CHAPTER - 3

BASE LINE PARAMETERS OF WJC & 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

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.

WATERING OR FREQUENCY OF IRRIGATION

The depth of each watering and frequency of such watering depends or 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 in crops in fine textured deep soils, Moisture use rate also increases as the crop growth and days became 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.

Table 3.1,3.2 & 3.3 indicate Agronomic practices for principle crops on WJC & adjoining areas in Haryana.

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

No. of Days

(Designed frequency) = Field capacity of the soil in the effective crop root zone available or residual moisture content at the time of starting irrigation

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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

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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 WJC system, the supplies during winter months is very lean & despite rotational programme; essential releases from water supply offtakes take precedence; head reach farmers sometimes overdrawing and equity is undermined. 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 WJC 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 Northern India Canal Act amended as Haryana Canal & Drainage Act 1974 provides for upkeep of water course by the beneficiary & Warabandi 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 WJC; 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.
Heading (earing)	The emergence of the ear from the tube formed by the leaf sheaths.
Flowering	The opening of the flower
Grain Formation	The peroid of grain development from fertilization untill maturarity 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 joint-ing 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

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
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
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

Irrigation Water Requirement of Crops

Rice is practically grown in half of the command of WJC. It is a semi-aquatic plant and thus consumes many times more water than other food crops. It is thus major consumer of resource on WJC tract whether from surface waters or by supplementing through ground water and proper water management on this crop can play dividends. It grows best on clay-loams to clays since these soils are retentive of moisture and have low percolation rates (1-5 mm/day) The crop thrives best under conditions of high temperature and humidity. General Rice cultivation practice is transplanting on puddled soils and land kept under submerged conditions by rain or by irrigation. This practice of puddling & submergence has been found to reduce percolation, check weed growth; increase the availability of plant nutrients; regulate soil & water temperature favour the fixation of atmospheric nitrogen in soil through algal growth and improve photosynthesis in the lower leaves due to reflected light from the water surface. Keeping the soil under shallow depth of submergence throughout the crop growth period is conducive to higher yields. Field studies indicate that specially in kharif continuous submergence is not needed; humidity in the season being high & evaporative demands low. Submergence only during critical stages of initial tillering and /or flowering and maintenance of saturation to field capacity during the rest of stages yield more comparable to those under continuous shallow submergence.

Considerable amount of water in rice cultivation is lost due to percolation. It has been observed that out of 1680 mm of water needed by rice 1200 mm were lost through deep percolation (about 70%) on the sandy loam soils on WJC & only 480 mm use actual consumptive use.

TABLE - 3.3

IRRIGATION SCHEDULE FOR SOME COMMON CROPS

Crop	Time of Sowing	Number of Irrigations (approx.) cm	Water Requirement (approx.) cm	Critical stages of crop Growth	Time of Irrigation, days reckoned from date of sowing
Wheat-Mexican, early sown variety (Kalyan sona group)	5th to 15th Nov.	5 to 7	45	Crown root initiation, tillering, jointing, booting, flowering, milk and dough stages.	25, 45, 70, 90, 105, 125,140
Wheat-Mexican late late sown variety (Sonalike group)	15th-25th Nov.	5 to 6	42	Crown root initiation, tillering, jointing, booting, flowering, milk and dough stages	25, 45, 65, 80, 105, 125
Wheat-tall indigenous varieties	1st week of Nov.	4 to 5	42	Boot stage, dough stage	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
Potatoes	3rd week of Oct. (winter crop)	8 to 10	50	Tuber enlargement stage (from sbout 60th to 85th day after sowing)	1, 13, 25, 37, 49, 65, 80 97, 100
Radish	3rd week of Oct. (winter crop)	6 to 7	40	Root formation and bulking (bulking about 30 days after sowing)	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 weiging type Lysimeters.

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 consumptively 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 WJC 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 into three zones taking rainfall, existing irrigation arrangements and depth of water table into consideration. These zones being,

(a) Perennial
(b) Non-perennial
(c) Restricted perennial

Perennial

(i) Water allowance for such zone is 0.195 cumecs per 1000 Ha of CCA. On the basis of availability & pattern of actual flows the capacity factor for such zone are indicative of following pattern.

Month	Capacity factor	Full supply Days
Kharif		
April	0.50	15.0
May	0.90	27.0
June	0.90	27.0
July	0.80	24.8
August	0.80	24.8
Sept	0.90	27.0
Mean Kharif	**0.80**	**24.4**
Rabi		
Oct.	0.90	27.9
Nov.	0.90	27.0
Dec. 1-10 11-31	0.90 0.80	9.0 10.5
Jan	0.50	15.5
Feb. 1-10 11-28	0.50 0.75	5.0 13.5
March	0.75	23.3
Mean Rabi	0.72	21.9

Total full supply days in a year = 278

(ii) Intensity of Irrigation

It is defined as area of CCA proposed to be irrigated during the year per 100 Ha of CCA on a particular channel. It is not rigid & can be changed but for project formulation and for evolving cropping pattern such figure is taken as basis for calculations

Zones	Intensity of Irrigation
Perennial	50%
Restricted perennial	33 to 42%
Non perennial	17%

(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; for non-perennial zone this ratio was decided to be adopted as 52:48.

However the non-perennial & restricted perennial were converted into perennial gradually by making up shortage by augmenting supplies through NBK link from Bhakra system as well as installation of Augmentation Tubewells.

(iv) Size of Holding & Family members

The size of holding & no. of family members have always been the controlling factors in adjusting the requirements of every farmer with regard to each kind of crop. The primary need of his family play a major part in determining the most suitable cropping pattern. In general the holding of an average zamindar was small. For purposes of designing cropping pattern; an average holding at the time of project formulation was taken as 5 hectares & 4 to 5 members were supposed to constitutes a family. Size of holding smaller than 5.0 hectares usually becomes an uneconomical unit.

(v) Quality of Soil

The mechanical composition & texture of soil play an affective role in selecting the kind of crops which would be successful in a particular land. For example : groundnut would be successful in lighter type of soil; Rice will give better yields in Chautang - Yamuna creek/WJC tract; Sirsa Branch, Nardak & Karnal tract or Pehowa tract; sugarcane in doab type area etc.

(vi) 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.

(vii) 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.

3.3. PRINCIPLE UNDERLYING THE DISTRIBUTION OF WATER ON THE WJC SYSTEM

Western Jamuna Canal as it existed before remodelling in the late fiftees; was an unlined network; generally on the alignment & pattern taken up construction in 1817 by GR Blanc of the Bengal engineers; this canal followed an old creek of the river until it joined the Pathrala & Somb torrents. The first Remodeling was taken up in 1873 when a permanent weir was constructed at Tajewala and a low masonry dam was constructed by Mr. John colvin at Dadupur in 1875-79. Fifty years later canal was extensively remodelled & extended between 1940-43. The area irrigated under WJC prior to 1951 was 0-488 million Hectares. Further remodeling continued to add capacity for water likely to be available from Satluj and Beas storages; in the plan period & irrigation to additional 0.248 M ha was thus intended through such extensions.

After construction of this unlined canal during its various stages considerable time elapsed in the attainment of its regime to facilitate the authorised drawal by the offtakes.

Water flowing in the natural stream of Yamuna was channelised as described above for the benefit of community through an agency of the Govt. Axiomatically the utilisation of this natural resource is for the greatest good of the greatest number. But as would the record of available flows in Yamuna indicate; discharges available at headworks ranged from as low as 80 cumecs in winter months to utilisable waters around 300 cumecs at the maximum during monsoon period keeping in view the share of WJC on the river & its capacity. Within such availability constraints it was not possible to irrigate the entire commanded area during both the crops. Also keeping in view availability; it was considered uneconomical to design channels on the maximum capacity based on CCA. Keeping in view that greatest good of the greater number could be achieved not by intensive irrigation or 100% coverage of CCA of some area & denial altogether to other; project intensity on the WJC tract was assigned to cover part of the CCA & holding of each farmer both during Kharif & Rabi. Combined intensity as designed in capacity of distribution network was revised to 50% from initial lower variable figures. Based on the criteria of soil characteristics; rainfall pattern, crop calender; depth of spring level; water allowance per 1000 ha of CCA was determined and capacity at head of outlet & head of distributary worked out on the Western Jamuna canal system.

