to occasional flooding. Under efficient irrigation practices surface outflow is small. Management losses and waste of water due to technical faults are normally accounted for in irrigation efficiency.

Subsurface inflow is only of local significance in areas where there is upward movement of water from deeper subsoil caused by seepage from reservoirs and canals. Subsurface inflow may also occur locally on or near the toe of sloping lands. Detailed field investigations will be required to determine the quantity of water involved.

Deep percolation below the root zone can continue for a long time after field capacity has been reached, following irrigation or heavy rain. The rate of deep percolation decreases with time. Total water loss by deep percolation in irrigated conditions can account for 20 per cent or more of the total amount of water applied. However soil water movement in and below the root zone, after an initially net downward outflow, can later be reversed to a net upward inflow from the wet sub-soil to the drying root zone above. Detailed field investigations will be required to determine the net rate of downward flow of water.

Measurement of Effective Rainfall : The evaluation of effective rainfall involves the measurement of rainfall and or irrigation, losses by surface runoff, percolation beyond root zone and soil moisture use by crops. Precise measurement are often done by weighing type Lysimeters. Normal effective rainfall in Upper Ganga Canal command is given at Annex. 3.1. Zonewise rainfall is given at Annex. 3.4.

Net Irrigation Requirement :

The net irrigation requirement is the depth of irrigation water, exclusive of precipitation, carryover soil moisture or groundwater contribution or other gains in soil moisture, that is required consumptivity for crop production. It is the amount of irrigation water required to bring the soil moisture level in the effective root zone to field capacity. Thus it is the difference between the field capacity and the soil moisture content in the root zone before starting irrigation.

This may be obtained by the relationship given below :

$$d = \sum_{i-1}^{n} \left(\frac{M_{fci} - M_{bi}}{100} \right) AtD_1$$

In which

d = net amount of water to be applied during an irrigation in cm

M_{fci} = field capacity moisture content in the i_{th} layer of the soil in percent

M_{bi} = moisture content before irrigation in the i_{th} layer of the soil in percent

At = bulk density of the soil in the I_{th} layer

D_I = depth of the i^{th} soil layer in cm within the root zone, and

n = number of soil layers in the root zone D.

In drawing up the seasonal or monthly net irrigation requirements for a given crop or cropping pattern the main variables composing the field water balance include : (I) crop water requirements as determined by climate and crop characteristics, (ii) contribution from precipitation, (iii) groundwater, and (iv) carry-over of soil water. The deficit in the soil water balance is compensated by the net irrigation requirement.

Gross Irrigation Requirement

The total amount of water applied through irrigation is termed as 'gross irrigation requirement'. In other words, it is net irrigation requirement plus losses in water application and other losses. The gross irrigation requirement can be determined for a field, for a farm, for an outlet command area or for an irrigation project, depending on the need, by considering the appropriate losses at various stages of the crop.

$$Gross\ irrigation\ requirement\,(in\ \ field) = \frac{Net\ irrigation\ \ requirement}{Field\ \ efficiency\ of\ \ system}$$

3.2 WATER ALLOWANCE & CAPACITY FACTOR

The water allowance on UGC was decided & fixed for the CCA on the basis of adopted water requirement of crops, Kharif-Rabi ratio and area under each crop in 1000 ha of ranking CCA : Initially; for the purpose of allocating water allowance, whole area proposed to be irrigated had been divided various zones.

(iii) Kharif – Rabi ratio

It is a very important factor for determining the quantities of water required in a particular channel during the two crop seasons and distribution of the proposed area for cropping under different kinds of crops.

Soil survey indicate that Kharif – Rabi Ratio for perennial & restricted perennial could be adopted as 1:1.25 or 4:5;

(iv) Sub-soil Water Table :

Sub-soil has great influence on the moisture gradient of the profile above it. The nearer it is to the natural surface the more pronounced this influence will be. In other words more moisture will be available in the soil in water logged areas than in deep water table lands. The more the moisture near the root zone of crops : the less will be their water requirements. Consequently comparatively larger areas can be put under cropping with a particular quantity of irrigation supply in high water table soils. Due consideration has therefore, to be given to this factor while fixing water requirements and percentage of cropped area for different tracts of the command. The detailed abstract of soil moisture storage is given at Annex. 3.2. The critical periods of soil water stress is given at Annex. 3.3.

(v) Area Proposed under each Crop

Having known the Kharif – Rabi ratio and intensity of irrigation it is essential to distribute the area proposed to be cropped in the individual holding; over each crop which is planned to be taken according to the needs of the cultivator. Variation in percentage of area under each crop are bound to occur in different tracts because of difference in climatic & other soil conditions.

The grain or cereal requirements were governed by the number of family members and cattle heads. Fodder produced should be sufficient for the cattle which will be needed for farming & to meet needs of milk, butter, cheese etc. However these requirements have now undergone vast change & have no bearing with use of Tractors & farm products readily obtainable in markets. Similarly, the area under sugarcane or cash crops not controlled by his primary needs any longer but more for commercial value.

METHOD OF DISTRIBUTION

From amongst the broad methods of distribution by
(a) Continuous flow
(b) Intermittent flow
(c) Supply on demand

Or a combination of above; on UGC the capacity of an outlet is fixed on the basis of water allowance per 1000 acres for the total CCA on the outlet. The releases from distributary which runs in rotation is for full designed capacity of the outlet for the entire CCA but each farmer takes water according to its apportionment of time based on his area according to a pre-determined weekly roaster under Canal Act. a small and big farmer is submitted to equal time for Irrigating equal areas ; while in continuous system, a small farmer with comparatively smaller stream of water will take a relatively longer period for irrigating an equal area.

