GOVERNMENT OF INDIA
PLANNING COMMISSION

A report
by the Study Group on Irrigation and Power
of the
National Planning Council

on

HE HIRAKUD PROJECT

AUGUST 1967

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Purposes and scope of the report.

At a meeting of the Study Group on Irrigation and Power of the National Planning Council, held in May 1965, it was decided to undertake case studies of a few typical multi-purpose projects with a view, ultimately, to evolve general criteria or norms in respect of the use of a available waters for various purposes. To start with, it was proposed that the Hirakud Project in Orissa and the Chambal Project in Rajasthan and Madhya Pradesh be taken up for such studies in association with the officers concerned of the State Governments. The Chief Minister of Orissa approved of the proposal and the following report represents the result of the studies made in respect of the Hirakud Project including the Delta Irrigation Scheme.

The study excludes from its purview all problems relating to the construction of the project which has been completed or is nearing completion. It concerns itself mainly with the operation of the project, all developments flowing from it and the measures relating to maximising benefits from the project.

The factual data in the report are as obtained by the Group from published reports or from the officers of the State. The comments and recommendations of the Group have been clearly indicated.

The Project.

2. The Hirakud Project, on the river Mahanadi, in Orissa, was undertaken in 1949 on the basis of a project report prepared by the Central Water and Power Commission in June 1947. It was then conceived as a multi-purpose project to provide :

(i) flood control in the Mahanadi Delta,

(ii) irrigation of 4,95,000 acres (C.C.A.) by flow, and 3,80,000 acres by lift, with an intensity of irrigation of 100 per cent in *kharif* and 25 per cent in *rabi*, for both flow and lift irrigation; annual irrigation about 11 lakh acres;

(iii) power to be generated at the toe of the dam, and at a lower power house, with an installed capacity of 3,50,000 KW, comprising 6 units of 25,000 KW each in the dam power house and 8 units of 25,000 KW each in the lower power house, with provision for future expansion;

(iv) navigation in the river below Hirakud.

3. The total cost of the project, as then estimated, was Rs. 47.81 *crores*, allocated as follows :

Flood control	6.11 *crores*
Irrigation	11.12 ,,
Power	29.58 ,,
Navigation	1·00 ,,

4. Several modifications were later made in the scope of the project. The proposal to develop irrigation by lift was abandoned; so was navigation. The power installation in the dam power house was reduced and the lower power house was indefinitely postponed in December 1951. In March 1956, however, the lower power house was again sanctioned and taken up as stage II of the project. This stage also restored the reduction made in 1951 in the generating capacity at the dam power house. The storage in the reservoir was increased and there were many changes of design etc.

The original project had indicated the possibility of increasing irrigation in the Mahanadi Delta by utilising the regulated flow from the Hirakud reservoir. The Delta Irrigation Scheme was, however, not sanctioned until September 1955; work was started only in 1958.

5. The main features of the Hirakud Project, including stages I & II and the Delta Irrigation Scheme, as finally approved are as follows:

(i) A composite dam, about three miles long, with dykes extending over 13 miles, maximum height 200 feet, spillway capacity 1,463,000 cusecs, total storage capacity 6.6 M.A.F., live storage between F.R.L. 630 and R.L. 590, dead storage level 4.72 M.A.F.

(ii) Three perennial, contour canals, unlined for most part, C.C.A. 378,000 acres, proposed annual irrigation 600,000 acres—

(a) Bargarh Canal, right bank, physical capacity 4,802 cusecs, full supply discharge 3,822 cusecs, C.C.A. 310,000 acres.

(b) Sason Canal, left bank, full supply discharge 630 cusecs, C.C.A. 55,500 acres.

(c) Sambalpur distributary, left bank, full supply discharge 127 cusecs, C.C.A. 10,100 acres

(iii) Two power houses—

(a) one below the main dam, 4 units of 37,500 KW each and 2 units of 24,000 KW each.

(b) another at Chiplima, about 16 miles below the dam, with 3 units of 24,000 KW each

(iv) Requisite transmission lines.

(v) Under the Delta Irrigation Scheme:

(a) A new weir at Mundali and a new unlined canal on the right bank of the Mahanadi, full supply discharge 6,000 cusecs. C.C.A 566,578 acres, proposed annual irrigation, including 67 per cent of double cropping, 923,00 acres.

(b) Raising the old weir for the Orissa Canals by 1.5 feet and enlarging and extending the three old canals on the left bank of the Mahanadi, aggregate full supply discharge 6,867 cusecs, C.C.A.

411,000 acres (including 200,000 acres under the old canals), proposed annual irrigation, including 67 per cent double cropping, 685,000 acres.

(c) Adequate drainage and protective measures.

6. Work on the main dam was started in 1949 and it was opened for operation in 1956. Irrigation was started, for the first time, from the Bargarh Canal on 27th September, 1956, and the other two channels were opened on 2nd October, 1956. The first unit for power generation in the upper power house went into action on 19th December 1956, and that at Chiplima power house on 15th July 1962; the last unit in the upper house was brought into operation on 25th July 1963 and that at Chiplima on 14th September 1963.

7. The work on the Delta Irrigation Scheme was started in 1958 and is still in progress. However, there has been a slow but steady increase in irrigated area in the old delta on the left of the Mahanadi and the new canal, on the right side, has been opened in *kharif* 1966. The entire work is expected to be completed by June 1969.

8. As at the end of 1963-64, the latest year for which administrative accounts of the project have been published, the expenditure on the project was:

Hirakud Dam Project	Capital outlay (Crores of rupees)	Estimated cost
Stage I	82.41*	68.35
Stage II	13.37**	15.00
	95.78	83.35
Delta Irrigation Scheme .	15.56	14.92†

*Inclusive of interest charges, 16.15 crores, capitalised at the end of 1961-62.

**Inclusive of interest charges, 0.17 crores, capitalised at the end of 1961-62.

†Estimate since revised to 34.33 crores, not yet sanctioned.

Hydrology.

9. **River at Hirakud.**—Observation of river flow was started at Hirakud in 1947, first at Sambalpur, 8 miles below Hirakud, and later at the new Mahanadi bridge below Hirakud. The monthly inflow, as observed or estimated since then,* is shown in Statement I. No flow data are available for any period prior to 1947 but, on the basis of a gauge record at Sambalpur and gauge-discharge curve, based on the observations made between 1947 and 1951 at Sambalpur, the river flow at Hirakud has been computed from 1921 to 1946, only for the monsoon months, July to October.

10. A perusal of Statement I shows that the average annual yield (for the period 1947-48 to 1965-66) of the catchment above Hirakud is 32.9 M.A.F. of which 30.4 M.A.F. (about 93 per cent) flows during the monsoon or 'reservoir filling period', July to October, and the balance during the depletion period, November to June.

11. A perusal of the inflow statement also shows that, during the 19 years period, for which flow data are available, there were five years in which the annual river flow was considerably less than the mean, the actual minimum being only 12.8 M.A.F. during 1965-66. In other words, one out of four years is likely to be a year of low supply at Hirakud

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*For the period from 1st July 1947 to 20th April, 1951, discharges have been taken from a gauge-discharge curve prepared for the Sambalpur site and for the period from 21st April 1951 to the beginning of reservoir operation in 1956, the discharges have been taken from a gauge-discharge curve prepared for Mahanadi bridge site.

The spillway dam was completed and water was inpounded in the reservoir during the monsoon of 1956. Since then, the rise and fall in the reservoir level, the outflow from the reservoir for different purposes and the water escaped from the surplusing works form the basis of the discharges. For this purpose, the quantity of water stored in, or released from, the reservoir is calculated on the basis of a capacity curve of the reservoir, prepared on the basis of a contour survey of the reservoir area, the quantity spilled is calculated on the basis of discharge formulae given by the Poona Research Station, that passed through the turbines is based on the formulae given by the manufacturers, and that let into the canals is based on formulae given by the Central Water and Power Commission (Central Design Office). The evaporation loss is taken the same as assumed in the project report.

12. **River above Hirakud.**—The catchment area above Hirakud is 32,200 square miles, out of which 27,900 square miles (about 87 per cent) lie in Madhya Pradesh. No data of river flow at any point in the catchment above Hirakud are available for any period prior to 1957. In that year, observation of river flow was started at two sites—One at Saradih on the river Mahanadi, about 60 miles upstream of Hirakud (catchment area 22,000 square miles) and other at Deogan, on the Ib tributary, about 43 miles upstream of Hirakud (catchment area 5,830 square miles). More recently, four additional discharge sites have been set up in the catchment, one in 1961, two in 1963 and the fourth in 1964. It is proposed to set up two more such sites.

Observations are made at these sites of gauge, discharge and rainfall during the monsoon months, June-October, at 6 hourly intervals, or more frequently during floods. During other months, discharges are not observed except at Saradih at which site discharges are observed daily all the year round.

13. **River below Hirakud.** —Data of river flow at Naraj, at the head of the Mahanadi delta, about 189 miles below Hirakud (catchment area 51,000 square miles) are available on a long term basis. Observation of gauge and discharges was started at two new sites in 1947—Barmul and Kaimundi, respectively 133 and 180 miles below Hirakud. Another discharge site was set up at Khairmal in 1957, about 59 miles below Hirakud, down stream of the confluence of a major tributary (river Tel) and, in 1963, one more discharge observation site was set up at Balgaon, on the river Tel about 70 miles above its confluence with the Mahanadi.

14. **Meteorological data.**—There are a large number of rain gauge stations in the Hirakud area. To get data for evaporation, a masonary tank 15 feet in diametre has been built in one of the islands in the reservoir and observations are being made from this tank since March 1966.

15. **Comments and recommendations.**—It would appear from the above that in connection with developments from Hirakud, costing about 130 *crores* and on which more than Rs. 111 *crores* have already been spent, even after 20 years from the inception of the project, hydrologic data collection leaves much to be desired, both in coverage and in the methods adopted.* It seems that hydrologic data collection has so far received little attention.

*A comparison of the discharges, as observed at Saridih and Deogaon, with those calculated at Hirakud, lower down, has been made in Appendix II. An abstract is given below.

Month and year	Volume of flow as observed at		Total	Volume of flow as calculated at Hirakud
	Saridih	Deogon		
Catchment area in square miles	22,000	5,830	27,830	32,200
		million acre-feet		
July 1965	2.64	0.44	3.08	2.30
Aug. '65	1.28	0.38	1.66	2.70
Sep. '65	2.66	0.39	3.05	4.44
Oct. '65	0.40	0.07	0.47	0.50
June 1966 (17-30)	1.05	0.29	1.34	2.06
July '66	2.54	0.44	2.98	3.96
Aug. '66	6.43	1.19	7.62	8.05
Sep. '66	1.28	0.20	1.48	1.64

It would be obvious from the above that the difference between the aggregate volume of flow, as observed at Seridih and Deogaon, and that calculated at Hirakud cannot be explained by the catchment area between Hirakud and the two upper sites (4,370 square miles). A large part of this difference must be due to the indifferent methods of observations, as adopted at the upper two sites, and that adopted for calculating the inflow at Hirakud.

16. From the point of view of optimum water use and to get maximum benefits from the large investments made, it is imperative that :

(i) a discharge site should be established in the Mahanadi, about 5 miles below Chiplima power house at which daily discharge observations should be made by current meter following the relevant standards of the Indian Standard Institute.

The results of these daily observations would provide a much needed check on all the empirical formulae being used for calculating discharges through gate openings etc. at the dam,

(ii) daily withdrawals by canals and distributaries should be estimated on the basis of properly maintained gauge discharge curves, again following the relevant Indian Standards;

(iii) the recommendations made in paragraph 33 should be implemented.

Reservoir operations

17. The principal features of reservoir operations, on a monthly basis, are shown in Statement II. The last power unit in the main dam power house was installed in July 1963 from which date the reservoir operations may be taken as representing ultimate conditions. A working table for the reservoir, as last prepared by the "Evaluation Committee" in 1962, is also shown in Statement II.

18. It will be seen that, since 1963, the conditions during the 'filling period' were as follows :

Year	Inflow	Utilisation			Quantity stored at end of period	Spills and evaporation losses
		for irrigation	for power	Total		
		million acre-feet				
1963	27.90	0.42	2.50	2.92	4.19	20.79
1964	41.37	0.47	2.64	3.11	4.17	34.09
1965	10.39	0.82	2.36	3.18	3.92	3.29
1966	13.97	0·66	2.31	2.97	1.22	9.79

In 1966, the river was very low in September and the maximum live storage in the reservoir was only 2.517 M.A.F. against the designed live capacity of 4.72 M.A.F.

19. During the 'depletion period', the project performance, since 1963, has been as under :

Year	Inflow	Utilisation			Net storage utilised in period	Spills and evaporation losse
		for irrigation	for power	Total		
		million acre-feet				
1963-64	2.41	1.14	4.26	5.40	4.31	1.32
1964-65	1.72	0.87	4.52	5.39	4.13	0.46
1965-66	2.44	0.93	3.69	4.62	3.73	1.55

20. On an annual (hydrologic year) basis, the position may be indicated as below :

Year	Inflow	Utilisation			Storage*		Spills and evaporation losses
		for irrigation	for power	Total	effected	utilised	
		million acre-feet					
1963-64	30.31	1.56	6.76	8.32	4.27	4.44	22.11
1964-65	43.09	1.34	7.16	8.50	4.36	4.27	34.55
1965-66	12.83	1.75	6.05	7.80	4.34	4.74	4.84

21. During rabi 1964-65, the irrigation channels of one of the sub-divisions remained closed for special repairs; hence the low irrigation use in that period and year.

As 1965-66 was a low supply year, even though the reservoir filled in September, it had to be drawn upon in October. It became necessary, by 1st April, 1966, to impose a power cut of

*These figures are on an annual basis and have been derivedindepenendently of those given earlier for the 'filling period' and the 'depletion period'.

20 per cent on all large installations drawing 125 KVA and more. It is stated that no limitation was placed on canal withdrawals, however, the canals remained closed from 15th May to 24th June.

22. It will be noticed by comparison with the 'working table' that, during the 'filling period', against an estimated irrigation use of 1.02 M.A.F., the maximum so far developed is 0.82 M.A.F. or about 80 per cent. In the same period, against a total designed use of 2.59 M.A.F. for generation of power, the actual use has been of the same order. The entire use in the 'filling period' except for a small amount in some years in October, is met directly from river flow.

The use during the 'depletion period' has reached a maximum of 5.40 M.A.F. against an estimated quantity of 6.1 M.A.F.; the maximum for power being 4.52 M.A.F.; against 4.68 M.A.F. designed, and that for irrigation being 1.14 M.A.F. against 1.42 M.A.F. as per 'working table', i.e., about 80 per cent.

It would be noticed that the storage actually effected in these years did not exceed 4.36 M.A.F. even though, in 1965-66, the total use from storage exceeded the designed use by a small margin.

Flood Control.

23. One of the principal purposes of the Hirakud Project is flood control in the delta area. There are, however, two limitations inherent in the situation. Of the total catchment area of 51,000 square miles at the head of the Delta at Naraj, only 32,200 square miles, or about 63 per cent, is upstream of Hirakud. The reservoir at Hirakud can thus have no effect on the run off from 18,800 acres below the Hirakud dam and the floods on account of this run-off must reach Naraj uncontrolled.* Since the Hirakud Project is a multi-purpose scheme, it is important from the point of irrigation and power that, at the end of the flood season, the reservoir should be full to meet the demands of these purposes during the eight dry months of the year.