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 WJC 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 distributory 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 Northern India Canal & Drg Act. 1873 modified in 1974 as Haryana Canal & Drg. Act. Under this system on WJC; a small and big farmer gets 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. In the system on WJC; since cultivator gets water for a fixed period; he pays full attention to utilisation of water at his hands This system is conducive to economical use of water.

3.4 PLAN OF RELEASES INTO CONVEYANCE SYSTEM

Cropping Pattern envisaged in the Project :

Western Jamuna Canal 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 WJC 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 inconsistant 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 WJC specially during Ist preference rotation fairly meet the requirement on the ground.

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 Western Jamuna Canal System; as also in other parts of Haryana, Projects & also in U.P., 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.

Conveyance System on Western Yamuna network receives supplies from runoff of the river mostly from Yamuna river. Some water is also augmented from storage reservoir of Bhakra Dam through Narwana Branch via NBK link.The flows from Bhakra i.e. Narwana Branch has no fluctuation & depending upon availability and a fair percentage of Indent is regularly received through NBK into the Western Jamuna Canal Main Branch upstream of Munak. The advantage of supplies fom a storage reservoir besides being certain is that it is also silt free.

The releases from storage also offer greater flexibility to conserve & release to the extent needed at will. Whereas on run of the river supplies the system has to do with availability as also escape the available waters d/s if not possible to utilize. This is what has been happening on the system from river Jamuna. While planning release in each rotation & crop season; the actual rainfall accuring in the command area is an important parameter. The retentive moisture consequent upon rains is important at the time of sowing for Rabi or first watering; depending on the species of crop.

WJC 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.

3.5 CONTROL OVER CONVEYANCE SYSTEM

3.5.1 Rotational Programme on WJC Distribution Network

The Western Yamuna Canal Main Line Upper takes off from Tajewala Headworks and carry the available supplies to Haryana's Share; for distribution on its Canal network. The main branch below Dadupur is unlined right upto Munak & entails very heavy loss specially so when during lean period small discharges are carried in this canal of over 250 cumecs capacity. Augmentation canal constructed & rehabilitated & huge money spent for its renovation though supposed to carry 128 cumecs has not been run beyond 90 cumecs & heavy losses allowed by diverting precious supplies via unlined canal (Photograph of Headworks is enclosed at Fig. 1).

Available flows for WJC fall to mere 80 cumecs in lean period. The WJC comprising of distribution network includes,

(i) Sirsa Branch
(ii) Hansi Branch
(iii) Chautang Feeder
(iv) Parallel Delhi Branch (PDB)
(v) JLN Canal
(vi) Bhalaut S/Branch
(vii) Delhi Branch

and direct offtakes between Indri to tail PDB & offtakes of above system. The requirement of supplies if all channels could be run as per demand in peak period would be colossal; of the order of 350 to 375 cumecs but availability during winter even after including supplies from Bhakra via NBK and augmentation Tubewells (intermittent 7 ± cumecs) is hardly ± 115 cumecs thus necessitating formation of groups of rotation.

The system has been divided into four major groups excluding Sirsa Branch which runs only during monsoons or surplus supplies.

Munak Escape is run only when Delhi Water Supply undertaking (DWSU) places indent to release supply for Wazirabad Water works.

The following direct offtakes & minimum releases for ecological considerations are perennial releases & thus form part of each group.

(1) Munak Escape if DWSU places indent
(2) Haidarpur Treatment plant 12 cumecs (Release at Munak 15 cumecs)
(3) Gurgaon Water Supply (2 cumecs)
(4) Najafgarh for release into river for Gurgaon canal as per demand and availability.
(5) Panipat Refinery Channel (0.57 cumecs)
(6) Panipat Thermal Power Plant (0.7-1.7 cumecs)
(7) National Fertilizer Ltd. (0.3 cumecs)
(8) For Nangloi Treatment Plant (1.2 cumecs) recently started

Minimum flow of 7 cumecs is kept for ecological reasons in river Yamuna below Wazirabad to dilute polluted flow in river Yamuna.

The four major groups as per rotation are

(I) ANTA GROUP

(a)	Rotational Requirement plus losses	= 90.50 cumecs
(b)	Essential supplies as indicated above shown as additional requirement plus losses	= 27.0 cumecs
	TOTAL	= 117.50 cumecs

(ii) BUTANA GROUP

(a)	Rotational Requirement plus losses	= 89.80 cumecs
(c)	Essential supplies as indicated above shown as additional requirement plus losses	= 28.40 cumecs
	TOTAL	= 118.20 cumecs

(iii) SUNDER GROUP

(a)	Rotational Requirement plus losses	= 83.38 cumecs
(d)	Essential supplies as indicated above shown as additional requirement plus losses	= 28.40 cumecs
	TOTAL	= 111.78 cumecs

(iv) BHALAUT GROUP

(a)	Rotational Requirement plus losses	= 82.53 cumecs
(e)	Essential supplies as indicated above shown as additional requirement plus losses	= 28.40 cumecs
	TOTAL	= 110.93 cumecs

The details in group of channels are shown in Annexure 3.1 to 3.5.

The rotational programme is got approved by respective Chief Engineer from the Engineer-in-Chief on the recommendations of Director regulation; taking into account projected demand; forecasts; recommendations of Agriculture & Horticulture deptts; and likely avilability of flows.

To meet the needs of additional rice shoots; running of lift areas & recharge etc. during period of monsoon or surplus waters; the releases are regulated as per demand but flows restricted at head works as per regulation instructions & safety of head works. Even though new Hathnikund Barrage has long been completed in 1999; it has not been operated & advantage forsaken & losses allowed only due to delay in taking up of Power Channel by State Electricity Board etc. Operation of new barrage could have solved many problems & avoidable heavy monetary loss.

Rotational Progamme of various groups shown in Annexures

Group A	Annexure	3.1
B	Annexure	3.2
C	Annexure	3.3
D	Annexure	3.4
E	Annexure	3.5

3.5.2 Rotational Programme below the Outlet

The available supplies on the WJC system are far short of the total crop water requirement of the Cultivable command area of the tract and thus of the designed capacity of the canal network. The available supplies are delivered in turn by formation of workable groups as described earlier, of almost equal discharge and each group run in turn such as group A, B, C, D . – say; group A is in first preference; any supplies available over & above the full supply or indented requirement of group A shall be released into the channels of group B etc. The group runs for minimum period of 8 days from head to ensure that the farmers field at the farthest end too receives water & that each channel runs for full week i.e. 168 hrs for equity in distribution.

Rotational System & Warabandi

The present scenario in the set up of water service units in the states generally embody responsibility for development of water resources through major, medium or minor projects & its delivery upto the outlet on a disty or minor only and distribution, upkeep and management beyond it are the function of the beneficiary i.e. a farmer or cultivator. The farmers do not join together to optimise the use of available waters either for maintenance of the field channel excepting what concerns them to fetch water to their own Naka & neither interfere or co-operate with each other in adoption of cropping pattern. The result had been that farmers in the head-reach and those who are socially prominent or politically influential end up utilising the bulk, denying the tail enders & weaker section their due share. This results in excessive Irrigation or over use in some areas resulting in waterlogging & salinisation whereas other areas left dry to face failure of crop even. Accordingly the experience that local cooperation amongst the farmers to implement equity in distribution did not work or that ‘Bhai’ chara Warabandi (framed mutually) did not function; a rotational system or Warabandi system to ensure delivery of water to each farmer according to logical share had to be devised & enacted under canal Act to have force of law for smooth implementation to bring about equity in distribution. On WJC system Warabandi is framed under canal Act by Zilldar of revenue Zilladari Section. He takes into consideration the suggestion & requirement of each Irrigator &

recommends a comprehensive warabandi to Deputy Collector; who considers and the warabandi is announced & implemented. Appeal against warabandi is with Divisional canal officer. Warabandi may vary to the extent that it may be village-wise, groupwise (thok) or individual turn-wise on the same outlet.