3.3 PLAN OF RELEASES INTO CONVEYANCE SYSTEM

Cropping Pattern envisaged in the Project :

UGC System remodelled from time to time envisaged the cropping pattern existing in the tract. The area is served for Irrigation by canal water as well as tube-well water. Booking of Irrigation is done on the basis of field acreage Irrigated & the farmer is at liberty to adopt any cropping pattern; change every season, do mixed cropping etc. The water allowance is fixed on the basis of soil characteristics, agronomic condition and intensity of irrigation envisaged for the culturable command Area. The crop water requirement of the traditional cropping pattern is worked out & the Irrigation System; distribution as well as Conveyance System is designed on the peak period rate of consumptive use. The peak period is the period during which the average daily rate of consumptive use of the various crops in the UGC area is at maximum Different crops have their peak rates of use at different times. Therefore some crops may not be using water at their maximum rate during project peak period.

Variation in planting dates also cause variation in the times individual fields or chaks of command reach their peak use rate. For this reason; the peak consumptive use of project would be somewhat less than that of an individual field.

Over the period, the cropping pattern has undergone a gradual but perceptible change. The use of fertilizers and water has made it possible for the farmer to grow two crops where one was raised a few years back. More than two crops too are being grown. There has been switch over to growing of commercial crops, vegetables and other cash crops. The agricultural research & technology has also introduced species & new diverse varieties amongst cereal crops; pulses oilseeds; vegetables, fruit & other crops that although yielding more, and remunerative to farmers consume far more quantity of water than the traditional varieties and the cropping pattern envisaged in the project. This has vastly transformed the scenario of supply and demand; added complexity to the rotational alternation and resulted also in haphazard flows or timing of releases or the quantum getting inconsistent with the crop water requirement at its various critical stages. But as the system, as desired above, was designed at peak consumptive use; irrespective of cropping pattern; thanks mainly due to innovations by farmer of supplemental irrigation too (where water intensive crops are grown); the overall releases on UGC can with manufacturer barring few months.

The rotational schedule though dependant on availability of water during various stages of crop growth and in keeping with satisfying the various groups under rotation; is based on an intensive exercise by the irrigation Deptt; Agriculture & Horticulture. The views of members or the irrigation Advisory committees constituted of officers of Irrigation Deptt., Deptt. of Drainage, Agriculture & Horticulture, farmers representatives and experts are duly incorporated but also considered in day to day operation wherever possible.

Restriction Free Cropping

On UGC System; as also in other parts of North-India, water allocation are based on size of holding of CCA & planned irrigation intensity of channel; the farmers are at liberty to select their cropping pattern & releases have nothing to do with crops grown in the Command Area.

UGC is an extensive project area and rainfall occurrence is neither uniform nor extensive in each rainfall pattern; it is also erratic and so many times the indents are revised during a rotation of one week itself. It also happens quite often mostly in winter rains as also in the monsoon that command areas on some of the minors of same distributary are dry whereas heavy rains experienced on others. In such cases reduction in distributary is obtained judiciously. And this upsets the fair & equitable distribution many a time as FSL is lowered in the parent channel, affecting direct outlets and some minors. All these eventualities are taken care of in day to day regulation and effective implementation depends on meticulousness of the regulation by speedy raising or lowering of supply in channels; passing of excess in channels under second preference or opening escapes; sometimes by reduction from Main Branch or even headworks.

3.4 STUDY OF WATER ALLOWANCE (DUTY PER CUSEC) - A TYPICAL STUDY

CROPS	INTENSITY % TO CCA	OUTLET FACTOR ADOPTED ON UGC
Sugarcane (SC)	15	104
Paddy	18	50
Other Kharif (O.K)	23	180
Wheat	41	110
Other Rabi (O.R)	14	136

Design during Rabi is based on Rabi + 1/3 Sugarcane
Design during July - Sept. is based on 1/3 S.C. + 1/3 O.K. + Paddy

<u>Weighted Average duty during Rabi</u>

Ratio of area irrigated is

Wheat 41/60 = 0.683

O.R. 14/60 = 0.233

S.C. 5/60 = 0.084

1.000

Hence for 100 acres of total irrigation in Rabi discharge required -

$$\frac{41}{60}+\frac{100}{110}+\frac{14}{60}+\frac{100}{136}+\frac{5}{60}x\frac{100}{104}$$

= 0.621 + 0.172 + 0.080

= 0.873 cusec

Hence 1 cusec would irrigate a composite area of

$$\frac{100}{0.873} = 114.5\, acres$$

Say 115 acres

Hence area irrigated per cusec during Rabi = 115 acres

Ratio of area irrigated for various crops per cusec is

$$\frac{0.621}{0.873} : \frac{0.172}{0.873} : \frac{0.080}{0.873}$$

When 60 acres is irrigated total CCA = 100 acres

Hence when 115 acres irrigated total CCA = 115 x 100 /60

$$Wheat \quad \frac{.621 \quad x \quad 115}{.873} = 81.80$$

$$O.R.: \quad \frac{.172 \quad X \quad 115}{.873} = 22.66$$

$$S.C. \quad \frac{.080 \quad X \quad 115}{.873} = 10.54$$

$$TOTAL \qquad = 115.00 acres$$

When Sugarcane Area sustained would be 3 x 10.54 = 31.62 acres

When60 acres area is irrigated, total CCA = 100 acres

Hence, when 115 acres are irrigated; total CCA= 115 x 100 / 60
= 191.6 acres

Hence CCA per cusec during Rabi = 192 acres
Say 190 acres

<u>Weighted Average duty during Kharif</u>

Since water consumption for sugarcane and other Kharif has been taken as 1/3, the actual area sustained under S.C. and O.K. would be 3 times.

Ratio of area to be irrigated as per cropping pattern

Crops	**Intensity**	**Effective intensity based on water requirement**	**Share**
Paddy	18	18	18/30.67 = 0.59
S.C.	15	5	5/30.67=0.16
O.K.	23	7.67	7.67/30.67 = 0.25
		TOTAL	**1.00**

Hence for 100 acres irrigation in Kharif as per cropping pattern, discharge required

$$\frac{0.59 \quad x \quad 100}{50} + \frac{0.16 \quad x \quad 100}{104} + \frac{0.25 \quad x \quad 100}{80}$$

Paddy S.C. O.K.