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*According to a study made in September 1964 by Shri J. Tripathy Chief Construction Engineer, Hirakud, the catchment below Hirakud is, by itself, known to have contributed an estimated peak discharge of about 9.5 lakh cusecs at Naraj.

24. In view of the limitations described above, from the very beginning, the intention has been that the reservoir should be utilised for flood control during the earlier part of the rainy season and the filling should be carried out towards the end of the monsoons in September and October. After detailed consideration of all the relevant factors, the "Evaluation Committee", appointed by the Orissa Government, proposed in August 1962 the following rules for the operation of the reservoir.

If there are early rains in June and the reservoir level is below 595, it would be brought up to to 595 and kept at 595 till the 30th June.

The reservoir level should be brought down to 592 by the 2nd of July and maintained at 592 during July.

In August, the reservoir level should be kept at 590. From the 26th August, filling should be commenced so that the reservoir level will not exceed R.L. 600 by the 1st September, R. L. 615 by 11th September and R.L. 625 by 21st September. After the 21st September, the filling should be continued to R.L. 630.

In June, July and August, the river flow below Hirakud should be controlled (subject to the rules formulated for the operation of the spillway and under-sluices) such as to limit the flood peak at Naraj to 9 lakh cusecs (gauge 87 at Naraj) until the reservoir level rises to 615. From R.L. 615 to R.L. 620, the flood peak at Naraj should be taken as 10 lakh cusecs (gauge 88.0). Above R.L. 620, the regulation has to be effected solely from consideration of the safety of the dam and there is no limit on the discharge from the reservoir. The maximum water level in the reservoir is limited to R.L. 630.0*, the same as the F.R.L.

In September, as the reservoir level is high and also in July, care is to be taken to lower the reservoir on intimation of heavy rains in the upper catchment.

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*It is understood that the dam is safe for a maximum water level of 631.0; but so far the water level has not been allowed to exceed R. L. 630.5. The gates were designed for a maximum water level of 630.0.

According to these rules, the full capacity of the reservoir, from R.L. 590 to R.L. 630, *i.e.*, 4.72 M.A.F. is available for flood control in June, July and most of August. In September, the capacity available for flood control depends on the level attained in the reservoir and the ability to lower it in anticipation of the approach of a high flood. Very heavy floods with large volumes were, it was stated, not frequent in September.

25. The following table shows the minimum time required to empty the reservoir at different elevations to R.L. 590, the dead storage level *i.e.*, by spilling at the maximum rate permissible under the regulation rules:

Maximum time for emptying reservoir

Reservoir level	Live storage (M.A.F.)	Maximum spilling rate (million cusecs)	Time required to attain spilling rate in col. (3) (hours)	Minimum time to release full live storage (hours)
(1)	(2)	(3)	(4)	(5)
592.0	0.147	0.677	6	6
595.0	0.368	0.692	6	9
600.0	0.736	0.715	6	15
605.0	1.280	0.736	8	24
615.0	2.438	0.887	8	41
625.0	3.889	1.120	8	58
630.0	4.723	1.435	8	66

It is thus seen that it takes only 15 hours to empty the reservoir at R.L. 600.00 and about 2 days if the reservoir level is at about 615.0.

26. For purposes of reservoir operation, with particular reference to the requirements of flood control, the data of rainfall and river flow are at present being received at Hirakud, by

wireless, as follows, from six stations in the catchment above Hirakud and from four below it:

Name and particulars of station	Date from which operating	Nature and frequency of data furnished
1. *Ghorari*, on the Mahanadi, 159 miles above Hirakud, C.A. 5,100 square miles.	1963	Gauge, discharge and rainfall, every 6 hours or more frequently during floods.
2. *Champa*, on the Hasdeo tributary 108 miles above Hirakud, C.A. 4,530 square miles.	1963	As for (1) above
3. *Seorinarayan*, on the Mahanadi, 99 miles above Hirakud, C.A. 18,000 square miles (inclusive of (1) above).	1961	As for (1) above.
4. *Saridih*, on the Mahanadi, 60 miles above Hirakud, C.A. 22,018 square miles (inclusive of (2) and (3) obove).	1957	As for (1) above and silt charge.
5. *Sundergarh*, on the Ib tributary, 67 miles above Hirakud.	1964	As for (1) above.
6. *Deogaon*, on the Ib tributary, 43 miles above Hirakud, C.A. 5,830 square miles	1957	As for (4) above.
7. *Khairmal*, on the Mahanadi, 59 miles below Hirakud and below the confluence of Tel tributary, C.A. 44,600 square miles.	1957	As for (1) above.
8. *Barmul*, on the Mahanadi, 133 miles below Hirakud.	1947	Gauge and rainfall (Gauge-discharge curve available).
9. *Kaimundi*, on the Mahanadi, 180 miles below Hirakud and 9 miles above Naraj.	1947	Same as (8) above.
10. *Balgaon*, on the Tel distributary, 70 miles above Khairmal.	1963	Same as (1) above.

27. In addition to the above, rainfall data are received daily from three other stations below Hirakud—Phulbani, Bhawanipatna and Bolangir. It is proposed to establish two more river gauging stations, one at Nandaghat, on the Seonath tributary, 143 miles upstream of Hirakud [C.A. 11,140 square miles included in (3) above] and another at Tarapore, on the Mand tributary, 75 miles upstream of Hirakud [C.A. 2,820 square miles, not included in (4) above]. During the year 1966, however, data were being received only from stations (3), (4) and (6) above.

All these stations operate only during five months from June to October, each year, except Saridih where discharges are observed all the year round.

28. Apart from the information set out above, heavy rainfall warnings (qualitative) are received from the Indian Meteorological Office Alipore.

Review of rules regarding Reservoir operations and recommendations of the Group.

29. Since the rules referred to in paragraph 24 above were formulated in 1962, reservoir operations have been more or less satisfactory from the point of view of flood control. These rules impose, however, a rather severe restriction on the irrigation and power uses possible from the reservoir, particularly in years of low river supply. The restriction will be felt more acutely as irrigation uses develop to the full potential envisaged in the project. So far these uses have developed only partially and some of the water allocated for irrigation has been utilised for generation of power with the result that the overall position has been satisfactory. However, the problem is likely to be felt more acutely in future whenever the monsoon fails and the reservoir does not fill. Another draw-back in the implementation of these rules is that they involve the maintenance of a relatively low operating head, much below the designed head, for a long period, extending over the three months of June, July and August every year. The designed head on the turbines at the dam power house actual operating head, during the three months of June, July and 104 feet for the two generating units of 24 M.W. each while the actual operating head, during the three months of June, July and August, under the present reservoir operating instructions, varies between 69 and 72 feet; the turbines are therefore required to operate under non-optimum conditions during this long period.

The position is particularly bad for the two units of 24 M.W. each rated for a designed head of 104 feet and calls for some improvement.

30. It will be seen from the 'working table' in Statement II that irrigation and power uses, together with evaporation losses, during the months of September and October, amount to 1.834 M.A.F. If the reservoir level on 1st September must not exceed R.L. 600, as required under the rules referred to in paragraph 22 above, the storage to be effected in these two months to R.L. 630 equals 3.987 M.A.F. In other words, if the river flow in these two months should fall below 5.821 M.A.F. (1.834 + 3.987), there would be a shortfall in irrigation and power uses during the following 8 months until the river rises again in the following June. A perusal of Statement I would show that, under these conditions, the reservoir would not have filled on 31st October in 5 out of 19 years, as follows :—

Year	Total river flow in September and October	Short fall
	million acre-feet	
1951	5.304	0.517
1957	3.510	2.311
1962	5.389	0.432
1965	5.340	0.481
1966	1.966	3.855

31. It would thus appear that regulation rules in paragraph 24 above should be modified to provide for :

(i) raising of the reservoir level as early as possible on the outbreak of rains in June to R.L. 600 and maintaining it there during July and August;

(ii) filling above R.L. 600 to commence from 26th August to raise the water level to R.L. 605.0 (live storage 1.28 M.A.F.) on 1st September; and

(iii) such changes in the raising schedule above R.L. 605.0 in September as may be indicated by a detailed study of the daily flows during that month.

The possibility of filling to a level somewhat higher than 605.0 by 1st September should also be examined by making a detailed study of flood disposal under such conditions and the risks involved, if any.

32. These modifications would make for a reasonably good operating head during the early part of the monsoon season and eliminate the shortfall in storage at the end of October in 1951, 1962 and 1965.* They would not impose any undue restriction on the storage capacity available for flood control purposes during June, July and August. As shown in paragraph 23 above, at R.L. 600, the reservoir can be emptied to R.L. 590 (dead storage level) in a period of 15 hours and there is no reason why it should not be possible to get sufficient prior warning of an approaching flood to be able to do so.

33. For proper reservoir operations, particularly from the point of view of flood control, it is necessary that the regulating officer at Hirakud should get a clear picture of the rainfall in the entire catchment, both above and below Hirakud, and not merely from the 14 stations indicated in paragraph 24 above. He should also have available to him, at all times, the most up-to-date long-term forecast of rainfall likely in the next 24 hours, position of all depressions and storms likely to affect the catchment and their movement trends in order that, with the help of actual river flow data at different points, he can anticipate not only the river flow likely at Hirakud but also at the head of the Delta, taking into account the rainfall in the catchment below Hirakud.

For this purpose, it seems imperative that a "Weather Forecasting Office" should be set up at Hirakud, with the help of the India Meteorological Department, on the lines of the Damodar Valley Meteorological unit of the D.V.C. operating for the last 17 years. The Director, Regional Meteorological Centre, Alipore

*During discussions with the Project Officers at Hirakud, in April 1966 they were advised to examine the possibility of adopting a minimum reservoir level of R.L. 600 in July and August. They were able to do so. As would appear from Statement II, the reservoir level was maintained at R. L. 600 in July and August and on 1st September it was 607.27. But for this, the shortfall in storage at the end of October, 1966 would have been still more. With 607.27 on 1st September, the reservoir could be filled in 1966 only up to 615.52 on 21st September after which it had to be drawn upon.

has, at the request of the Study Group, prepared a short note in this connection which is enclosed as Appendix I. It would seem, that, with an annual expenditure of about Rs. 80,000 and a non-recurring expenditure of about Rs. 50,000, the regulating officer at Hirakud would be enabled to regulate the Hirakud reservoir to maximum advantage in the interest of all the purposes—flood control, irrigation and power. The expenditure involved is relatively small in the light of the likely gains.

34. Another important advantage to be gained by the establishment of a Weather Forecasting Office at Hirakud would be in relation to the reservoir operations in September when there is even danger to the safety of the dam should a very high flood occur in the latter half of September. The dam and appertinent structures were designed for a maximum water level of R.L. 630.0 and are considered safe even for R.L. 631.0; but it has been estimated that, during a very heavy flood, the reservoir level may go even 2 feet higher than 631.0. A Weather Forecasting Office at Hirakud would enable the regulating officer to anticipate such a flood and prepare for it by lowering the reservoir level as much as possible. As shown in paragraph 25 above, when the reservoir level is about R.L. 615.0 it would take almost two days to empty the reservoir in order to make the maximum use of the storage capacity of the reservoir for purposes of flood regulation. This can be achieved only if a Weather Forecasting station is set up and functions efficiently.

35. As a complement to the 'Weather Forecasting Office' referred to in paragraph 33 above, it would also be necessary to review the rain gauge stations and discharge sites already established, or being established, above and below Hirakud, and to establish such new stations and sites as may be found necessary. Discharge observations must be organised at all these sites either by current meter ratings or from gauge discharge curves, following the relevant Indian Standards.

Power generation.

36. After flood control, the next important purpose of the Hirakud Project is the generation of power. Of the fatal net utilisation (excluding evaporation losses), at Hirakud, of 6.10 M.A.F. during the 'depletion period', November to June, as shown in the 1962 Working Tables (reproduced at the end of Statement II), 4.676 M.A.F. or about 77 per cent are to be utilised for power

generation, first at the dam power house and again at the Chiplima power house. The releases below Chiplima are, however, available for irrigation development in the Mahanadi Delta.

In addition to the above, utilisation for power generation of 2.594 M.A.F. is planned during the 'filling period'—July to October.

37. As shown in paragraphs 15-17 above, during 1964-65, the actual utilisation for power generation was almost equal to that proposed. During 1965-66, due to unusually low supplies during October-May, a power cut had to be imposed at Hirakud, for the first time. This cut would have been more severe had the irrigation use been as planned. Unfortunately, the prospects for 1966-67 are also poor due to an unprecedented low river in September. A perusal of Statement I would, however, show that power development, as planned at Hirakud, may be taken as assured for most years.

38. The development of power at Hirakud and its utilisation do not seem to require any further comment. No change appears to be indicated in the present system of operations, whether at the main dam or at Chiplima. Except when the reservoir is low, two out of the three units at Chiplima are in operation. At the dam power house, a minimum of 3 units but usually 4 or 5 units are in operation. Although the Chiplima power house was intended to be a base load station and all the fluctuations were to be taken by the upper power house, in practice, it is not exactly so. Between the two stations, however, they are able to take all the load fluctuations and the pondage capacity in the power channel and that in the pond above Regulator I in the power channel (5,764 acre-feet) are adequate. The transmission losses are within reasonable limits.

39. Although there is plenty of the water available in the river for additional power generation during the monsoon, it is understood that there is not much scope for doing so as any increase in the present releases down-stream of the power house in the dam would raise the tail water level unduly high when compared with the floor level of the power house.

Irrigation development.

40. The third principal purpose of the Hirakud Project is

the development of irrigation, about 6 lakh acres* annually, from the Hirakud reservoir, and about 14 lakh acres annually, in the Mahanadi delta, apart from the area already irrigated in the delta by the old Orissa Canals.

41. **Irrigation from Hirakud.**—As stated in paragraphs 5 and 6 above, three canals, one on the right bank and two on the left bank (with an aggregate full supply discharge of about 4,600 *cusecs*) take off from the Hirakud reservoir and have been in operation since 1956. The total length of the main canal and branches is 91 miles and of the distributaries and minors, as constructed, 254 miles. Apart from the quantum of supplies let into these canals from November 1967, as shown in Statement II, there is not much information available about irrigation development from these canals prior to *kharif* 1962. Important particulars of the development since then are shown in Table I. Taking the figures of the irrigation Department, the area irrigated, ten years after the project came into operation, is 84 per cent of the designed, in kharif, and about 83 per cent in *rabi*. According to revenue records, the performance would be about 73 per cent.

42. It will be seen that according to the 'Working Table' prepared in 1962, 1.363 M.A.F. of water is intended to be utilised for the irrigation of 380,000 acres in *kharif*, giving a seasonal delta at canal head of 3.6 feet. During *rabi* it is proposed to utilise 1.085 M.A.F. for the irrigation of 2,20,000 acres, a seasonal delta of 4.9 feet. Taking the year as a whole, it is proposed to utilise 2.448 M.A.F. of water over an area of 380,000 acres, giving a delta, at canal head, of 6.4 feet on (C.C.A.). The annual rainfall in the area is well over 50 inches, mostly in kharif.

The actual deltas for the latest year for which information is available are :

	As per figures of Irrigation Department (feet)	As per figures of Revenue Department (feet)
Kharif	3.0	3.5**
Rabi	4.7	6.8

*In the original (1947) project, the proposed annual irrigation from the reservoir was 11 lakh acres and the annual water use for irrigation 3.63 M.A.F.

