



GOVERNMENT OF MAHARASHTRA

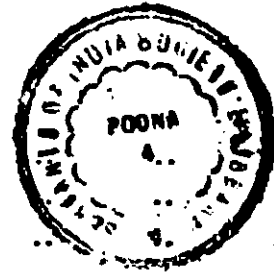
A NOTE ON PREPARATION OF LIFT IRRIGATION SCHEMES

IRRIGATION AND POWER DEPARTMENT

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LIFT IRRIGATION SCHEMES.**

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A NOTE ON PREPARATION OF LIFT IRRIGATION SCHEMES

1.00. INTRODUCTORY

1.01. Preparation of plans and estimates for a lift irrigation scheme involves a few engineering principles. If these are properly understood and appreciated it would not be difficult even for an Overseer to prepare these.

1.02. According to the recent Government orders, lift irrigation schemes costing less than Rs. 5 lakhs are to be undertaken by the Zilla Parishads. These are supposed to be understaffed and therefore as much guidance to the lower technical staff as is required may not be available. This note will help them in preparing the schemes as well as help others entrusted with the scrutiny and power of technical sanction.

1.03. It is to be clearly understood that this note is for general guidance and would be applicable to a large majority of cases. There could however be cases which will not conform to the general pattern and these will need special consideration.

2.00. AVAILABILITY OF WATER

2.01. The first and the most important consideration is to ensure that the source of water is reliable and can be depended upon. The source is usually a river or a big nala. Small nalas cannot be depended upon unless there are storages above and release of water from them is agreed to by the authorities concerned, or there is a guaranteed regeneration flow from irrigation in the catchment of the nala. There are various agencies which carry out gauging of important streams and data about water flowing in them at different times of the year would be available. Where such data is not available, it would be worthwhile carrying out the gauging to ascertain the availability. Enquiry with local people if made judiciously would also help to form an estimate. This however has to be very carefully made as their information is many times influenced by self-interest.

2.02. For gauging a stream a straight channelised portion should be selected. The gauge run should be marked by pegs on either side. Cross-sections at the ends and one in the centre of this gauge length should be obtained by levelling. The average of these sections will give the area 'A'. Velocity should be measured with conical shaped wooden floats and stop watch. The float should be run from end to end and the time taken to travel measured by stop watch. The observations should be taken in three compartments of the channel, two near the bank and one in the middle. Three observations in each compartment would suffice. The average of these nine observations gives the surface velocity 'V'. The discharge is given by—

$$Q=0.7 AV$$

For small discharges a triangular notch can be used.

2.03. If the scheme is to cater for perennial crops, obviously the lowest discharge in the stream in a year will determine the acreage of perennial crop. Where the source is not perennial the scheme will have to be restricted to two seasonal crops only. Such schemes would rarely be economical unless two crops are taken every year in every acre. As the Kharif crop is usually harvested by the end of October the follow on crop can be sowed by the end of November. It would therefore mature by the end of March next year and would require its last watering in February. The Rabi area would therefore have to be restricted to the discharge available at the end of February.

2.04. It is many times argued that although there is no flow of water there is a big "doha" having unlimited supply of water. This argument is usually deceptive. Even a big doha say a mile long 100 ft. wide and average eight feet deep holds 4 M.ftc. of water which can irrigate only 14 acres of sugarcane during Rabi and Hot Weather or 91 acres of Bhusar crop not taking into account the evaporation losses. It is therefore always necessary to roughly estimate the quantity stored in a doha. It should also be understood that in order to utilise the entire contents of the doha, it would be necessary to lay a pipe line reaching to the lowest point of the doha which would be near the centre of the stream. Such an operation of laying the pipe line would be difficult. A doha cannot therefore be depended upon unless there are good underground springs which would replenish it after depleting the same is started.

2.05. While determining the availability of water it is important to take into account the existing commitments and established irrigation by flow or by lift both upstream and downstream of the site. Under no circumstances should a scheme be planned which would adversely affect an existing irrigation or water supply scheme.

2.06. After it is ascertained that the supply of water is assured permission from the competent authority to utilise the water for lift irrigation should be obtained. This authority in respect of notified streams is the Executive Engineer in charge of irrigation management in whose jurisdiction the source falls and in respect of non-notified streams the Collector of the district. As there are usually restrictions on types of crops to be grown the permission should be asked for specifying the crops contemplated to be grown under the scheme.

3.00. SELECTION OF SITE

3.01. An examination of topo-sheets (with contours) gives indication of suitable sites for lift irrigation schemes. Such sites are where the tip of a contour loop comes close to the river (see figure below). In such cases the length of rising main is short and irrigation channels can be taken on both sides along the contour loop.

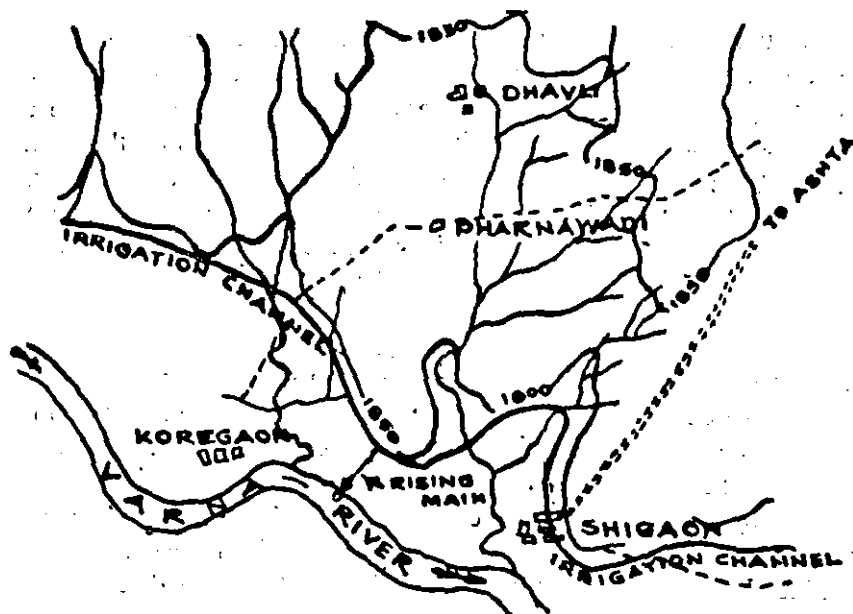


FIG 1

3.02. The post-monsoon flow in Deccan rivers usually hugs to one bank. The site for pumping plant has therefore to be located where the water flows along the bank. If the water is at the opposite bank, it will necessitate laying pipe line in the river bed which would not only be expensive but may also give trouble. The site for the well should be such as will necessitate a short inlet pipe and be above the high flood level. It is not always possible to satisfy the latter requirement and in such cases the dry well or the jekwell should project above the ground level its top being above the high flood level.

3.03. For a permanent scheme, it is not advisable to provide mobile pumping units which are moved as the water rises or recedes and are fixed on foundation blocks constructed at different levels. Locating pumping units in a dry or jackwell is a much more satisfactory arrangement.

3.04. The location should be such that the length of rising main is the shortest. The alignment of the rising main should also not traverse any depressions or high mounds. These will cause either excessive cutting due to the need of lowering of pipe line below the depressions or require provision of bends in the rising main which is not desirable.

3.05. The site should be either in the centre of the command or at the upstream end. From a central position channels can be taken on either side so that the length of each is small and irrigation can be better managed. If the site is situated towards the downstream end of the command it would be unnatural

run the channel contrary to the direction of the flow of the river as the command area would normally be rising from the downstream end towards the upstream. This is however a general observation and each site may have its own peculiarities.

4.00. FIELD WORK AND SURVEY

4.01. No field work should as a rule be started unless the site is inspected by the Executive Engineer, A thorough visual inspection is necessary to fix the sites for inlet, jackwell and the delivery chamber and to determine the extent of the command. These should be determined with such finality that only minor adjustments should be necessary after the detailed survey. It has been the experience that much effort is likely to be wasted if the site is not so inspected and subordinates are not properly and sufficiently instructed. They should be told exactly what surveys are to be carried out and the area to be covered. The S. D. O. should pay a visit atleast once while the survey is in progress. This helps in solving the difficulties if any of the survey parties and also in detecting and correcting the mistakes. In these days when the subordinate staff is inexperienced it is of vital importance that both the Executive Engineer and S.D.O. pay proper attention and in proper time rather than blaming the mistakes and omissions on the inexperience of the staff.

4.02. The first *sine qua non* before the survey work is started is to obtain copies of village map or maps in which the area is situated. Eventhough only part of a village area is to be brought under irrigation the entire village map should be obtained or copied. Where more than one village is covered by the scheme a combined tracing should be prepared.

4.03. After the sites for inlet jackwell and delivery chamber are tentatively fixed the survey work should be taken in hand. It is always a good idea to have the entire area contour surveyed. It not only determines the area under command accurately but also helps in choosing an economical lift. It is also useful in planning and constructing field channels. The survey does not take much time or effort and the short cut of designing the scheme by visual inspection is not advisable except in very flat areas where contours do not have much meaning.

4.04. For contour survey the usual procedure of fixing a base line and taking levels at equal intervals on lines at right angles to it is to be followed. Sometimes the expedient of taking levels at corners of survey numbers is adopted. This is not always possible as it is not easy to know the corners with accuracy. Villagers are not able to show them and the Talathi cannot be expected to be available all the time during the survey. Usually one base line would suffice but where the shape or size of the command warrants it two or more base lines can be adopted. In moderately flat country levels should be taken at interval of 80 metres (262 ft.). Where the slopes are steeper the grid should be of 40 metres (131 ft.) in very steeply sloping ground or at local depressions or maunds levels may be necessary at closer interval say 8 metres. The contour interval should normally be one metre but may be increased to two metres in flat areas and reduced to 0.5 metre in very steep areas.

4.05. One very important thing which is not unfortunately sufficiently appreciated and followed is that the base lines must be fixed with reference to survey boundaries. The surveys carried out are to be plotted on village maps. The plotting is many times done by bearings and goes wrong in almost cent per cent cases. The bearings taken in the field are rarely correct and the north line on the village maps also is many times inaccurate. Particularly in these days when overhead electric lines cross the commanded area the bearing cannot be very much depended upon. Fixing the base line with reference to survey bands therefore is the only sure method. The points of intersection of the base line with survey bands should be located by measurements from survey corners. This should be done for the starting and end point of the base line and for a few intermediate points. This does not, however, mean that bearings are to be done away with. They are to be taken in the field and should serve as a check.

4.06. Plotting of the survey work should be done immediately the survey work is completed preferably in the camp of the survey party if possible. Mistakes are revealed only after the levels are plotted and contours interpolated. If this work is done immediately while the memory is still fresh they can be rectified. If the contours reveal any peculiar feature, it can be verified on site. If the work of plotting is delayed and done in the office long after the survey is completed, there is reluctance to go back to site to rectify mistakes detected and the tendency is to manipulate and "cook up" figures rather than verify and correct the levels on site.

4.07. After contouring is completed the sites chosen for the jackwell and delivery chamber should be checked, adjusted if necessary and confirmed. After this the L-section for the inlet pipe and rising main should be surveyed. This should be done judiciously taking levels at all points of change of ground slope and not necessarily at fixed intervals. They should depict a correct profile of the ground surveyed. The levels should invariably extend beyond the edge of water at least about eight metres (25 ft.). The plan of this profile which would usually be a straight line should also be drawn giving location according to the procedure prescribed for fixing the base line for contouring.

4.08. The lowest water level and the highest flood level must be marked accurately on the L-section. Unfortunately the only way of doing this is by local inquiry. The inquiry should therefore be done with searching cross questioning and corroborated by questioning different individuals independently. In many cases H.F.L. can be found recorded on a nearby structure like a bridge. The ordinary flood level should also be marked where it varies much from the maximum H. F. L.

4.09. A village map is available to a scale of $1'' = 660'$ or $1'' = 330'$. Having changed over to metric system the survey instruments are now supplied in metric system only. Plotting of survey work done with metric measurements on village maps, however, does not present any problem. It is not necessary to convert all the metric measurements into feet. The scale of the village maps may be taken as 1 : 8000 ($1'' = 660'$) or 1 : 4000 ($1'' = 330'$) and plotting done with a metric scale i.e. by adopting 1 cm. = 80 metres or 40 metres as the case may be. The inaccuracy involved in this is negligible and in any case the accuracy of plotting is never greater.

4.10. The centres of the inlet chamber, the well and delivery chamber should be marked with long headers (at least 750 m.m. long) buried flush into ground. If the stones are not kept projecting above ground, there is less danger of their being removed. Where there is danger of these stones being removed small but deep pits may be excavated at these points. As the centre of inlet chamber would be usually in water the marking stone or pit should be located a little away clearly indicating its chainage. Where the rising main has kinks all such points should be similarly demarcated. These markings are extremely useful for all future reference and should be clearly shown both in the field book and on drawings.

5.00. CROPPING PATTERN AND REQUIREMENT OF WATER

5.01. The cropping pattern will depend upon the agro-climatic conditions of the area and the nature of the source of water. Perennial crops are possible only if the source is perennial. Otherwise the scheme has to be designed for two seasonal irrigation only. According to the agro-climatic conditions the Maharashtra State is divided into eight zones (see map drawing No. 1). Table 1 gives the general existing cropping pattern of these zones.

5.02. The cropping pattern has necessarily to change after irrigation is provided. However it must not be radically different from the pattern to which the farmers have been used to for generations; particularly the pattern in Kharif must not change much as the crops do not entirely depend upon irrigation and there would generally be reluctance on the part of the cultivators to adopt a radically different pattern. For example where groundnut or cotton are established Kharif crops, they should not be tiredly done away with under the plea of "grow more food". Schemes have known to have failed when such cash crops were prohibited. Paddy should not normally be recommended in area where rainfall is less than 75 c.m. (30 in.) Wayanagan paddy can be grown only in coastal regions where the weather in summer is humid and temperatures are not excessively high.