= 1.18 + 0.15 + 0.14

= 1.47 cusecs

Hence 1 cusec would irrigate 100/1.47 = 68 acres

Share of crops per cusec

$$Paddy \quad \frac{1.18 \quad x \quad 68}{1.47} \quad = \quad 54.6 \; acres$$

$$S.C. \quad \frac{0.15 \quad X \quad 68}{1.47} \quad = \quad 6.9 \quad acres$$

$$O.K. \quad \frac{0.14 \quad X \quad 68}{1.47} \quad = \quad 6.5 \quad acres$$

$$= \quad 68.0 \quad acres$$

During Kharif	S.C. area = 3 x 6.9	= 20.7 acres
"	O.K. area = 3 x 6.5	= 19.5 acres

When 30.67 acres is irrigated, CCA is = 100 acres

When 68 acres is irrigated, CCA is = 222 acres

Average annual area irrigated per cusec will be as below :

Wheat + other Rabi	= 104.4
Paddy	= 54.6
Sugarcane 3 x 6.9	= 20.7
Other Kharif 3 x 6.5	= 19.5
Total	199.2 say 200 acres

During Rabi, Sugarcane area works out to 10.54 x 3 = 31.62 say 32 acres while it was 20.7 acres only during July-October paddy season. Hence lower of the two figures has been adopted.

The area of Sugarcane and Other Kharif to be sustained during April-June is only 40.2 acres which can easily be irrigated with the water available during said seasons.

Thus on UGC one cusec of water during Rabi with diversified cropping pattern irrigates 115 acres whereas during Kharif it irrigates 68 acres of composite cropping pattern. Against intensity of irrigation designed for W.J.C. command initially as 50% & than 62% with water allowance of 2.4 /00 assess at outlet head; & achieved intensity of over 50% now, the intensity on UGC on the pattern of water allowance corresponding to UGC; works out to 43% in this typical example. However, actual intensity of irrigation varies on commands of UGC as well as in Head, middle & tail reaches of same sub-command.

3.5 OUTMODED IRRIGATION AND INEQUITY ORIENTED OUTLETS

Despite evolution of outlets & patenting of APM & AOSM (Adjustable Orifice Semi-modules); the widespread practice of allowing pipe outlets on the UGC system is not understandble. Discussion with field officers at site on some distys; telephonic talk with Executive Engineer; SE & discussion as to why A.P.M. not installed like the practice in other parts of Northern India i.e. Punjab & Haryana canals and with enough research & practical experience on the same; answer was merely that pipe outlet sizes were prescribed & some officers even showed surprise on the need to be asked such questions. When requested about setting of outlets & whether installation of pipe at proper level was done; reply was not assuring or confident. SE Aligarh informed that lot of unauthorised irrigation was going on; & there was deficiency in control & thus reluctance to allow or facilitate discharge observation on some of the canal system as under prevailing conditions of inequity results would not be correct & study would not relate to exact losses besides causing embarrassment to them. Such like situation may be occurring on the system on many of the channels but we did make measurements of our own on different occasions as well as in the company of officers of Mathura circle during the said visit.

The practice of pipe outlets as observed in the field have following repercussions.

1. The size prescribed relate to area in the command of outlet and it makes a world of difference as to level of its installation, if installed at bed level; discharge would be more; than if setting is higher alternatively installation at bed may partly cover the pipe with silt. Most of pipes were installed at bed level; with bed cleared of silt near opening of the pipe. Some pipes were fixed a little higher; than apparent bed level.

2. Size of the pipe cannot be the same; if setting is same because full supply depth or working head would vary from channel to channel.

3. Discharge of outlet will vary directly with difference in water level in the canal & that in the water courses.

4. Discharge drawn by outlet will vary with level of fields being irrigated at any particular time.

5. Discharge will be variable from field to field with the same size of outlet depending on level of fields

6. If size of life is area-wise only, full supply depth being more in the head reach; discharge will, be more in head reach than the then the tail or middle reach etc. as setting not prescribed or enforced at site thus inequity appears built-up in the system W.U.E. (Water Use Efficiency) is greatly impaired due to this practice; besides inequity & differential water allowance.

3.6 DYNAMIC REGULATION

The existing system of canal regulation has been with traditional Karri or Wooden needle control over head regulators & cross regulators; replaced in phases recently by gates & gearing even though outmoded system is still prevalent on many of the canals & the distribution network.

The existing system apart form loss of time; requiring more personnel for manual operation results also in losses due to leakage & is prone to tampering also.

The agricultural practices with mechanized technology; diversified cropping pattern aided by micro irrigation & conjunctive use practices; makes it imperative that versatile regulation to release timely deliveries, eschew wastage and incorporate the fluctuations in demand due to rainfall, breaches, mishaps; supplementary source of irrigation or critical need to crop be devised. The traditional system of placing indent, its revision & wait till control of supplies from head or diversion or operating of escapes resulting in wastage of supplies & even damage to crops or flooding at tails besides loss of yield & crop if supply at its crucial stage of growth is impeded has become obsolete. Communication system & automation in control at head regulators, cross regulators etc, thus assumes paramount importance. Wireless network and computerization has been done but half-hearted efforts result in stumbling upon the existing system as without thorough automation it is difficult to break inertia. The allocation of share as per fluctuating cropneeds and weather conditions is a tedious & complicated affair. Available supplies are in excess or shortage; adjustment commensurate with equity as well as Cropwater needs at the juncture is cumbersome. The response can be made faster and existing drudgery can be done away with considerably if entire system & process is automated and computerized. It may look in the beginning that the effort would complicate procedure; but it is bound to succeed and streamline the system by developing a software for this.