Implication of an officially implemented Warabandi

'Wara' means turn. This warabandi is a vernacular term to describe rotational system of Irrigation water delivered from an outlet. It is a weekly roaster of equitable distribution of water to an individual field in a stream size which is efficient, can be well managed by farmers thereby reducing the time & labour required for Irrigation. Better Water Control, freedom of sowing any crop within certain limits, higher unit area yield & larger irrigated area can be achieved per unit of water by adopting Warabandi. It helps in reducing wastage of water, water disputes, litigation and at the same time it enhances the reliability of irrigation water delivered to all shareholders including the tail enders. It enables the irrigator to know in advance when his turn & duration of turn would occur & he can plan his cropping operation as well as attend to other errands. It encourage & helps the farmer to use inputs like seeds, fertilisers or even hire or borrow implements etc. before his turn by sharing. A good warabandi however should take into consideration soil structure, drainage, agroclimatic factors, suitable cropping pattern, availability of water etc. The practice of warabandi should ensure participation and involvement of the farmers through persuation; motivation & demonstration. Criteria for working out time for each Irrigator is simple and based mainly on the size of holding. Water on WJC system runs day & night and the time is allocated on the basis of size of Chak. 168 hours of day & night running (over a period of a week) is allocated by Rotation through; an agreement amongst farmers or crop-wise; night & day irrigation can be switched amongst the share holders of an outlet.

Broadly : -

i) Time allocated for Irrigating field is proportional to the holding
ii) The cropping pattern & intensity is pre-determined & decided
iii) While determining or allocating time for holding of each farmer; travel time from the outlet to the farm gate & from Ist turn-out to the next one should he reckoned as common time. To minimise this the sequence of delivery is contiguous field wise rather than in any random manner or from tail end.
iv) The starting time for wari for first allocated Irrigator shall take into account the time of release of supply in feeding channel & the travel time for water to reach the head of the outlet. The opening time for channel as such is same every week.
v) The Bharai & Jharai is taken into account depending upon the turn of a farmer required extra time or time lost in filling of stream and in doing so the warabandi takes into account all 'plus' & 'minuses' on account of these.

The Drg. 4.2, 4.3 & 4.4 shows the Chak of outlet RD 10180-R (Km 3.103 Km) Lampur Disty; --- outlet RD 29 (Km 8.84) Jaunti Mr. outlet RD 274 (Km 83.53) Delhi S/B and the turn of each of the irrigator out of a total available period of 168 hrs. the warabandi is framed and implemented & actually working in the above said three chaks.

3.6 IMPORTANT CONTROL WORKS FOR REGULATION

3.6.1 Tajewala Headworks & its Replacement by New Hathni Kund Barrage (HKB)

Tajewala Headworks on river Yamuna constructed over a hundred years ago has almost outlived its life; has with-stood many a flood seasons and suffered structural damage due to which there had been reduction or disruption in smooth regulation. Replacement of this old structure; to obviate the recurring necessity of constructing a forcing – bund each year Eastern Jamuna Canal (EJC) after monsoons and sometimes again in winter after winter floods; to feed EJC; for safe regulation & importantly to meet the futuristic needs of higher discharges of sustained supplies post Kishau Renuka dams; was felt necessary. A new barrage upstream of present Tajewala headworks was mooted in early sixties and after model testing at CWPRS Pune & sanction from GOI on 1/1/82 the work was planned to be executed. It was also necessary keeping in view the fact that 1954 agreement on sharing of Yamuna waters between the then state of Punjab & U.P. was to expire in recent future. Drawing & Photograph of Hathni Kund Barrage are enclosed at Drawing 3.1 & Fig. 1 respectively.

There were repeated complaints on the part of U.P. that releases into EJC were delayed during Rabi due to delay in construction of forcing bund in the first instance & then its damage again in winter rains due to inadequate structural care. Haryana complained of unauthorised diversion of water upstream Tajewala directly into EJC from the tail race of Khara. This new Barrage aimed to eliminate such misgivings; complaints & genuine difficulties.

Construction of Hathni Kund Barrage was accordingly processed after signing of MOU on sharing of river Yamuna waters effective from April 95; and work was started in Oct 1996. The barrage was completed in April 1999. The construction and completion of WJC Link from barrage to main line was to synchronize with completion of Barrage in April 1999 but it got delayed due to faulty alignment noticed at advanced stage of land acquisition; even though it is completed now. But Commissioner, (Power); who held the charge of Irrigation also recommended in late 97/early 98 to Irrigation Deptt. that Tajewala headworks may continue to be operated even after completion of HK Barrage as power channel to be constructed by Haryana state Electricity Board would not be complete by then.

Discussion of WAPCOS Officers with Engineer-in-Chief, Irrigation Deptt Haryana on the Water use efficiency of WJC during June 2001 & again in March 2002, elicited that power channel had not been completed even till March 2002 and that power wing Haryana had informally agreed to bear the cost of maintenance of Tajewala Headworks and its appurtenants and protective works since HKB was complete as far back as 1999. He also indicated that U.P. Irrigation Deptt. might decline to bear/share cost of maintenance as also logically for forcing bund. This was confirmed by CE Upper Ganga Canal during discussion with WAPCOS Officers at Meerut. The delay in construction of Power channel has already resulted in delay and loss in power generation very heavy transit loss of precious water & resulting loss of revenue due to Water & Power running into hundreds of crores as well as avoidable expenditure on forcing bund and double maintenance.

The availability of water and the conveyance efficiency of main line upper which was to improve consequent upon offtake from the Barrage will thus remain a moot questions with operation & regulation of WJC canal continuing to remain unsafe from Tajewala H/W instead of from Hathni-Kund Barrage completed in 1999. This avoidable delay would also mean more of sediment/silt flow as here-to-fore and no advantage at all of newly constructed barrage.

3.6.2 Adverse repurcussion on losses and water-use efficiency due to non-commissioning of long-completed HKB.

Engineer-in-Chief Haryana had informed that Haryana Electricity Board had offered and agreed to bear extra cost of maintenance of Tajewala & appurtenant works but this is besides the point and avoidable national loss has been occuring in addition to huge transit loss of water & non-generation of power which is likely to attract audit objection no doubt.

The estimated loss even with empiricial formula @ 2.45 cumecs/ million sq. metres of wetted perimeter (for unlined canals) works out to an average of 15 cumecs days each day & taking cost per cusec days on basis as per Haryana Canal Act Schedule of rates revised 1997 the loss for the period works to over Rs. 100 crores. This 15 cumecs specially in the lean period of winter & summer is sufficient to meet the drinking water requirement of Delhi if additionaly made. If utilised for irrigation this amount on the basis of rational water allowance can irrigate two to three crops per year an area of three lakh acres. This loss is also irretrievable as it does in no way contribute to environment improvement or recharge in effected area.

Thus total avoidable loss due to such malfunction is over Rs. 300 crores besides national loss by loss of production of foodgrains & less productive out-turn of industries due to non-generation of power and a score of resultant setbacks; which can be elaborated.

Salient Features of Hathni Kund Barrage Project

Barrage & Canal Regulators

A. Barrage

a.	High flood Discharge (1 in 100 years frequency)	22,000 cumecs (7,76,900 cs)
b.	High flood Discharge (1 in 500 years frequency)	28,200 cumecs (9,95,900 cs)
c.	Highest flood level	342.35m (1123.20')
d.	Pond Level	334.32 m (1096.85')
e.	Crest Level (i) Spillway portion (ii) Undersluices portion	 330.00m /(1082.68') 329.00 m (1079.40)
f.	System level (i) Spillway portion (ii) Undersluices portion	 320.00 m (1049.87') 379.00 m (1046.59')
g.	Clear Waterway (i) Spillway 10 Bays 18 m each; (ii) Right Undersluices 5 bays; 18 m each (iii) Left undersluices –3 bays ; 18 m each Total clear waterway	 180 M (590.55') 90.00m (259.28') 54 m (177.17') 324.00 M
h.	Nos. & width of piers	15; 2.1 M each
i.	Nos. & width of divide walls – cum piers	2; 2.1 m each
j.	Fish ladder wall cum pier	1; 2.1m
k.	Fish ladder bay	1; 2.0 m
B.	WJC :- Head Regulator	
a.	Design Discharge	708 cumes (25,000 cs)
b.	Nos. & clear width of each bay	10; 8 m each
c.	No. and width of each pier	9; 2.00 m each
d.	Clear waterway	80.00 M (262.47')
e.	Overall Waterway	98.00 M (321.52')
f.	Crest RL	331.00 (1085.96')
g.	Cistern RL	328.00 (1076.12')
h.	WJC bed RL	329.00 m (1079.40')
i.	Bed width	92.00 m (301.84')
C.	EJC Head Regulator	
a.	Design Discharge	208 cumcs (7350 cs)
b.	Nos. & Clear width of each bay	4: 8.00 m each
c.	No. & width of each pier	3; 2.00 m each
d.	Clear waterway	32.00 M (104.97')
e.	Overall waterway	38.00 m (124.67')
f.	Crest RL	331.00 M (1085.96')
g.	Cistern RL	328.00 M (1076.12)
h.	EYC bed RL & Bed width	329.00 M (1079.40) ; 26 M (85.30')