**Taking the area irrigated as 278,000 acres, same as in 1963-64.

43. The canals remain closed for about a month during May-June. The actual dates of closure during the last 5 years were as follows :

Year	Period	No. of days
1962	May 15 to June 15	32
1963	May 15 to June 21	38
1964	May 3 to June 7	36
1965	May 1 to June 1	32
1966	May 15 to June 24	41

The pattern of canal withdrawals, as during 1965-66, is illustrated in figure 1 which shows the discharge let into the head-regulator of the Bargarh Canal. It will be seen that the canal approaches its full supply from mid-September to end-October and three-quarter full supply from mid-February to mid-April. In December the canal withdrawals are low.

44. Little information is available about the pre-project cultivation pattern in the area covered by the project. For the Sambalpur district, as a whole, of the area cultivated annually, autumn paddy* was 20 per cent, winter paddy 72 per cent, pulses and oil seeds 6 per cent, and other crops 2 per cent.

According to the officers of the Agriculture Department, as a result of the introduction of irrigation, the *kharif* cultivation within the commanded area (mostly paddy) has increased from an estimated 2,60,000 acres to 3,00,000 acres. There is also some increase in the area under ground-nuts, from about 2,000 acres to about 10,000 acres.

45. To begin with, after the introduction of irrigation, there was a tendency towards growing long-term paddy in the higher areas (*At* and *Mal*) but, over the last two or three years, this tendency has been reversed and long-term paddy is now generally confined to the lower areas (*Berna* and *Bahal*), the short-term

*i.e., paddy harvested in autumn.

paddy to higher areas, Whereas, prior to the introduction of irrigation, most of the rice was broadcast, it is now transplanted in the lower areas (*Berna* and *Bahl*-estimated variously between 25 and 40 per cent of the C.C.A.).

46. There has been little change in the calendar of agricultural operations. In *kharif*, paddy continues to be broadcast or sown in nursery beds about the middle of June, after the first monsoon shower. Sowing operations take about two weeks. Transplanting begins about a month later and is carried on from mid-July to mid-August. Harvesting begins in the higher lands about 10th of October, it continues until mid-December. Irrigation of paddy ceases about mid-November. Ground-nuts are sown in mid-June after the first shower and harvested by mid-October. This crop requires only supplemental irrigation during breaks in the monsoon.

In *rabi*, *dalua* paddy is sown in mid-January and harvested from end-April to end-May.

47. According to the statistics available from the Irrigation Department, the crop pattern during *rabi*, for the last three years, was as follows:

	Dalua paddy	Sugarcane and bananas	Wheat	Potatoes and vegetables	Others	Total
			thousand acres			
1963-64	127	7	2	6	2	144
1964-65	127	6	2	5	3	143
1965-66	165	4	1	6	6	182

It will be noticed that *dalua* paddy contributes about 90 per cent of the rabi crop.

48. It may be noted that the revised estimate of 1953 envisaged the following crop pattern:

Kharif

Paddy	70 per cent of C.C.A.
Other *kharif*	20 per cent of C.C.A.
Sugarcane	10 per cent of C.C.A.

Rabi

Dalua paddy	30 per cent of C.C.A.
Cash *rabi*	15 per cent of C.C.A.
Light *rabi*	5 per cent of C.C.A.

However, since the C.C.A. was later found to be only 380,000 acres (against 448,000 acres assumed in the revised estimates of 1953) the *rabi* percentages were increased to the following :

Dalua paddy	35 per cent of C.C.A.
Cash *rabi*	17 per cent of C.C.A.
Light *rabi*	6 per cent of C.C.A.

The crop pattern which has actually developed on the Hirakud project is, however, much different from that proposed in the 1953 revised estimate or decided upon later. While the exact crop pattern for *kharif* is not available, it appears that about 90 per cent is paddy, the remaining 10 per cent comprising sugarcane, bananas, ground-nuts etc. In *rabi* as shown above, *dalua* paddy pre-dominates other *rabi* crops are of minor importance.

49. **Water rates.**—No water rates were assessed for the first few years; as already indicated, little information is available of the developments until 1961. An assessment of water rates was, for the first time, made in *kharif* 1961 under the Orissa Irrigation Act 1959, which came into force in 1961 after the Rules under the Act had been notified. There was no assessment, however, during *rabi* 1961-62 but, from 1962 onwards, assessment is being made for both crops, of the 'basic water rate' for *kharif* and the fluctuating water rates for *rabi*. The sums assessed, the amounts realised and the balances outstanding for each crop are shown below :

Crop		Amount assessed	Amount realised	Balance outstanding
		rupees lakhs		
kharif	1961	12.06	0.36	11.70
rabi	1961-62	no assessment		
kharif	1962	13.50	0.32	13.18
rabi	1962-63	3.04	1.65	1.39
kharif	1963	14.09	4.97	9.12
rabi	1963-64	5.90	2.46	3.44
kharif	1964	14.13	1.12	13.01
rabi	1964-65	7.69	3.48	4.21
kharif	1965	14.07	0.78	13.29
	TOTAL	84.48	15.14	69.34

It would thus appear that only 18 per cent of the assessment made has so far been recovered.

50. **Irrigation in the Delta.**—The old Orissa Canals had been designed to serve a C.C.A. of 406,000 in the Mahanadi delta, on the left of the river. The area actually irrigated (average of 10 years ending 1951-52) was 195,000 acres in *kharif*. In rabi, with a dry weather flow of about 150 cusecs, the area irrigated was 77,000 acres.

51. Under the Delta Irrigation Scheme, it is proposed to develop a new area of 566,578 acres, on the righet bank of the Mahanadi, including 51,000 acres to which water will have to be lifted (by 60 feet for 34,000 acres and by 10-15 feet for the rest). On the left bank, it is proposed to provide water for 411,000 acres, including the earlier 200,000 acres irrigated by the Orissa Canals. As regulated flow from the Hirakud power house is available all the year round, it is proposed to irrigate 67 per cent of the entire C.C.A. with a second crop in *rabi*, thus providing an annual irrigation of 1,608,000 acres or an increase of 13.36 lakh acres per year.

52. Canal capacities have been fixed with a duty of 90 acres (of C.C.A.) per cusec of outlet capacity, for most of the area, with 15 per cent for losses from the outlet to the canal head. For some areas in the tail reaches of the canal, a duty of 100 acres per cusec has been adopted and, for the lift areas, a duty of 120 acres per cusec is proposed.

53. As stated in paragraph 7 above, the new canal on the right bank has been opened for operation only in the *kharif* of 1966 and irrigation water made available to 71,000 acres. It is anticipated that the new channels will be completed to irrigate 320,000 acres in 1967, 450,000 acres in 1968 and the entire C.C.A. by 1969.

On the left side, however, the area irrigated has increased by 1966, from 195,000 acres to 349,000 acres in *kharif*, but in *rabi* from 77,000 acres to only 88,000 acres, even though about 10,000 cusecs of regulated flow has been flowing down the river since 1956.

54. The crop pattern, on the left side, actual for 1965-66 (based on the figures furnished by the Irrigation Department) was as follows (percentage of C.C.A. developed) :

Kharif		Rabi	
Paddy . .	92 per cent	*Dalua* paddy . .	2.2* per cent
Jute . . .	7 per cent	Cash . . .	0.6 per cent
Paddy following jute	7 per cent	Light *rabi* . .	21.6 per cent
Sugarcane . .	1 per cent	Potatoes . .	1.2 per cent
Total .	107 per cent		25.6 per cent

This may be compared with the crop-pattern, as proposed in the 1955 Project :

Kharif		Rabi	
Paddy . . .	75 per cent	*Dalua* paddy . .	12 per cent
Jute . . .	15 per cent	Cash *rabi* . .	13 per cent
Sugarcane . .	10 per cent	Light *rabi* . .	40 per cent
		Potatoes . .	2 per cent
Total .	100 per cent		67 per cent

Drainage.

55 The area covered by the canals from Hirakud reservoir lies on both sides of the Mahanadi and is further divided and sub-divided by natural torrents and *nallahs*; there are in all, it is stated, about 2,000 ridges and valleys in this area. Ample slope is available towards and along these natural drainages; the water courses have a slope of about 5-10 feet per mile. The general configuration of the area indicates a varying depth

*According to officers of the Agricultural Department the area under *Dalua* paddy was about 45,000 acres. The Revenue Department figures are not yet available.

of soil over a varying depth of *murram*. The natural drainage is thus good and in spite of the heavy rainfall and the large doses of irrigation water, water-logging has not appeared yet on any significant scale. Also, there is no indication so far of widespread efflorescence or incrustation of salts on the soil surface.

56. Seepage water has appeared on the surface near some irrigation channels and in the lower parts of the valleys which are blocked by numerous village tanks; the total area so affected is, however, of the order of only about 1,400 acres. A scheme was prepared at one time to excavate shallow graded channels along the bottom of the valleys to drain off standing water but, in view of the consequent loss of relatively fertile land under these channels, nothing further was done. Instead, a suggestion has been made that areas which show signs of water-logging should be used for banana cultivation which has shown promising results in some experimental areas.

57. In the delta, where lands are flat, steps are being taken to open up the natural drainages by making a graded channel 10-20 feet wide in their beds. It is proposed to acquire this strip of land and an additional strip of about 10 feet alongside it. It is also proposed to notify these drainages in order to be able to prevent cropping and putting obstructions in them for fishing *etc.*

Irrigation water management.

58. **Water courses.**—As a part of the Hirakud project, about 1,500 miles of water courses were constructed, at a cost of about Rs. 41 *lakhs*. In accordance with the original intentions, this sum was to be recovered from the cultivators over a number of years after the introduction of irrigation. The total number of outlets were 2,094. The average discharge of each outlet was thus less than 2 cusecs and the average length of water courses below each outlet about 0.7 miles.

59. In May 1963, the State Government stated in a letter to the Chief Engineer :

> "2. ..... It should be clearly understood that Government have accepted the responsibility for constructing and maintaining at their own cost all channels upto .....

a block of about 100 acres ..... and that the construction and maintenance of channels ..... within each block is the responsibility of beneficiaries. The latter kind of channels ..... should hereafter be known as Water courses in accordance with the Orissa Irrigation Act ....

"3. The following criteria should be followed for classifying existing channels as water courses and for planning new ones in terms of the Orissa Irrigation Act:

(i) The command of the water course should be such that the discharge required is about 1 cusec unless of course the land is under heavy perennials and/or the owners are few in which case the command could be increased.

Also in exceptional cases the discharges may have to be lower than 1 cusec where the command is badly cut up by sub-drainages and it would not be economical nor practical to have bigger command under the outlets.

(ii) The usual length of the water course should be about 1/2 to 1 mile. If, however, the discharge is higher, the command may be even a little longer.

(iii) The number of land owners drawing water from the water course should not be very high and should be restricted to a managable number.

(iv) The water course should run in its own command from the head downwards.

"4. It has been reported that under the existing Hirakud Irrigation system, there are only 955 outlets and channels with a command of 100 acres and less and the remaining 1139 have commands ranging from 100 to 800 acres. The latter are supposed to serve in all an area of more than 3 lakh acres and these have been described as water courses all these days and proposed for being transferred to the people for maintenance. Government now reiterate that these irrigation channels should no longer be called water courses and no attempt should be made to transfer them to the people. On the other hand, immediate steps should be taken to provide in them suitable outlets to irrigate

compact blocks of 100 acres or so depending on the contour in accordance with the principle laid down above and that these irrigation channels should hence forward be called sub-minors or minors as the case may be."

60. While implementing instructions set out above, a decision was taken by the "Action Committee", at its 6th meeting, that all the 1,500 miles length of water courses, as constructed originally under the Hirakud system, be classified as minors and sub-minors. Accordingly, new outlets have been fixed in the newly called minors and sub-minors and there are now, it is stated, as many as 16,500 outlets which deliver water to 380,000 acres of the C.C.A. of the Hirakud canals. Thus each outlet has an average capacity of about 0.25 cusec and an average command of 23 acres. Hardly any field channels have been constructed below these new outlets and water is taken from field to field.

61. The sum of Rs. 41 lakhs spent on the construction of these water courses would no longer be recovered from the beneficiaries; an additional expenditure of about Rs. 11 lakhs has been incurred on the construction of the new outlets. Apart from this, except for repairing breaches etc. in the new minors and sub-minors (originally water courses), little attention is so far being paid towards the maintenance of these channels; this maintenance is now responsibility of the Government.

62. For the Delta Irrigation Scheme, the original sanctioned estimate provided for the construction of water courses, below outlets of about 5 cusecs each. There was a provision of Rs. 71 lakhs for the areas on the right side of the Mahanadi and Rs. 92 lakhs for those on the left side, recoverable from the cultivators.

According to the new Government orders, outlets must not exceed 1 cusec capacity and all channels leading to such outlets will have to be constructed at Government cost. The Irrigation Department is furnishing to the Collectors concerned maps showing the alignment of water courses below outlets of about 1 cusec capacity for getting the cultivators to construct the water courses. Nothing has, however, so far been done about their construction. It has not been possible to ascertain the total number of outlets actually provided in the delta area.

63. **Government control.**—Three departments of Government are concerned with the management and utilization of the waters of the Hirakud canals:

(i) The Irrigation Department is responsible for the operation and maintenance of the canal net-work (including 1,500 miles of new minors and sub-minors) and for the equitable distribution of supplies to 16,500 outlets on the net-work.

(ii) Six "Irrigation Officers" under the Act (Tehsildars of 4 tehsils in Sambalpur district and of 2 tehsils in Bolangir district) are responsible in addition to their other duties, for dealing with all problems and complaints etc. relating to the internal distribution of water between cultivators on each outlet and for the assessment of canal water charges.

(iii) The Department of Agriculture is responsible for the development of appropriate crop patterns and, acting through the Block Development Officers of the two Zila Parishads (Sambalpur and Bolangir), for all extension work-rendering appropriate advice to the cultivators on all agricultural matters.

64. The Irrigation Department organisation for the Hirakud Project comprises a Superintending Engineer (post at present held by Chief Construction Engineer) who is assisted by an executive engineer for the dam and an executive engineer for the canals. The Executive Engineer Canals Division have five assistant engineers in charge of sub-divisions, four on the canal system on the right bank and one for the canal on the left bank. The five sub-divisional officers are, in turn, assisted by 23 overseers, 1 surveyor, 27 'work sarkars' (*mistris*), 4 *amins*, 181 mates and other skilled and unskilled workers as required from time to time.

65. Of the six Irrigation Officers (Tehsildars), only three have a sizeable area of the project under them; the exact distribution being as follows:

Sambalpur District

	C.C.A. (acres)
Sambalpur Tehsil	69,573
Bargarh Tehsil	193,501
Padmapar Tehsil	2,060
Kochinda Tehsil	571

Bolangir District	C.C.A. (acres.)
Sonepur Tehsil	110,813
Bolangir Tehsil	1,189

Full details of the organisation under each Irrigation Officer are not available. However, the Sambalpur District has in all 11 revenue circles, only six of which are concerned with the area under command of the Hirakud Project. The tehsildar, Sambalpur, concerned with less than one-fifth of the C.C.A., has under him two revenue inspectors (naib-tehsildars), 15 *amins* (of which 12 deal with the commanded area) and about 45 *khalasis.*

66. The principal activities of the Irrigation Officers, apart from those in their capacity as tehsildars, *viz.*, assessment and collection of land revenue, are the assessment and collection of the basic water rate on the entire C.C.A. in *kharif* and the assessment and collection of the fluctuating water rate in *rabi.* In addition, they attend to the complaints of cultivators in regard to the supply of irrigation water in so far as these complaints relate to internal distribution of water between different cultivators on an outlet.