The supplies augmented through augmentation tubewells in various reaches; time of their requirement & its effect on the hydraulic parameters such as Full Supply Levels of distribution system to avoid overdrawal & underdrawal need to be amalgamated in the rotational programmes & day to day regulation.

3.6.1 Suggested Approach for Modernising Communication System

The ultimate development in automation of irrigation system comprises remote control through computerisation and centralised system where visual pictures of control points is available to water controllers including availability of suitable mechanism for remote control of operation of gates and pumps and data processing system incorporating all data on crops and rainfall. A study if conducted no doubt will be advantageous for such a system but it appears that many other simpler and relatively inexpensive measures may have much higher precedence prior to introduction of the latest technology.

a. Existing karries wooden and needles be replaced with gates. Hydraulically operated gates be installed, on trial basis, at point of off take of a few distributaries. The gates to start with may be operated manually but these be upgraded to electrical operation as soon as possible. Since the entire operation may not be possible in one phase, the control points are proposed to be categorised in order of strategic importance to facilitate completion of this operation in two or three phases.

b. Gauge discharge tables be based on gate opening as is already being done in case of WYC at Tajewala. When the gates are fitted with electric motors the gate opening can be synchronized with time duration of operation of electric motors. At Assan Barrage, up stream of Tajewala, the gate opens by one foot of operating the motor for one minute. One man sitting in a suitably situated cabin can operate all gates and can receive information on gauges automatically and transmit the same to water controllers. The electrical system at Assan barrage is simple to operate and is being manufactured at Roorkee. This system when installed obviates the need of gauge readers & data recorded automatically is firm and reliable.

c. Residential accommodation for signalers and sectional officers be constructed and it be ensured that the staff stays at their designated headquarters.

d. Telegraph offices be modernised and the signalers be imparted training in operation and maintenance of communication equipment.

e. The UPID has already procured a large number of Computers. Concerted house training programmes be conducted at each District headquarters to train senior staff. E-mail connections be obtained at District head quarters and other important control points to strengthen communication network.

3.7 OUTLETS ON THE UGC SYSTEM - EVOLUTION & PRACTICES

OUTLET

Outlets are a contrivance designed to regulate supplies from a canal, distributary or a minor to a water course or field channel to meet the established needs for raising crop or for any other purpose as approved under unit the canal act. An outlet serves to release a measured or quantitative discharge and acts as an efficient adjunct in equitable distribution of water.

Different types of outlet are

a. Modular outlets
b. Semi-modular
c. Non-modular

(a) Modular Outlets

The outlet is modular when discharge passing through it remains independent of water levels in the parent channel as well as water course within certain limits. A modular outlet delivers a fixed discharge. If parent channel is overdrawing, excess with reach the tail. If on the other hand parent channel is running with lower supply, the outlets in the head reaches would continue to draw their prescribed share resulting in shortage of water in tail reaches. In actual practice on UGC System; specially in tail reaches; the channels maynot run with designed or even adequate discharge all the time and such limitation restricts use of modular outlets or rigid modules. Such outlets are of course installed on

i) Branches as direct outlets
ii) Just upstream of cross-regulators or raised crest falls where heading up has to be done to feed offtaking channels
iii) Where channels can run with authorised full supply or reasonable high supply.

(B) Semi-Modular Outlets

Semi-modular or flexible outlets are dependent on the water level in the parent channel but are independent of water level in the water course so long as minimum working head required for its workability is available.

Semi-modular outlets are : -

i) Pipe outlets discharging freely in air this condition is created by dropping water into a sump & then lifting it again. Since condition of free fall into the air are limited; pipe outlets do not operate as semi-modules. Discharge passing through pipe is proportional to the discharge carried by parent channel only within a limited range of setting of outlet.

ii) Adjustable Orifice Semi-modules (AOSM)

It is an orifice provided with gradually expanding flume; flow through the orifice being hyper-critical it results in the formation of jump & it makes it independent of the water level in the water courses. Even this type AOSM commonly used in India was not found on channels seen. It is an improvement over Adjustable proportional module; which though draws proportional discharge but did due not draw proportional silt. From practical stand point the throat width of the Orifice Bt should not be kept less than 6 cm even if it so works out from the empirical formula and the height of the orifice, 'Y' should be calculated corresponding to the Bt, provided. To keep Bt to be minimum as 6 cm; 'Y' would workout less resulting in higher setting of AOSM. Similarly 'Y' should also not be less than 6 cm from practical considerations & if 'Y' works out less; AOSM would not be working proportional for Kharif & Rabi discharge. The AOSM is usually found to have a higher setting to meet requirement of proportionality & hence does not draw its fair share of silt.

iii) Open Flume Module

It is a weir type with a throat constricted sufficiently to ensure hyper-critical velocity. The length of the throat is such that the controlling section remains within it for all ranges of discharge within which the outlet needs to operate. A gradual expansion is provided below the throat the obtain maximum recovery of head. The side walls are built in masonry & top is generally R.C.C. precast slab. To prevent tampering an ironbase plate is fitted in the centre of the controlling section in the gullet with two side plates which can be adjusted for distance by sliding base bolts. Discharge formula adopted is

$Q = CB_t + H^{3/2}$

Q discharge in litre / Sec

H height of full supply level in canal above the crest of outlet

Bt the throat width & constant 'C' are

Bt	C
6-9 cm	0.0160
9-12 cm	0.0163
Over 12 cm	0.0166

In the case of these open flume outlets the setting is high for small dischargs to meet requirement of proportatinaly & fair share of silt is drawn only when the crest of the outlets is at bed level or close to it. Hence the open flume is more suitable for tail reaches of minors or as Tail-clusters.

iv) Pipe cum semi-module outlets

a. Pipe-cum-open Flume outlet

This consists of a pipe outlet offtaking from the channel near its bed and opening into a cistern on toe of bank. Open flume outlet is constructed with its crest at designed level in the downstream wall of the cistern. An enamelled gauge is installed or gauge engraved on the wall of cistern which is parallel to the flow in parent channel. The pipe cum OFM requires greater working head to overcome frictional losses through the pipe. The diameter of pipe as such is kept slightly larger. The drawback is in it inherent design as controlling structure being outside at tail-end of outlet; it is vulnerable to tampering by cultivators who may do so to draw more discharge & detection of this may be difficult for inspecting officers as structure is located at outer end of bank of distributions. However, on U.G.C. system only pipe outlets were seen.

v) Bend cum AOSM

To improve silt-drawl by ASOM a 90^0 bend is fitted at the mouth of AOSM & its intake is kept at 0.8 D. However, the depression head required for passing the design discharge is more than in normal AOSM.