5.03. The percentage of sugarcane is at present restricted to 20 for co-operative schemes by Government orders. The same percentage should be adopted for Government run schemes also. Where other perennials such as fruit gardens are established in the area, they should also find a place in the cropping pattern by suitably reducing the area under sugarcane. For optimum benefit from irrigation, it is essential to take at least two crops from every acre under command except the land under perennials. When two cereal crops are taken successively in two seasons in the same piece of land, it is necessary to take a crop of green manure in between to maintain fertility level. On the basis of 20 per cent sugarcane therefore the pattern should be 20 per cent sugarcane, 70 per cent Kharif seasonals and 70 per cent Rabi seasonals, 10 per cent area being left out for overlap. The cropping pattern should be decided taking all the above factors into account and be finalised in consultation with the Agricultural Department authorities in the district.

5.04. After the cropping pattern for the whole year is fixed the discharge required in each of the three seasons should be calculated. This is done by dividing the area under various crops by the duty and adding up these discharges. A lift scheme should be designed on the basis of pumping for 16 hours a day. This is done for the following reasons :—

- (i) Irrigators are generally averse to work for longer hours particularly at night.
- (ii) As no standby is provided the pumping units can be given rest only by working for less than 24 hours a day.
- (iii) In case of break down of a unit remaining units can be worked longer so that loss of irrigation is minimised.
- (iv) This allows for future expansion without increasing the pumping capacity by increasing the numbers of pumping hours to say 18 or 20.
- (v) Any shortfall in pumping capacity due to non-realizations of assumptions made in calculations can be made good by increasing the hours of pumping.

5.05. The duty is calculated by working out the area irrigated per day cusec (day of 16 hours) and multiplying it by the interval between two waterings. The inch depth per watering, the number of waterings per season, the interval between waterings and the duties based on 16 hours pumping for various crops are given in Table II. The inch depth required and the interval of irrigation will depend upon the rainfall and climatic conditions and will vary from place to place. The information given in the table is however intended for design purposes and for calculating the water rates.

In monsoon, part of watering is done by rain and therefore the number of waterings is less than those obtained by dividing the season period by the interval of watering. In zones 1, 2, 3 and 8 no irrigation is required in monsoon in a normal year. In working out this table, the following seasons are assumed :—

Kharif	..	..	..	90 days July to September.
Rabi	..	..	..	150 days October to February.
Hot weather	..	..	..	120 days March to June.

5.06. Generally a lift irrigation scheme has a small and compact command area. The losses of water due to canal seepage therefore are small. The inch depth given in table II is including the losses. If pipe line is provided for distribution of water in the field, the inch depth may be reduced by 10 per cent. i.e. the duties increased by 10 per cent.

5.07. In calculating the discharge the overlap of sugarcane area has to be taken into account. This overlap is due to the lag between planting of new cane and cutting of old matured cane. The overlap area may be assumed as 50 per cent. in Rabi season for "suru" cane. Where adsali cane is planted an overlap of 50 per cent. both in Kharif and Rabi seasons should be assumed.

6.00. CHOICE OF DESIGN

6.01. As already stated the arrangement of shifting pumping units to foundations to different levels as the water level rises or falls is not recommended except for purely temporary schemes or for very small schemes. The arrangement is cumbersome, and if the management is not alert and active much damage could be caused by accidental submergence of the motors or engines. In the case of electric drive, the power line may also have to be removed if it gets submerged which is not easy and the local persons managing the scheme may not be able to handle it.

6.02. For permanent schemes therefore a well should invariably be provided for locating the pumping units. The wells are of two types :—

- (i) Dry well.
- (ii) Wet well or jackwell.

6.03. A dry well is a well constructed on the bank of the river which protects the pumping units from flood water. It is recommended for small schemes upto a discharge of five cusecs and on rivers or streams for which the flood lift is not excessive. Only centrifugal pumps can be used in a dry well and with only electric drive. Diesel engines cannot be used as the exhaust would be a problem.

The dry well has the disadvantage that if it is not made waterproof, water may leak in and damage the motors. A small dewatering pump can be fitted to keep the well dry during floods. The well has to be situated at a distance of not more than 100' from the edge of lowest water as longer suction pipes are not desirable.

6.04. Where time for construction of a scheme is roughly the same as the time for delivery of turbine pumps, one should invariably go in for a jackwell.

6.05. A jackwell is the best arrangement and is recommended for all schemes except where choice is guided by urgency and centrifugal pumps can be procured more easily than turbine pumps. It can be located on a high ground with a suitable length of inlet pipe.

6.06. All these arrangements are shown on drawing Nos. 3 and 4.

7.00. INTAKE CHAMBER AND INLET PIPE

7.01. It is always advisable to provide an intake chamber as it has several advantages. In any case, a head wall would be necessary to fix the river end of the inlet pipe and the difference in cost between a head wall and a chamber would not be much. As entry of water to the inlet chamber is provided towards the d/s, it prevents the silt and floating matter to enter the chamber. A grating is also provided which further helps in keeping out undesirable matter. If grating is to be provided at the end of the pipe (doing away with inlet chamber) flaring would be necessary to maintain the same area. A silt pocket is also provided at the bottom of the chamber. With all these arrangements only fine silt would enter the jackwell which would ordinarily be pumped out.

7.02. If a dry well is provided no inlet pipe is necessary and the suction pipe itself is taken from the pumps to the river. In this case also it is advisable to provide an inlet chamber as it prevents clogging of the foot valve which would otherwise happen if it is left unprotected in the river.

7.03. A design for intake chamber is shown in drawing number 2. In designing this, it is assumed that the depth of water in small rivers and streams at the lowest level is 1'-6". For most of the sites, this would be the case. Where larger depth is available, the size of the chamber can be reduced.

7.04. The intake chamber has to be taken down to hard strata which would not scour away. Good hard murum or compact conglomerated sand layer would meet the requirement. In such strata foundations should be taken down two feet. Where such a strata is not met with and the river bed consists of sand for a large depth, the foundations must be taken two feet below the scoring depth. The scoring depth D measured down from the H.F.L is given by the formula—

$$D = 0.5 Q^{\frac{1}{3}}$$

where Q is the discharge during highest flood. For finding out Q the cross-section of the river upto H.F.L. and the river bed slope should be found out by survey. Then—

$$Q = AV$$

$$\text{and } V = 90 \sqrt{rs}$$

7.05. The diameter of an inlet pipe should not be less than 450 m.m. (18"). Smaller pipes may get choked up and in worst cases may require removal and relaying of the entire pipe line. The diameter and the slope of the pipe are given in table III. These depend upon the available driving head at the river end above the top of pipe and the table gives values for a driving head of 75, 150, 225 m.m. (3, 6 and 9 inches). From table IV diameter of suction pipe for centrifugal pumps can be found out.

7.06. The non-pressure spun concrete pipes (A or NP-2 class) can be used for an overburden upto 3m. (10 ft). They are not however recommended for inlet pipes as they do not stand well in handling. As the cost of excavation of trench for laying the pipe forms a considerable part of the total cost of inlet, the use of slightly costlier pipe is justified. The special extra thick pipe (pipe having more reinforcement and larger shell thickness) is therefore recommended for inlet where overburden exceeding 10 ft.

7.07. It is not necessary to provide concrete below or round the joints. It is sufficient to ensure that the pipes rest on their entire length and the soil is properly compacted on sides. Where the pipe is laid in rock cutting a good murum bedding 150 m.m. (6") thick should be provided and the side filling properly compacted with special care.

8.00. THE WELL AND THE PUMP HOUSE

8.01. As already remarked, it is considered advisable to locate the pumping units in a well to protect them from flood. Two types of wells have already been indicated. The two typical layouts are shown in drawing numbers 3 and 4. On these drawings, the diameter of the well for the number of pumping units and the horse power are given. The steining thickness have also been indicated.

8.02. The well should be located as close to the water as possible. Although it would be an advantage to locate it on high ground above the H. F. L. This is rarely possible without increasing the inlet length and consequently the cost. It may therefore be cheaper to locate it near low water even if a good portion of its height remains above the ground level. In such a case, access should be provided by a simple but rigid step ladder and no elaborate arrangements are necessary. The well is not required to be approached during floods as no irrigation would then be necessary. High floods also do not last for more than a few hours.

8.03. The thickness of the well steining below G. L. is governed by the earth pressure and the super-imposed load. The values given on drawing numbers 3 and 4 are based on the coefficient of earth pressure at rest assumed as 0.6, the weight of earth 1915 Kg./cu.m. (120 lbs/cft.) and compressive strength of masonry as 6.8 Kg./sq. c.m. (6 tons/sft.). The super-imposed load that can be allowed has also been indicated. This load consists of the pumps, motors, valves, other accessories, live load and load of pump house. In order that this load be evenly distributed over the entire steining, an R. C. C. ring 300 m.m. (12") thick should be provided on top of steining masonry. The thickness of the steining above G. L. will be controlled by requirements of stability.

8.04. The well should be founded on a hard strata with a bearing capacity of not less than 4.3 Kg/cm² (4 tons./sft.). In rare cases where such a strata is not met with an R. C. C. raft may be provided at the bottom. Even when the well is taken down in rock it is desirable to provide masonry lining. It would be necessary to get down to the bottom for maintenance and desilting operations and this would be hazardous if uneven rock is left in the sides. The bottom of the well for turbine pumps should be kept 3.5 metres, (11.5 ft.) below the lowest water level in the well to accommodate the bowl assembly, suction pipe and strainer and allow for a silt pocket. For centrifugal pumps this may be only 1.8 metres (6 ft.).

8.05. Steps of M. S. bar 20 m.m. (3/4") diameter bent in the form of U-embedded in masonry should be provided for getting down the well. The details are given on the drawings. Two M. S. girders should also be provided at mid height between L. W. L. and floor level. These will enable erection of a platform during erection and maintenance of machinery. A dry well should be provided with plaster both inside and outside to make it water tight. A mortar made of 1 part of cement, 2 parts of slaked lime and 8 parts of fine sand is recommended. In addition the well may be painted with bitumen from outside.

8.06. ^{Blade} The pump house is most conveniently located on top of the well. In the case of the jackwell, this will house the vertical motors of the turbine pumps, the starters and the switchboard. (With dry well it will house only the starters and switchboards, the motors being located at a lower level.)

8.07. A square shape of the pump house would be more convenient than a circular shape. It gives more room for locating starters etc. In the case of dry well, however, much space is not required as motors are not located at the same level and it would be more convenient to continue the steining masonry i.e. adopt the circular shape. The square shape can be obtained by providing girders over the top of steining and cantilevering them out suitably. The details of the arrangement are shown on drawing number 5. The walling should consist of corrugated G. I. or asbestos cement sheets fixed to angle iron frame as that would be lighter. The roof should also consist of G. I. or asbestos sheets. Where round shape is adopted it may be more convenient to provide an R. C. C. slab for the roof. This should be given a slope of not less than 1 in 30 on one side as it helps drainage of rain water and prevent leakages.

8.08. The pump house floor should be made of teak wood planks as they would be cheaper than chequered plate and also minimise possibility of electric shock due to any accidental leakage of current. The planks should preferably be fixed to girders with bolts or clamps than laid loose. They should be protected by proper painting on all sides. A lightning conductor should invariably be provided on top of the pump house where it projects for more than 20' above the ground.

9.00 HORSE POWER AND NUMBER OF UNITS

9.01. The horse power is calculated by the following formula—

$$\text{H.P.} = \frac{5 QH}{44 e}$$

where Q = discharge in usecs

H = total head from all causes in ft.

e = efficiency expressed as a fraction

The following efficiencies may be assumed :—

B.P.I.T.	Vertical turbine pumps	.....	..	0.8
	Directly coupled centrifugal pumps	.....	..	0.7
	Belt driven pumps	.....	..	0.6

The following formulae are also useful—

$$\text{K.V.} = 0.746 \text{ HP}$$

$$\text{K.V.A.} = \frac{\text{K.W.}}{\text{power factor}}$$

$$= \frac{0.746 \text{ HP}}{0.85} = 0.88 \text{ HP}$$

9.02. The total head comprises of static head (i.e. the difference between the full supply level in the delivery chamber and the lowest water level in the river) plus the losses on account of various causes. These losses are enumerated below :—

(i) Frictional loss in suction and delivery pipes. A nomogram published by the Indian Hume Pipe Co. based on the Scobey's formula is enclosed (drawing number 6) from which the loss can be found for concrete pipes for a given discharge and diameter of pipe. For galvanised or black steel pipes used as suction or delivery table TV gives the values of frictional loss.

(ii) Loss of head in foot valve of centrifugal pumps.

(iii) Loss of head in bends.

(iv) Loss of head in sluice and reflux valves.

(v) Loss of head in reducers and expansion pieces.

The loss of head in foot valves and reflux valves may be taken as equivalent of loss of head in a 44 ft. length of pipe of the same diameter. A nomogram (drawing number 7) is enclosed giving the losses for other fittings and valves.

9.03. Usually for a lift irrigation scheme unless the area is large (say more than 3,000 acres) it is not possible from economic considerations to provide a standby. This can however be partially provided by breaking up the required horse power into a number of units. If one of the units breaks down the others can be worked for longer time thus restoring the loss at least partially. Thus a minimum of two units must invariably be provided. The following number of units are recommended :—

Upto 300 H.P.	..	..	..	2 numbers.
300 to 500 H.P.	..	..	..	3 numbers.
Above 500 H.P.	..	..	..	4 numbers.

9.04. The manufacturers usually provide tables giving the type of pump and horse power required for a given discharge and total head. These should be consulted for selection of pumping units.

10.00. PUMP LAYOUTS AND CONNECTIONS

10.01. In a dry well, pumps and motors are installed on concrete foundations at the bottom of the well. They should be kept at least about 1.2 metres (4 ft.) above the bottom so that seepage water if any can collect for some time before it is pumped out. Usually installation of more than two units in a dry well is not advised as the cost of suction pipes would be large. In a jackwell they are installed on grinders embedded in well steining at suitable level.