3.6.3 AUGMENTATION CANAL

Prominent & conspicuous lapse or non-performance of a major canal is evident in case of release into Augmentation canal. This canal was constructed specially lined to save losses through old route of W.J.C. in unlined channel. This canal with designed capacity of 128 cumecs was renovated and rehabilitated at huge cost under Haryana Water Resources Consolidation Project in the year 1999-2000; as stated by the Engineer-in-Chief and CE Yamuna water Services then even informed that even concrete lining allowed at huge cost despite design provided for brick lining but this channel has never been run to authorized capacity even for a day for which it had been spent to be rehabilitated. The Engineer-in-Chief earlier declined to supply daily releases & supplied only consolidated releases for the month but later on such data had been collected which shows despite very low flows in river Yamuna during lean periods of Nov. to March etc. when supplies are very precious & we cannot afford to route supplies or part supplies through unlined canal despite capacity available in lined augmentation canal; Augmentation canal has not been run above 91 cumecs.

Daily releases supplied for some period show even in November when flow in Yamuna has been lean; Augmentation canal run as low as 41 cumecs; in December, to order of 59 cumecs; in January 2001 to 32 cumecs; (See Annexure 4.2 & table below). This would establish avoidable wasteful losses incurred.

There are huge discrepancies in the water account as per releases at Dadupur works; those reaching cross regulator plus Augmentation canal head & those reaching & distributed at Munak.

Some information made available on release d/s cross regulator actual withdrawls by offtakes on old WJC will show there was no need to release such heavy excess in the unlined WJC when capacity in lined Augmentation canal was theoretically available and vacant.

Month	Releases d/s cross regulator in unlined W.J.C. main canal (cumec days)	Actual withdrawal by offtakes (Cumec days)
10/99	5736	1477.00
11/99	2973	33.35
12/99	2312	10.63
1/2000	2175	37.00
2/2000	2060	12.80
3/2000	411	45.00
4/2000	792	30.00
6/2000	1827	22.50
1/2001	155	15.74

This confirms Augmentation canal even after rehabilitation at heavy cost has never been fit to take discharge even near to its 75% designed capacity.

3.6.4 Effective Structures on WJC Distribution Network

The following major structures exist on WJC to run the distribution network to convey water to the Command Area of the project

1. Head Regulutors.
2. Cross-Regulators
3. Falls

4. Meter Flumes or fall cum meter flume
5. Proportionate Distributors
6. Bed Bars
7. Escapes
8. Aquaducts
9. Syphons
10. Modular & Non Modular outlets
11. Tail Clusters
12. Micro-Hydel Schemes
13. Inlets

HEAD REGULATORS

Each canal, Main Branch, sub branch, Distributary & minor have a head regulator which is controlled by gates & gearing or wooden needles/stoplogs. The operation can be done mechanically, manually or electrically operated.

Field observations along WJC conveyance system all along d/s RD 145 (KM 44.2) Parallel Delhi Branch during Kharif reveal that even at the important regulation and control point at 'Khubru where from parallel Delhi Branch, JLN & BSB originated, old Karri system (wooden needles) was being used to regulate releases into Delhi Branch, Bhainswal Disty. and Sardhana Disty. Photograph of Regulation Control Point, Khubru and downstream enclosed as Fig. 4.

The same practice was being followed at the head of Delhi sub branch at RD 282300 (KM 86) of Delhi Branch. Photograph at Tail DB/Head DSB enclosed as Fig. 9 & Fig. 10.

It was noticed that even with best efforts; the regulation staff at these control point, could not control leakage through the offtakes so managed by wooden needles. 0.09 cumecs leakage was observed on Sardhana Distributary head regulator against its design capacity of 1.15 cumecs. The channel was closed at head.

The Head regulators of offtaking channels are so designed as to draw a fair proportion of discharge but the running condition on WJC system are such that during lean period; heading up has to be done when drawl by offtakes would be comparatively almost silt free and during monsoon months; being available; no heading up necessary but water always silt laden.

(a) Western Jamuna Canal System is essentially a run of the river scheme where there is huge variation between availability of supplies during monsoons & winter. The availability varies from as low as 71 cumecs to as high as over 341 cumecs. Demand during period of availability is also high keeping in view that paddy is the most popular crop on the entire WJC tract in the districts of Yamuna Nagar, Karnal, Kurukshetra, Panipat, Jind, Sonepat, Rohtak etc. and the projects of JLN feeder, (JLN canal, Loharu Canal etc.) and extensive lift irrigation system on arid areas of southwest need lot of irrigation water during Kharif season.

Accordingly capacity of channels are kept based on the Rabi discharge with freeboard margin for Kharif; where as during months of lean supply in Yamuna; channels run in rotation resulting in flows in the carrier canal far below the capacity. This is inspite of augmentation of supplies from Bhakra system through NBK link and some insignificant erratic contribution of augmentation tubewells. These tubewells have only fractional efficiencies, erratic running, shut down, sick & intermittent electric supply; and do not contribute to affect the quality of flow in canal.

Such low supplies result in low supply levels in the parent channels sometimes even below the crest of offtakes. The heading up of supplies below the offtake point of disty & minors from canals or of minors thus becomes necessary. The cross regulators as such are provided below most of the offtakes.

The cross regulators such as below Panipat thermal channel, Israna Disty, Naraina Disty, Jua Disty., SPT Disty, Karkroi Disty, Pai Disty; Rohna Minor, Bowana Disty, even Haidarpur Treatment plant are some of the structures as far as Delhi Branch alone is concerned. Similar Cross regulators exist on other system of Hansi Branch, Sirsa branch, Parallel Delhi Branch. Bhalaut s/Branch, Jhajjar Sub Branch, Dulera's /Branch, Gurgaon Canal in fact all the branches, sub branches and even some distributaries. Photgraph of Jua fall is annexed at Fig. 10.

The necessity of cross-regulator is also to facilitate authorised discharge in offtakes to take care of non-attainment of regime of canal; & tendency of scouring and shoaling.

Cross regulators are also provided where round the year supplies are needed such as for water supply; intake channels for power houses; refinery channels, such as Panipat Thermal Plant, etc.

The heading up of supplies at cross regulator results in formation of pond at its upstream which if not maintained properly for silt clearance results in shoals; silting up & growth of vegetation as was observed on the regulator at Daryapur fall; Jua fall so much that the structure was not even clearly visible.

PROPORTIONATE DISTRIBUTORS

If two or more offtakes branch out from the tail of a canal, their head regulators generally with the same crest level can be designed with width of crest Bt. individually for each so that available supplies are distributed proportional to the Bt. The design in such cases need to ensure that all channels draw proportional share of silt also. Examples are heads of Mundka Minor & Sultanpur at tail Bowana Disty. Baghru Badhana and Sissana at tail Jua Disty.

FALLS :

Falls are located wherever the change of command area demands so that adequate working head is available and the channel is kept in economical section.

Meter Flume or Fall cum Meter - flume

These structures are necessary to act as intermediate control points for estimating of discharge as also to serve purpose of fall. The existence of such structure also serves to help in maintaining regime of channel - specially if bed gets scoured.

Bed bars had extensively been provided before lining lent even after lining some of these exist and sometimes resorted to even on lined canal when required to obtain desired water level. Bed bars provided on Bawana Disty. over two decades back still existed. The reason can be :

(i) Scouring of bed

This results in low full supply level than at which offtakes & outlets are designed resulting in crest of outlet left high & dry.