67. The activities of the Agriculture Department are on a district-wise basis and cover both irrigated and non-irrigated areas. There is thus no special organisation for the development of agriculture on the Hirakud Project. The Sambalpur district, however, is included in the Intensive Agricultural District Programme (I.A.D.P.) and the Deputy Director of Agriculture, Sambalpur (Shri B. Misra) is the project leader for the district. This programme extends over about 8 lakh acres of cultivated land in the district out of which 2.7 lakh acres are irrigated. Of the 29 blocks into which the district has been divided, the C.C.A. of the Hirakud Project covers seven blocks fully and four partially.

68. The Deputy Director of Agriculture is assisted by a team of specialists—agricultural chemist, farm management officer, soil chemist, plant protection officer, seed development officer and two agricultural engineers; the last named officers deal with farm layout, machinery *etc.* On the agricultural extension side, the Deputy Director of Agriculture, Sambalpur, is assisted by three district agricultural officers who are administratively under

him; two of these are presently engaged on the irrigated areas. These officers have, however, no assistants of their own and work through the staff of Communities Development under the Block Development Officers. In addition, there are two Agricultural Extension Officers for the Government farms, and two others in charge of co-operatives. Seeds and fertilizers are distributed through these co-operatives.

69. While the intensive agriculture programme extends to large un-irrigated areas in Sambalpur district, it excludes from its purview about 30 per cent of the Hirakud Project area lying in Bolangir district. By *kharif* 1966, this programme had been extended to about 15,000 acres; it is expected to cover about 50,000 acres additional during *rabi* 1966-67. According to the Deputy Director of Agriculture, Sambalpur, as a result of the interest aroused by this programme, the use of fertilizers in Sambalpur district has already increased ten-fold.

70. Apart from a number of seed multiplication farms, the Agriculture Department has three Government research farms in the Sambalpur district; those at Sambalpur and Parmanpur carry out research on different varietal and fertilizer and agronomic practices and the farm at Chakuli on irrigation practices. The Japanese technique of growing paddy is being demonstrated at Chakuli. These farms are under the charge of Farm Managers, assisted by specialists. For example, at the Agricultural Research Station, Sambalpur, there are five research assistants, each a specialist in a branch of the work undertaken at that station.

71. No attempt has so far been made to conduct any co-ordinated studies on soil-crop relationship i.e., aspects such as water use, changes in soil structure, chemical changes in soil, sub-soil water table conditions. Likewise no work has been done on assessing the quality of sub-soil waters and of soils as affected by irrigated cropping practices. A move in this direction has recently been made at Chakuli where on a 10 acre farm, research in agronomic practices under irrigated conditions is being initiated as part of "Major River Valley Project Scheme".

72. The demonstration work undertaken by the Agriculture Department may be described under the following heads:

(a) **Composite demonstration of agricultural fertilizer practices.**—Combination of factors to ensure optimum yield

of a single crop, for example paddy or ground-nut (*kharif*) : Demonstrations are carried out in cultivators' fields under the advice of the Agriculture Department. Such demonstrations are on fields ranging from 1/3 to 2 acres and cover a four-year period. Fertilizers and pesticides are sometimes subsidized.

(b) **Crop pattern demonstration.**—This demonstration is carried out in cultivators' fields on a whole farm, about 5 acres, for both *kharif* and *rabi* crops and extend over a period of three years. The crop pattern adopted is in accordance with the advice of the Agriculture Department, who also arrange supply of seeds, fertilizers *etc.* About 15 such demonstration farms were started in the Sambalpur district in 1965.

(c) **Nation-wide demonstration** relating to crops such as paddy, maize and *ragi* undertaken by specialists aiming at winning the awards offered for obtaining maximum yield of the crop, over an area of 1 to 2½ acres. There are 10 such farms in the district.

73. As a result of the studies and research by the Agriculture Department, the following crop rotation has been recommended for different classes of lands under the Hirakud project, in Sambalpur district :

Kharif	Rabi	
1st crop	2nd crop (non-irrigated)	2nd crop (partially irrigated)
Att lands		
ground-nut (June to Sep.)	niger, *kulthi*	winter vegetables, potato (Oct. to Jan.)
(i) *til*, minor millets, maize, *mung* (June to Oct.)	*kulthi*	do
(ii) niger, castor, *biri* sweet potato (July-Aug. to Dec.)		

Kharif	Rabi	
1st crop	2nd crop (non-irrigated)	2nd crop (partially irrigated)
Mal lands		
jute (June to Sep.) paddy (June to Sep.)	niger, *kulthi*	(i) wheat (Nov. 15 to Mar.) (ii) mustard (Oct.-Mar.) (iii) ground-nut or maize (Oct. to Jan.)
Berna lands		
paddy (June to Oct. 15)	(i) mustard (ii) linseed (iii) gram	onion (Nov. to Mar.)
Bahal land		
danicha (May 15 to July 15)	(i) field peas	pulses (Jan. to Mar.)
paddy (July 15 to Dec.)	(ii) *mung*.	

74. The Delta Irrigation Scheme is under the charge of two superintending engineers of the Irrigation Department—one for the canals on the left of the Mahanadi and the other for the canal on the right side. The superintending engineers are assisted by the usual engineering organisation.

75. Until a few years ago, the Superintending Engineer of the Mahanadi Delta (canals on the left bank of the Mahanadi) was assisted by a revenue deputy magistrate working under him who, together with the executive engineers, looked after all aspects of irrigation in the delta and the assessment and collection of revenue *etc*. This unified control was then changed by the transfer of the revenue deputy magistrate to the Revenue Department. The system of irrigation water management in the delta area will now be on the same lines as in the Hirakud project. There will be as many as 24 Irrigation Officers to look after the collection and assessment of revenue and other problems—16 of them for 411,000 acres on the left side of the river and 8 for 566,000 acres on the right side.

76. The delta lies in two districts of Cuttack and Puri and the Agriculture Department organisation in these two districts will look after the irrigated agriculture in the delta along with un-irrigated farming. No special steps for the development of irrigated agriculture in the delta have so far been initiated.

Review of irrigation developments and recommendations of the Group.

77. It would have been clear from paragraph 63 to 76 above, that irrigated agriculture from the Hirakud project, both under the canals from the reservoir and in the delta, is under the control severally of the Irrigation Department, the Revenue Department and the Agriculture Department. While the Irrigation Department organisation has as its units specific parts of canals, the Revenue and Agriculture Department organisations are on district-wise basis, each unit dealing with such part of the commanded area as falls in the respective district.

As the Intensive Agricultural District Programme (I.A.D.P.) is organised on a district-wise basis, along with large un-irrigated farming in the Sambalpur district, irrigated agriculture in this district is receiving special attention from the Deputy Director of Agriculture, Sambalpur; but that in the Bolangir, Cuttack and Puri districts is not receiving any such special attention.

78. An 'Action Committee' has been dealing, at high level, with all questions relating to the activities of different departments concerned with agricultural development from Hirakud and the co-ordination necessary between these activities; but in spite of this, and to some extent because of this, the management of the waters stored, at heavy cost, at Hirakud is far from satisfactory. Little is known of the developments in the first five years after the canal was opened for operation and, ten years after it has been in operation, apart from the disparities in the data as collected by the Irrigation and Revenue Departments, cultivation is largely following the pre-irrigation methods, except for the introduction of winter paddy and the fact that pre-irrigation fertile areas, mainly in valley bottoms, now have too much water and that the higher lands are now growing rice in *kharif*. Irrigation deltas are high and there is no effort at all at economising on the use of water or to make the maximum from the waters available. Except for the recent efforts under the I.A.D.P., cultivators have largely been on their own, mainly following their own initiative and adopting their own methods. There is little that has so far been done in connection with land 'farming' on any organised basis—the cultivators are trying to lower their high lands to grow rice; there is little interest in diversification of cropping. No water rates were assessed for five years; after that only 18 per cent of the assessment made has been recovered.

79. It is a sad commentary both on the system of administration and of planning that a regulated flow from the power house at Hirakud, of the order of about 10,000 cusecs, has been flowing down, since 1956, unutilised to the Bay of Bengal, that these waters obtained, at heavy cost, have not been used for irrigation during a period when the country has been facing chronic food shortage.

80. The irrigation delta on the Hirakud areas—both as proposed and as actually obtained (see paragraph 42 above)—is relatively high. It should be possible to grow even better crops with a reduced quantity of water. This would enable extension of irrigation to large blocks of un-commanded land which lie along the Hirakud Canals and which do not now grow good crops on rain water.

81. One reason for the high irrigation delta is the large number of outlets of small capacity (see paragraphs 58-61). While some of the water courses, as originally proposed, were for much too large outlets, the present system under which 16,500 outlets have been provided on the Hirakud Canals, with an average discharge of less than 1/4 cusec, is highly inefficient from the point of view of economy in water use. There is considerable experience as well as literature on the subject and it has been held conclusively that, for best results, an outlet capacity of about 1.5 cusec is the ideal, both from the point of view of water economy and the ease with which cultivators can handle the supply from an outlet. Trying to irrigate a field with a supply as small as 1/4 cusec involves high wastage of water in percolation in the field.

82. If the waters from the Hirakud reservoir, stored at such high cost, have to be used for maximum benefit, the present policy with regard to outlets will have to be reviewed and revised. Wherever the terrain permits, outlets should have a capacity of 1-2 cusecs and the water-course system must be re-organised to suit the terrain and properly maintained.

83. As shown in paragraphs 47 and 48 above, 90 per cent of the actual irrigated crop, in both *kharif* and *rabi*, is paddy. While *kharif* paddy receives a large part of its water requirements from seasonal rainfall, *rabi* paddy consumes a very large quantity of the expensively stored waters from Hirakud. One

reason why the cultivators resorts to the cultivation of paddy in *rabi*, in preference to other crops, is the non-existence of any water course system. Water courses are not particularly necessary in *kharif* when almost the entire area is under rice cultivation; but a diversified crop pattern in *rabi* is not possible without water courses. It seems, therefore, that special efforts will have to be made for a change-over from *rabi* paddy to a diversified crop pattern in winter.

84. The crop pattern recommended by the Agriculture Department, as set out in paragraph 73 above, is very different from that being followed and has not yet been tried on the ground on any significant scale. This crop pattern includes jute in the *Mal* lands. Although there is no doubt that jute can be grown in the Hirakud areas, it is extremely doubtful if such expensive water, as is provided by the Hirakud dam, should be used for the cultivation of jute. On the other hand, there is ample water in the delta and extensive borrow areas where jute could perhaps be the only crop.

85. In view of the unsatisfactory position described above, the Group strongly recommends that the State Government should explore the possibility of radically altering the present system of governmental control on the Hirakud Canals and the Mahanadi delta towards one which would enable an integrated approach to all the closely related problems of water supplies, its distribution, crop production, land forming, drainage, assessment of water rates, soil amelioration etc. The Hirakud Canal and the Delta Canals are two of the few irrigation projects in India which have an assured supply of water, at all times, and in relative abundance. Land is generally free from salts; drainage possibilities are good. The Group considers that there is considerable scope for improvement, the area to be irrigated can be increased considerably and a much better use than at present envisaged can be made of the waters provided. The potential for development is large, bold and concerted efforts need to be made, in an integrated manner, for optimum development and the Group recommends creation of suitable machinery for the purpose.

Such an integrated approach would aim at extending programmes like the I.A.D.P., which at present covers only Sambalpur district, to the entire commanded area of the Hirakud

Canal as well as the Delta Canals, if necessary, in preference to the un-irrigated areas of Sambalpur district. The programme would have to be more broad-based than at present and include, in addition to agronomic activities and use of fertilizers and pesticides, all other aspects of irrigated agriculture, in co-operation with the Irrigation Department—land forming, provision of water courses, economy in water use, drainage etc. There is no reason why the assessment of water rates could not also be part of this programme together with assistance to the cultivators in marketing their produce.

86. To implement the recommendations made in paragraph 85 above, it may become necessary to amend suitably the Orissa Irrigation Act, 1959. Even otherwise, several provisions of the Act are not being enforced at present. For example, written applications required under Section 21 of the Act are not being submitted by the cultivators nor do they seem to be necessary. Similarly, Rule 19(1) is not being put into practice regarding crop pattern in specified blocks. Also, there is hardly any necessity in the case of Hirakud Canal and the Delta Canals to enforce a guarantee for the supply of 28 inches of water during the period June to November.

87. The Group recommends that the ultimate crop pattern on the Hirakud Canal and in the delta should be evolved on the basis of perennial supplies of water and should aim at a more or less uniform capacity factor in the canals in all but the monsoon months. It will be thus that maximum use can be made of available irrigation waters, all the year round or for most part of it. In addition, the crop pattern, including un-irrigated crops in the commanded area, should :

(a) make maximum use of the seasonal rainfall and of high water table in low-lying areas;

(b) take due note of soil depth and the varying location of the lands in respect of valley bottoms;

(c) aim at providing maximum production in the area commanded by the project and other areas to which water can be conveyed by lift; and

(d) aim at providing not only a reasonable proportion of cash crops but also green-manure and leguminous crops in the crop rotation.

To enable a reasonable percentage of perennial crops, vegetables and gardens to be included in the crop pattern, the system of closing the canals for the entire month of May should be discontinued. Instead, it would be advisable to have two closures every year—a two weeks' closure in May and a three weeks' closure in December. Almost every perennial crop can stand a closure of two weeks in May and that of three weeks in December. These two closures would provide ample opportunity for carrying out works of annual maintenance and repairs.

88. Paddy (one or two crops) should be encouraged in *kharif* to make use of seasonal rainfall; but during *rabi* a diversified crop pattern would provide a much better use of the available waters and provide a richer life for the people. Low-lying areas, likely to be water logged, can, as demonstrated in the area, grow a good crop of bananas. The climate, the soil and the water supply can provide two or three crops per year provided proper care is taken in the use of water and the soil is enriched by the judicious application of chemical and green manures.

89. Even though it appears that the natural drainage of the area commanded by Hirakud Canals is generally efficient, it is extremely important that a careful watch be kept on the behaviour of the sub-soil water table. For this purpose, it is necessary to make regular observations of the water table, twice a year, before and after the rainy season, from a number of selected wells (village drinking water wells, if possible), suitably spaced, preferably along lines across the commanded area. Some irregular observations have been made in the past but the records do not appear to be continuously maintained.

Similar well observations must be introduced in the area commanded by the Delta Canals. It was stated that some wells were under observation; but particulars were not readily available.

90. It is unfortunate that no co-ordinated research had been undertaken, until recently, on the soil-crop-water relationship. The investigations recently started at Chakuli (paragraph 71 above) are, therefore, of great importance and should be pursued vigorously. In addition to research relating to agronomic

practices and use of fertilizers, soil behaviour under irrigation, the effect of drainage etc. must be carefully studied.

Research stations, similar to the one at Chakuli must also be established, at an early date, on the Delta Canals, one on the left Delta Canal and the other on the right Delta Canal.

Soil conservation

91. Of the total catchment area of 132,200 square miles extending 280 miles upstream of Hirakud only 4,500 square miles lie in Orissa. The rest of the area, about 87 per cent lies in Madhya Pradesh.