10.02. The layouts for pumps and motors for dry and jackwells are shown on drawing numbers 3 and 4.

10.03. The manufacturers advise that best results are obtained when the static suction head is limited to 10 ft. Wherever possible this should be done. It may not however in some cases be possible to do so but in no case, should the static suction head exceed 15 ft. and the total suction head 26 ft.

10.04. The delivery pipes of the pumps are to be connected to the rising main in such a manner that the flow is smooth and dismantling of connections for maintenance and repairs is easy. With centrifugal pumps they are connected through a Y piece. With more than two units a multiple Y piece would be necessary. The Y pieces can be of cast iron but it would be much more easy and expeditious to fabricate them in m.s. plate by welding.

10.05. With turbine pumps these connections can be made in two ways. In one method the delivery pipes are taken out of the jackwell and connected by Y piece to the rising main. In the second method the rising main itself is taken into the jackwell and the delivery pipes of the pumps directly connected to it. The latter is a more neat layout and the losses are also a minimum as bends and Y pieces are avoided. It may however be more costly. The valves are required to be located within the well and hence a larger diameter may be required. For turbine pumps the delivery pipe can be taken out at any level. It is therefore convenient to take it out at the level of the rising main so that bends are avoided. All the pipes and valves are thus located below the floor level and the floor remains neat and clear of all obstructions.

10.06. On each pump a sluice and reflux valve must be fitted. The latter prevents emptying of the rising main and the sluice valve permit regulation of the discharge. The various types of connections described are shown on drawing numbers 3 and 4.

11.00. THE RISING MAIN

11.01. Drawing number 6 gives the data required for calculating the diameter of a rising main for the given discharge. The frictional loss should be normally restricted to 3 ft. per 1,000 ft. On this basis table V is worked out giving the diameter for a given discharge. The type of pipe will depend upon the pressure or the head it has to withstand. The head at any point is calculated by plotting the hydraulic gradient between the starting and the end point of the rising main and measuring the ordinate at the required point. As the head reduces a lower class of pipe should be progressively used. Table VI gives the class of pipe to be used for different pressures.

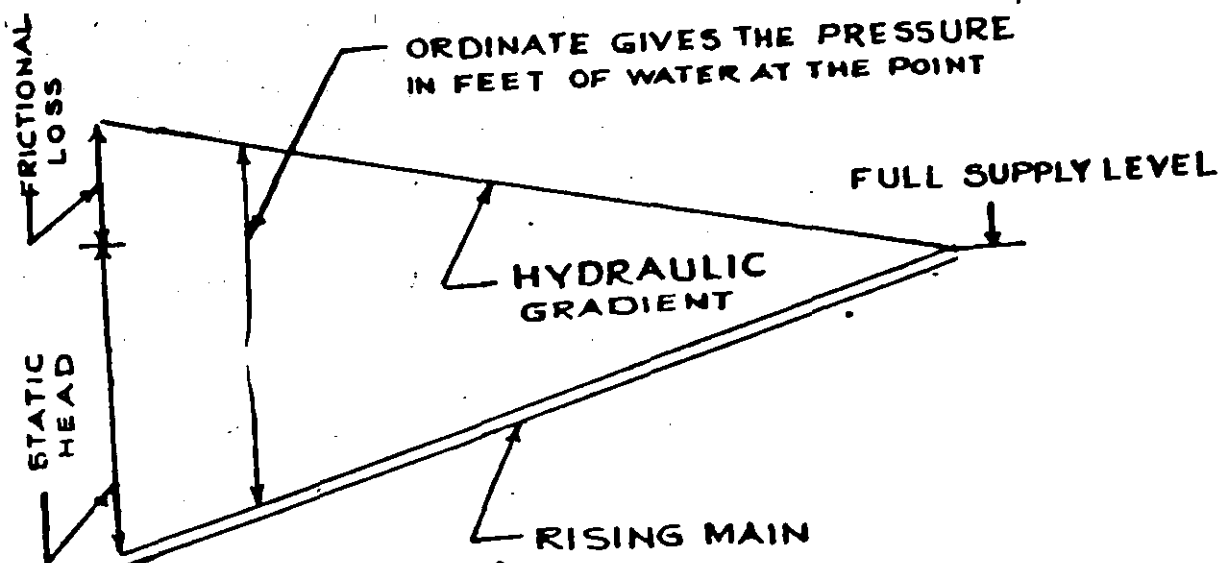


Fig. 2

Table VII gives the cost of pipe line i.e. cost of pipe and transport and cost of laying and jointing but excluding cost of excavating the trench. The cost of transport is broken up into two parts, one is the fixed charge which includes loading and unloading and transport over katcha road which is always involved in a lift irrigation scheme and the other is variable depending upon lead and is given as the cost of transport per ft. of pipe per mile. The actual cost of transport should be obtained by multiplying by the number of miles over which the pipes are required to be carted and adding the fixed charges. The cost of excavation of trenches should be separately estimated.

11.02. As only concrete spun pipes or steel pipes coated with concrete are recommended to be used for rising main, as they are always full of water and as they are buried underground there is no need for an expansion joint. No sluice valve is also necessary on rising main as sluice and reflux valves are provided on individual delivery pipes of pumps before they are connected to the rising main. As far as possible the rising main should be a continuously rising straight line. Where however ground profile does not permit of this, bends would be necessary in the vertical plane at change of gradients. These bends should be of mild steel plate coated with concrete if possible, otherwise heavily painted with anticorrosive bituminous paint. The bends should have plain ends connected to concrete pipes at each end by collar joints in the ordinary way. A concrete block should be placed over the bend to take the thrust due to change of direction of flowing water. At summit points air valves should be provided.

At the pump end the last pipe should be of concrete coated steel (hume steel) with flanged end. To this flange, can be bolted either the Y-piece, the taper piece or the steel pipe coming from the jackwell according to pump layout and connections (see para. 10). On this pipe can also be fixed the pressure release valve. A thrust block of concrete should also be provided at this end to protect the pumps from water hammer. At the delivery end the pipe should be simply embedded in the wall of the delivery chamber and left open.

11.03. The rising main should be buried in ground with a cover of at least 600 m.m. (2) on top. A strip about 3.5 metres (11'-6") wide over the rising main should be left uncultivated so that it can be approached for repairs at all times. This strip can also serve as an approach road to the well and pump house.

11.04. In many cases the command is divided by a valley. Between the valley and the river is a ridge generally running parallel to the river. In such cases two off-take points on the rising main are necessary one at the intermediate ridge and the other at the end of the rising main. Such intermediate off-take may also be more advantageous when the command is large so that the entire discharge need not be lifted to the entire height. When the intermediate off-take is not far from the river the best arrangement is to provide an independent rising main. Providing a sluice valve at an intermediate point on the rising main is not a very efficient arrangement. When this valve is opened there is a fall in pressure and water does not reach the upper delivery point and therefore off-take at the two points cannot be simultaneous. This means that full discharge has to be run at both the points for a shorter period and larger irrigation channels are required at both ends. Moreover the pumps are required to function at two radically different heads and therefore the overall efficiency would be low. The range of heads over which the pumps can normally function satisfactorily are given by the manufacturers and if the heads at the end and intermediate off-take fall within this range the loss in efficiency may not be much; otherwise the pump would be working at low efficiencies and running costs would increase. However, when the intermediate off-take is away requiring a very long second rising main its cost may off-set the disadvantages and it may be cheaper to use only one rising main and provided a sluice valve at an intermediate point.

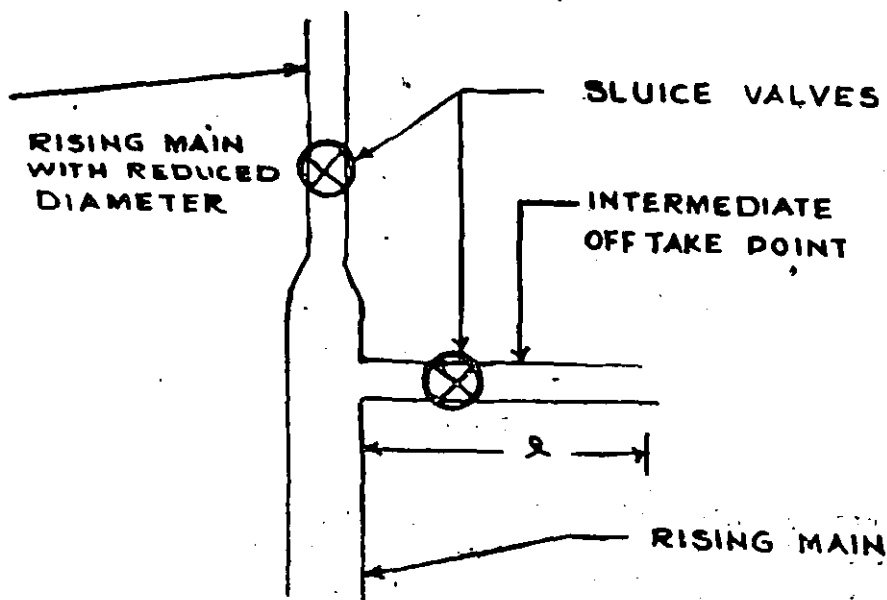


Fig 3

With such an arrangement (*see figure above*) it is not desirable that the intermediate off-take suddenly discharge into the atmosphere. Such a sudden discharge causes a release of pressure in the rising main with the result that water cannot travel further up the rising main. Instead the intermediate off-take should have a certain length of pipe "1" which is given by the formula—

$$\frac{V^2}{2g} = H_B - h_t - h_v - h_1$$

where

V = velocity at the off-take

$$= \frac{4Q}{\pi d^2} \quad (Q = \text{discharge and } d = \text{diameter of the off-take pipe})$$

H_B = Pressure head at the bifurcation point in the rising main

h_t = Loss of head due to change of direction at the off-take

h_v = Loss of head in the sluice valve on the off-take pipe

h_1 = Loss of head due to friction in the off-take pipe

Hence—

$$\frac{16Q^2}{\pi^2 d^4 2g} = H_B - h_t - h_v - 4fl \quad \frac{16Q^2}{\pi^2 d^5 2g}$$

$$\therefore l = \frac{(H_B - h_t - h_v) \pi^2 d^5 g}{32fQ^2} - \frac{d}{4f}$$

f may be taken equal to 0.01.

The length "1" should neither be too short nor too long. "d" should therefore be so chosen that a proper length "1" of the off-take is obtained.

12.00. DELIVERY CHAMBER

12.01. The rising main should end into a masonry delivery chamber. At all intermediate points also where valves are provided the exit of water should be into a masonry chamber so that the flow into the channel is gentle and with the required low velocity. From a delivery chamber channels would take off on one, two or three, sides depending upon the topography and lie of the command. The size of the chamber will also depend upon the size of the channels. Drawing numbers 8A, B & C give type designs for different cases.

12.02. As there is hardly any load on the foundations, they need be taken down to only a stable strata. Good murum or shadu mixed with kankar will serve the purpose. It should however never be founded on black soil. If soil is deep, an R. C. C. raft may be provided if it is cheaper than taking the foundations deeper.

13.00. DISTRIBUTION SYSTEM

13.01. The distribution system should be marked on the contour plan in detail down to field channels. The main channels are usually contour channels taking off from the delivery chamber in different directions. In some cases the chamber is located on a ridge in which case the main channel would be taken along the ridge. Both the contour or ridge channels can be marked from contours and no separate survey is necessary. Outlets for field channels should be located where the main channel crosses subsidiary ridges. Where falls are provided they are suitable positions for outlets.

13.02. Table XI gives sections to be adopted for irrigation channels for different discharges taking off from the delivery chamber. The best arrangement would be to locate the channel such that about one-third the depth is above ground and two-thirds below. The side slopes recommended are as 1:1 in cutting and 1 : 1½ in bank. This table is worked out on the basis of non-scouring velocity. In the case of a ridge channel, the ground slope may be steeper than the bed slope of channels. A number of falls would then be necessary to avoid the channel running into high banks.

13.03. Use of pipes for distribution system is not recommended unless it is unavoidable as it is very expensive the cost ranging from Rs. 160 to Rs. 430 per acre. This forms as much as 50 to 100 per cent of the cost of the remaining portion of a scheme. In very deep soils where maintenance of channels is difficult or in highly pervious soils where losses would be heavy, use of pipes may become necessary. Even then alternatives of lining the channels with brick or any other suitable material should be tried.

The best arrangement is to run a large pipe along the higher contour and run a system of smaller pipes running parallel to each other but across the contours. These should be 300 m. (1000 ft.) apart and should have sluice valves and chambers every 150 m. (500 ft.). In this way water is not required to travel on surface for more than 500 ft.

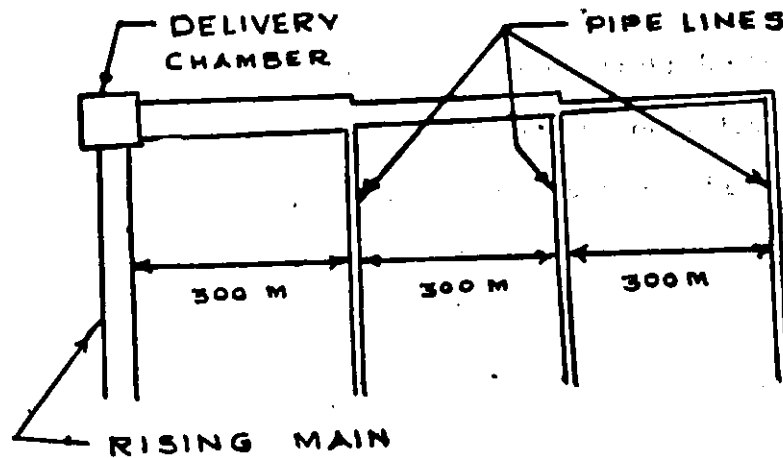


FIG. 4

14.00. PLANS AND ESTIMATES

14.01. There should be two stages in preparation of plans and estimates. The first stage should be an approximate estimate for administrative approval. The form of this estimate is given in Appendix II. The estimate should be accompanied by an index map and village map showing contours and positions of inlet chamber, jackwell, rising main and delivery chamber. The commanded area should also be distinctly shown. The estimate should be accompanied by a descriptive note fully explaining the various provisions. A form of such a note is also given in Appendix III. In this note the water availability should be fully discussed giving reference to gauge data if available. In this estimate each item of the work is provided on a lump sum basis. The data for pipe line is given in Table VII, for other features, the rough cost is shown on respective drawings and for pumps and motors and other accessories the following will be useful :—

	Horse power	Approximate cost of pumping machinery with all accessories in
Centrifugal pumps	Up to 15 H.P.	Rs. per H.P. 60
	16 to 60	500
	61 to 200	450
Turbine pumps	Up to 25	850
	26 to 50	700
	51 to 200	650
	above 200	600

The distribution system may be estimated at Rs. 50 per acre for earthen channels and between Rs. 160 and Rs. 430 for concrete pipes depending upon the area and shape of command.