(ii) Scouring of bed or over digging of bed of minor etc. by lower order tail Irrigators resulting in middle reach outlets not able to draw authorized discharge because the setting of outlet does not permit crest at bed level. Most of the outlets are converted into APM once channel attains regime.

Escapes : Escapes are inescapable requirement on the conveyance & distribution network. The Western Jamuna Canal is a long conveyance & distribution system with its one limb/link from Tajewala to Delhi; another upto Jhajjar & Rewari distt., Tail system of Hansi Branch in Distt. Hissar and some links going as far as Narnaul on the border of Rajasthan.

Once the water has been released into canal from Tajewala headworks or/and augmented from Bhakra through NBK; it cannot be halted - it has to flow down. In period of rotation, when supplies are lean or restricted; the diversion of supplies is possible from one system say of group A in 1st preference to other system of group B in turn or even group C & this can be switched on within reasonable time with co-operation of adjoining Canal Division, Circles or Admn. But such exigencies can also arise due to : -

(i) Sudden rainfall in some of the area after placement of Indent.
(ii) Widespread rain in entire chak or command of a distributary
(iii) Widespread rain in part command of a number of disty on the some group.
(iv) Breach on any of the distributary; minor or sub-branch
(v) Cut on any channel

But it does happen that due to adequate availability of indented supplies; all or more than one group may be running full supply and demand slackens or fall suddenly due to any of the above reasons.

In such cases; it would take considerable time to take relief from head & works etc. Accordingly to counter such an event of occurrence or causing damage of safeguard against damage, escapes have been provided on Western Jamuna Canal all along upto tail end of system and these escapes have been used & utilized many a time for effective relief. These are located on Mainline upper D/s Tajewala

Main Line Lower U/s Dadupur

Dhanaura Escape

Indri escape

Munak Escape on Parallel Delhi Branch RD 0 (KM 0)

Escape on DD 8 crossing RD 256 (KM 78), Escape on Delhi S/Branch ; Bowana Escape

Escape along HTP RD 54 (KM 16.5)

Such escapes also exist on other systems similarly.

Adquaduct are passages for canal over Drainage crossings. A main aquaduct exist at RD 256 (KM 78) over Diversion Drain No. 8. Another aquaduct on the same system is over Najafgarh Drain at RD 73 (KM 22.25)

Tail clusters : are constructed at tail of every minor through which water of channel flows into field water course. Tail clusters on Western Jamuna Canal are open flume outlets and are designed to give a gauge of 0.3 meter while delivering designed discharge.

There is only one micro hydel scheme on the system i.e. at Kakroi fall at RD 228 (KM 69.5) of Delhi Branch.

3.6.5 Outlets -History of evolution and factors bearing the design of outlets on Western Jamuna Canal System

An 'outlet' as it is called on the Western Jamuna Canal; 'Sluice in some parts of country, turn out in America is the point of contact between the Canal Administration and the Cultivator. The `Irrigator' knows only one test of efficiency of the Irrigation Canal Management Agency - does it have an ample supply of water whenever needed for his crops & the success of an Irrigation network enterprise as the progressive remodeling over WJC for over a Century has shown; depends on the success with which this test is answered; that is equity in the distribution of water on a canal. And this distribution is affected through an outlet and there is probably no single item in the design of an irrigation system which has a greater effect on the distribution of water than the type and design of outlet.

The Western Jamuna Canal was opened as a system for facilitating Organised Irrigation in early 19th Century; there is no doubt that to start with a very large number of outlets were open cuts in the banks of Irrigation Channels; which were increased or decreased discharge.

Gradually outlets were protected as wooden shoots; brickbarrels or pipe outlets. Experiments were carried out by field engineers to evolve an outlet that could : -

a) Release a measured or quantitative discharge.

b) It should not be easily tampered with.

c) The criteria of an outlet is to deliver equitable discharge in the command of channel and flow should be regulated as per rotational programme; as such outlets should not be allowed in branches / canals which run continously.

d) Outlets if fixed just upstream of corss-regulators or raised crest falls are liekly to draw more; & should be discouraged.

(e) When the supply channel is at very low water level or inadequate supply level; it will be more or less proportionately distributed to all outlets; those with very high command not being allowed to draw off all the water there in.

(f) Discharges to be provided for may be anything between half and four cusecs; with possible duplication above the latter figure.

(g) Outlet should draw its fair share of silt carried by the parent channel.

OPTIMUM CAPACITY OF AN OUTLET

The optimum capacity of an outlet should be such that the absorption losses in the water course and in the field are a minimum. The longer the time taken to Irrigate a field, the greater is the amount of absorption in the part of the field already irrigated; while applying the minimum irrigation required for the remainder.

RICE SHOOTS

Each year a notification is issued by the Govt. of Haryana through Irrigation Deptt. that rice shoots (Imdadi pipes for paddy cultivation) can be issued effective certain dates depending upon expected monsoon period & generally from middle of July to end of Sept. Those shoots are embedded alongside the main outlet of the Chak or even for individual fields on the basis of application. The sanction for rice shoot is accorded by the divisional canal officer generally on first come first serve basis but those who apply and have been growing paddy for a long time; their rice shoots become traditional and are considered on preferential terms. The grant of rice shoots is limited to the extra Kharif capacity of individual canal minor or distributary in the command of which such rice shoots are demanded. Generally additional rice shoots are limited to 10% of the Rabi design discharge of the irrigation channel. The rice shoots have traditionally been wooden shoots; CI pipes even G.I. pipes, since CI pipes & GI pipes are available only in standard sizes; collars are fitted to adjust the diameter of the pipe to exact discharge sanctioned for the purpose.

PIPE OUTLETS

Pipes are embedded in the bank in concrete with face-wall of masonry when submerged; these act as non-modular outlets; whereas they behave as semi modular when flow has a free fall. The discharge can be worked out

$Q = C \times A \sqrt{2gh}$

Where Q is the discharge of outlet in cusecs C is a coefficient; taken as 0.74 for drowned orifice and 0.63 in case of free fall.

A is internal cross sectional area of pipe `h' is difference in running water level of the parent channel and water-course under non modular condition. In case of semi-modular conditions ‘h’ is measured upto the centre of the pipe.

TYPES OF OUTLETS

(A) Modular outlets or modules are those whose discharge is independent of the water level in the parent channel and the water course;

(B) Semi-modular or semi-modules : whose discharge, although depending on the water levels in the parent channel; is independent of the water levels in the water course; as long as the minimum working head required for the working of semi module is available.

(C) Non-modular outlets are those outlets, whose discharge is a function of the differince in levels between the water surface in the distributing channel and the water course. Variation in either affect the discharge.

Upto 1920 general type of outlet on WJC was a barrel type; rectangular type of masonry outlet introduced by Kennedy. This type was fitted with CI orifices. Major development occurred after ES crump presented the Panjab Irrigation Branch paper No : 26 on the Moduling of Irrigation channels. Mr. Anee in 1924 issued an order that APMs (Adjustable Proportional Modules) or where more suitable; the open flume should be adopted in all future remodelling.

OUTLETS IN USE ON WESTERN JAMUNA CANAL SYSTEM

The following three type of outlets viz Modular, Semi-modular and Non Modular outlets are in use on WJC.

These outlets patented over experience since 1920 have been developed for local adoption into Adjustable Proportional Module (APM);

Open Flume Outlet and Pipe Outlet.

On a newly constructed Channel; pipe outlets are initially installed till channel has attained regime. Even on very old unlined and lined canals where APM & O.F. outlets are working; additional (imdadi) pipes are given for Kharif to supplement discharge specially for Kharif.

These outlets can be fixed and adjusted easily; inside collars or sockets can reduce the discharge to required quantum. These are generally installed on newly constructed channel; where regime is not yet attained; or area to be served is small and modular outlets cannot be designed or modified. It is generally adopted for temporary or initial or imdadi or additional installation. These outlets have the advantage also to work on low working heads and draw fair share of silt when fixed near to bed level.