Not much was done during the first two Plans regarding soil conservation in this catchment. In the Third Five Year Plan, the Government of India allotted Rs. 1.50 crores for soil conservation measures in the Hirakud catchment (Madhya Pradesh Rs. 100 lakhs and Orissa Rs. 50 lakhs). According to the information available with the Central Water & Power Commission (Director, Soil Conservation), an expenditure of Rs. 2.03 crores has been incurred during Third Plan (Rs. 107 lakhs in Madhya Pradesh and Rs. 96 lakhs in Orissa) and the area covered is 201,000 acres (about 314 square miles out of 32,200 square miles) or less than 1 per cent of the total area.

92. In Orissa, the catchment has been divided for purposes of soil conservation work by the Agriculture Department into 42 sub-catchments; the present activities of that department are stated to extend over some 35 of these sub-catchments. The entire areas has been classified as under:

Forest land	1,064,000 acres
Crop land	1,142,000 acres
Pastures	102,000 acres
Waste lands	291,000 acres
Village roads, water bodies etc.	286,000 acres

The work actually carried out, to end of Third Plan has been classified as follows:

Contour bunding of agricultural lands (wholly subsidized by government)	60,000 acres
Tree planting (trees on government waste land) .	16,675 acres

Pasture developments (growing grasses and controlling grazing)	2,000 acres
Stream bank protection (vegetable growth on 100 feet width on each bank and controlling grazing) along streams	131 miles
Silt retention or check dams	21 structures

According to the assessment of local officers, the work described above, which has cost about Rs. 72 lakhs, represents about 22 per cent of the total work of soil conservation on agricultural lands in the Hirakud catchment in Orissa.

Apart from this, some work has been done by the Orissa Forest Department. It is understood that compact blocks of land of more than 100 acres needing afforestation are under the charge of the Forest Department. About 14,000 acres have been covered by that department at a cost of about Rs. 24 lakhs. Further details of the work done could not be obtained.

93. As regards the work of soil conservation in the Madhya Pradesh part of the catchment, particulars of the work done were not available with the Project authorities or the soil conservation staff in Orissa. Apparently, there is no co-ordination between the two States. According to the information obtained from the Central Water & Power Commission the major items of work carried out in Madhya Pradesh include contour bunding of agriculture lands over about 94,000 acres, afforestation on about 20,000 acres, pasture development 1,500 acres, fringe afforestation 945 acres and construction of 80 check dams. The location of these areas with respect to the dam could not be ascertained.

94. No assessment can be made of the effect, if any, of the work done so far on the silting of the Hirakud reservoir. Recently, proposals have been formulated for estimation of sediment load on small streams.

95. No master plan has yet been prepared of the entire soil conservation work in the Hirakud catchment. However, aerial photographs of the area has been undertaken and, as of date, out of a total area of about 132,000 square miles, 22,000 square miles have been photographed (3,102 square miles at a scale of 1/15,000 and 19,333 square miles at a scale of 1/25,000).

96. It would thus appear that relatively little has been done regarding soil conservation of the catchment of the reservoir even though about 20 years have elapsed since the project was undertaken.

97. The Group *recommends* that a master plan for soil conservation be prepared and work carried out in each State, according to that plans, in such manner as is likely to have the maximum and earliest effect on reduction of silting in the reservoir. Even if full information about the entire catchment is not yet available, a plan must nevertheless be prepared on the basis of such data as can be got together. When further information becomes available, the plan can be modified suitably.

Arrangements need also be made to finance the master plan in such manner as to complete bulk of the initial task within the next ten years, at the most.

98. Some co-ordination must be provided regarding the activities in regard to soil conservation in the two States and the Project authorities.

The reservoir area

99. **Capacity surveys.**—No capacity survey has yet been carried out after the first capacity survey prior to the initial filling of the reservoir. The efforts made to take soundings from specified points in a grid do not seem to have been successful. It seems that the best way to ascertain the capacity of the reservoir would be by aerial surveys carried out periodically, when the reservoir is low, at the end of May or early June. The Group recommends that this proposal should be examined.

100. **Cultivation in the reservoir area.**—Some foreshore lands in the reservoir are leased out for cultivation every year. This leasing is under the control of the Revenue Department and the proceeds are credited to Miscellaneous Revenus, not to the Project. About 3,000 acres are stated to have been so leased in Sambalpur tehsil, the area leased in other tehsils could not be ascertained.

101. The Group considers that detailed attention needs to be devoted to the question of cultivation in the reservoir area. This

can be done only if the leases for such cultivation are entered into by the Executive Engineer, who would carry out periodical surveys to satisfy himself that such cultivation does not, in any way, help in eroding the foreshore lands adding to the silting in the reservoir. It is possible that the cultivation of some crops helps in reducing soil erosion during the rainy season; at the same time the cultivation of some other crops may have the contrary effect. The problem needs to be dealt with along the lines indicated.

102. **Fisheries.**—The attempt to develop fisheries in the Hirakud reservoir seems to have been somewhat half-hearted. It is stated that during 1957-58 about 33,000 fish seedlings were stocked in the reservoir; in 1958-59, 213,000 and in 1965-66 about 293,000. In other years, the stocking was either nil or nominal. The quantity of fish caught by fisherman and by the departmental units is reported to be 52,000 kg. in 1961-62, 32,000 kg. in 1962-63, and between 15,000 kg. and 12,000 kg. annually thereafter. For a lake area varying between 180,000 acres (R.L. 630) and 69,000 acres (R.L. 590), the catch is very poor.

Recently a fisheries technology sub-station has been set up at Hirakud by the Central Government for evolving suitable gears for operation in the lake.

103. The Group recommends that some concerted attention should be paid to the development of fisheries in the large lake at Hirakud. Not only it would provide an additional source of revenue on account of the project but also it would provide employment to a large number of people who have been displaced from the reservoir.

General

104. **Administrative reports, working statistics.**—No administration reports, working statistics or reports on the results of operations etc. have yet been published for the Hirakud Project. No standard log-books have yet been brought into use for the Hirakud dam or different works on the canal system.

105. The Group recommends that log-books to be maintained at the dam and works on the canals should be standardised, printed and bound registers maintained at each site. These are permanent records and should receive due attention. Also, the form and content of the annual administration reports, working statistics, etc. should be approved early and printed annual reports should be available on all features of the project including river supplies, their distribution to irrigation and power, flood control affected, working of distributaries and statistics of crops grown etc. For the dam, annual reports on the behaviour of different component works should be prepared to give a connected history of these works.

A continuous record of the behaviour, the nature and extent of damage, if any, and the repairs carried out to each component part of the dam is most important for the regulating and supervisory staff on the dam. Similarly, for optimum operation of the canal system, a continuous record of the discharges run, quantity of water used in each season, crops grown, seasonal delta, etc. is important. The best way of ensuring the maintenance of such records is to have a system of annual reports which should be printed. This will avoid any lack of continuity as is being noticed at present in some of the observations on the instruments installed in the dam, in the well observations periodically made in the commanded area and the silt observations in the main river.

106. **Administrative Accounts.**—With the completion of Stage I of the project, the Government of Orissa took over the project and the Revenue Account of Stage I was opened on 1st April, 1960.

The Revenue Account of Stage II of the project is stated to have been opened on 1st April, 1964.

107. The Administrative Accounts of the Project are being maintained separately for Stage I and Stage II. The distinction between the two stages is not real and serves little purpose now. The Group, accordingly, recommends that Administrative Accounts of Stage I and II be amalgamated into one for both stages, taken together.

108. Against an expenditure of Rs. 79.46 crores* on both stages of the project (not including interest charges on capital investment) to end of 1963-64, the total net revenue from the project was only Rs. 3.45 crores. On the other hand, to end of 1963-64, the interest charges alone amounted to Rs. 28.44 crores*.

109. The total expenditure on the project has not yet been allocated to different purposes, flood control, power, irrigation from the Hirakud Canals, irrigation in the delta. It is important that this distribution should be made at an early date and Administrative Accounts prepared for each part separately. The correct financial picture would not be clear until then.

110. On the power side, power is being sold in two major blocks :

(a) Bulk power to the State Electricity Board at 3.4 paise per kwh. at the power house.

(b) Steady power of approximately 48,000 kW. to the Aluminium factory at the following rates :

(i) first block of 25,000 kW. at Rs. 120 per kW. year; and a

(ii) second block of 23,000 kW. at Rs. 165/- per kW. year.

So far as the bulk supply of power to the State Electricity Board is concerned, the rate being charged is already somewhat high when compared with comparable hydel power stations in India and there seems to be little scope of increasing this rate. Whatever improvement is possible would be by way of increased sale of energy for which there is some scope. As regards the sale of bulk power to the Aluminium factory, the present rates are low and there is scope for an increase in these rates after the expiry of the period of ten years for which the existing agreement holds.

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*Interst accumulated during period of construction to end of March 1961, Rs. 16·15 crores on Stage I and Rs. 0·17 croses on Stage II, has been capitalised and the total capital cost shown in Administrative Accounts is Rs. 95·78 crores, leaving the balance of the interest in the Revenue Account as Rs. 11·12 crores. Taking into account the net revenue of Rs. 3·45 crores, the accumulated interest, to end of 1963-64, was Rs. 7·67 crores.

111. The latest orders of the State Government with regard to the allocation of proceeds of power from the Hirakud dam require that, with effect from 1st June, 1962.

(a) 3 paise per unit out of a total of 3.4 paise recovered from the State Electricity Board be credited to the Head of Account XXXIII—Multi-purpose River Schemes; and

(b) the balance of 0.4 paise per unit to the Head of Account XXXVI—Electricity Schemes.

The purpose of this change in allocation is not clear.

112. On the irrigation side, the present revenues are almost insignificant. No credit is being afforded on account of flood control benefits and the question of the betterment levy has, for the present, been held in abeyance. Some revenue realised from cultivation in the reservoir area is not being credited to the project.

113. In the light of the above, the Group would recommend that a committee be appointed, immediately, to examine the financial picture of the project, as now revealed by the experience up to date. The present position under which, year after year, the project continues to run into deficit is hardly satisfactory; there is little purpose in continuously adding to the accumulated interest charges. After a detailed examination of the likely revenues from the project, including all the indirect benefits from it, the committee should evolve a practical arrangement to :

(a) continued maintenance and operation of the project for the benefit of the people of Orissa; and

(b) ensure the return to the Central Government of the loan granted to the State Government for the construction of the project.

114. The Group also recommends that the construction estimates of both Stage I and Stage II of the project should be closed at an early date. Such further work as may become necessary, from time to time, and cannot be charged to the head 'Maintenance' can be done, under proper authorisation, chargeable to the open capital account of the project.

115. In conclusion, the Group likes to draw attention to the fact that little seems to have been done so far to bring under irrigation and cultivation about 60,000 acres of culturable waste lands, included in the area commanded by the Hirakud Canals (the difference between 3,80,000 acres, total C.C.A. as verified in 1962, and 320,000 acres, area at present being irrigated in *kharif*, as per Table I). The Group recommends that early action be taken to bring this area under irrigation in order to make full use of the waters made useable at a heavy cost.

116. The Group is unable to advise, at this stage of development, whether any change is called for in the present use of available waters at Hirakud as between irrigation and power. While the waters allocated to power are being used for that purpose, there is much more yet to be done regarding the optimum utilisation of the waters allocated to irrigation and the reuse for irrigation in the delta lower down of the waters allocated to power. For the present, the Group would strongly recommend that every effort should be made to develop, as early as possible, the full potential for irrigation created by the Hirakud Project by :

(a) developing the full C.C.A. both under the Hirakud Canals and in the delta;

(b) extending irrigation to such of the uncommanded areas as can be developed from the Hirakud Canals;

(c) developing the optimum crop pattern both on the Hirakud Canals and in the delta; and

(d) bring into effect appropriate measures for the economic use of the available waters;

on the lines recommended in this report.

APPENDIX I

Need for a Weather Forecasting office at Hirakud for Reservoir Operations

(referred to in paragraph 33)

Introduction

The Hirakud reservoir stores water in the Mahanadi river during the rainy season for use during the dry period. The roservoir has also to be operated to minimised floods in the lower catchment. The rainfall in the Mahanadi catchment occurs mostly in the South West Monsoon period. Heavy rainfall in this season is often associated with depressions and storms which develop in Northwest Bay and travel westnorthwestwards. Occasionally the cyclonic storms of the post-monsoon period also affect this area. Depending upon the track etc. of these depressions and storms, the distribution of rainfall will vary in the different parts of the catchment.

For daily reservoir operations during the rainy period, engineers would like to have following information :

(i) Rainfall in the catchment in the last 24 hours.

(ii) Rainfall expected in the next 24 hours.

(iii) Further outlook of rainfall.

(iv) Positions of depressions and storms and their trend of movement.

Weather Forecasting Office at Hirakud

The Meteorological Office, Alipore, is at present issuing heavy rainfall warnings in a qualitative way to the Hirakud engineers. The detailed meteorological services, as has been enumerated above, cannot be provided to the engineers by the Meteorological Office, Alipore, with its existing organisation and responsibilities. Hence, to meet the needs for such specialised Meteorological Service, it is considered necessary that a separate Weather Forecasting office should be started at Hirakud which may supply all the meteorological information required by the operating personnel.

It may be mentioned in this connection that for providing similar special meteorological service to the Damodar Valley engineers, the D.V C. has created in 1949 the Damodar Vally Meteorogical Unit which is functioning satisfactorily during the past 17 years. The D.V.C. Meteorological Unit is maintaining a network of certain number of hydro-meteorological observatories in the Damodar Valley, collecting valuable meteorological data from these observatories and arranging for their publication. This Unit is also issuing quantitative precipitation forecasts, and undertakes studies on special hydrometeorological problems posed by the engineers. The proforma in which daily information is supplied to D.V.C. engineer is given as Annexure I. The proposed Weather Forecasting Office at Hirakud for the Mahanadi Valley may be formed and developed on similar lines.

Organisation of the Weather Forecasting Office at Hirakud

The proposed Meteorological Office at Hirakud will be equipped with RTT Receivers for receiving the meteorological data from broadcasts. With the data received, weather charts will be prepared twice daily during the monsoon season and once daily during the rest of the year. Additional charts will be prepared as required during the disturbed weather periods. A Senior Meteorologist (equivalent to Executive Engineer) will be incharge of this office and issue precipitation forcasts for the Mahanadi catchment. The techniques for issuing such forecasts will progressively develop with the experience gained. From the time any depression or storm developes in the Bay of Bengal. operating engineers will be cautioned and kept posted with full information.

In the Mahanadi catchment there are about 170 state rain-gauges. The list is given in Annexure II. Daily rainfall reports will be arranged from some of these stations which will be consolidated by this Unit and passed on to the engineers for computation of inflow. The adequacy of the existing network of raingauges will also be studied and new stations opened in unrepresented areas.

During the dry seasons, studies will be conducted on the different hydro-meteorogical problems of the catchment like QPF techniques, storm analysis etc., which form the background information for improving procedures of reservoir operation.