14.02. After the estimate is submitted for administrative approval; the work of preparation of detailed plans and estimates should be taken in hand. This estimate should serve not only for technical sanction but also as a working estimate for construction. The estimate should be sub-divided into the following sub-estimates:—

- (i) Intake chamber
- (ii) inlet pipe
- (iii) Well and pump house
- (iv) Rising main
- (v) Delivery chamber
- (vi) Distribution system
- (vii) Land acquisition
- (viii) Pumping machinery and accessories.

For Intake chamber, adequate provision should be made for a ring bund and dewatering. For distribution system, only the main channels need be estimated in detail and for field channels, a provision of Rs. 8 per acre would be sufficient. If pipe line is to be provided for distribution system, the length of pipe varies between 40 and 90 ft. per acre the diameters varying according to discharge. The cost varies between Rs. 160 and Rs. 430 per acre at present-day prices. For land acquisition a strip of land 11 ft. wide over the rising main, a piece of land 110' × 99' for the well and 55' × 49' 5" for delivery chamber and a strip as required for main channels should be proposed. The extra land near the well is useful for locating transformer etc. and as storage space. A power line will be required from the transformer to the pump house. This may be estimated at Rs. 7 per metre. In the case of L. T. supply, a length of 300 metres is given free by the M.S.E.B. and only additional length need to be provided for. For transport and installation of machinery, a provision of 16 per cent of the cost of machinery would be adequate.

14.03. The following should be the drawings attached with every detailed estimate:—

- (i) Index map (scale 1 : 63360).
- (ii) Village map with contours (scale 1 : 8000 or 1 : 4000).
- (iii) L-section and plan showing the L. W. L. the ordinary and extra-ordinary H. F. L. the intake chamber, inlet pipe, well, rising main and delivery chamber. Suitable scales for this are horizontal 1 : 1000 and vertical 1 : 100. As a rule all L-sections which are across the river should be drawn looking down stream i.e. a section on the right bank will extend from left to right on the drawing. The chainages should always extend from left to right.
- (iv) Details of intake chamber well and pump house and delivery chamber.
- (v) Pump layout with details of connections to rising main.
- (vi) Longitudinal and cross sections of channels and cross drainage works. The L-section of the channels should be drawn in the direction of the channel from left to right.

14.04. The index map should show the approach road to the site, distance to the nearest railway station the position of existing grid line giving its voltage and the nearest diesel depot in case of a diesel scheme. It should also clearly show the position of rising main and the commanded area. It should show at least one latitudinal and one longitudinal line. The toposheet from which it is traced should also be indicated. The village map should show the positions of main irrigation channels as well as indicate the positions of field channels with the command area of each. The plan below L-section should show the position of all features like intake chamber, well etc. with their location from corners of survey number. The rising main should also be similarly located at two or three points. Detailed drawings for all cross drainage works are not necessary; but type drawings should be included.

14.05. The most important drawing is the village map showing the commanded area with contours and proper attention should be paid to its preparation. Different colours should not be employed for showing different contours. In fact colours should not be used at all on tracings as they are not reproduced on prints and much labour is involved in colouring every individual print. When different features are to be distinguished different types of lines (e.g. full, dash, dash and dot, dash and cross etc.) should be employed. It is convenient to read a drawing if alternate contours are shown differently one by a full and the other by a dash line. Values of contours should be given in bold figures at their both extremities; but where a contour is long, the value should be written at an intermediate point also.

14.06. The following sizes of drawings are recommended :—

Index map — 340 × 210 mm. (13½ × 11 in.), or 340 × 560 mm. (13½ × 22 in.).

All other drawings—

520 × 1016 mm. (22 × 40 in.).

508 × 762 mm. (20 × 30 in.).

Drawings larger than 520 × 1016 mm. should be exceptional and used only when absolutely unavoidable.

14.07. Plain simple lettering should be employed and ornamentation avoided. The north line should also be shown with a single arrow without any decoration. Different sizes of lettering can be employed for relative emphasis. All lines on the drawing should be bold and dimension lines should be thin to distinguish them from the lines of the feature. All necessary dimensions for the execution of works should be given on the drawing and it should not be necessary to deduce dimensions from other dimensions.

14.08. The drawings should have copious notes so that ordinarily reference to other documents should not be necessary during execution of work.

15.00. WORKING OUT WATER RATES

15.01. The water rates are the actual cost of water supplied to a crop during a year or season. It is calculated by determining the total acre inches required by a crop from sowing to its maturity and multiplying by the cost of pumping one acre inch. The cost per acre inch comprises of two parts :—

- (i) Fixed charges.
- (ii) Running charges.

15.02. *Fixed charges* comprise of the interest on the capital, depreciation (or loan instalments for co-operative schemes), maintenance and repairs and cost of staff for running the scheme. The present rate of interest on loans to Co-operative Societies is 5½ per cent. and the same may be taken as rate of interest on capital for Government schemes also. The depreciation should be worked out as annual contribution to a sinking fund for redemption of capital at the end of a fixed number of years. This period may be taken as 40 years for civil works and 15 years for machinery. When a scheme is to be run by a Co-operative Society, the loan is to be returned in 15 years. The Society also gets a subsidy of 25 per cent. In such a case, depreciation should not be provided for but 1/15 of the 75 per cent of the estimated cost should be taken as annual loan instalment. The provision for M and R may be 1½ per cent. per year for civil works and 3 per cent. per year for machinery. The cost of staff for running the scheme may be taken as Rs. 2.50 per acre with a minimum of Rs. 7,500 per year.

15.03. The running cost is the actual charges for electrical consumption or cost of diesel oil in respect of diesel schemes. In addition an amount of Rs. 1000-1500 per pump may be added for lubricating oil and other sundry materials for oil lubricated turbine pumps and for diesel schemes. A note on the terms and conditions and the present rates for supply of electric power by the M.S.E.B. is given in Appendix IV. Typical calculations for water rates are given in Appendix V.

16.00. FEASIBILITY OF A SCHEME

16.01. Government has at present prescribed two criteria for determining the economic feasibility of a scheme. One is that the cost should not exceed to Rs. 1000 per acre irrigated and the other that the benefit cost ratio should not be less than one.

16.02. The benefit cost ratio is defined as the ratio of annual additional benefit on account of irrigation divided by the annual cost of providing those benefits. The additional benefit is the difference between the value of agricultural produce after irrigation and that before irrigation. The annual cost is the cost of running a scheme comprising of fixed and running charges as explained in paragraph 15 above plus administrative expenses calculated at Rs. 5 per acre irrigated.

16.03. For working out the value of agricultural produce before irrigation, it is necessary to know the existing cropping pattern. As a lift irrigation scheme is mostly confined to a village the existing pattern has to be obtained from the revenue records. When this cannot be easily obtained, the taluka pattern may be adopted as published figures for all the talukas in Maharashtra are available. Table VIII gives the values of produce for unirrigated crops per acre or per quintal. Table X gives the average yield for different unirrigated crops. By using these two tables and knowing the cropping pattern for the village in which the scheme is situated, the net value of produce before irrigation can be determined.

16.04. The value of agricultural produce after irrigation can be found out from the cropping pattern adopted for the scheme and the net values of produce given in table IX. A typical example is worked out in Appendix VI.

TABLES

TABLE I

General cropping pattern in the various agro-climatic zones of Maharashtra in 1957-58

Crops	ZONES OF RAINFALL								
	150" to 100"	100" to 40"	40" to 25"	25" to 35"	30" to 50"	35" to 55"	50" to 55"	55" to 60"	
	IB	IA	II	III	IVB	IVA	VB	VA	VI
1. Rice ..	.. 15-88	20-73	3-46	0-27	0-24	0-03	0-05	0-24	41-63
2. Wheat ..	.. 0-16	0-16	0-21	1-25	2-17	3-15	0-25	2-25	0-11
3. Kharif Jawar ..	.. ....	0-11	0-25	0-52	0-38	0-48	17-63	0-50	0-02
4. Rabi Jawar ..	.. 0-03	0-19	0-34	0-77	0-60	0-57	0-26	0-44	0-27
5. Bajri ..	.. 0-14	0-30	0-37	0-64	0-44	0-27	0-02	....	....
6. Maize ..	.. 0-01	0-05	0-02	0-02	0-07	....	....	....	0-03
7. Ragi ..	.. 0-36	9-37	0-34	0-06	0-01	....	....	....	....
8. Other food crops ..	.. 0-26	5-22	0-21	0-21	0-20	0-01	0-01	0-02	0-02
9. Gram ..	.. 0-05	0-08	0-08	0-06	0-07	0-12	0-09	1-04	1-04
10. Tur ..	.. 0-06	0-05	0-05	0-05	0-10	2-09	3-17	0-10	0-02
11. Other pulses ..	.. 0-11	0-15	0-13	0-10	0-27	0-24	1-16	2-22	5-22
12. Sugarcane ..	.. ....	....	0-02	0-06	0-01	0-01	....	....	....
13. Groundnut ..	.. 0-01	1-16	0-23	0-32	0-35	0-14	0-15	....	....
14. Other oil seeds ..	.. 0-18	0-18	0-18	0-10	0-31	0-15	0-09	4-27	3-05
15. Condiments ..	.. ....	0-01	0-01	0-02	0-01	0-05	0-01	....	....
16. Fruits and vegetables ..	.. 0-09	0-10	0-04	0-08	0-08	0-02	0-03	0-02	0-01
17. Cotton ..	.. ....	....	0-08	0-14	0-34	0-59	0-37	0-08	....
18. Other fibre crops ..	.. ....	....	....	....	....	0-01	0-05	....	....
19. Fodder ..	.. 0-56	0-58	1-58	0-55	0-07	0-01	....	....	....
Other crops (Tobacco etc.)..	0-01	..	0-05	0-10	....	....	....	....	....

TABLE II
Water requirement of crops and duties to be adopted

Serial No.	Name of crop	Period	Interval between waterings (days)			Inch depth per watering			Number of waterings			Duties on 16 hours working in acres			Remarks
			K	R	H.W.	K	R	H.W.	K	R	H.W.	K	R	H.W.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	<i>Sugar Cane—</i>														
	(a) Adsali	1st July to 31st October next year.	12	12	10	3	3.5	4.5	4+4 ^①	12+5 ^②	12	65	55	35	① The additional four waterings are for the 2nd Kharif season.
	(b) Suru	1st November to 31st October.	12	12	10	3	3.5	4.5	4	12+5	12	65	55	35	② Five waterings are for the overlap period.
2	<i>Other Perennials—</i>														
	(a) Bananas	Throughout the year	12	12	6	2.5	2.5	3	4	12	20	75	75	30	③ Only two waterings are required in monsoon and therefore the interval (col. 4) is not given. The duty is calculated on the basis of completing each watering in 15 days.
	(b) Other gardens.	Do.	12	12	10	2.5	2.5	3	4	12	12	75	75	50	
3	<i>Rice—</i>														
	(a) Kharif	1st July to 31st October	10	10	..	4	..	..	23	..	..	60	55	35	④ Potatoes are not recommended to be grown in Hot Weather. Hence no data is given.
	(b) Wayangan	1st January to 30th April.	10	10	..	..	3.5	4.5	..	6	5	..	55	35	
4	<i>Vegetables—</i>														
	(a) Onion	Any season	12	12	10	2.5	2.5	3	4	12	12	75	75	50	⑤ Although the interval between waterings is 30 days the duty is calculated on the basis of completing each watering in 20 days.
	(b) Potatoes	Do.	20	20	④	2.5	2.5	3	4	12	..	75	75	..	
	(c) Others	Do.	15	15	10	2.5	2.5	3	4	12	12	75	75	50	
5	<i>Groundnut—</i>														
	(a) Kharif	1st July to 30th September	..	..	..	3	..	..	20	..	..	80	..	50	
	(b) Hot weather	1st March to 30th June	..	..	10	..	..	3	..	..	12	..	..	50	
6	<i>Two seasonal—</i>														
	(a) Tur	1st July to 31st December.	..	20	..	3	3	..	20	3	..	80	80	..	
	(b) Cotton—														
	(i) Ordinary	1st July to 30th November	30	..	③	3	..	..	20	2	..	80	80	..	
	(ii) L. staple	1st April to 30th November.	..	30	12	3	3	3	20	2	7	80	80	75	
7	<i>Kharif Jowar and bajri</i>	1st July to 31st October	..	..	..	3	..	..	2	..	..	100	..	..
8	<i>Rabi Jowar</i>	1st October to 28th February.	..	30	..	..	3	..	..	4	..	..	100	..	
9	<i>Wheat</i>	1st November to 28th February.	..	20	..	..	3	..	..	6	..	..	100	..	
10	<i>Maize</i>	Any season	..	30	10	3	3	3	2	6	9	100	100	50	
11	<i>Gram</i>	1st November to 28th February.	..	30	..	..	3	..	..	5	..	..	100	..	
12	<i>Hybrid—</i>														
	(a) Jowar	Any season	..	15	15	10	3	3	3	3	6	9	80	80	50
	(b) Maize	Do.	..	15	15	10	3	3	3	5	7	10	80	80	50

TABLE III

Statement showing the diameters and slopes of inlet pipe

Discharge in cusecs	*H=3' (75 mm)		6" (150 mm)		9" (225 mm)	
	Dia. (inch)	Slope (1 in)	Dia. (inch)	Slope (1 in)	Dia. (inch)	Slope (1 in)
1	2		3		4	
0-4	15	190				
5	18	210	15	95		
6	21	250	18	110	15	65
7	21	250	18	110	15	65
8	24	290	18	110	..	..
10	24	290	21	125	18	75
11	27	325	21	125	..	..
13	27	325	24	145	21	77
14	30	390	24	145	..	..
16	30	390	27	160	24	83
17	33	400	27	160	24	83
18	33	400	27	160	..	..
19	33	400	30	190	27	110
22	36	440	30	190	27	110
23	36	440	33	200	30	130
27	39	480	33	200	30	130
31	42	520	36	220	33	135
32	45	530	36	220	33	135
33	45	530	39	250	33	135
36	45	530	39	250	36	150
38	48	560	39	250	36	150
40	48	560	42	260	36	150

*See drawing No. 2.