(C) Non-Modular Outlets

Discharge through a non-modular outlet depends on the difference in water level in the parent channel and the water course. Variation in either of the two channel levels will affect the discharge. Most common outlet of this type is pipe. Pipe is generally kept horizontal and at right angles to the direction of flow in the parent channel.

Discharge formula is

$$Q = CA\sqrt{h}$$

The table as under shows sizes of type for various average discharges approved for adoption on the UGC System by the U.P. Irrigation Department.

The outlet size is selected for any command based on duty factor (Outlet factor) for the crop to be irrigated and the intensity of irrigation proposed.

This type of outlets being largely fitted & practised on UGC System is not at all sophisticated and has obvious technical and in herent defects and deficiencies.

SIZE & DISCHARGE OF PIPE OUTLETS AS RECKONED & PRACTISED ON UGC SYSTEM

Ventage (Diameter of circular pipes)	Qty.	Unit	Average discharge for			
Inch.			Free over-fall	Outlets with sub merged outfalls		
				Lift areas 0-20%	Lift areas 21 to 50%	Lift areas over 50%
1	2	3	4	5	6	7
6	15.0	Cusec Cumec	0.90 0.025	0.66 0.185	0.55 0.154	0.40 0.11
5	12.5	Cusec Cumec	0.68 0.019	0.50 0.14	- -	- -
4	10.0	Cusec Cumec	0.40 0.011	0.30 0.008	0.25 0.007	0.20 0.006
3	7.5	Cusec Cumec	0.20 0.006	0.15 .004		

Note : * Above table applies for pipe lengths upto 18 feet
* When length exceeds 18' next higher ventage is adopted

3.7.1.1 Roster

Total weekly availability of water to a division is fixed as per share & then roster to run different channels is prepared by the Executive Engineer in consultation with Deptt. of agriculture. After roster is finalised a copy of roster of running of canals for the entire crop season is made available to all concerned including public.

A typical roster / Sample chart is attached as annexure 4.11.

3.7.1.2 Adjustment in Allocation and Rosters

Distributaries & minors should be run with full supply discharge so that allocated share is fully utilized at all offtake points. In actual practice the available supplies may be in excess or short. The Executive Engineers are expected to place their indents in time & the instructions issued by the Superintending Engineer have to be unambiguous & clear enough on how to absorb excess supply or make up shortage. Whether supply surrendered due to slack demand by a division can be re-allocated to it later on or should lapse too is decided by the superintending engineer. Normally no supply is escaped during Rabi period as overall availability is short of total demand.

3.7.1.3 Regulation of Supplies on W.J.C. / U.G.C.

Whereas Superintending Engineer make the allocations as described above on U.G.C. the Divisional Canal Officer or the Executive Engineer is incharge of regulation & running of supplies on W.J.C. and in case of slack demand or extra requirement; he depends on the upstream counter-part who again is an Executive Engineer may be under the control of a different Superintending Engineer. Thus on W.J.C. regulation responsibilities generally end at the level of an Executive Engineer.

3.7.1.4 Supply at Tail-ends of UGC

The allocation division-wise as per system on UGC becomes deficient to operate; when supplies fall short of expectations. The tendency on the part of upper reach circle / divisions or farmers is to take their full share; even usurp share of the lower end farmers resulting in running of distributaries and minors far below the share supplies. The fate of middle & tail end farmers, on the disty. & minors or their outlets is similar resulting in disparity & defeat of the spirit of equity in distribution. The Warabandi or Osrabandi despite equity as their core-function can hardly be enforced or possible if the outlet itself receives less water or upper farmer tends to overuse the supplies.

Suggestion to make 5% more allocation for tail end divisions is only an escape route to slack enforcement of share. Penal action against defaulters in upper reaches can hardly prove deterrant as sufferers are farmers whereas control of canals & supplies rest in the control of Irrigation Department; & Upper & Middle reach farmers would rather tolerate penalty; as it is seldom enforced or water charge itself which is too nominal. Even percentage rate of recovery of canal water charge is very low in Uttar Pradesh.

3.8 FIELD OBSERVATIONS

During field visit on Jewar disty. command area as well as tail end distributaries of Mat Branch.

It was observed that :

i) Supply running in Jewer Disty. tail reach was short of its authorised share

ii) Supply running in Math Minor tail reach area was much short of its authorised share :

iii) There were a large number of cross bunds especially on the Jewer Disty. in the jurisdiction of Khurja Division; open cuts to draw water from the Jewer disty. were common practice, Vitiating the hydraulics of the channel.

iv) Some internal clearance or berm cutting done in patches but disposal of undressed earth done on the banks & slopes itself in heaps which was seen slipping back into the canal.

v) The officers accompanying lamented lack of control; as far as unauthorised withdrawal and putting of cross-bunds, earthen bed bars or bunds were concerned; & lack of funds to poor state of maintenance of internal section & overall upkeep of channel.

vi) There was hardly any relevance to measuring of discharge in the Jewar disty reaches seen as velocity was much below designed due to numerous cross bunds in the channel and open cuts to draw water etc.