Budget

The staff required and expenditure involved are given below :

(A) **Staff required**

Meteorologist Grade I	1	
Assistant Meteorologist	1	
Chartsmen	4	(2 for morning charts (2 for evening charts)
Operator for RTT Reception	1	
Peons	2	

(B) **Expenditure (Recurring)**

(I) *Pay*

Meteorologist Grade	1,200/-	
Assistant Meteorologist	600/-	
5 Class III staff (5 × 300)	1,500/-	
2 Class IV staff (2 × 90)	180/-	
Rs.	3,480/-	
Rs.	42,000/-	per annum

(II) *Allowances*	15,000/-
(III) *Contingencies*	18,500/-
(Charts, stores and Telegraphic expenditure)	
(IV) *Foreign Service Contribution* . .	8,500/-
Total	84,000/- per annum

(Recurring expenditure)

(C) **Expenditure (Non-recurring)**

1. Receiver set with attachment for RTT reception (from BEL) . . .	25,000/- (with Rs. 14,000/- as foreign exchange)
2. Two Teleprinter machines . . .	11,000/-
3. Voltage stabiliser	1,000/-
4. Aerial material and installation charges	6,000/-
Total Rs.	43,000/-

Appendix II
(Sheet 1 of 8)

Discharges (cusecs)

July 1965	As observed at Saridih	As observed at Deogaon	Total	As calculated at Hirakud
Catchment area (square miles)	22,000	5,830	27,830	32,200
1.	86,686	15,285	101,971	10,185
2.	64,251	7,172	71,423	8,614
3.	48,015	3,434	51,449	14,990
4.	27,488	2,022	29,510	17,842
5.	14,239	1,193	15,432	22,958
6.	9,484	708	10,192	12,322
7.	7,542	2,123	9,665	9,578
8.	8,501	3,757	12,258	11,238
9.	5,727	1,837	7,564	11,230
10.	5,695	1,599	7,294	9,268
11.	5,163	983	6,146	9,234
12.	5,306	777	6,083	9,297
13.	4,959	1,184	6,143	6,156
14.	4,889	1,760	6,649	6,832
15.	9,050	7,344	16,394	4,494
16.	10,799	3,049	13,848	4,894
17.	10,959	3,163	14,122	5,278
18.	14,621	3,062	17,683	7,778
19.	22,755	2,684	25,439	27,014
20.	77,280	2,045	79,325	27,880
21.	71,189	5,806	76,995	39,669
22.	51,494	16,762	68,256	37,682
23.	33,134	17,255	50,389	35,227
24.	33,489	9,596	43,085	28,343
25.	37,524	4,789	42,313	38,555
26.	27,488	3,164	30,652	38,801
27.	37,993	2,756	40,749	97,964
28.	37,071	3,135	40,206	138,261
29.	56,692	19,120	75,812	103,597
30.	190,623	35,225	225,848	180,107
31.	297,399	39,998	337,397	176,085
Total (Cusec-days)	1,317,505	222,787	1,540,292	1,151,373
Volume (M.A.F.)	2·635010	0.445574	3.080584	2.302746

Appendix II
(Sheet 2 of 8)

Discharges (cusecs)

August 1965	As observed at Saridih	As observed at Deogaon	Total	As calculated at Hirakud
Catchment area (square miles)	22,000	5,830	27,830	32,200
1.	32,880	4,510	37,390	50,041
2.	20,451	2,738	23,189	37,088
3.	21,113	2,032	23,145	28,902
4.	11,065	6,181	17,246	29,248
5.	9,196	8,125	17,321	32,892
6.	6,956	7,436	14,392	28,357
7.	7,455	3,509	10,964	20,219
8.	8,036	4,384	12,420	18,569
9.	6,273	2,546	8,819	15,568
10.	5,769	1,645	7,414	19,373
11.	5,498	1,121	6,619	17,500
12.	5,866	3,855	9,721	19,446
13.	6,089	5,165	11,254	19,794
14.	14,250	3,219	17,469	24,021
15.	16,591	2,182	18,773	31,214
16.	22,038	2,466	24,504	33,903
17.	23,484	4,165	27,649	37,569
18.	17,187	2,466	19,653	32,968
19.	12,432	2,151	14,583	24,841
20.	10,054	8,219	18,278	21,480
21.	7,830	9,217	17,047	25,333
22.	8,520	3,017	11,537	24,202
23.	11,215	2,182	13,397	19,011
24.	15,222	2,897	18,119	39,324
25.	17,331	2,389	19,720	69,214
26.	76,994	47,311	124,305	174,439
27.	103,861	27,159	131,020	199,490
28.	57,644	8,875	66,519	103,409
29.	35,613	5,429	41,042	68,992
30.	24,185	3,518	27,703	43,005
31.	19,761	3,518	23,279	42,739
Total (Cusec-days)	640,859	188,627	829,486	1,352,151
Volume (M.A.F.)	1.281718	0.377254	1.658972	2.704302

Appendix II
(Sheet 3 of 8)

Discharges (cusecs)

September 1955	As observed at Saridih	As observed at Deogaon	Total	As calculated at Hirakud
Catchment area (square miles)	22,000	5,830	27,830	32,200
1.	17,070	6,447	23,517	52,319
2.	45,474	9,810	55,284	74,656
3.	42,768	3,991	46,759	66,110
4.	33,939	2,466	36,405	54,517
5.	44,677	2,022	46,699	59,527
6.	35,968	3,991	39,959	91,006
7.	84,518	43,141	127,659	195,370
8.	95,400	18,650	114,050	189,978
9.	72,920	10,642	83,562	125,053
10.	43,883	8,884	52,767	88,121
11.	41,189	5,639	46,828	64,344
12.	27,597	3,906	31,503	46,958
13.	17,548	2,389	19,937	31,234
14.	15,581	1,679	17,260	22,903
15.	12,355	1,183	13,538	21,874
16.	11,754	937	12,691	17,449
17.	9,975	825	10,800	14,826
18.	8,598	588	9,186	9,250
19.	8,003	361	8,364	13,847
20.	7,907	501	8,408	81,591
21.	7,473	419	7,892	14,246
22.	7,936	11,280	19,216	25,335
23.	83,794	7,996	91,790	135,197
24.	356,783	7,934	364,717	95,987
25.	19,302	14,599	33,901	221,690
26.	75,903	7,243	83,146	261,420
27.	38,009	6,670	44,679	49,965
28.	28,447	3,404	31,851	38,432
29.	19,414	3,819	23,233	31,246
30.	16,444	2,580	19,024	24,713
Total (Cusec-days)	1,330,629	193,996	1,524,625	2,219,164
Volume (M.A.F.)	2.661258	0.387992	3.049250	4.438328

Appendix II
(Sheet 4 of 8)

Discharges (cusecs)

October 1965	As observed at Saridih	As observed at Deogaon	Total	As calculate at Hirakud
Catchment area (square miles)	22,000	5,830	27,830	32,200
1.	14,250	2,030	16,280	17,880
2.	12,432	1,753	14,185	12,575
3.	11,238	1,664	12,902	10,307
4.	10,156	1,440	11,596	14,594
5.	9,375	1,373	10,748	12,132
6	8,372	1,373	9,745	11,313
7.	7,464	1,440	8,904	8,545
8.	6,920	1,022	7,942	8,839
9.	6,534	1,125	7,659	4,608
10.	6,238	1,110	7,348	10,172
11.	6,018	961	6,979	7,528
12.	5,871	907	6,778	9,169
13.	5,801	1,272	7,073	8,320
14.	5,584	1,125	6,709	6,726
15.	5,513	1,022	6,535	8,996
16.	5,406	1,125	6,531	4,828
17.	5,234	1,110	6,344	5,237
18.	5,234	961	6,195	10,695
19.	5,306	907	6,213	6,352
20.	5,306	1,272	6,578	7,826
21.	5,238	1,125	6,363	9,764
22.	5,268	961	6,229	4,783
23.	5,098	961	6,059	6,720
24.	4,996	907	5,903	7,004
25.	4,927	806	5,733	5,842
26.	4,927	726	5,653	5,137
27.	4,832	607	5,439	4,426
28.	4,764	567	5,331	4,949
29.	4,764	513	5,277	4,813
30.	4,764	462	5,226	5,697
31.	4,633	410	5,043	4,650
Total (Cusec-days)	202,463	33,037	235,500	250,427
Volume (M.A.F.)	0.404926	0.066074	0.471000	0.500854

Appendix II
(Sheet 5 of 8)

Discharges (cusecs)

June 1966	As observed at Saridih	As observed at Deogaon	Total	As calculated at Hirakud
Catchment area (square miles)	22,000	5,830	27,830	32,200
1.	NOT OBSERVED			
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.	2,433			2,000
16.	2,449			4,000
17.	2,449	2,140	4,589	6,283
18.	2,511	303	2,814	10,000
19.	2,964	12,173	15,137	12,500
20.	3,208	4,942	8,150	12,500
21.	8,119	6,026	14,145	20,513
22.	8,448	1,833	10,271	25,204
23.	15,049	1,745	16,794	28,641
24.	14,046	1,825	15,861	34,307
25.	19,560	24,057	43,617	136,834
26.	74,673	28,302	102,975	166,364
27.	113,542	24,441	137,983	158,000
28.	68,343	10,204	78,547	118,628
29.	89,958	12,292	102,250	132,902
30.	101,127	14,247	115,374	166,972
Total (Cusec-days)	523,997	144,510	668,507	1,029,648
Volume (M.A.F.)	1.047994	0.289020	1.337014	2.059296

Appendix II
(Sheet 6 of 8)

Discharges (cusecs)

July 1966	As observed at Saridih	As observed at Deogaon	Total	As calculated at Hirakud
Catchment area (square miles)	22,000	5,830	27,830	32,200
1.	86,686	15,285	101,971	151,885
2.	64,251	7,172	71,423	106,548
3.	48,015	3,434	51,449	68,361
4.	27,488	2,022	29,510	44,450
5.	14,239	1,193	15,432	28,372
6.	9,484	708	10,192	18,245
7.	7,542	2,123	9,665	20,150
8.	8,501	3,757	12,258	26,809
9.	5,727	1,837	7,564	15,477
10.	5,695	1,599	7,294	14,787
11.	5,163	983	6,146	12,268
12.	5,306	777	6,083	10,370
13.	4,959	1,184	6,143	10,929
14.	4,889	1,760	6,649	13,339
15.	9,050	7,344	16,394	15,837
16.	10,799	3,049	13,848	28,267
17.	10,959	3,163	14,122	26,797
18.	14,621	3,062	17,683	30,834
19.	22,755	2,684	25,439	37,273
20.	77,280	2,045	79,325	60,380
21.	71,189	5,806	76,995	82,588
22.	51,494	16,762	68,256	89,102
23.	33,134	17,255	50,389	61,548
24.	33,489	9,596	43,085	50,200
25.	37,524	4,789	42,313	41,933
26.	27,488	3,164	30,652	43,122
27.	37,993	2,756	40,749	62,598
28.	37,071	1,335	38,406	71,620
29.	56,692	19,120	75,812	106,840
30.	190,623	35,225	225,848	205,763
31.	247,399	39,998	287,397	423,057
Total (Cusec-days)	1,267,505	220,987	1,488,492	1,979,749
Volume (M.A.F.)	2.535010	0·441974	2.976984	3.959498

Appendix II
(Sheet 7 of 8)

Discharges (cusecs)

August 1966	As observed at Saridih	As observed at Deogaon	Total	As calculated at Hirakud
Catchment area (square miles)	22,000	5,830	27,830	32,200
1.	218,483	17,978	236,461	265,962
2.	125,688	11,115	136,803	142,795
3.	81,932	29,395	111,327	124,843
4.	78,668	26,173	104,841	125,180
5.	58,379	40,952	99,349	120,069
6.	135,106	46,278	181,384	163,293
7.	123,624	31,741	155,365	179,710
8.	156,498	28,948	185,446	191,774
9.	178,250	18,406	196,656	179,788
10.	94,311	13,250	107,561	139,642
11.	74,512	9,488	84,000	95,494
12.	65,376	14,342	79,718	94,020
13.	60,449	10,684	71,133	76,132
14.	119,381	11,520	130,901	136,362
15.	122,862	24,827	147,689	175,684
16.	202,745	22,158	224,903	188,206
17.	165,404	17,846	183,250	195,372
18.	170,840	15,301	186,141	118,429
19.	139,290	12,859	152,149	168,321
20.	169,590	38,119	207,709	213,419
21.	174,724	20,461	195,185	200,329
22.	118,380	21,456	139,836	159,175
23.	88,319	20,163	108,482	123,159
24.	71,087	25,567	96,654	110,714
25.	63,860	30,268	94,128	96,877
26.	52,084	14,665	66,749	69,651
27.	32,133	8,291	40,424	49,139
28.	26,356	5,252	31,608	49,253
29.	19,114	3,136	22,250	26,667
30.	15,106	1,948	17,054	22,990
31.	11,338	1,523	12,861	20,835
Total (Cusec-days)	3,213,907	594,110	3,808,017	4,023,284
Volume (M.A.F.)	6.427814	1.188220	7.616034	8.046568

Appendix II
(Sheet 8 of 8)

Discharges (cusecs)

September 1966	As observed at Saridih	As observed at Deogaon	Total	As calculated at Hirakud
Catchment area (square miles)	22,000	5,830	27,830	32,200
1.	10,094	5,071	15,165	20,652
2.	9,862	6,686	16,548	24,180
3.	14,402	9,319	23,721	48,654
4.	19,456	6,278	25,734	49,852
5.	29,747	7,817	37,564	45,972
6.	107,560	7,575	115,135	79,137
7.	89,626	6,415	96,041	97,885
8.	79,414	10,993	90,407	94,563
9.	58,738	6,601	65,339	66,447
10.	43,807	4,433	48,240	44,135
11.	28,741	3,413	32,154	33,650
12.	21,268	3,042	24,310	23,422
13.	16,372	2,473	18,845	20,284
14.	12,750	1,981	14,731	18,154
15.	10,326	1,837	12,163	14,344
16.	9,291	1,705	10,996	14,334
17.	7,957	1,594	9,551	11,060
18.	7,643	1,498	9,141	11,774
19.	6,279	1,594	7,873	10,033
20.	5,803	1,250	7,053	10,862
21.	5,479	996	6,475	6,113
22.	5,152	1,346	6,498	8,936
23.	6,187	985	7,172	9,394
24.	4,989	996	5,985	9,335
25.	4,892	1,100	5,992	7,962
26.	4,989	1,720	6,709	8,731
27.	4,989	1,366	6,355	9,404
28.	4,425	1,007	5,432	7,217
29.	3,960	979	4,939	8,870
30.	4,092	872	4,964	6,302
Total (Cusec-days)	638,290	102,942	741,232	821,658
Volume (M.A.F.)	1.276580	0.205884	1.482464	1.643316

Annexure I

Message dated.....T.O.O. of the message.....
Message passed/not passed to Howrah Sub-station for transmission to M.R.O. Maithon/Project Manager, DTPS III Unit, DVC, Waria, Durgapur.

To : The General Maneger/Dy. C.E. (B&I)/Administrative Officer, D.V.C.