TABLE IV

Frictional loss of head in clean black or galvanised piping used for suction or delivery pipes

Discharge		Loss of head per cent. for given diameter												
G.P.M.	L.P.M.	m.m. 75	100	125	150	200	250	300	350	400	450	500	600	750
		Inch. 3	4	5	6	8	10	12	14	16	18	20	24	30
125	570	8.8	2.17	0.68	0.28	..	..	..	..	..	..	..	..	..
150	680	12.7	3.01	0.95	0.40	0.09	..	..	..	..	..	..	..	..
175	800	17.23	4.18	1.25	0.50	0.13	..	..	..	..	..	..	..	..
200	910	..	5.20	1.70	0.70	0.17	..	..	..	..	..	..	..	..
250	1135	..	8.36	2.30	1.10	0.26	0.085	..	..	..	..	..	..	..
300	1365	..	12.05	3.20	1.58	0.37	0.123	..	..	..	..	..	..	..
350	1590	..	16.4	5.00	2.15	0.51	0.167	0.067	..	..	..	..	..	..
400	1820	..	..	6.2	2.81	0.66	0.219	0.087	..	..	..	..	..	..
450	2045	..	..	7.8	3.56	0.84	0.277	0.11	..	..	..	..	..	..
500	2270	..	..	9	4.4	1.04	0.34	0.137	0.063	..	..	..	..	..
750	3410	..	..	..	9.9	2.35	0.77	0.31	0.143	..	..	..	..	..
1000	4545	..	..	..	17.63	4.18	1.36	0.55	0.254	..	..	..	..	..
1250	5680	..	..	..	..	7.3	2.38	0.96	0.442	..	..	..	..	..
1500	6820	..	..	..	..	10.42	3.41	1.37	0.631	..	..	..	..	..
1750	7955	..	..	..	..	..	4.43	1.78	0.82	0.42	0.205	..	..	..
2000	9090	..	..	..	..	..	5.46	2.19	1.01	0.52	0.29	..	..	..
2250	10230	..	..	..	..	..	..	2.87	1.83	0.68	0.38	..	..	..
2500	11365	..	..	..	..	..	..	3.56	1.65	0.845	0.47	..	..	..
3000	13635	..	..	..	..	..	..	..	2.29	1.17	0.65	0.39	..	..
3500	15910	..	..	..	..	..	..	..	3.17	1.62	0.90	0.53	..	..
4000	18180	..	..	..	..	..	..	..	..	2.08	1.16	0.69	0.30	..
4500	20455	..	..	..	..	..	..	..	..	2.67	1.48	0.88	0.38	..
5000	22730	..	..	..	..	..	..	..	..	3.27	1.81	1.80	1.47	..
5500	25000	..	..	..	..	..	..	..	..	..	2.25	1.30	0.57	..
6000	27180	..	..	..	..	..	..	..	..	..	2.60	1.55	0.68	0.10

TABLE V

Statement showing diameter of pipes for rising main for various discharges with frictional loss within 3 ft./1000 rft. based on Scobay's formula—

$$V = 0.36 H^{0.5} d^{0.625}$$

Discharge in cusecs	Dia. in inches	Loss of head in ft./1000 rft.	Discharge in cusecs	Dia. in inches	Loss of head in ft./1000 rft.
1	2	3	1	2	3
1	10	1.5	13	24	2.50
2	12	2.20	14	24	3.00
3	14	2.5	15	28	1.70
4	16	2.1	16	28	1.80
5	18	1.70	17	28	2.00
6	18	2.50	18	28	2.00
7	18	3.50	19	28	2.40
8	20	2.5	20	28	2.70
9	20	3.0	25	32	2.00
10	24	1.8	30	32	3.00
11	24	1.90	35	36	2.50
12	24	2.20	40	36	3.00

TABLE VI

Statement showing class of Hume pipes to be used for rising mains under different heads

Total working head or pressure	Diameter of Pipe														
	mm.	250	300	350	400	450	500	600	700	800	900	1000	1100	1200	1400
	Inch.	10	12	14	16	18	20	24	28	32	36	40	44	48	56
0.30 KG/CM ² or 10' head	NP2														
upto 1 KG/CM ² or 32' head	P1														
upto 2 KG/CM ² or 65' head	P2										Hume steel with plate thickness 3/16" or Prestressed pipes				
upto 3 KG/CM ² or 100' head	P3							Hume steel with 1/8" plate	Hume steel with 3/16" plate	Hume steel with 1/4" plate					
	or Prestressed pipe														
upto KG/CM ² or 200' head					Hume steel with 1/8" plate			Hume steel with 3/16" plate			Hume steel with 1/4" plate				
	or Prestressed pipes														
upto 9 KG/CM ² or	Hume steel with 1/8" plate			Hume steel with 3/16" plate				Hume steel with 1/4" plate							

Note.—For gravity mains the head (values in column 1) should be increased by 50 per cent.

TABLE VII

Statement showing the rates for pipes to be provided in the Estimates for Lift Irrigation Schemes

Dimeter		Basic price per meter of pipe including collars if required and Government taxes							Cost of laying and jointing including materials per meter but excluding cost of excavation of trench	Cost of transport per meter			
mm.	Inches	NP2	Spl. extra thick	P1	P2	P3	Hume steel	Pre-stressed		Fixed Cost	Additional cost per meter per Kml. of actual lead		
										NP2,P1,P2,P3 Prestressed	Hume steel and special extra thick	NP2,P1,P2,P3 Prestressed	Hume steel and special extra thick
250	10"	11.45	16.05	15.45	20.40	27.50	.....	.....	4.95	0.066	0.115	0.035	0.074
300	12"	16.30	22.80	20.15	29.70	36.55	62.85	56.55	5.90	0.098	0.148	0.035	0.064
350	14"	20.50	28.70	26.75	37.30	43.80	74.90	67.40	6.90	0.11	0.185	0.054	0.078
400	16"	25.00	35.00	33.70	44.10	50.95	86.95	78.25	7.90	0.117	0.222	0.222	0.092
450	18"	30.35	42.50	43.25	51.15	.....	99.05	89.10	8.85	0.164	0.260	0.070	0.106
500	20"	33.50	46.90	47.90	59.00	.....	123.70	108.40	9.85	0.172	0.282	0.0875	0.124
600	24"	42.85	60.00	56.60	74.85	.....	173.05	147.10	11.80	0.196	0.328	0.10	0.160
700	28"	45.90	64.30	72.90	.....	.....	211.10	180.30	13.80	0.262	0.350	0.14	0.190
800	32"	43.35	74.70	89.15	.....	.....	250.15	213.50	15.75	0.270	0.272	0.175	0.220
900	36"	65.00	91.00	112.15	.....	.....	290.15	246.60	17.75	0.390	0.394	0.175	0.250
1000	40"	80.15	112.20	130.75	.....	.....	326.95	277.80	19.70	0.490	0.547	0.29	0.330
1100	44"	94.95	132.95	147.65	.....	.....	362.75	309.00	21.65	0.590	0.700	0.70	0.410
1200	48"	110.05	154.10	168.00	.....	.....	400.35	340.30	23.65	0.690	0.853	0.70	0.492
1400	56"	150.15	210.20	.....	.....	.....	.....	.....	27.55	08.90	1.465	0.70	.....

TABLE VIII

Statement showing net value in rupees of agriculture produce of different un-irrigated crops

Serial No.	Crop	Produce						Expenses								Net benefit columns 8-15 per quintal
		Market rate per quintal	Deduction 10 per cent for farm harvest prices	Farm harvest prices	Fodder 30 per cent of column 5	Dung 3 per cent of column 5	Total columns 5+6+7	Seed	Mannure	Total columns 9+10	Fodder 10 per cent column 5	Implement 3 per cent of column 5	Labour 20 per cent column 5	Total columns 11+14		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1	Paddy	45	4.5	40.5	12.2	1.2	53.9	1.6	4.1	5.7	4.1	1.2	8.1	19.1	34.8	
2	Wheat	55	5.5	49.5	14.9	1.5	65.9	5.4	5.4	10.8	5.0	1.5	9.9	27.2	38.7	
3	Bajri	35	3.5	31.5	9.5	1.0	42.0	1.3	8.6	9.9	3.2	1.0	6.3	20.4	21.6	
4	K. Jowar and R. Jowar	40	4.0	36.0	10.8	1.1	47.9	0.7	4.4	5.1	3.6	1.1	7.2	17.0	30.9	
5	Groundnut	67	6.7	60.3	18.1	1.8	80.2	6.1	3.6	9.7	6.0	1.8	12.1	29.6	50.6	
6	Gram	48	4.8	43.2	..	1.3	44.5	5.6	7.0	12.6	4.3	1.3	8.6	26.8	17.7	
7	Maize	35	3.5	31.5	9.5	1.0	42.0	3.3	3.3	6.6	3.2	1.0	6.3	17.1	24.9	
8	Cotton	100	10.0	90.0	..	2.7	92.7	4.2	16.6	20.8	9.0	2.7	18.0	50.5	42.2	
9	Other oil seeds such as sesame	67	6.7	60.3	..	1.8	62.1	3.9	14.6	18.5	6.0	1.8	12.1	8.4	23.7	
10	Ragi	35	3.5	31.5	..	1.0	32.5	0.6	4.0	4.6	3.2	1.0	6.3	15.1	17.4	
11	Other food crops	35	3.5	31.5	..	1.0	32.5	1.1	7.4	8.5	3.2	1.0	6.3	19.0	13.5	
12	Tur	48	4.8	43.2	..	1.3	44.5	3.0	3.7	6.7	4.3	1.3	8.6	20.9	23.6	
13	Tobacco	225	22.5	202.5	..	6.1	208.6	1.9	48.7	50.6	20.3	6.1	40.5	117.5	91.1	
14	Sugarcane (gur)	80	8.0	72.0	..	2.2	74.2	9.8	6.0	15.8	7.2	2.2	14.4	39.6	34.65	
15	Other pulses (mug, udid)	48	4.8	43.2	..	1.3	44.5	3.6	..	3.6	4.3	1.3	8.6	17.8	26.7	
16	Fodder (kaddan) etc.	100 per acre.	10	90	..	3.0	93.0	Per acre	..	10.0	9.0	3.0	18.0	40.0	53.0	
17	Fruits and vegetables	150 per acre.	15	135.0	..	4.0	139.0	Per acre	..	50.0	14.0	4.0	27.0	95.0	44.0	
18	Grass (uncultivated)	10 per acre with no expenses.	1.0	9.0	..	..	9	..	..	..	..	..	..	..	9.0

TABLE IX

Statement showing net value per acre of

Serial No.	Crop	Yield in quintals	Rate per quintal	Price	Ddt. ten per cent	Net price	Fodder 25 per cent of column 7	Dung 3 per cent of column 7
1	2	3	4	5	6	7	8	9
1	Grapes	60	100	6,000	600	5,400	..	162
2	Rabi Potato	56	50	2,800	280	2,520	..	76
3	Chillies	7.46	250	1,870	187	1,683	..	50
4	S. Cane : Poona, Satara, Sangli, Kolhapur (with Adasali).	500	6	3,000	300	2,700	..	81
5	Plantain	200	14	2,800	280	2,520	..	76
6	R. & H. W. Onion	93.3	16.1	1,500	150	1,350	..	41
7	Orchards	at 1500	..	1,500	150	1,530	..	46
8	S. Cane: Poona, Satara, Sangli, Kolhapur (without Adasali) & Nasik.	450	6	2,700	270	2,432	..	73
9	S. Cane : Jalgaon & Dhulia	400	6	2,400	240	2,160	..	65
10	L. S. cotton	5.6	180	1,005	100	905	..	27
11	Other Perennials	at 800	..	800	80	720	..	22
12	Gr. Nut Rabi & H. W.	9.33	67	625	63	562	140	17
13	S. Cane : Marathwada, Vidarbha	350	6	2,100	210	1,890	..	57
14	Kh. Onion	56	16.1	900	90	810	..	24
15	Gr. Nut Kh.	7.46	67	500	50	450	112	14
16	Paddy (Konkan, Chanda)	9.33	45	418	42	376	94	11
17	Maize R. H. W. Bhandara	9.33	35	326	33	293	73	9
18	Other two seasonals	at 600	..	600	60	540	..	16
19	Paddy	7.46	45	336	34	302	76	9
20	Jowar	5.60	40	224	22	202	50	6
21	Fodder	at 300	..	300	30	270	..	8
22	Wheat	3.74	55	205	21	184	46	5
23	Bijri	5.60	35	196	20	176	44	5
24	Maize Kharif	7.46	35	261	26	225	59	7
25	Cotton ordinary	3.74	100	374	37	337	..	10
26	Gram	2.62	48	126	13	113	..	3
27	Green Manure	at 75	..	75	8	67	..	2
28	Mug, Udid	1.12	48	54	5	49	..	2
29	Hy. Jowar Kharif	20	53	1,060	106	954	239	29
30	Hy. Rabi	20	53	1,060	106	954	239	29
31	Hy. H. W.	15	53	795	80	715	179	21
32	Hy. Bajri Kharif	15	55	825	83	742	185	22
33	Hy. Rabi	20	55	1,100	110	990	248	30
34	Hy. H. W.	12	55	660	66	594	148	18
35	Hy. Maize Kharif	22	50	1,100	110	990	248	30
36	Hy. Rabi	20	50	1,000	100	900	225	27
37	Hy. H. W.	20	50	1,000	100	900	225	27

Note.—Rates of yields, prices, seed and manure, etc. may not be taken as accepted by the Agriculture Department for Agriculture Department.