The channel U/s Aligarh road as well as d/s looked as if it was abandoned as far as control was concerned. Discharge was measured at head reach of Mahavan Disty. is shown in Annex 3.5. Observation of discharge; a mere streak upstream under such conditions was thus of no avail; no extra supplies due to losses in the lower each of branches had been accounted for while making the share allocation. Besides such accountal; it was responsibility of Khurja Division to deliver supplies d/s his division as per share. Reason for not doing so was partly poor control & lack of maintenance altogether in his division.

3.9 TYPICAL ALLOTMENT ORDER FOR WEEK COMMENCING 7/11 DURING RABI

Unit - Cusecs

MZN (A) 1800 including losses 350 cs	Dhanauri	9800
		1800
MZN (B) 400	Belra	8000
A.B. 1650 including 450 for NRA		
Meerut Div. 1100 including losses 400 cs		
Khatauli Escape Nil		3150
Mat Br 2000	Newari	4850
Bulandshahr Dn - 1100 including losses 120 cs		3250
Delhi Supplies 150 cs	Walipura	1600
for Aligarh (D) Circle including Losses		

Note :

I) EE Muzaffarnagar Division Divn. is allowed to raise or reduce Dhanauri discharge subject to Belra Division being maintained 8000 cusecs steady.

II) EE Meerut Division to see that Newari Division will not go above 4850 cusecs, use excess in Meerut Division.

III) EE Bulandsahar Division to use any excess in Bulandsahar Division & maintain Walipura Divn. 1600 cusecs steady

IV) EE Muzaffarnagar Division & EE Meerut Division to keep strict watch on Main Canal & Bhola P.H.

Boundaries will be maintained as per allotment order at the cost of the channels.

3.10 SHARE CALCULATIONS FOR ROTATION COMMENCING 7/11 (RABI SEASON)

(Typical for a particular year)

Note :

i) There are enough supplies available at Okhla in Yamuna River to meet the requirement of Agra Canal

ii) There is escaping of about 1000 cusecs at Haridwar in Ganga River which will be used by LGC.

Therefore average supply of 9410 cusecs will be shared on UGC System

Actual Avg. Dhanauri Discharge = 9410 cusecs

Deduct Main line losses 1100 + 150 cs = 1250 cusecs

(for Delhi Supply) ____________

Net Supply = 8160 cusecs

			Due	Used/ Supplied	+ Excess - Short
1.	Share MZN Divn. @ 16.0 %	-	1305	1608	+ 303
2.	Share A B (MT) @ 12.0 %	-	980	1200	+ 220
3.	Share AB (NRA) @ 5.4 %	-	440	450	+ 10
4.	Share MT Divn. @ 9.5 %	-	775	1195	+ 420
5.	Share Bul Divn. @ 9.8%	-	800	945	+ 145
6.	Share Mat Br Divn. @ 30.0 %	-	2450	1362	- 1088
7.	Share Aligarh (D) @ 17.3 %	-	1410	1400	- 10

Note : 2000 cs supply was being allotted to Mat Branch but 1362 cs supply has been taken by the officers of Mat Branch.

3.11 CANAL TELEGRAPH & COMMUNICATION NETWORK ON UPPER GANGA CANAL SYSTEM

The traditional irrigation canal telegraph lines operated on Morse Code served the purpose of transmission of messages relating to regulation of canal network including relaying of data of gauge, discharge, warning of excess supplies or incidents of mishaps etc. This network consisted of about 75 canal telegraph stations with an approximate 330 K.M. of coverage mainly along the canals. The department of irrigation has been dependent on Deptt. of P&T or Deptt. of Telecommunication for the upkeep maintenance of system. This system has become outmoded & is under total replacement gradually on U.G.C. as also in other parts of northern India.

The system operates however from 10 am to 1600 & then from 1900 to 2000 hrs, whereas on Western Jamuna Canal System in Haryana it is supposed to work from 6 am to 2200 hrs.

The work land on the telegraph lines & duties of signalers include communication of regulation instructions, daily gauge & discharge releases from headworks and at various control point and headregulators of canal network, rainfall data & other messages connected with running of canals and visit of inspecting officers etc. This manually operater system has been plagued with want of occasional repairs, breakdown during monsoon, non-clarity of speech, slow speed & telegraph stations located as they are on canals not easily accessible generally not properly kept up. The range of audibility too is limited. These stations, most of them were added with telephones for communication of messages over nearby regulation points or offices. Gradually dependence shifted to P&T telephone where available. The system has always though been supplemented with wireless stations or hot lines in control rooms of district HQ and important stations for communication of urgent messages.

List of wireless stations as canal communication network in Ist Irrigation Circle, Meerut is annexed at Dwg. 3.1.

The Need for Modernisation

With modernisation of canal network; increased capacity of canals; present day requirement of agricultural needs due to diverse cropping pattern; drinking water priorities; limited availability during winter; proper & judicious water management is closely lnked to efficient communication network.

Any time lag between the fall in demand & this indent & reduction from control point if delayed is likely to result in avoidable wastage which can be minimised or eliminated by timely diversion of supplies through rapid communication. Enforcement of regulation instructions; crop needs at critical stages of growth or rains in certain parts of command; utilization of supplies on escapes where releases may have to be resorted to; depend on versatile communication aids. The communication system has to be modernised also for the safety of structures; canals and to tackle emergency situations

System of Communication

The modernised communication system would mainly include Radio Relay System, multi-access radio telephone system and the EPAXS; the telecommunication network to include multi-tier long distance transmission for speech & message / data / image comprising multi-channel UHF radio relay links (pair to pair communication through automatic repeaters) for trunk route Roorkee to Hathras initially connecting seven main stations viz. Roorkee, Muzaffarnagar, Meerut, Dehra, Bulandshehar, Shehar Aligarh & Hathras with facility of voice & message / data / image transmissions.