However their easy tampering and misuse and fluctuating drawl disfavour their adoption. The farmer can increase its drawl by digging the water course to increase the difference in head, when it is working under non-modular conditions. In low supplies it extracts greater share of discharge when fixed in head reaches & thus cause shortage at tail - the drawl of such outlet also fluctuates depending upon particular time.

OPEN FLUME OUTLET

Open flume outlet is a smooth weir with a throat constricted adequately to ensure velocities higher than the critical and long enough so that the controlling section remains within the parallel throat at all discharges upto maximum. A gradually expanding flume is provided at outfall, to obtain the maximum recovery of head. Proportionality i.e. when ratio of the rate of change of discharge in the outlet is the same as the rate of discharge in the parent channel) can be secured by keeping the crest level of the outlet at 0.90 of depth of the channel.

Discharge can be worked out by $Q = C \times Bt \times H^{3/2}$

Where C is a coefficient for different values of Bt as below

Bt between 0.20 & 0.30 feet C = 2.90

Bt between 0.30 & 0.40 feet C = 2.95

Bt more than 0.40 feet C = 3.00

Bt is the width of the throat

H is the depth of water above crest,

The silt drawing capacity of the outlet will be reduced with raising of the crest level of the outlet. Generally width of the outlet is limited to a minimum of 0.20 the working head required with slope of 1 in 5 of glacis & side walls play 1 in 5 is 20% of the depth of water above the crest. These outlets are of the same type as proportional distributors and are adopted on all the tail - clusters of WJC system. The type has the distinct merit that with high setting it can work just on a fraction of head. To over come defect of high flexibility a roof block is some times fitted in the gullet of the outlet. This enables the outlet to work as an orifice as soon as the roof block comes into action. The roof block is fixed at a height of 0.7 H from the crest.

ADJUSTABLE PROPORTIONAL MODULE (APM)

APM outlet; of all the outlet types has been considered useful on the WJC & other pioneering canal works after detailed study of the various types Besides its modularity : it offers immunity to tampering & the adjust ability and adjusting the roof block; it is fixed by blocks and secured by masonry key. The outlet can be re adjusted by breaking the key when required.

The rise in FSL tends to make the outlet rigid while fall in FSL increases the flexibility of outlet & it moves towards proportionality.

This type was evolved after great effort & experiments by a large number of Irrigation Engineers who worked on Western Jamuna Canal and other canals of northern India since early nintees.

Outlet essentially consists of an orifice provided with a gradually expanding flume on the downstream. The critical velocity is exceeded in the orifice and the discharge is thus independent of water level in the water course. It is a long throated flume with a roof block on the upstream end capable of vertical adjustment by mere sliding & inserting of bolts. The base plates and roof blocks are manufacturered in standard sizes.

Modularity is achieved by formation of standing wave and the discharge is given by : Q = C x Bt x y x ⌦h

Where C is a coefficient usually taken as 7.3 on the entire WJC system & in the Northern India Canals.

Bt is width of the throat as per standard sizes 0.20, 0.25, 0.32, 0.40 feet etc. Y is the height of the bottom of APM block above the crest.
H is the difference of FSL in the parent channel & crest (bottom level) of APM block Minimum modular head = 0.82 h - Bt/2
Proportionality is achieved by setting crest at 0.6 D; D being the FSD (Depth of water in the parent channel)

Y = h : However, the outlet, are susceptible to some adjustment in accordance with site condition which may slightly disturb it proportionately.

When the crest is set near the bed level : it is one of the best form of outlet to adopt except in those reaches where the outlets have to work as safety valve for excess supply and at control points where heading up may be required frequently & under such conditions open flume are adopted.

APMs were got locally made on order from some private workshops in the beginning when it was on trial. Once large scale adoption was accepted & ordered; Nangal dam workshop near Bhakra Dam project area became the sole supplier to entire Panjab Irrigation Deptt. since fiftees. At present however these blocks are being manufactured at many places & even Masonry APMs are being installed. New APM constructed on WJC system are generally Masonary APMs.

3.6.6. Modernising Regulation Of Irrigation Supplies On W.J.C. Network

Regulation of canal water includes estimating the demand for water to broadly match crop water needs, intimating the demand to supplier (Placing Indent), timely securing the indented supplies of water, distributing the water amongst large number of farmers in an equitable manner, keeping faithful and accurate record of these operations (Information) and conveying the status of these operations to all water controllers (Communication). This is the most vital and key function of the water service units and all other activities including data collection on meteorology, hydrology, drainage and ground water are its complimentary operations. Any shortcoming in regulation of supply of water and keeping accurate information or serious delay in its communication to water controllers could be highly detrimental to the very basic objectives of water service units to ensure timely and equitable distribution of water to farmers., Any intervention, therefore, must aim at achieving precise regulation, recording of accurate and reliable data and making the system more responsive to emergencies and situations requiring crisis management. These very specific objectives would form the basis of the recommendation on Modernisation of communication system and establishment of Information System.

PRESENT STATUS

Canal Systems, in Haryana, operate on rotation. The distribution channels are run either full or kept fully closed at the beginning of each crop season; rotational programme is issued by the Chief Engineer (YWS), for operation of WJC. The rotational programme is based on crop water needs in different periods and corresponding likely availability of water estimated from experience of past years. Irrigation channels are placed in three or four groups of nearly equal requirement of water and these groups of channels are placed in order of priority ensuring that at least one group of channels runs with full supply for eight days.

Regulation of water is achieved through more than 50 control points. Each Divisional Canal Officer (DCO) places his demand for supply of water (INDENT) with his counterpart in the upper reach who in turn adds his own indent and intimates it to his counter part upstream. The process is repeated and thus total demand of water supply required for the entire Canal System is computed. Placing an indent is a basic but vital function in the process of regulation and the quantity of water indented is equal to or less than the authorised supply based on total cultivable commanded area. The DCO is assisted by the supporting staff in the field for assessment of requirement of water. This function is closely supervised by the Superintending Engineers and the Chief Engineers.

Gauge discharge table is prepared for each control point and for every site where indented water is handed over by one Sub division to another or even by one Sectional officer to another. The gauge discharge table is based on joint measurements of water flow and this exercise is repeated as often as possible and at least once every year. The gauges (Depth of Water) in each channel are recorded, at each control point, by a gauge reader, every two hours, and are recorded in a register maintained by the signaller at every control point. Based on the gauge discharge tables, the signaller guides the regulation staff if any changes are required in regulation of supplies in accordance with indent and the rotational programme. The signallers intimate the gauges to different water controllers both for morning and evening. Gauges at the tail of each channels are observed once a day and intimated to local officers. Gauges as received are carefully scrutinized at all levels and there is constant dialogue on changes in indents and discrepancies in regulation including shortage at tails of channels in supply of water released in various channels is altered every eight days in accordance with approved rotational programme and this change is affected before the morning gauges transmitted at six in the morning.

The system of recording regulation data and its communication was designed many decades ago and has out lived its utility and it is in urgent need of being upgraded to improve service to water users, increase efficiency of operation and to provide more responsive reactions to emergencies. Following issues, in this regard, have been identified during discussions and field visits.

a. Many control points have not been fitted with gates. Use of wooden karries and needles is a serious impediment in ensuring precise and timely regulation
b. Due to non-availability of requisite number of boat and current-meters, discharge observations are not being made as often as required. This serious default has further been compounded because of heavy ingress of silt load in most of the channels under WJC system resulting in frequent changes in bed levels necessitating revision of gauge discharge tables.
c. It is not practical for the Gauge readers to observe gauges every two hours especially during winter nights.
d. Due to non-availability of residential and other facilities, Signallers mostly live in near by townships leaving the operation of control points to junior staff. For similar reasons the sectional officers in some cases also do not reside at their designated head quarters and are not accessible readily to deal with emergent situations relating to regulation.
e. Housing facilities for sensitive communication equipment is unsuitable and the signallers have not been trained either in proper operation or preventive maintenance of communication equipment.

f. The single wire system telephone lines used for communications are out dated and unreliable. Similarly the working of wireless system, acquired recently, is subject to weather conditions.