IX

different irrigated crops

Total Produce Rs.	Seed		Manure		Total 12+14	Fodder 10 per cent of col. 7	Imple 3 per cent of col. 7	Labour 20 per cent of col. 7	Total 15 to 18	Net (10-19) Benefit Rs.
	Rate	Cost	Rate	Cost						
10	11	12	13	14	15	16	17	18	19	20
5,562 at	1,500				1,500	540	162	1,080	3,282	2,280
2,596 at	400/Ac				400	252	76	504	1,232	1,364
1,733	1	1	200	200	201	168	50	336	755	978
2,619	180	180	750	750	930	270	81	540	1,821	879
2,596	240	240	725	725	965	252	76	504	1,797	799
1,391 at	150				150	135	41	270	596	795
1,576 at	300				300	153	46	306	805	771
2,357	180	180	700	700	880	243	73	486	1,682	748
2,225	180	180	650	650	830	216	65	432	1,543	682
932	2	2	120	120	122	91	27	182	422	510
742 at	200				200	72	72	144	438	304
719	17	17	25	25	42	56	17	112	227	492
1,947	180	180	600	600	780	189	57	378	1,404	486
834 at	150				150	81	24	162	417	417
576	17	17	25	25	42	45	14	90	191	385
481	8	8	60	60	68	38	11	76	193	288
375	10	10	40	40	50	29	9	58	146	229
556 at	150				150	54	16	108	328	228
387	8	8	60	60	68	30	9	60	167	220
258	1.5	1.5	40	40	41.5	20	6	40	107.5	150
278 at	50				50	27	8	54	139	139
235	10	10	40	40	50	18	5	36	109	126
225	1.5	1.5	40	40	41.5	18	5	36	100.5	124
301	10	10	40	40	50	24	7	48	129	172
347	8	8	60	60	68	34	10	68	180	167
116	8	8	15	15	23	11	3	22	59	57
69 at	25				25	7	2	14	48	21
51	8	8	10	10	18	5	2	10	35	16
1,222	30	30	145	145	175	95	29	190	489	733
1,222	30	30	145	145	175	95	29	190	489	733
915	30	30	145	145	175	72	21	144	412	503
949	15	15	90	90	105	74	22	148	349	600
1,268	15	15	90	90	105	99	30	198	432	836
760	15	15	90	90	105	59	18	118	300	460
1,268	21	21	160	160	181	99	30	198	508	760
1,152	21	21	160	160	181	90	27	180	478	674
1,152	21	21	160	160	181	90	27	180	478	674

each and every project. These are only the average standard figures assumed and are subject to periodical verification

TABLE X

Districtwise ten years' yield of principal crops in Maharashtra State in lb/acre (unirrigated condition)

Serial No.	District/Division	Paddy	Wheat	Jowar	Bajri	Ragi	Tur	Gram	Sugarcane. (Gur)	Cotton	Gr. Nut.	Sesame	Rape, Mustard and Linseed	Tobacco	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Greater Bombay	1,846	..	..	..	..	..	..	..	..	..	..	..	..	..
2	Thana	1,874	..	516	..	592	255	278	1,991	..	..	224	..	..	Note.—For the remaining crops yield per acre for all the Districts should be taken as under :—
3	Kolaba	1,812	..	..	..	631	290	293	2,240	..	..	215	..	..
4	Ratnagiri	1,406	546	270	..	2,864	..	918	197	..	..		(1) Maize 640 lb.
5	Nasik	1,176	337	288	280	920	645	297	3,709	381	571	258	334	..	(2) Other food crops 300 lb.
6	Dhulia	554	504	496	391	593	618	328	3,792	288	621	262	285	..	(3) Other pulses—(Mug, Udid, Kulith, Math, Masur, etc.) 240 lb.
7	Jalgaon	785	485	833	266	693	655	338	3,953	303	619	284	245	784	
8	Ahmednagar	1,088	366	333	218	458	498	308	9,097	321	545	214	199	522	
9	Poona	1,352	356	304	297	479	463	288	7,129	501	710	204	275	511	
10	Satara	1,190	601	519	247	560	609	359	5,696	579	906	..	277	713	
11	Sangli	1,170	462	681	171	618	636	348	5,851	354	639	260	..	456	
12	Sholapur	858	476	337	75	809	448	284	6,552	435	557	180	224	542	
13	Kolhapur	1,511	540	980	186	601	637	366	6,731	255	789	384	..	408	
14	Aurangabad	777	344	442	200	205	232	255	3,738	189	460	170	197	451	

15	Parbhani	..	791	386	486	221	...	398	340	3,824	162	571	204	201	907
16	Bhir	..	759	315	492	205	158	214	290	3,932	201	690	228	205	651
17	Nanded]	..	773	368	490	181	809	372	276	3,945	165	611	98	198	459
18	Osmanabad	..	686	325	512	211	359	312	344	4,678	159	609	235	188	478
19	Buldana	..	761	391	609	323	...	897	290	2,241	222	526	199	224	725
20	Akola	..	771	398	547	327	...	928	301	2,352	213	465	224	240	...
21	Amravati	..	771	423	556	314	...	1,079	300	2,352	207	516	223	231	572
22	Yeotmal	..	747	367	477	307	...	1,001	292	2,131	183	479	184	215	...
23	Wardha	..	792	375	464	301	...	1,055	322	2,464	150	525	231	217	...
24	Nagpur	..	1,268	397	426	390	...	814	342	2,688	168	591	242	216	679
25	Bhandara	..	1,250	364	431	...	485	738	329	2,729	...	611	269	163	...
26	Chanda	..	1,176	361	420	307	315	681	329	3,972	138	578	160	204	550

TABLE XI

Type Sections for irrigation channels

Serial No.	Discharge in cusecs	Bed gradient	'N' Mannings	Section proposed		Velocity ft./sec. $V = \frac{1.486}{N} \times R^{2/3} \times S^{1/2}$	Area in S. ft. side slope 1:1	Calculated discharge in cusecs	Remarks
				Bed width in ft.	Depth (F.S.D.) in ft.				
1	2	3	4	5	6	7	8	9	10
1	5	1/2000	0.03	3.0	1.25	0.95	5.31	5.05	A free board of 300 m.m. (1'-0") should be provided for channels upto 5 cusecs ; and 450 m.m. (1'-6") for channels above 5 cusecs.
2	10	1/2000	0.03	4.0	1.6	1.14	8.96	10.21	
3	15	1/2000	0.03	4.0	2.0	1.28	12.00	15.36	
4	20	1/2000	0.03	5.5	2.0	1.35	15.00	20.25	
5	25	1/2000	0.0275	6.0	2.1	1.53	17.00	26.00	
6	30	1/2000	0.0275	6.0	2.3	1.60	19.09	30.54	
7	35	1/2000	0.0275	6.0	2.50	1.67	21.25	35.59	
8	40	1/2000	0.0275	6.25	2.7	1.75	24.07	42.12	
9	25	1/3000	0.0275	6.00	2.3	1.31	19.09	25.03	
10	30	1/3000	0.0275	6.00	2.6	1.39	22.36	31.08	
11	35	1/3000	0.0275	6.00	2.8	1.45	24.64	35.73	
12	40	1/3000	0.0275	6.25	3.0	1.51	27.75	41.90	

APPENDICES

APPENDIX I

Typical Calculations of Horse Power.

Discharge—2 cusecs

Total head—

(i) Static head	.. .. .	..	Say 90 ft.
(ii) Frictional loss—			
(a) In suction pipe length 20' diameter 6" (from table IV)	.. .. .	$\frac{9.9 \times 20}{100} =$	2.00
(b) In delivery pipe length 40', diameter 6"	.. .. .	$\frac{9.9 \times 40}{100} =$	4.00
(c) In rising main length 3000 ft. diameter 12" (from table V)	.. .. .	$2.2 \times 3 =$	6.60
(iii) Loss in valves, bends etc.—			
(a) Foot valve equivalent of 44' of 6" diameter pipe	.. .. .	$\frac{9.9 \times 44}{100} =$	4.35
(b) Elbows 2 Nos. 6" diameter (from drg. 8)	.. .. .	$\frac{2 \times 9.9 \times 16}{100} =$	3.16
(c) Reducer 6" × 5" (from drg. No. 8)	.. .. .	$\frac{9.9 \times 10}{100} =$	0.99
(d) Sluice valve 6" diameter (from drg. No. 8)	.. .. .	$\frac{9.9 \times 20}{100} =$	2.00
(e) Reflux valve equivalent length 44' of 6" diameter pipe	.. .. .		4.35
(f) Reducer 12" × 6" (from drg. No. 8)	.. .. .	$\frac{9.9 \times 11}{100} =$	1.00
		<hr/>	
		Total ..	118.45 ft.
		Say ..	120 ft.

$$\text{H. P. required } \frac{5 \times 2 \times 120}{44 \times 0.7} = 39$$

$$\text{Add for unforeseen 10 per cent } = \frac{4}{43}$$

The next available motor is of 50 H. P. Hence adopt 50 H. P. motor.

APPENDIX II

Form of Estimate for Administrative Approval

Name of work :									
Serial No.	Item	Description and Specifications.	Quantity	Rate		Unit	Amount		Remarks
				Rs.	P.		Rs.	P.	
1	2	3	4	5		6	7	8	
1	Intake Chamber	.. Circular in shape constructed in U. C. R. masonry/brick work* in c.m. 1:5 with cement pointing/plaster* to exposed faces. Internal diameter Thickness of steining..... Depth of foundation below river bed..... Height above bed..... Foundation concrete 1:4:8, 150 mm. thick. R. C. C. slab 1:2:4, 150 mm. thick on top. Side grating with shutter and grating on top for admitting water.	One No.			No.		The rate includes cost of ring bund and dewatering.	
2	Inlet pipeline	.. Average depth of cutting of the trench— In soft and hard rocks..... In murum In soil Class of pipe—Special extra thick/NP-2*.				Metre		Rate includes cost of dewatering.	
3	Jack well/Dry well*	.. Construction in U.C.R. masonry/brick work* in c.m. 1:5 with cement pointing/plaster* to exposed faces. Internal diameter..... Depth of excavation below ground level— In soft and hard rock..... In murum..... In soil Total height above foundations Average thickness of steining..... Bottom concrete 1:4:8, 300 mm. thick. R. C. C. ring 300 mm. thick at top. Providing with 20 mm. M. S. bar U-shaped steps and R. S. Js. at mid-height for erecting platform.	One No.			No.		Rate includes cost of dewatering.	
4	Pump House	.. To be constructed on top of well, circular/square* in shape size Floor : Side walling :	One No.			No.			

APPENDIX II—contd.

Name of work :									
Serial No.	Item	Description and Specifications	Quantity	Rate		Unit	Amount		Remarks
				Rs.	P.		Rs.	P.	
1	2	3	4	5		6	7	8	
		<p>Roof :— A steel portal frame/R.S.J.* for chain pulley block, M. S. step ladder for access from ground, one incandescent lamp for lighting, one power and one light plug. All steel work painted with 3 coats of oil paint and all masonry work white washed.</p>							
5	Rising Main	<p>.. Average depth of cutting for the trench— In murum In soil Class of pipe-Diameter— (i) Mild steel (ii) Cast iron (iii) Prestressed concrete (iv) Hume steel Spun concrete— (v) P-1 (vi) P-2 (vii) P-3</p>							
		<p>Provided with one pressure relief valve and other specials like bends, tees, airvalves as necessary and a thrust block of concrete at the starting point.</p>							
6	Delivery Chamber	<p>.. Constructed in U. C. R. masonry/brick work* in c.m. 1:5 with cement pointing/plaster* to exposed faces. Internal dimensions— Length.....Breadth..... Height..... Top width of masonry..... Side batter Bottom concrete 1:3:6, 225 mm. thick finished in cement plaster 25 mm. thick. C.C. 1:2:4 coping on top, openings for irrigation channels with grooves and planks for regulation.</p>	One No.						No.
		<p>Internal dimensions— Length.....Breadth..... Height.....</p>	One No.						No.
7	Distribution system	<p>.. Spun concrete pipes NP-2 class with discharging chambers and valves—Diameter. Earthen channels of required capacity including necessary C. D. works and outlets, etc.</p>							Metre Metre Metre Acres

8	Land Acquisition	.. Nature of land— (a) Bagayat (b) Jirayat (c) Waste	Acre Acres Acres
9	Pumping Machinery	.. Centrifugal/turbine* pumps..... Nos. having a capacity of.....g.p.m./c.p.m. each at a head of..... metres coupled directly/through V. belt/Vertical shaft* to horizontal/vertical electric motors/ diesel engine* of.....H. P. each. All accessories such as switch Boards, starters, sluice and reflux valves, foot valves, suction and delivery pipe, trees, Y-S, pressure gauges etc. as required. Including erection and all sundry materials.	H.P.
10	Chain Pulley block	.. Moving mono rail type for erection and removing of pumping machinery. Capacity.....tonnes.	One No. No.