I. *General Bulletin :*

II. *Forecast for next 24 hours*

Damodar Catchment (Catchment I)—Average rainfall.....mms

Barakar Catchment (Catchment II)—Average rainfall..... mms

Lower Valley (Catchment III) —Average rainfall..... mms

III. Outlook subsequent 24 hours.....

IV. Rainfall in mms. for past 24 hours ending 8-30 A.M. of today.

(1) *Damodar Catchment*			(2) *Barakar Catchment*		
Station	Rainfall	Present weather	Station	Rainfall	Present weather
Chandwa (01)			Padma (21)		
Balumath (02)			Barhi (22)		
Khalari (03)			Kodarma (23)		
Ranchi (04)			Hirodih (24)		
Hendegir (05)			Parsabad (25)		
Barkagaon (06)			Bagddar (26)		
Ramgarh (07)			Suriya (27)		
Mandu (08)			Dhanwar (28)		
Hazaribagh (09)			Giridih (29)		
Peterbar (10)			Maheshmunda (30)		
Bokaro (11)			Nandadih (31)		
Nawadih (12)			Nirsa (32)		
Dumri (13)			Jamtara (33)		
Chas (14)			Maithon (34)		

Purulia (15)
Katras (16)
Para (17)
Dhanbad (18)
Raghunathpur (19)
Panchet (20)

(3) *Lower Valley*
Govinpur (35)
Asansol (36)
Gangajalghati (37)
Durgapur (38)
Sonamukhi (39)
Indus (40)
Burdwan (41)
Arambagh (42)
Tarakeswar (43)
Amta (44)
Ulubaria (45)
Calcutta (46)

Annexure II

List of raingauges in the Mahanadi Catchment

(Includes I.M.D. and State gauges).

1. Baikunthapur
2. Pasan
3. Pondaleta
4. Katghore
5. Korila
6. Dharmanaajgarh
7. Sitapur
8. Ginabahal
9. Pathalgaon
10. Tapkura
11. Kurgag
12. Talsra
13. Bargaon
14. Sundargarh
15. Gobindpur
16. Dharmadhi
17. Kusumi
18. Kuchinda
19. Jharsuguda
20. Dhasma
21. Ujalpur
22. Lafripara
23. Hingir
24. Jharsgoda
25. Balakuchai
26. Raighar
27. Sakti
28. Champa
29. Jangir
30. Bilaspur
31. Khotaghat
32. Khodri
33. Gaurela
34. Pendra
35. Khuria
36. Pandarica
37. Mongeri
38. Kawardha
39. Khamuria
40. Bometara
41. Gandai
42. Chhuikhadam
43. Khiragarh
44. Dongargarh
45. Amtagarhchowki
46. Sanjari
47. Pahandgaon
48. Adambad
49. Bhatgaon
50. Khapari
51. Selod
52. Durg
53. Bhillai
54. Adhanabad
55. Kharra
56. Bamolara
57. Simga
58. Pindran
59. Kandapar
60. Balondabazar
61. Pallari
62. Kanki
63. Lakhali
64. Kandri
65. Bhundipara
66. Kandai
67. Keskul
68. Khijrwan
69. Galtasilli
70. Dhantari
71. Maramsilli
72. Rudri
73. Kurud
74. Budeni
75. Rajim
76. Lunhandi
77. Raipur
78. Lakhali
79. Kusrangi
80. Aranj
81. Mahasumudra
82. Lahud
83. Khandatan
84. Sandi
85. Sheorinarayan
86. Gariaband
87. Mainpur
88. Raighar
89. Saraipalli
90. Pithora
91. Arjuni
92. Indagaon
93. Urmal
94. Deobhag
95. Jayapatna
96. Thuanalrampur
97. Parlapat
98. Bhowanipatna
99. Sundharkela

100. Kharia
101. Konma
102. Nawapara
103. Kshatiar Road
104. Dhabara
105. Sakti
106. Sarangarh
107. Padampur
108. Paikmal
109. Bongomunda
110. Titalgarh
111. Turekada
112. Khaparkhol
113. Belpara
114. Kanpabanji
115. Tikkerpara
116. Saintala
117. Tusra
118. Madanpur
119. Baliguda
120. Patnaghar
121. Agalpur
122. Ambabhona
123. Gobindpur
124. Bharuadhihi
125. Kuchinda
126. Barghar
127. Hirakud
128. Sambalpur
129. Sosela
130. Bijepur
131. Dungripalli
132. Binka
133. Loisangha
134. Bolangir
135. Sonepur
136. Marnamonda
137. Ghantapara
138. Nallikud
139. Golumdapara
140. Banusuni
141. Sagara
142. Phulbani
143. Phriangia
144. Udaigiri
145. Phosara
146. Khujorpara
147. Adhonighar
148. Baghepara
149. Baudhraj
150. Rairakhol
151. Krishnanagar
152. Handapa
153. Athmallik
154. Harbhanga
155. Purnakot
156. Baramul
157. Kunjabanghar
158. Narsingpur
159. Kanpor
160. Nayaghar
161. Khanparaghar
162. Bolghar
163. Baramuba
164. Tigiria
165. Rajathgarh
166. Bankighat

Statement I

HIRAKUD DAM

Inflow in million acre-feet

Year	Filling Period					Depletion Period									Annual
	July	Aug.	Sep.	Oct.	Total	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1947–48	8.970	15.988	12.688	2.936	40.402	0.695	0.462	0.438	0.094	0.071	0.221	0.016	0.622	2.619	43.021
48–49	6.584	17.080	7.434	2.582	33.680	0.840	0.344	0.054	0.144	0.080	0.069	0.188	0.456	2.175	35.855
49–50	5.446	15.846	7.962	4.084	33.338	1.129	0.365	0.179	0.337	0.347	0.054	0.209	0.624	3.244	36.582
50–51	9.058	17.958	5.996	0.934	33.946	0.390	0.018	0.857	0.634	1.067	0.814	0.018	0.303	4.101	38.047
1951–52	1.654	11.584	3.492	1.812	18.542	0.541	0.183	0.083	0.063	0.046	0.017	0.042	0.574	1.549	20.091
52–53	6.594	12.144	15.336	2.008	36.082	0.652	0.280	0.297	0.151	0.033	0.018	0.014	0.178	1.623	37.705
53–54	7.954	14.546	4.786	1.383	28.669	0.560	0.157	0.075	0.014	0.007	0.006	0.008	0.344	1.171	29.840
54–55	1.804	4.318	8.430	1.373	15.925	0.299	0.027	0.030	0.013	0.006	0.006	0.006	0.817	1.204	17.129
55–56	5.966	7.454	10.528	5.050	28.998	3.771	0.165	0.140	0.114	0.048	0.026	0.022	2.479	6.765	35.763
1956–57	11.577	13.245	4.190	2.008	31.020	0.666	0.088	0.097	0.088	0.206	0.113	0.073	0.098	1.429	32.449
57–58	5.055	10.134	3.172	0.338	18.699	0.232	0.188	0.111	0.230	0.357	0.006	-0.041	0.106	1.189	19.888
58–59	11.037	6.406	10.804	4.604	32.851	0.712	0.184	0.306	-0.093	-0 007	0.069	0.029	0.166	1.316	34.167
59–60	4.479	15.482	14.681	1.794	36.436	0.401	0.139	0.153	0.028	0.105	0.030	0.056	0.401	1.313	37.749
60–61	6.123	17.567	3.992	3 256	30.938	0.435	0.166	0.101	0.270	0.035	0.081	0 036	5.388	6.512	37.450
1961–62	22.011	13.360	23.685	5.363	64.419	1.020	0.347	0.099	0.271	0.076	0.042	0.035	0.300	2.190	66.609
62–63	3.133	6.134	4.730	0.659	14.656	0.315	0.221	0.175	-0.081	0.092	0.032	-0.034	0.683	1.403	16.059
63–64	3.901	11.886	10.389	1 724	27.900	0.542	0.196	0.077	0.058	0.106	0.016	-0 027	1.154	2.122	30.022
64–65	12.200	20.115	5.472	3.579	41.366	0.806	0.182	0.149	0 049	0.168	0.127	-0.004	0.243	1.720	43.086
65–66	2.301	2.750	4.816	0.524	10.391	0 168	0.041	0.097	0 078	-0.002	-0.074	0.062	2.070	2.440	12.831
19 Years Mean (1947–48 to 1965–66)	7.140	12.316	8 557	2.422	30.435	0.746	0.198	0.185	0.130	0.147	0.088	0.037	0.895	2.426	32.861
1966-67	3·960	8·047	1·643	0·303	13·973										

Statement II

RESERVOIR OPERATIONS AT HIRAKUD

All figures in columns 2 to 10 are in million acre-feet

Year and month	Reduced level of reservoir on 1st of the month	Live storage in reservoir 1st of the month	Inflow during the month-(7)+(8)+(9)	Utilisation during the month				Quantity stored (+) or depleted (—)during the month	Quantity escaped during the month	Outflow into the river below Hirakud=(9)+(5)	Remarks
				For irrigation	For power	Evaporation losses	Total=(4)+(5)+(6)				
	1	2	3	4	5	6	7	8	9	10	
1956-57 July											
Aug.											
Sep.											Bargarh Canal opened.
Oct.	608.80								2.888		Sason Canal and Sambalpur Distributary opened.-
Total											

Statement II—(*contd.*)

1	2	3	4	5	6	7	8	9	10
Nov.	611.80							0.392	
Dec.	614.00							0·046	One power-unit begins operation.
Jan.	612.60							0·406	
Feb.	609.70							0.116	
Mar.	608.90							Nil	
Apr.	608.50							Nil	
May.	607.50							Nil	Second power unit begins operation.
June	605.90							0.002	
Total									
Annual									

Statement II—(*Contd.*)

	1	2	3	4	5	6	7	8	9	10
1957-58 July									5.084	
Aug.	599.00								8.809	
Sep.	616.00								1.420	
Oct.	627.80								0.084	
Total										
Nov.	628.60	4.490	0.232	0.080	0.059	0.040	0.179	—0.017	0.070	0.129	Third power unit begins operation.
Dec.	628.50	4.473	0.188	0.067	0.076	0.030	0.173	—0.383	0.398	0.474	
Jan.	626.20	4.090	0.111	0.065	0.093	0.030	0.193	—0.668	0.586	0.684	
Feb.	622.20	3.422	0.230	0.071	0.118	0.030	0.219	—0.601	0.612	0.730	
Mar.	618.10	2.821	0.357	0.055	0.114	0.050	0.249	—0.506	0.614	0.758	
Apr.	614.00	2.315	0.006	0.090	0.154	0.050	0.294	—0.874	0.586	0.740	
May	606.50	1.441	—0.041	0.047	0.211	0.070	0.328	—0.509	0.140	0.351	Fourth power unit begins operation.
June	601.80	0.932	0.106	0.001	0.240	0.050	0.291	—0.195	0.010	0.250	
Total (Nov.-June)			1.189	0.476	1.100	0.350	1.926	—3.753	3.016	4.116	
Annual										

Statement II—(*Contd.*)

		1	2	3	4	5	6	7	8	9	10
1958-59	July	600.00	0.736	11.037	0.033	0.242	0.060	0.335	+0.315	10.387	10.629
	Aug.	602.90	1.051	6.406	0.025	0.271	0.050	0.356	+1.461	4.589	4.860
	Sep.	615.60	2.512	10.804	0.046	0.226	0.070	0.342	+1.611	8.851	9.077
	Oct.	626.40	4.123	4.604	0.077	0.242	0.050	0.369	+0.551	3.684	3.926
Total				32.851	0.181	0.931	0.240	1.402	+3.938	27.511	28.492
	Nov.	629.70	4.674	0.712	0.054	0.214	0.040	0.308	+0.050	0.354	0.568
	Dec.	630.00	4.724	0.184	0.055	0.240	0.030	0.335	-0.167	0.016	0.256
	Jan.	629.00	4.557	0.305	0.052	0.414	0.030	0.505	-0.200	Nil	0.414
	Feb.	627.80	4.357	-0.093	0.060	0.418	0.030	0.508	-0.601	Nil	0.418
	Mar.	624.20	3.756	-0.057	0.057	0.510	0.050	0.627	-0.684	Nil	0.510
	Apr.	620.10	3.072	0.059	0.073	0.518	0.050	0.641	-0.572	Nil	0.518
	May	615.50	2.500	0.029	00.86	0.540	0 070	0.696	-0.667	Nil	0.540
	June	610.10	1.833	0.166	0.016	0.556	0.050	0.622	-0.457	0.001	0.557
Total				1.316	0.483	3.410	0.350	4.243	-3.298	0.371	3.781
Annual				34.167	0.664	4.391	0.590	5.645	+0.640	27.882	32.273

Statement II—(*Contd.*)

		1	2	3	4	5	6	7	8	9	10
1959-60	July	605.90	1.376	4.479	0.011	0.600	0.050	0.671	+0.174	3.634	4.234
	Aug.	607.50	1.550	15.482	0.051	0.590	0.060	0.701	+0.900	13.881	14.471
	Sep.	615.10	2.450	14.681	00.83	0.520	0.070	0.673	+1.940	12.068	12.588
	Oct.	628.00	4.390	1.794	0.105	0.468	0.050	0.624	+0.334	0.836	1.304
Total				36.436	0.251	2.178	0.240	2.669	+3.348	30.419	32.597
	Nov.	630.00	4.724	0.401	0.080	0.404	0.040	0.524	—0.151	0.028	0.432
	Dec.	629.10	4.573	0.139	0.076	0.416	0.030	0.522	—0.383	Nil	0.416
	Jan.	626.00	4.190	0.153	0.076	0.448	0.030	0.554	—0.401	Nil	0.448
	Feb.	624.40	3.789	0.028	0.078	0.420	0.030	0.528	—0.500	Nil	0.420
	Mar.	621.40	3.289	0.105	0.074	0.474	0.050	0.598	—0.493	Nil	0.474
	Apr.	617.90	2.796	0.030	0.071	0.440	0.050	0.561	—0.531	Nil	0.440
	May	613.60	2.265	0.056	0.076	0.506	0.070	0.652	—0.596	Nil	0.506
	June	608.60	1.669	0.401	0.001	0.578	0.050	0.629	—0.228	Nil	0.578
Total				1.313	0.532	3.686	0.350	4.568	—3.283	0.028	3.714
Annual				37.749	0.783	5.864	0.590	7.237	0.065	30.447	36.311

Statement II—(*Contd.*)

		1	2	3	4	5	6	7	8	9	10
1961-62	July	606.50	1.441	6.123	0.050	0.535	0.060	0.645	—0.086	5.564	6.099
	Aug.	605.70	1.355	17.567	0.056	0.451	0.060	0.567	+0.812	16.188	16.639
	Sep.	612.80	2.167	3.992	0 051	0.465	0.070	0.586	+2.456	0.950	1.415
	Oct.	629.40	4.623	3.256	0.072	0.464	0.050	0.586	+0.101	2.569	3.033
Total				30.938	0.229	1.915	0.240	2.384	+3.283	25.271	27.186
	Nov.	630.00	4.724	0.435	0.078	0.418	0.040	0,536	—0.117	0.016	0.434
	Dec.	629.30	4.607	0.166	0.068	0.452	0.030	0.550	—0.384	Nil	0.452
	Jan.	627.00	4.223	0.101	0.118	0.470	0.030	0.618	—0.517	Nil	0.470
	Feb.	623.90	3.706	0.270	0.093	0.414	0.030	0.537	—0.267	Nil	0.414
	Mar.	622.30	3.439	0.035	0.092	0.524	0.050	0.666	—0.631	Nil	0.524
	Apr.	618.00	2.808	0.081	0.116	0.482	0.050	0.648	—0.567	Nil	0.482
	May	613.40	2.241	0.036	0.098	0.602	0.070	0.770	—0.734	Nil	0.602
	June	607.10	1.507	5.388	Nil	0.614	0.050	0.664	+0.376	4.348	4.962
Total				6.512	0.663	3.976	0.350	4.989	—2.841	4.364	8.340
Annual				37.450	0.892	5.891	0.590	7.373	+0.442	29.635	35.526