3.6.7. Dynamic Regulation By Modernising Communication Network

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 prevailent 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; diverse cropping pattern & micro irrigation & conjunctive use coming into play; it has become imperative that versatile regulation control to release timely deliveries, eschew wastage and incorporate the fluctuations in demand due to rainfall, breaches; mishaps; supplementary source of irrigation or need of crop has become important. The traditional system of placing indent, its revision & wait till control of supplies from head or diversion or operating of escapes results 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. Communication system & automation in control at head regulators, cross regulators etc; thus assumes paramount importance. Wireless network, computerisation has been done but half-hearted effort results in stumbling upon the existing system as without thorough automation it is different to break inertia. The allocation of share as per fluctuating crop needs, weather conditions is a tedious process. When available supplies are in excess or shortage; adjustment commensurate with equity as well as crop water 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 involve complicated procedure; but it is bound to succeed and streamline the system by developing a software for this.

The supplies augmented through augmented tubewells in various reaches; time of their requirement & accountal in the hydraulic parameters such as FSL of distribution system to avoid overdrawal and under drawl need to be amalgmated in the rotational programes & day to day regulation.

Annex - 3.1

ROTATIONAL PROGRAMME FOR RUNNING OF CHANNEL OF WJC

SYSTEM DURING KHARIF 2001
W.E.F. 3.5.2001 TO 25.10.2001

PERIOD		PREFERENCE ORDER				
From	To	I	II	III	IV	V
3.5.2001	10.5.2001	BTA	SDR	BLT	JLN	ANT
11.5.2001	18.5.2001	ANT	BTA	SDR	BLT	JLN
19.5.2001	26.5.2001	JLN	ANT	BTA	SDR	BLT
27.5.2001	3.6.2001	BLT	JLN	ANT	TA	SDR
4.6.2001	11.6.2001	SDR	BLT	JLN	ANT	BTA
12.6.2001	19.6.2001	BTA	SDR	BLT	JLN	ANT
20.6.2001	27.6.2001	ANT	BTA	SDR	BLT	JLN
28.6.2001	5.7.2001	JLN	ANT	BTA	SDR	BLT
6.7.2001	13.7.2001	BLT	JLN	ANT	TA	SDR
14.7.2001	21.7.2001	SDR	BLT	JLN	ANT	BTA
22.7.2001	29.7.2001	BTA	SDR	BLT	JLN	ANT
30.7.2001	6.8.2001	ANT	BTA	SDR	BLT	JLN
7.8.2001	14.8.2001	JLN	ANT	BTA	SDR	BLT
15.8.2001	22.8.2001	BLT	JLN	ANT	TA	SDR
23.8.2001	30.8.2001	SDR	BLT	JLN	ANT	BTA
31.8.2001	7.9.2001	BTA	SDR	BLT	JLN	ANT
8.9.2001	15.9.2001	ANT	BTA	SDR	BLT	JLN
16.9.2001	23.9.2001	JLN	ANT	BTA	SDR	BLT
24.9.2001	1.10.2001	BLT	JLN	ANT	TA	SDR
2.10.2001	9.10.2001	SDR	BLT	JLN	ANT	BTA
10.10.2001	17.10.2001	BTA	SDR	BLT	JLN	ANT
18.10.2001	23.10.2001	ANT	BTA	SDR	BLT	JLN

BTA(Butana) SDR(Sunder) BLT(Bhalaut) JLN(Jawahar Lal Nehru) ANT(ANTA)

ROTATIONAL PROGRAMME FOR RUNNING OF CHANNEL OF WJC
SYSTEM DURING KHARIF 2001
W.E.F. 3.5.2001 TO 25.10.2001

BUTANA GROUP

S.NO.	NAME OF CHANELS	A.F.S. (Discharge in Cs.	Total
1.	**DIRECT OFF TAKES OF SUNDER SUB BRANCH**		
	Jui Feeder including Nigana Feeder (100 Cs., deducted due to change in jui feeder as per CW. No. 1210 dt. 12.1.2001)	450 - 100 = 350	350
2.	**DIRECT OFF TAKES OF BHIWANI SUB BRANCH**		
i)	Miham Minor	86.00	
ii)	Bainsi Minor	22.00	
iii)	Behran Minor	10.36	
iv)	Mokhra Minor	17.00	
v)	Dadri Feeder	351.00	
vi)	Bhiwani Dy.	215.00	
vii)	W.W. Tanks of Bhiwani	24.00	
	TOTAL	**725.35**	725.35
3.	**JLN FEEDER**		
i)	JLN System	1200.00	
ii)	Maret Mr. & Chuckakwas	20.00	
	TOTAL	**1220.00**	1220.00
4.	**DIRECT OUTLET ON**		
i)	Hansi Br. RD 0-60	1.40	
ii)	Bhutana Dr. R.D 0-Tail	84.98	
iii)	Bhiwani Sub Branch	63.53	
iv)	Delhi Br. Delhi S/Br.	39.00	
	TOTAL	**188.91**	188.91
5.	**ABSORAPTION LOSSESS**		
i)	Hansi Branch RD 0-00	20.00	
ii)	Bbutana Br RD O-fail	37.06	
iii)	Bluwani Sub Branch	44.28	
	TOTAL	**101.34**	101.34

S.NO.	NAME OF CHANELS	A.F.S. (Discharge in Cs.	Total
6.	**ADDN. REOUIREMENT**		
i)	HTP	523.00	
ii)	PTP	80.00	
iii)	NFL	40.00	
iv)	GWS	70.00	
v)	Addn. Losses	25.00	
	TOTAL	**738.00**	738.00
7.	**REFINERY CHANNEL**	**30.00**	30.00
8.	**FOR MINIMUM FLOW ON YAMUNA BELOW WAZIRABAD**	**240.00**	240.00
9.	**LOSSESS AND DIRECT OUTLETS OF SUNDER SUB BRANCH**	**117.16**	117.16
		GRAND TOTAL (1 - 9)	**3710.76 Say 3711 Cs**

Annex. 3.2

ROTATIONAL PROGRAMME FOR RUNNING OF CHANNEL OF WJC
SYSTEM DURING KHARIF 2001
W.E.F. 3.5.2001 TO 25.10.2001

ANTA GROUP

S.NO.	NAME OF CHANELS	A.F.S. (Discharge in Cs.	Total
1.	**DIRECTORATE OFF TAKES OF MAIN RANCH (AT MUNAK)**		
i)	Gohana Disty.	321.00	
ii)	Goli Disty.	51.16	
	TOTAL	**372.16**	372.16
2.	**DIRECT OFF TAKES OF HANSI BRANCH**		
i)	Jind No. 1	33.00	
ii)	Joshi Disty.	23.00	
iii)	Jind No. 2	6.80	
iv)	Jind Dy. 3	228.50	
	TOTAL	**291.30**	291.30
3.	**DIRECT OFF TAKES OF HANSI BRANCH D/S ANTA**		
i)	Muana Dy.	35.30	
ii)	Jind Dy. No. 4	70.00	
iii)	Jind Disty. No. 5	55.40	
iv)	Jind Dy. No. 6	34.50	
v)	Jind Disty. No. 6A	25.00	
vi)	Jind Disty. No. 7	26.00	
vii)	Jind No. 8	10.00	
viii)	New Rajpura Minor	8.50	
ix)	Masudpur Dy.,	115.00	
x)	Narnaund Disty.	35.00	
xi)	Hisar Major	300.00	
xii)	PTR Dy. Including sewani canal	536.00	
xiii)	New Dewani FDR L/C 11 Cs. For Harita	141.00	
	TOTAL	**1411.70**	1411.70
4.	**DIRECT OFF LAKES OF DELHI BRANCH**		
i)	Bawana Disty.	89.49	
ii)	Hulambi Disty.	5.80	
iii)	Delhi Sub Branch	35.65	
iv)	Nahri Major Disty.	33.48	
v)	Lampur Disty.	11.75	
vi)	Furkpur Dy. W/C	1.63	
vii)	Mandoni Minor	2.60	
	TOTAL	**180.40**	180.40