Total .. _____
 Add 3 per cent. contingencies.. _____
 2 per cent. W. C. Establishment .. _____
 Per cent. Agency charges .. _____
 Grand total Rs. : : .. _____

*Strike out whichever is not applicable.

APPENDIX III

Descriptive Note

Name of Scheme :—

River:—

Taluka:—

District:—

1. Location	..	..	..	..	..
2. Nearest railway station and distance	..	..	..	..	..
3. Nearest diesel depot (for diesel scheme) and distance	..	..	..	..	..
4. Nearest power line (for power scheme) and distance	..	..	..	..	..
5. Availability of water	..	..	..	..	..
Discharge available	..	..	..	..	..
(i) Kharif	..	..	..	..	..
(ii) Rabi	..	..	..	..	..
(iii) Hot weather	..	..	..	..	..
6. Area under command	..	..	..	..	..
7. Area proposed for irrigation	..	..	..	..	..
8. Crop pattern and discharge requirement—					

Serial No.	Name of crop	Area acres	Discharge required on hours basis			Remarks
			Kharif season Acres/Duty=Q	Rabi season Acres/Duty=Q	Hot weather Acres/Duty=Q	
1	2	3	4	5	6	7
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
		Total	..			

9. Design discharge (Q)	..	..	..	..
10. Salient levels (Arbitrary)—				
(i) River bed level	..	..	..	..
(ii) Low water level	..	..	..	..
(iii) Normal High flood level	..	..	..	..
(iv) Maximum High flood level	..	..	..	..
(v) F. S. L. in delivery chamber	..	..	..	..
11. Static Head 10 (v) minus 10 (ii)	..	..	..	..

12. Frictional and other losses—

- (i) Frictional loss in suction pipe
- (ii) Frictional loss in delivery pipe
- (iii) Head loss in rising main at ft./mt. per 1,000 ft./mt.
- (iv) Loss of head in bends, valves, reducers, etc.
- (v) Total

13. Gross Head (11+12) (H)

14. H. P. Calculations (H. P. = $\frac{5QH}{448e}$ where e = efficiency of pump)

15. Description of pumping units

16. Rough cost (Rs.)

- (i) Civil portion
- (ii) Mechanical portion

Total Rs.

Agency charges at per cent.

Total Rs.

Rs.

17. Cost per acre

18. Benefit Cost Ratio

19. Water charges for different crops (Rs. per acres)—

Serial No.	Name of crop	Acre inches	Rate per acre inch	Amount	Irrigation charges or royalty	Total
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

20. Cement requirement (tonnes)

21. Remarks

APPENDIX IV

Electric power supply for Lift Irrigation Schemes by Maharashtra State Electricity Board (Tariff for Agricultural Pumping)

The following information will be useful for estimating the cost of installations required for electric power supply and for working out the running expenses on account of electrical energy consumption for lift irrigation schemes.

Type of supply

1.01. Where the connecting load is 50 KW or less, the Maharashtra State Electricity Board gives a supply or low tension (400/440 volts). For higher connected loads, the supply given is of high tension.

2.00. Overhead lines

2.01. The Board provides overhead lines free of cost upto 300 metres from the nearest distributing point i.e. from an existing rural transformer sub-station or from a service line already laid for supply to any other consumer. If the length required is more than 300 metres, the balance has to be laid at the cost of the consumer. For the purpose of estimate, this extra length may be estimated at the rate of Rs. 6.56 per metre. If the service line does not terminate at a permanent structure of the consumer such as a building and if it becomes necessary to provide a terminal pole, the Board would charge an additional amount of Rs. 100.

2.02. A guarantee of three years for taking L. T. supply from the Board is required to be given. In the case of H. T. supply the required transmission line is laid by the Board at their cost provided the consumer gives a guarantee to take supply for a minimum period of seven years and pay annually 15 per cent. for hydro and diesel grid of the cost incurred in laying the entire line. This minimum guarantee will not however be less than the minimum charges prescribed under the relevant rate schedule.

2.03. When an isolate consumer or a group of consumers situated away from a sub-station require supply, it becomes necessary to extend the high tension line and set up a new rural transformer sub-station. In such cases, the Board would provide the necessary high tension line at their cost provided the connected load is not less than 15 H. P. and the consumer gives a guarantee to take electric supply for a period of not less than seven years and pay minimum annual charges as given in para. 3 above. The capital cost of giving supply may be calculated for estimate purpose as follows:—

- (1) Cost of extending H. T. line at Rs. 9,800 per mile.
- (2) Cost of transformer sub-station—
50 KVA—Rs. 6,800.
100 KVA — Rs. 8,900.
- (3) Cost of extending L. T. line at Rs. 6.56 per metre.
- (4) Service connection charges as given in para. 5.
- (5) Cost of terminal pole as given in para. 2.01.

3.00. Transformer

For high tension supply, the transformer at the consumers end has to be provided by the consumer. However, the Board would provide a transformer on hire for maximum period of six months provided it is available with them. The current rates of hire charges are the following:—

KVA	Charges for transport erection and dismantling	Hire charges		
		11KV	22 KV	33 KV
50	125	40	40	....
100	150	55	60	100
250	200	....	....	....
500	250	150	190	220

4.00. Energy charges

4.01. *Low tension supply.*—(1) Minimum charge of Rs. 40 per B.H.P. or part thereof of connected load per year subject to a minimum of Rs. 80 (i.e. a minimum load of 2 B.H.P. will be charged if the connected load is less than 2 B.H.P.).

If a consumer so desires and if his load is less than 2 B.H.P. but more than 1 B.H.P. he will be charged on the actual connected load on the condition that the free allowance for overhead line will be only 150 metres instead of 300 metres (see para. 2.01).

- (2) Meter rent Re. 1 per month.
- (3) Charge for units Consumed.

For the first 50 units consumed during a month per B. H. P. of connected load, 13 paise per unit.

For the next 150 units consumed during a month per B. H. P. of connected load per month 12 paise per unit.

For additional units consumed during the month—10 paise per unit.

- (4) plus Electricity duty at 4 paise per every 5 units.

4.02. *High tension supply.*—(a) Hydro Tariff—(i. e. places supplied with power from hydro power stations in Western Maharashtra excluding Khandesh).

Demand charges.—(1) 9 per KVA of billing demand per month for the first 1000 KVA.

(2) Rs. 8 per KVA of billing demand for next 1000 KVA.

(3) Meter rent Rs. 5 per month.

Energy charges (in addition to demand charges).—(1) For the first 150 units per KVA of billing demand per month 4 paise per unit.

(2) For the next 5,00,000 units consumed during a month 3·8 paise per unit.

(3) For the next 5,00,000 units consumed during the month 3·5 paise per unit.

(4) For additional units consumed during the month 3·2 paise per unit.

(5) Electricity duty at 4 paise per every 5 units.

(b) **Thermal Tariff.**—(i.e. places supplied with power from thermal power stations in Khandesh, Marathwada and Vidarbha.)

Demand charges.—Same as per hydro power tariff.

Energy charges (in addition to demand charges).—(1) For the first 100 units per KVA or 50,000 units whichever is greater per month—7 paise per unit.

(2) For the next 2,00,000 units consumed during a month—6 paise per unit.

(3) For the next 3,00,000 units 5 paise per unit.

(4) For additional units—4·25 paise per unit.

(5) Electricity duty at 4 paise per unit.

(6) Fuel cost adjustment charge depending upon rise or fall of fuel cost above or below Rs. 7 per million kilo-calories.

4.03 Rates for seasonal supply.—(a) **Hydro tariff.**—The seasonal consumers will have to pay a minimum annual bill at Rs. 100 per KVA of the maximum billing demand during the year or 75 per cent of connected load of 50 KVA whichever is higher. The year for this purpose is taken from 1st October to 30th September.

(b) **Thermal tariff.**—The same as above but the minimum rate will be Rs. 120 plus fuel cost adjustment charge on actual energy consumed.

5.00. Service connection charges

The Board levies the following installation charges—

Low tension supply.—(1) For the loads more than 5 HP—Rs. 125.

(2) For loads 5 HP and less—Rs. 75.

Deposit.—Rs. 15 per H.P. or 3 months average consumption whichever is more.

High tension supply.—

(1) First 500 KVA	..	..	..	Rs. 1,000
(2) Next 500 KVA	..	..	..	Rs. 100 per 100 KVA or part.
(3) Balance	..	..	..	Rs. 50 per 100 KVA or part

6.00. Testing charges

Testing charges for intallation and sub-station are required to be paid to Government. The current charges are as follow :—

Testing of installation i.e. Electric Motors, starters, switches, oilcircuit, breakers, etc.

Capacity	Fees.
	Rs.
Upto 5 Kw.	5-00
Upto 10 Kw.	7-50
Upto 20 Kw.	10-00
Uptp 50 Kw.	20-00
Upto 100 Kw.	30-00
Upto 500 Kw.	30-00 For first 100 Kw. plus Rs. 15-00 for every 50 Kw.
Uptp 1,500 Kw.	150-00 For the first 500 Kw plus Rs. 10-00 for every addition of 50 Kw.
Exceeding 1,500 Kw.	350-00

The fee shall be paid by the owner to whom energy is or is about to be supplied.

Testing charges for transformer sub-stations.

Capacity	Fees
	Rs.
Upto 25 Kw.	25-00
Upto 50 Kw.	50-00
Upto 100 Kw.	35-00
Upto 250 Kw.	125-00
Upto 500 Kw.	175-00
Upto 750 Kw.	225-00
Upto 1,000 Kw.	275-00
Exceeding 1,000 Kw.	300-00

Fees shall be paid by receiving party.

These charges are required to be paid every year.

7.00 : Billing Demand

Billing demand means the maximum of the following :—

- (1) The maximum demand established during the month i.e. the average KW/KVA supplied during 30 minute period of maximum use during the month.
- (2) 75 per cent. of the contract demand i.e. the maximum KW/KVA for the supply of which the Board undertakes to provide.

APPENDIX V

Calculations of water rates

The following calculations of water rates are given for guidance and they are for a hypothetical scheme with the following assumed data :—

(i) Irrigable area	..	..	..	500 acres.
(ii) Cropping pattern	..	..	..	As given in calculations.
(iii) Static lift	..	..	..	70 ft.
(iv) Gross lift	..	..	..	90 ft.
(v) Pumping capacity	..	..	..	7 cusecs (perennial scheme). 6 cusecs (non-perennial scheme).
(vi) Horse power	..	..	..	120 (perennial scheme). 110 (non-perennial scheme).

(vii) Cost :—

Electric Power—

A. Perennial Scheme—

(i) Civil part	..	..	..	..	..	..	Rs.	1,11,000
(ii) Mechanical part	..	..	..	..	..	..		1,89,000

Total .. 3,00,000

B. Non-Perennial Scheme—

(i) Civil part	..	..	..	..	..	..	Rs.	1,11,000
(ii) Mechanical part	..	..	..	..	..	..		1,39,000

Total .. 2,50,000

Diesel Power—

C. Perennial Scheme—

(i) Civil part	..	..	..	..	..	..	Rs.	1,11,000
(ii) Mechanical part	..	..	..	..	..	..		2,25,000

Total .. 3,36,000

D. Non-Perennial Scheme—

(i) Civil part	..	..	..	..	..	..	Rs.	1,11,000
(ii) Mechanical part	..	..	..	..	..	..		1,75,000

Total .. 2,86,000

A. Perennial Scheme with Electric Power

1. Direct (running) charges—

(i) Total water to be pumped—

Crop	Area	No. of waterings	Inch depth	Acre inches _±
<i>Kharif season (July to September)</i>				
Sugarcane	100	4	3	1,200
Other perennials	25	4	2.5	250
Paddy	50	2	4	400
G. Nut	50	2	3	300
Cotton	25	2	3	150
Jowar	100	2	3	600
Hy. Jowar	100	3	3	900
	450			3,800
<i>Rabi season (October to February)</i>				
Wheat	100	6	3	1,800
Hy. Jowar	175	6	3	3,150
Cotton	25	2	3	150
G. Manure	200	2	3	1,200
Sugarcane	100	17	3.5	5,950
Other perennials	25	12	2.5	750
	625			13,000
<i>Hot Weather season (March to June)</i>				
Cotton	25	7	3	525
Sugarcane	100	12	4.5	5,400
Other perennials	25	12	3	900
	150			6,825

Total for the year 23,625 acre inches.

(ii) No. of working hours (Acre inches divided by cusecs)

Kharif	..	..	..	..	$\frac{3800}{7} = 543$
Rabi	..	..	..	..	$\frac{13000}{7} = 1857$
Hot weather	..	..	..	..	$\frac{6825}{7} = 975$
Total for the year				..	<u>3375 hours</u>

(iii) Consumption of electricity

H.P. = 120

Assuming 90 per cent efficiency of motors

$$\text{Input} = 0.746 \times 120 \times \frac{100}{90}$$

$$= 99.6 \text{ say } 100 \text{ K.W.}$$

$$\text{KVA} = \frac{120 \times 0.746}{0.85} = 105 \text{ (Assuming a power factor of } 0.85)$$

Units consumed

Kharif (July to September)

$$543 \times 100 = 54,300$$

i.e. 27,150 units per month (pumping for 2 months only)

Rabi (October to February)

$$1857 \times 100 = 1,85,700$$

i.e. 37,140 per month

Hot Weather (March to June)

$$975 \times 100 = 97,500$$

i.e. 24,375 per month

(iv) Energy charges (H.T. supply)

$$(i) \text{ Demand charge—} 12 \times 9 \times 105 = 11,340$$

(ii) Energy charge—

$$\text{Kharif—first } 15,750 \text{ (} 105 \times 150 \text{) units @ } 0.04 = 630$$

$$\text{Remaining } 11,400 \text{ @ } 0.038 = 433$$

$$\underline{27,150}$$

$$2 \times 1063 = 2126$$

$$\text{Rabi First } 15,750 \text{ units @ } 0.04 = 630$$

$$\text{Remaining } 21,290 \text{ units @ } 0.038 = 813$$

$$\underline{37,140}$$

$$5 \times 1,433 = 7,215$$

$$\text{Hot weather First } 15,750 \text{ units @ } 0.04 = 630$$

$$\text{Remaining } 8,625 \text{ units @ } 0.038 = 328$$

$$\underline{24,375}$$

$$4 \times 958 = 3,832$$

Total .. 24,513

Electricity duty @ 0.04 per 5 units.

$$337500 \times 0.04 = 2700$$

5

Meter rent @ Rs. 5 per month

$$12 \times 5 = 60$$

Total per year	24513	+	Elcc. duty	2,700	+	Meter rent	60	=	27,273
----------------	-------	---	------------	-------	---	------------	----	---	--------

(This is more than minimum charge of Rs. 100 × 105 KVA)

Cost per acre inch = 27,273

$$\frac{27,273}{23,625} = \text{Rs. } 1.15$$

2. Fixed charges (Government Scheme)—

(i) Depreciation as annual contribution to a sinking fund, etc.