Statement II—(*Contd.*)

		1	2	3	4	5	6	7	8	9	10	
1961-62*	July	610.50	1.883	22.011	0.019	0.559	0.060	0.638	+0.432	20.941	21.500	
	Aug.	614.00	2.315	13.360	0.097	0.531	0.060	0.688	+0.406	12.266	12.797	
	Sep.	617.30	2.721	23.685	0.043	0.475	0.070	0.588	+1.919	21.178	21.653	
	Oct.	629.50	4.640	5.363	0.069	0.425	0 050	0.544	+0.117	4.702	5.127	
Total				64.419	0.228	1.990	0.240	2.458	+2.874	59.087	61.077	
	Nov.	630.20	4.757	1.020	0.058	0·533	0.040	0.631	+0·033	0.356	0.889	
	Dec.	630.40	4.790	0.347	0 065	0.452	0.030	0.547	—0.200	Nil	0.452	
	Jan.	629.20	4·590	0.099	0·075	0.628	0.030	0.733	—0.634	Nil	0.628	
	Feb.	625.40	3.956	0.271	0.070	0.605	0.030	0.705	—0.434	Nil	0.605	
	Mar.	622.80	3.522	0.076	0.106	0.693	0 050	0.849	—0·773	Nil	0.693	
	Apr.	617.60	2.759	0.042	0.098	0.733	0.050	0.881	—0.839	Nil	0.733	5th power unit begins operation
	May	610.80	1.920	0.035	0.053	0.716	0.070	0.839	—0.804	Nil	0.716	Canals closed from May 15
	June	603.50	1.116	0.300	0.016	0.731	0.050	0.797	—0.497	Nil	0.731	Canal opened on June 15
Total				2.190	0.541	5.091	0.350	5.982	—4.148	0.356	5.447	
Annual				66.609	0.769	7.081	0.590	8.440	—1.274	59.443	66.524	

Statement II—(*Contd.*)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	
1962-63	July	598.40	0.619	3.133	0.075	0.848	0.060	0.983	–0.174	2.324	3.172	
	Aug.	596.04	0.445	6.134	0.077	0.580	0.060	0.917	+1.319	3.898	4.678	
	Sept.	609.47	1.764	4.730	0.121	0.647	0.070	0.838	+2.973	0.919	1.566	
	Oct.	630.08	4.737	0.659	0.184	0.598	0.050	0.832	–0.177	0.004	0.602	
Total				14.656	0.457	2.873	0.240	3.570	+3.941	7.145	10.018	
	Nov.	629.02	4.560	0.315	0.067	0.615	0.040	0.722	–0.407	Nil	0.615	
	Dec.	626.58	4.153	0.221	0.061	0.474	0.030	0.565	–0.344	Nil	0.474	
	Jan.	624.52	3.809	0.174	0.102	0.467	0.030	0.599	–0.424	Nil	0.467	
	Feb.	621.98	3.385	—0.081	0.096	0.467	0.030	0.593	–0.674	Nil	0.467	
	Mar.	617.21	2.711	0.092	0.120	0.584	0.050	0.754	–0.662	Nil	0.584	
	Apr.	611.85	2.049	2.032	0.105	0.562	0.050	0.717	–0.685	Nil	0.562	
	May.	605.79	1.364	—0.034	0.056	0.500	0.070	0.626	–0.660	Nil	0.500	Canals closed from the 14th May.
	June.	599.56	0.704	0.683	0.014	0.544	0.050	0.608	–0.091	0.166	0.710	Canals opened on the 21st June.
Total				1.403	0.621	4.213	0.350	5.184	–3.947	0.166	4.379	
Annual				16.059	1.078	7.086	0.590	8.754	–0.006	7.311	14.397	

Statement II—(*Contd.*)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	
1963–64	July	598.32	0.613	3.901	0.093	0.767	0.060	0.920	–0.113	3.094	3.861	6th power unit goes into operation
	Aug.	596.79	0.500	11.886	0.106	0.682	0.060	0.848	+0.938	10.100	10.782	
	Sep.	606.47	1.438	10.389	0.097	0.565	0.070	0.732	+3.135	6.522	7.087	
	Oct.	629.10	4.573	1.724	0.125	0.485	0 050	0 660	+0.234	0.830	1.315	
Total				27.900	0.421	2.499	0.240	3.160	+4.194	20.546	23 045	
	Nov.	630.50	4.808	0.542	0.079	0.564	0.040	0.683	–0.227	0.086	0.650	
	Dec.	629.14	4.580	0.196	0 113	0.525	0.030	0.668	–0.472	Nil	0.525	
	Jan.	626.31	4.108	0.077	0.140	0.503	0.030	0.673	–0.596	Nil	0.503	
	Feb.	622.74	3.512	0.058	0.151	0.429	0.030	0.610	–0.552	Nil	0.429	
	Mar.	619.23	2.960	0.106	0.174	0.482	0.050	0.706	–0.600	Nil	0.482	
	Apr.	614.37	2.360	0.016	0.141	0.497	0.050	0.688	–0.672	Nil	0.497	
	May.	608.77	1.688	–0.027	0.013	0.668	0.070	0.751	–0.778	Nil	0.668	Canals closed from 3rd May.
	June.	601.60	0.910	1.154	0.041	0.591	0.050	0.682	–0.416	0.888	1.470	Canals opened on 7th June.
Total				2.122	0.852	4.259	0.350	5.461	–4.313	0.974	5.233	
Annual				30.022	1.273	6.758	0.590	8.621	–0.119	21.520	28.278	

Statement II—(*Contd.*)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	
1964–65	Julv.	596.67	0.491	12.200	0.048	0.732	0.060	0.840	+0.043	11.317	12.049	
	Aug.	597.25	0.534	20.115	0.113	0.685	0.060	0.858	+3.934	15.323	16.008	
	Sep.	628.47	4.468	5.472	0.137	0.612	0.070	0.819	+0.237	4.416	5.028	
	Oct.	629.89	4.705	3.579	0.168	0.612	0.050	0.830	–0.043	2.792	3.404	
Total				41.366	0.466	2.641	0.240	3.347	+4.171	33.848	36.489	
	Nov.	629.63	4.662	0.806	0.117	0.528	0.040	0.685	+0.013	0.108	0.636	
	Dec.	629.71	4.675	0.182	0.116	0.526	0.030	0.672	–0.490	Nil	0.526	
	Jan.	626.77	4.185	0.149	0.135	0.565	0.030	0.730	–0.581	,,	0.565	
	Feb.	623.29	3.604	0.049	0.144	0.516	0.030	0.690	–0.641	,,	0.516	
	Mar.	619.25	2.963	0.168	0.151	0.644	0.050	0.845	–0.677	,,	0.644	
	Apr.	613.77	2.286	0.127	0.142	0.585	0.050	0.777	–0.650	,,	0.585	
	May.	608.29	1.636	–0.004	0.002	0.584	0.070	0.656	–0.660	,,	0.584	Canals closed whole month.
	June	602.21	0.976	0.243	0.066	0.569	0.050	0.685	–0.442	,,	0.569	
Total				1.720	0.873	4.517	0.350	5.740	–4.128	0.108	4.625	
Annual				43.086	1.339	7.158	0.590	9.087	+0.043	33.956	41.114	

Statement II—(*Contd.*)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	
1965–66	July.	597.25	0.534	2.301	0.122	0.680	0.060	0.862	+0.054	1.385	2.065	
	Aug.	597.98	0.588	2.750	0.219	0.645	0.060	0.924	+1.608	0.218	0.863	
	Sept.	613.04	2.196	4.816	0.241	0.485	0.070	0.796	+2.606	1.414	1.899	
	Oct.	630.47	4.802	0.524	0.240	0.552	0.050	0.842	–0.350	0.032	0.584	
Total				10.391	0.822	2.362	0.240	3.424	+3.918	3.049	5.411	
	Nov.	628.37	4.452	0.168	0.072	0.507	0.040	0.619	–0.451	Nil	0.507	
	Dec.	625.67	4.001	0.041	0.093	0.495	0.030	0.618	–0.577	,,	0.495	
	Jan.	622.21	3.424	0.097	0.159	0.490	0.030	0.679	–0.582	,,	0.490	
	Feb.	618.27	2.842	0.078	0.173	0 478	0.030	0.681	–0.603	,,	0.478	
	Mar.	613.39	2.239	–0.002	0.207	0.505	0.050	0.762	–0.764	,,	0.505	
	Apr.	606.81	1.475	–0.074	0.168	0.455*	0.050	0.673	–0.747	,,	0.455	
	May	599.89	0.728	0.062	0.051	0.387*	0.070	0.508	–0.446	,,	0.387	Canals closed from 15th May.
	June	593.83	0.282	2.070	0.008	0.374*	0.050	0.432	+0.442	1.116	1.570	Canals opened on 24th June.
Total				2.440	0.931	3.691	0.350	4.972	–3.728	1.116	4.887	
Annual				12.831	1.753	6.053	0.590	8.396	+0.190		10.298	

*Power cut 20 per cent on all installations drawing 125 K VA or more

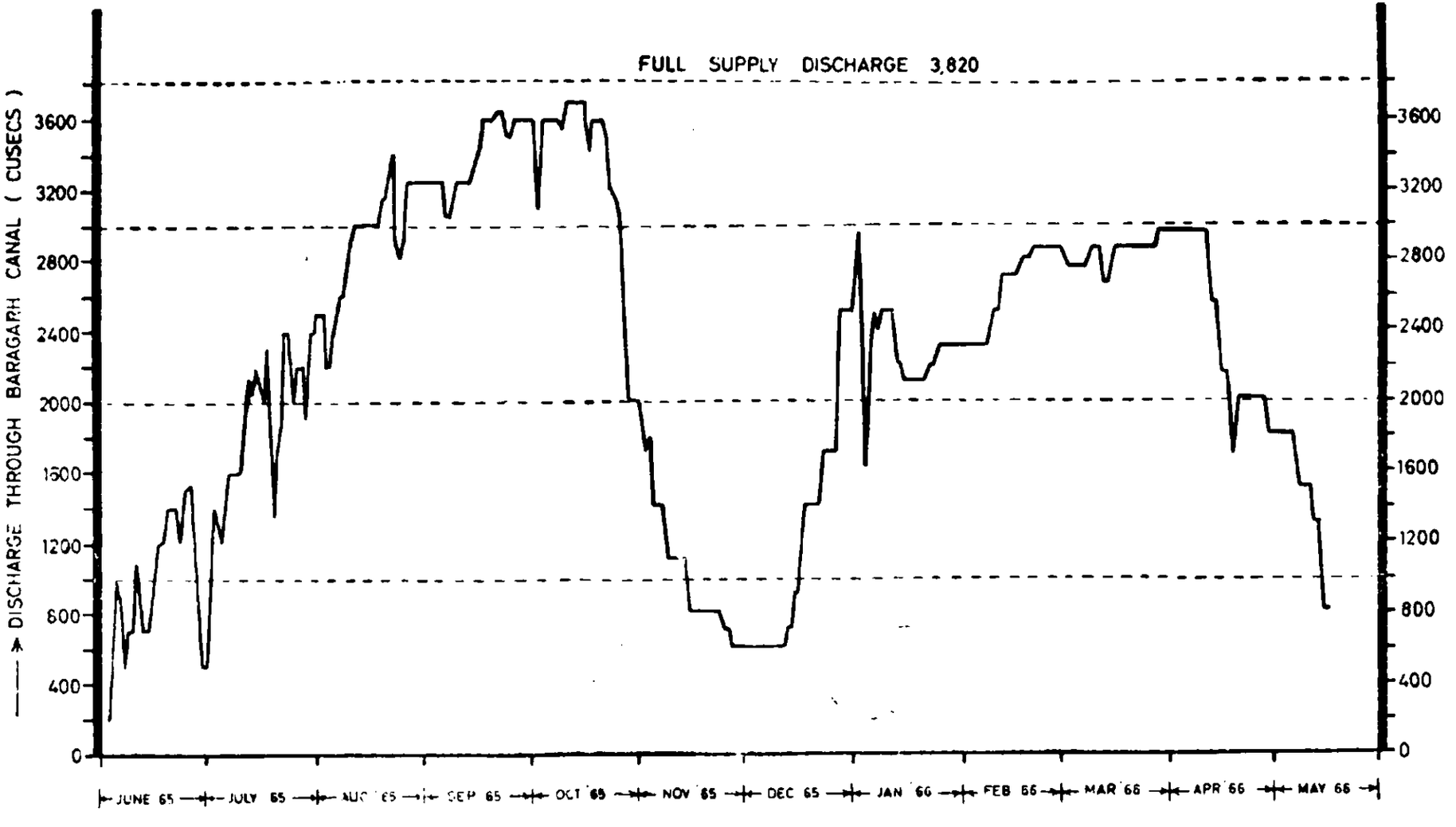
Statement II—(*Contd.*)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1966–67	July	599·83	0·724	3·960	0·125	0·625	0·060	0·810	+0·424	2.726	3·351
	Aug.	603·79	1·148	8·047	0·137	0·650	0·060	0·847	+0·377	6.823	7·473
	Sept.	607·27	1·525	1·643	0·196	0·516	0·070	0·782	+0·861	Nil	0·516
	Oct.	614·58	2·386	0·323	0·199	0·519	0·050	0.768	—0·445	Nil	0·519
Total				13·947	0·657	2·310	0·240	3·207	+1·217	9·549	11.859
	Nov.										
	Dec.										
	Jan.										
	Feb.										
	Mar.										
	Apr.										
	May										
	June										
Total											
Annual											

Statement II(—*Contd.*)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
WORKING TABLE (Derived from Appendix 9 of the Report of the Evaluation Committee, 1962)										
	July	590·0	Nil	6·290	0·274	0·714	0·060	1·048	Nil	5·242	5·956
	Aug.	590·0	Nil	16·400	0·202	0·714	0·060	0·976	+0·736	14·688	15·402
	Sep.	600·0	0·736	6·650	0·274	0·625	0·070	0·969	+3.988	1·693	2·318
	Oct.	630·0	4·724	3·486	0·274	0 541	0·050	0·865	Nil	2·621	3·162
Total				32·826	1·024	2·594	0·240	3·858	+4·724	24·244	26·838
	Nov.	630·0	4·724	0.445	0·237	0·535	0.040	0·812	—0·367	Nil	0·535
	Dec.	627·8	4·357	0·252	0·049	0·541	0·030	0·620	—0·368	Nil	0·541
	Jan.	625·6	3·989	0·251	0·241	0·547	0·030	0·818	—0·567	Nil	0·547
	Feb.	622·2	3·422	0.131	0·241	0·560	0·030	0·831	—0·700	Nil	0·560
	Mar.	617·3	2·722	0·056	0 241	0· 80	0·050	0·871	—0·815	Nil	0·580
	Apr.	610·7	1·907	0·037	0·241	0·601	0·050	0.892	—0·855	Nil	0·601
	May	603·0	1·052	0·032	0·072	0·633	0·070	0·775	—0·743	Nil	0·633
	June	594·2	0·309	0·522	0·102	0·679	0·050	0·831	—0·309	Nil	0·679
Total				1·726	1·424	4·676	0·350	6·450	—4·724	Nil	4·676
Annual				34·552	2·448	7·270	0·590	10·308	Nil	24·244	31·514

PATTERN OF CANAL WITHDRAWALS
1965-66



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