S.NO.	NAME OF CHANELS	A.F.S. (Discharge in Cs.	Total
5.	**ABSORPTION LOSSES**		
i)	Hansi Br. RD 0-238	**122.97**	122.97
6.	**DIRECT OUTLET ON**		
i)	Hansi Br. RD 0-238	17.23	
ii)	Delhi Br/Delhi Sub br.	39.00	
	TOTAL	**56.23**	56.23
7.	**ADDN. REQUIREMENT**		
i)	HTP	523.00	
ii)	PTP	80.00	
iii)	NFL	40.00	
iv)	GWS	70.00	
v)	GWS	25.00	
	TOTAL	**738.00**	738.00
8.	**REFINERY CHANNEL**	**30.00**	30.00
9.	**FOR MINIMUM FLOW ON YAMUNA FELOW WAZIRABAD**	**240.00**	240.00
	GRAND TOTAL (1 - 9)		**3442.66** **Say 3443 Cs**

Annex. 3.3

ROTATIONAL PROGRAMME FOR RUNNING OF CHANNEL OF WJC SYSTEM DURING KHARIF 2001 W.E.F. 3.5.2001 TO 25.10.2001

J.L.N. GROUP

S.NO.	NAME OF CHANELS	A.F.S. (Discharge in cusecs)	Total
1.	**DIRECT OFF TAKES OF W.J.C.**		
i)	Budha Khera Dy.	23.00	
ii)	Depot Minor	3.00	
iii)	Old Nardak Dy.	120.00	
iv)	Bazida Dy.	163.84	
	TOTAL	**314.84**	314.84
2.	**DIRECT OFF TAKES OF NBK LINK**		
i)	Nardak Dy.	393.00	
ii)	Gogripur Dy.	8.39	
	TOTAL	**401.39**	401.39
3.	**JLN FEEDER**		
i)	JNL System	1200.00	
ii)	S.L.C.	158.00	
iii)	Patuwas & Kachrauli	154.00	
iv)	Bakra Minor	81.00	
	TOTAL	**1593.00**	1593.00
4.	**ADDN. REQUIREMENT**		
i)	HTP	523.00	
ii)	PTP	80.00	
iii)	NFL	40.00	
iv)	GWS	70.00	
v)	Addn. Losses	25.00	
	TOTAL	**738.00**	738.00
5.	**REFINERY CHANNEL**	**30.00**	30.00
6.	**FOR MINIMUM FLOW ON YAMUNA BELOW WAZIRABAD**	**240.00**	240.00
7.	**OFF TAKES OF PARALLAL DELHI BRANCH**		
i)	Bhaniswal Dy.	**97.00**	97.00
	TOTAL (1 - 7)		**3414.23 Say 3415 cusecs**

Annex. 3.4

ROTATIONAL PROGRAMME FOR RUNNING OF CHANNEL OF WJC SYSTEM DURING KHARIF 2001 W.E.F. 3.5.2001 TO 25.10.2001

BHALAUT GROUP

S.NO.	NAME OF CHANELS	A.F.S. (Discharge in cusecs	Total
1.	**OFF TAKES OF PARALLEL DELHI BRANCH**		
i)	Israna Dy.	171.00	
ii)	Narsina Dy.	42.00	
iii)	Hulana Dy.	64.00	
iv)	Sinalkha Dy.	52.00	
v)	Ganaur Dy.	22.00	
vi)	Rajpura Dy.	135.28	
vii)	Debeta Dy.	12.00	
viii)	Sardana Dy.	35.00	
ix)	Bajana Dy.	6.00	
	Total	539.53	539.53
2.	**DIRECT OFF TAKES OF BHALAUT SUB BRANCH**		
i)	Lath Minor	10.00	
ii)	Rohtak Dy.	11.55	
iii)	Rithal Dy.	17.50	
iv)	Jasrana Minor	89.00	
v)	Dhamar Minor	4.00	
vi)	Makrauli Minor	24.50	
vii)	Bohar Dy.	30.00	
viii)	Bhaulaut Dy.	76.58	
ix)	New Kaioi Minor	10.00	
x)	Pahrawar Minor	6.47	
xi)	Khari Sadh Minor	4.60	
xii)	Dulherea Dy.	382.00	
xiii)	J.S.B. excluding Partuwas, S.L.C. Bakra Minor, Machrauli Dy. Chuchakwass Mr. & Marot Minor	420.45	
xiv)	W.W.T.	43.15	
	Total	1230.80	1233.80

3. DIRECT OFF TAKES OF DELHI BRANCH

i)	Harsana Dy.	27.40	
ii)	Kalaor Dy.	3.15	
iii)	Ladhpur Dy.	3.42	
iv)	Pai Dy.	188.95	
v)	Munshi Ram Minor	4.20	
vi)	Bindhrauli Dy.	3.98	
vii)	Sonepat Dy.	22.60	
viii)	Bayanpur Minor	4.00	
ix)	Dua Dy.	110.30	
x)	Mohamdabad Minor	3.36	
	Total	371.44	371.44

4. DIRECT OUT LET ON

i)	Bhalaut Sub Minor	26.69	
ii)	Delhi Br. / Delhi Sub Br.	39.00	
	Total	65.59	65.59

5. ABSORPTION LOSSES

i)	Bhalaut Sub Branch	22.71	22.71

6. ADDN. REQUIREMENT FOR

i)	HTP	523.00	
ii)	PTP	80.00	
iii)	NFL	40.00	
iv)	GWS	70.00	
v)	Addn. Losses	25.00	
	TOTAL	738.00	738.00

7. REFINERY CHANNEL

	30.00	30.00

8. FOR MINIMUM FLOW ON YAMUNA BELOW WAZIR BAD

	240.00	240.00

TOTAL REQUIREMENT OF BHALAUT GROUP

539.53+1230.80+371.44+65.69+22.71+738.00+30.00+240.00= 3238.17
SAY : 3238.00 cusecs

Annex. 3.5

ROTATIONAL PROGRAMME FOR RUNNING OF CHANNEL OF WJC SYSTEM DURING KHARIF 2001 W.E.F. 3.5.2001 TO 25.10.2001

SUNDER GROUP

S.NO.	NAME OF CHANELS	A.F.S. (Discharge in cusecs)	Total
1.	DIRECT OFF TAKES OF BUTANA BRANCH		
i)	Gangesar Distv.	29.70	
Ii)	Butana Disty.	154.00	
	TOTAL	183.70	183.70

2.	OFF TAKES OF SUNDER SUB BRANCH		
i)	Ludana Minor	24.10	
ii)	Qilla-Z-garh	31.50	
iii)	Karsola Disty.	75.50	
iv)	Brarkhera Minor	20.50	
v)	Jamani Khera Minor	23.25	
vi)	Khani Kheri Minor	7.60	
vii)	Bhaklana Minor	12.70	
viii)	M.S.L.	17.00	
ix)	Jui Feeder	450+100= 550.00 (As per C.W. No. 1210 dated 12.1.2001)	
x)	Mithathai Feeder	284.00	
xi)	D/S 121 S.S.B.	564.00	
	TOTAL	1610.35	1610.35

3.	DIRECT OUTLET ON		
i)	Hansi Branch RD 0-60	1.40	
ii)	Butane Br. RD 0-83	51.53	
iii)	Sunder Sub Branch RD 0-121	63.00	
iv)	Delhi Branch / Delhi Sub Br.	39.00	
	TOTAL	154.93	154.93

4.	**LOSSES ABSORUPTION FOR**		
i)	Hansi Branch RD 0-60	20.00	
ii)	Burana Br. RD 0-83	27.86	
iii)	Sunder Sub Branch RD 0-121 & Additional losses and outlets of Butana Br. 83 to tail	54.16 + 42.65	
	TOTAL	144.65	144.65

5.	**ADDITIONAL REQUIREMENT**		
i)	HTP	523.00	
ii)	PTP	80.00	
iii)	NFL	40.00	
iv)	GWS	70.00	
v)	Addn. Losses	25.00	
	TOTAL	738.00	738.00

6.	**KAHNAUR DY.**		
		354.00	354.00

7.	**REFINERY CANAL**		
		30.00	30.00

8.	**FOR MINIMUM FLOW ON YAMUNA BELOW WAZIRABAD**		
		240.00	240.00

TOTAL REQUIREMENT OF SUNDER GROUP

183.70+1610.35+154.93+144.65+738.00+354.00+30.00+240.00= 3455.63

SAY : 3546.00 cusecs