Digital multi-access Radio Telephone System connecting the base station to field stations.

Provision for EPAXs & Word Processors at Main Stations.

Mobile radio sets including walkie-talkie sets for officers on tour & emergency stations.

Stations like Roorkee, Muzaffarnagar, Meerut, Dehra, Bulandshahar, Aligarh & Hathras are main & important stations for UGC. There would be about 100 other field stations connected in groups to each of the above stations.

Okhla, Mathura, Saharanpur & Haridwar are important field stations. The field stations intend to serve regulation point of UGC conveyance & distribution system

3.11.1 BASE STATIONS & PROPSOED CONNECTED FIELD STATIONS

	Base Station	Connected Stations
1	**Roorkee**	i) Mayapur ii) Laljiwala iii) Dhanauri iv) Bahadrabad v) Asifnagar vi) Mohamadpur vii) Kotwal viii) Bestan ix) Saharanpur x) Rishikesh
2	**Muzaffarnagar**	i) Belra ii) Jauly

	Base Station	Connected Stations
		iii) Nirgagani iv) Naudra v) Chitaura vi) Khataul vii) Raolighat viii) Shahpur ix) Salarpur x) Morha xi) Bainsi xii) Jansath
3.	**Meerut**	i) Salawa ii) Jani iii) Bhola iv) Akbarpur v) Dhikauli vi) Daurala vii) Kalard viii) Sardhana ix) Niwari x) Pari chatgarh xi) Shahjahanpur xii) Timakia xiii) Baksar xiv) Modinagar xv) Garhmukte-swar
4.	**Dehra**	i) Muradnagar ii) Dasna iii) HG Junction iv) Sanauta v) Bhatijan

	Base Station	Connected Stations
		vi) Nizampur vii) Simohi viii) Dadri ix) Gulaothi x) Shivnagri xi) Lakhaoti Br. Head xii) Kot xiii) Okhla xiv) Ghaziabad xv) Hinden B. Site xvi) Hapur xvii) Jakhera
5.	**Bulandshahar**	i) Wali pura ii) Mundarkhera iii) Palra iv) Khurja v) Banjar Pur vi) Chachaura vii) Dayanatpur viii) Sikandrabad ix) Makri x) Charaura xi) Anibas xii) Makhina
6	**Aligarh**	i) Nagar ii) Balanpur iii) Kurana iv) Sumara v) Machua

	Base Station	Connected Stations
		vi) Nanau vii) Sangora viii) Pahasu ix) Narora x) Sujanpur xi) Bhureka xii) Khaira xiii) Bayana xiv) Nayabas xv) Karampur xvi) Tilokpur
7.	**Hathras**	i) Jao ii) Pilkhatra iii) Borah iv) Gadeshjer v) Jolesar vi) Popia vii) Sujia viii) Loncha ix) Sikandra Road x) Nasithi xi) Raya xii) Gindholi xiii) Mathura xiv) Nidhauli xv) Kandli

3.12 CONTROL STRUCTURES ON UGC

Upper Ganga Canal & branches offtaking from in have a large number of control structures to facilitate distribution of supplies into various canal and disty-network.

(a) Cross Regulators

Cross Regulators are necessary important control structure on all canals to

i) Enable feeding of offtakes with full supply discharge when the supply in parent channel is low or when full supply level in some channel is not attained. Discharge in U.G.C. varies from 397.36 cumecs to 127.44 cumecs.

ii) These structure are located head regulators of offtaking channels & are sometimes composite unit working as cross regulator and a head regulator aligned on left length or right or both.

iii) These facilitate operation of escapes on the upstream; when supplies are in excess or demand is slack downstream or a mishap necessitates opening of an escape.

iv) These are also provided for ponding to keep the lining loaded & reduce unbalanced hydrostatic pressure on lining during closure of canal; thus preventing sudden drawdown conditions and ultimately to regulate the rate of lowering of water level in case lined canal has to be emptied for annual repairs or otherwise. This also facilities even in normal running of the canal at different gauges to regulate the raising & lowering of supplies consistent with regulation instructions.

The cross regulators on U.G.C. had been constructed combined with falls where they served these purpose of regulating flow in bypass channels used for negotiating the falls for navigation; such structures exist on U.G.C. & also on W.J.C. even though navigation channels have become defunct now.

(b) Regulation System on Cross-Regulators

Mainly vertically operated sliding wooden karries or needles were provided on U.G.C. to act as gates. Steel gates with rollers were fitted on bypass channels upstream of Hydropower stations. The bypass gates upstream of Pathri Power house are Fish Belly type automotive gates, which regulate & control the pond level and the gates lower automatically & allow water to escape as soon as the pond level rises over a pre-determined level for which the gates are set.

The cross regulator at Dhanauri near RD 30.9 Km which is also used as head regulator for controlling supplies into U.G.C. & the cross regulator downstream of Delhi Drinking Water Supply conduit at 160.09 Km also have steel gates.

There are in all about 20 cross-regulators on UGC.

Cross-regulators on parallel Upper Ganga Canal had been proposed additionally exclusively for loading the lining against unreleased hydrostatic pressure. Undershot & overshot gates on cross-regulators.

The regulators installed with wooden needles have to be run over shot & water running on the crest formed by the wooden needles / planks has a fall on the d/s of the regulator. In such case the design of the d/s floor is based on the static head of water. Old regulators on main canal & branches were constructed like wise.

Silting up is caused instead of the regulator even though slits are left in the bottom needles to allow silt to pass down. The existing cross regulators in Branches and distributaries and also the head regulators of offtaking channels have been / are being replaced by steel gates operated vertically with the help of which or hoist arrangement. The downstream floors of such structures / works have been protected / strengthened for the shooting velocities from the undershot gates. These steel gates are not allowed to be over topped.