(a) Civil part 1,398 @ 1.26 per cent.

(b) Mech. 9,337 @ 4.94 per cent.

(ii) Interest 16,500 @ 5½ per cent.

(iii) Maintenance at 3 per cent on machinery

$$\frac{1,89,000 \times 3}{100} = 5,670$$

(iv) Maintenance at 1½ per cent on civil works

$$\frac{1,11,000 \times 1.5}{100} = 1,665$$

(v) Staff for running the scheme 2,000

Total 36,568

Cost per acre inch = Rs. 1.55

3. Total cost per acre inch = $1.15 + 1.55 = \text{Rs. } 2.70$

4. Water rates—

Crop	Acres	Rate	Amount	Irrigation charges	Total
1	2	3	4	5	6
1. Sugarcane	125.5	2.70	339	40	379
2. Other perennials	76	2.70	202	25	227
3. Paddy	8	2.70	22	....	22
4. Groundnut	6	2.70	16	6	22
5. Green Manure, K. Jowar	6	2.70	16	....	16
6. Hy. Jowar (K)	9	2.70	24	....	24
7. Wheat & Hy. Jowar (R)	18	2.70	49	....	49
8. Cotton	33	2.70	89	33	122

B. Non-Perennial Scheme with Electric Power

1. Direct (running) charges—

(i) Total water to be pumped—

Crop	Area	No. of waterings	Inch depth	Acres
1	2	3	4	5
Kharif season (July to September)				
1. Paddy	50	2	4	400
2. Groundnut	50	2	3	300
3. Jowar	250	2	3	1,500
4. H.B. Jowar	150	3	3	1,350
	500			3,550
Rabi season (October to February)				
5. Wheat	100	6	3	1,800
6. H.B. Jowar	325	6	3	5,850
7. G. Manure	325	2	3	1,950
	750			9,600
Hot weather season (March to June)				
Nil				
Total for the year 13,150 acre inches.				

(ii) No. of working hours (acre inches divided by cusecs)—

Kharif	$\frac{3550}{6}$	=	592
Rabi	$\frac{9600}{6}$	=	1600
Hot weather	....	....
Total for the year		=	2192 hours

(iii) Consumption of electricity—

$$\text{K.W.} = 0.746 \times 110 = 82.06$$

$$\text{Input} = 82 \times \frac{100}{90} = 91.1 \text{ K.W. say } 91 \text{ K.W.}$$

$$\text{KVA} = \frac{110 \times 0.746}{0.85} = 97$$

Units consumed—

$$\text{Kharif } 592 \times 91 = 53,872 \text{ i.e. } 26,936 \text{ per month.}$$

$$\text{Rabi } 1600 \times 91 = 1,45,600 \text{ i.e. } 29,120 \text{ per month.}$$

Hot weather—Nil.

(iv) Energy charges (H. T. Supply)—

(i) Demand charge— $8 \times 9 \times 97 = 6,984$

(ii) Energy charge

Kharif—First 14,550 (97 × 150) units at Rs. 0.04 = 582

Remaining	12,386		
	26,936		at Rs. 0.038 $\frac{= 471}{2 \times 1,053} = 2106$

Rabi—First 14550 units	14,570		
Remaining	29,120		at Rs. 0.038 $\frac{582}{5 \times 1,136} = 554$

Hot weather—Nil

Total 14,770

Energy charge		Elec. duty		Meter rent.	
Total per year = 14,770	+	596	+	60	= 15,426

(This is more than the minimum charge of Rs. 100 × 97 KVA)

Cost per acre inch = $\frac{15,426}{13,150} = \text{Rs. } 1.17$

2. Fixed charges.—(for scheme in State of Local Sector)

(i) (a) Depreciation calculated as annual contribution to a sinking fund bearing interest at 5 per cent—

Civil part (life 40 years) = $0.0126 \times 1,11,000 = 1,398$

Mechanical part (life 15 years) = $0.0494 \times 1,39,000 = 6,867$
8,265

(b) Interest at $5\frac{1}{2}$ per cent $\frac{2,50,000 \times 5.5}{100} = \frac{13,750}{22,015}$ (ii) Maintenance at 3 per cent on machinery $\frac{1,39,000 \times 3}{100} = 4,170$ (iii) Maintenance at $1\frac{1}{2}$ per cent on civil works $\frac{1,11,000 \times 1.5}{100} = 1,665$ (iv) Staff for running the scheme = $\frac{2,000}{29,850}$

• Cost per acre inch = $\frac{29,850}{13,150} = \text{Rs. } 2.27$

3. Total cost per acre inch = $1.17 \times 2.27 = \text{Rs. } 3.44$

4. Water rates

Crop	Acres	Rate	Amount	Irrigation charges	Total
1	2	3	4	5	6
1. Paddy	8	3.44	28	6	28
2. Groundnut	6	3.44	21	6	27
3. Jowar (K) & Green Manure	6	3.44	21	6	21
4. Hy. Jowar (K)	9	3.44	31	6	31
5. Wheat (R) & Hy. Jowar (R)	18	3.44	62	6	62

C. Perennial Scheme with Diesel Power

(i) Direct (running) charges

(i) Total water to be pumped

Same as per A-Perennial Scheme with Electric Power = 23,625 Acre inches.

(ii) No. of working hours.

Same as per A-Perennial Scheme with Electric Power = 3,375 Hours.

(iii) Cost of fuel consumption

H. P. = 120

Consumption of low Diesel oil (crude oil) specific gravity 0.86 is 0.5 lb. per B.H.P. Hour.

∴ Quantity of L.D. O. in lbs.

= H.P. × total working hours × rate of oil consumption per B.H.P. Hour.
= $120 \times 3,375 \times 0.50 = 202,500$ lbs.

The rate of L.D.O. per lb. including transport charges upto pumping station = Rs. 0.21.

∴ cost of L.D.O. = $2,02,500 \times 0.21 = \text{Rs. } 42,525$.

for consumption of lubricating oil etc. add 25 per cent of cost for L.D.O.

∴ Total cost of running = $42,525 + 10,631 = 53,156$

cost per acre inch = $\frac{53,156}{23,625} = \text{Rs. } 2.25$

2. Fixed charges

Government Scheme

(i) Depreciation—

(a) Civil	1,398
Mechanical	1,115
(b) Interest	18,480

(ii) Maintenance at 3 per cent on machinery	
$\frac{2,25,000 \times 3}{100}$	6,750

(iii) Maintenance at 1½ per cent on civil works	
$\frac{1,11,000 \times 1.5}{100}$	1,665

(iv) Staff for running the scheme	2,000
Cost per acre inch =	$\frac{41,408}{Rs. 1.75}$

3. Total cost per acre inch = $2.25 + 1.75 = Rs. 4.00$

4. Water rates—

	Crop	Acres	Acres inches	Rate	Amount	Irrigation charges	Total
	1	2	3	4	5	6	
1.	Sugarcane	.. .. .	125.5	4	502	40	542
2.	Other perennials	.. .. .	76	4	304	25	329
3.	Paddy	.. .. .	8	4	32	....	32
4.	Groundnut	.. .. .	6	4	24	6	30
5.	Green Manure, K. Jowar	.. .. .	6	4	24	....	24
6.	Hy. Jowar (K)	.. .. .	9	4	36	....	36
7.	Wheat and Hy. Jowar (R)	.. .. .	18	4	72	....	72
8.	Cotton	.. .. .	33	4	132	33	165

1) Non-perennial Scheme with Diesel Power

(i) Direct (Running) charges—

Total water to be pumped.

Same as per B-Non-perennial Scheme with Electric Power = 13,150 Acres inches.

(ii) Number of working hours—

Same as per B-Non-perennial Scheme with Electric Power = 2,192 hours.

(iii) Cost of fuel consumption—

H.P. = 110.

Consumption of Low Diesel Oil (Crude oil).

Special gravity 0.86 is 0.50 lbs. per B. H. P. hour.

∴ Quantity of L. D. O. in lbs.

= H.P. × Total working hours × rate of oil consumption per B. H. P. hour.

= $110 \times 2,192 \times 0.5$.

= 1,20,560 lbs.

The rate of L. D. O. per lbs. including transport charges up to pumping station = Rs. 0.21

Cost of L. D. O. = $1,20,560 \times 0.21 = Rs. 25,318$.

For Lubrication oil etc. add 25 per cent of cost of L. D. O. = Rs. 6,330

31,648

Cost per acre inch $\frac{31,648}{13,150} = Rs. 2.40$

(2) *Fixed charges.*—(For the scheme in state or local sector)

(i) (a) Depreciation calculated as annual contribution to a sinking fund bearing interest at 5 per cent.

$$\text{Civil part (life 40 years)} = 0.0126 \times 1,11,000 = 1,398$$

$$\text{Mech. part (life 15 years)} = 0.0494 \times 1,75,000$$

$$\text{Total} = \frac{8,645}{10,043}$$

$$(b) \text{ Interest at } 5\frac{1}{2} \text{ per cent} = \frac{2,86,000 \times 5.5}{100} = \frac{15,730}{25,773}$$

(ii) Maintenance at 3 per cent on machinery

$$\frac{1,75,000 \times 3}{100} = 52,50$$

(iii) Maintenance at 1½ per cent on Civil works—

$$\frac{1,11,000 \times 1.5}{100} = 1,665$$

(iv) Staff for running the schemes = $\frac{2,000}{34,688}$

$$\text{Cost per acre inch} = \frac{34,688}{13,150} = \text{Rs. } 2.64$$

(3) Total cost per acre inch = 2.40 + 2.64 = Rs. 5.04

(4) Water rates—

	Crop	Acre inches	Rate	Amount	Irrigation charges	Total
	1	2	3	4	5	6
1.	Paddy	8	5.04	41	....	41
2.	Groundnut	6	5.04	30	6	36
3.	Jowar (k) and Green Manure	6	5.04	30	....	30
4.	Hy. Jowar (k)	9	5.04	45	....	45
5.	Wheat (R) and Hy. Jowar (R)	18	5.04	91	....	91

APPENDIX VI

Typical calculations of benefit cost ratio

Assume irrigable area 500 acres.

$$\text{Benefit cost ratio} = \frac{A}{B}$$

A. represents annual net benefit.

B. represents annual cost.

A. Annual net benefit :—

(1) Value of irrigated produce

Serial No.	Name of Crop	Area in acres	Value of net produce in Rs. per acre (Table IX)	Amount Rs.
1	2	3	4	5
1	Sugarcane	100	879	87,900
2	Other perennials	25	304	7,600
3	Cotton L. S.	25	510	12,750
<i>Kharif Seasonals</i>				
4	Paddy	50	220	11,000
5	Groundnut	50	385	19,250
6	Jowar	100	150	15,000
7	Hy. Jowar	100	225	22,500
<i>Rabi Seasonals</i>				
8	Wheat	100	126	12,600
9	Hy. Jowar	175	225	39,375
10	Green Manure	200	21	4,200
				2,32,175

(II) Deduct value of existing (unirrigated) produce

An existing (before irrigation) cropping pattern is assumed and the value of existing crop is worked out as per statement attached which comes to Rs. 40,290.00.

Thousand Rs.

I. Value of irrigated produce	..	..	..	..	..	..	232.2
II. Value of unirrigated produce	..	..	..	..	..	..	40.3
							Net benefit
							191.9

B. Annual cost (from Appendix VI)—

(a) Direct (running) charges	..	..	..	..	..	..	27,273
(b) Fixed charges	..	..	..	..	..	..	36,568
(c) Administrative charges at Rs. 5 per acre for 500 acres	..	..	..	..	..	..	2,500
							66,341

$$\therefore \text{Benefit cost ratio} = \frac{A}{B} = \frac{191.9}{66.34} = 2.90$$

ACCOMPANIMENT TO APPENDIX VI

Serial No.	Name of Crop	Per cent of existing crops	Area in acres	Produce in quintals per acre Table No. X	Net benefit per quintal (Rs.) Table No. VIII	Net benefit per acre (Rs.) Column 5 × 6	Net benefit in Rs. for the area in Column 4
1	2	3	4	5	6	7	8
1	Jowar (K)	30	150	3.07 Q.	30.9	94.36	14,229
2	Groundnut (K)	16	80	2.88 Q.	50.6	145.73	11,658
3	Bajari (K)	22	110	0.77 Q.	21.6	16.63	1,829
4	Tobacco (K and R)	5	25	2.05 Q.	91.1	186.76	4,669
5	Wheat (R)	2	10	2.08 Q.	38.7	80.50	805
6	Gram (R)	3	15	1.57 Q.	17.7	27.79	417
7	Jowar (R)	10	50	3.07 Q.	30.9	94.86	4,743
8	Grass	4	20	....	....	9.00	180
9	Tur	3	15	2.86 Q.	23.6	67.50	1,013
10	Other pulses	5	25	1.12 Q.	26.7	29.90	747
		100	500				40,290

Say 40.3 thousand