In new cross regulators undershot gates are being provided and the downstream floors are provided necessary cisterns and dentated cills to take care of dissipation of energy from the undershot operation of gates.

The advantage of these undershot steel gates is more efficient operation and absence of accumulation of silt in the upstream bed.

Ponding at the cross regulator increases seepage losses & should be kept to the minimum required to feed the offtake.

(C) Head Regulators / Proportional Distributors & their operation

These are structures that regulate flow of water from parent channel to a smaller offtake channel or at bifurcation of the main channel into two channels. There are also proportional distributors constructed to bifurcate or trifurcate the entire flow of parent channel into two or three offtakes at the same point. Their head regulators should also be gated & should be so designed as to draw proportionate share of silt load in the flow.

The operation of head regulators should be versatile; and leakproof. The bottom seat sides should be caulked properly to stop the leakages.

In regulating structures both on cross regulators & head regulators where regulation is done with wooden needles; plugging of leakage is being ensured by filling gaps / leakage with clayey earth etc. though it is never perfect & leakages occur.

Annex. 3.1

UPPER GANGA CANAL IRRIGATION PROJECT

NORMAL MONTHLY EFFECTIVE RAINFALL AS RELATED TO NORMAL MONTHLY RAINFALL AND AVERAGE MONTHLY CONSUMPTIVE-USE

MONTHLY NORMAL RAINFALL (mm)	AVERAGE MONTHLY CONSUMPTIVE USE IN MM													
	25	50	75	100	125	150	175	200	225	250	275	300	325	350
12.5	8	8	9	9	10	10	11	11	12	13				
25	15	17	18	18	19	20	21	22	25	25	25	25	25	25
50	25 42	33	35	35	36	37	40	41	44	48	50	50	50	50
75		47	51	54	56	58	61	65	69	74	75	75	75	75
100		50 81	65	69	73	75	79	83	88	95	100	100	100	100
125			75 124	83	89	91	96	102	108	116	123	125	125	125
150				97	104	106	113	120	127	136	144	150	150	150
175				100 162	117	120	128	136	143	154	166	172	175	175
200					125 200	131	140	148	158	169	184	191	197	200
225						142	152	162	175	189	200	210	220	225
250						148	164	175	192	206	216	226	236	245
275						150 260	173	188	205	223	233	242	255	265
300							175 290	195	215	235	246	258	273	288
325								199	220	242	258	275	290	304
350								200 330	224	245	265	285	303	320
375									225 360	248	270	292	310	328
400										250 390	273	296	317	335

Annex. 3.2

UPPER GANGA CANAL IRRIGATION PROJECT
SOIL MOISTURE STORAGE (Net Depth Of Application)
Factor For Effective Rainfall

Crop	Effective Moisture Storage (mm)	Factor for Effective Rainfall
Cotton	85	1.01
Sugarcane	128	1.04
Maize	85	1.01
Fodder	85	1.01
Arhar	102	1.02
Vegetables	45	0.89
Pulses	77	1.0
Toria	77	1.0

Annex. 3.3

UPPER GANGA CANAL IRRIGATION PROJECT

Critical Periods of Soil Water Stress for Different Crops

S.NO.	NAME OF CROP	CRITICAL STAGES
1.	Wheat	Crownroot initiation (20-25 days) Tillering (40-45) Jointing (60-65) Flowering (75-85) Milk (100-105) Dough (115-120)
2.	Barley	Tillering Jointing Milk
3.	Gram	Preflowering Pod filling
4.	Peas	Flowering Pod filling
5.	Mustard	Flowering Pod filling
6.	Maize	Early vegetative growth Tasselling
7.	Moong and Urd	Flowering Pod formation
8.	Arhar	Flowering Grain formation
9.	Cotton	Seedling establishment Flowering Boll formation
10.	Bajra	Flowering Grain formation
11.	Sugarcane	Tillering to ground growth period
12.	Rice	Tillering Boot to flowering

Annex. 3.4

UPPER GANGA CANAL
Zonewise Rainfiall

CCA in 000 ha

Zone	Distt (Meterological State)	Mean Annual Rainfall (mm)	Mean Annual ETo (mm)	U.C.	MGC (I)
1	**2**	**3**	**4**	**5**	**6**
I Sugar Cane	Saharanpur (Roorkee)	1121	1719	46	-
	Muzaffarnagar	878	1825	91	-
II Partial Sugarcane Zone	Meerut	831	1896	221*	9
	Bulandshehar	774	1875	216	134
III Non-Sugarcane zone	Aligarh	779	1847	119	-
	Mathura	675	1880	113	-
	Agra	713	1910	50	-
	Etah	722	1880	58	-
	Mainpuri	749	1910	6	-
Overall		-	-	1000	256

*** Includes CCA of Ghaziabad Distt.**

ANNEX. 3.5

1.	Name of Channel	Mahavan - Dy
2.	Date of Discharge	17.1.2002
3.	Time	11.30
4.	Gauge	3.2'
5.	Run	30 M

Distance from Lleft to Right in M	Sourndings	Area in M^2	Difference	Hydpo	Time in Sec.
0.00	0.00	-	-	-	-
1.00	0.60	0.30	0.60	1.17	90 Sec
2.00	0.68	0.64	0.08	1.00	85 Sec
3.0	0.63	0.655	0.05	1.00	85 Sec
4.00	0.51	0.570	0.12	1.00	90 Sec
4.8	0.00	0.204	0.51	1.12	-

$$R\ \frac{A}{P} = \frac{2.369}{5.29} \quad = 0.448$$

Value of ct. at 0.048 = 0.729

$$Surface\ Velocity = \frac{Run}{Time} = \frac{30}{87.5} = 0.34 m/\sec$$

Mean velocity = 0.729 x 0.343

= 0.25 m / Sec

Discharge (Q) = A X V

= 2.369 x 0.25

= 0.592 Cumecs

or 20.90 cumsecs

Say 012 21.0 cusecs