

HIRAKUD DAM PROJECT

REPORT ON THE INVESTIGATIONS FOR
EXTENSION OF IRRIGATION IN
THE MAHANADI DELTA

By

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New Delhi, the 20th October, 1953.

From:-

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To:-

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Burla.

Subject:- Report on the Investigations for extension
of Irrigation in the Mahanadi Delta.

Sir,

I am forwarding herewith 50 copies of the Report on the Investigations for extension of Irrigation in the Mahanadi Delta for further disposal.

Four copies of details of Estimates on which the Abstract of cost is based and three files containing design statements also accompany.

Eleven portfolios containing Index Plans, Drawings of Masonry structures, designed in the C.D.O. and the Circle Office, Longitudinal and Cross Sections of main canals, Branches and Distributaries etc. are sent separately.

2. The estimated cost of the present Revised proposals, discussed in paras 6 to 6.13 of the Report amounts to Rs. 14.82 Crores as under:-

(i) Remodelling the Existing Canal system. Rs. 4.08 Crores.

(ii) Cost of construction of New canal system in the Puri District coupled with flood control with the off-take of the New Canal above the new weir upstream of Naraj.

Rs. 10.82 "

Total.

Rs. 14.82 Crores.

A culturable area of 10,77,000 acres will be commanded under this proposal which will cost Rs. 138/- per acre of C.C.A.

2.1 The Mazundar Committee had estimated a cost of Rs. 11.0 Crores for irrigating a culturable area of 7,68,000 acres which gave a rate of Rs. 143/- per acre of C.C.A.

3. The cost of an alternate proposal discussed in para 6.15 of the Report has also been estimated. This proposal is nearly similar to the one approved by the Mazumdar Committee and consists of irrigating the new areas in the Puri District through the Taldanda canal and the construction of two Barrage one on Katjuri and the other on Kuakhai to provide a level crossing.

The cost of this alternative which will command a culturable area of 9,92,000 acres amounts to Rs. 12.31 Crores. This gives a cost of Rs. 124/- per acre of C.C.A.

The adoption of this proposal is likely to result in the increase of Bellevue gauge from 27.8, the maximum so far recorded, to 29.8 which may affect the safety of the Cuttack town, as explained in para 6.15 of the report.

4. The Mazumdar Committee had suggested alternative arrangements for irrigation of new areas and disposal of flood in the Puri District vide appendix IV of its report.

Cost of these proposal has also been estimated and amounts to Rs. 22.3 crores. The cost per acre of C.C.A. works out to Rs. 225/-.

Apart from the heavy cost involved, the alternative arrangements suggested by the Committee are subject to technical objections described in para 4.3 and 6 of the Report.

5. It has not been possible to work out the financial aspect of this scheme, as water rates and rates of betterment levy to be adopted for the delta area have not yet been finalised by the Committee appointed by the Hirakud Control Board for appraisal of direct benefits from the Hirakud Dam Project.

6. Programme of construction and requirements of funds for works expenditure for the Delta Project have been worked out on the assumption that the construction will be started in 1954-55, and completed in 1959-60.

Yours faithfully,

M. G. Hiranandani

(M. G. Hiranandani)

D.A/ As above.
"Chaman" 20.10.

C O N T E N T S.

<u>Paras</u>		<u>Page.</u>
I.	<u>INTRODUCTION.</u>	1-2
II.	<u>THE MAHANADI DELTA.</u>	3-8
2.	Physical features.	3
2.1	Rainfall.	3
2.2	River system.	4
2.3	Drainage.	7
2.4	Famines and Floods.	7
III.	<u>EXISTING IRRIGATION.</u>	9-21
3.	The Orissa canal system.	9
3.1	Diversion works.	10
	Naraj Weir.	11
	Mahanadi & Birupa Weirs.	11
3.2	Canals.	12
	High Level Canal Range No.1	12
	Kendrapara Canal.	12
	Taldanda Canal.	14
3.3	Irrigation Development.	15
3.4	Irrigation on Godavari Canals.	16
3.5	Canal Administration.	16
	3.51 System of granting leases.	16
	3.52 Long Leases.	17
	3.53 Seasonal Leases.	17
	3.54 Provisional Leases.	18
	3.55 Seasonal leases for crops other than autumn rice.	18
	3.56 Classification of Land.	18
	3.57 Defects of lease system.	18
3.6	Reasons for unsatisfactory progress of irrigation development.	19
IV.	<u>PREVIOUS PROPOSALS FOR EXTENSION OF IRRIGATION IN THE MAHANADI DELTA.</u>	22-28
4.	1947 Project proposals.	22
4.1	Proposals according to revised Project report (1952)	22

Paras.		<u>Page.</u>
4.2	Mazundar Committee proposals.	23
	4.21 Disposal of floods.	23
	4.22 Irrigation system.	24
4.3	Chief Engineer Orissa's proposals.	25
V.	<u>PRESENT INVESTIGATIONS.</u>	29-40
5.	Present Investigations.	29
5.1	The existing canal systems.	29
5.2	The new areas in Puri District.	30
	5.21 Flood control.	30
	5.22 Extension of Irrigation.	31
5.3	Soil Survey.	31
5.4	Contour survey.	32
5.5	Culturable area.	33
5.6	Distribution of discharges in Mahanadi & its branches.	35
	5.61 Statistical analysis of the gauge & discharge data.	36
5.7	Model experiments.	37
5.8	Sub-soil water level observations.	38
5.9	Discharge observations at Naraj.	39
5.10	Discharge observations on existing canals.	40
VI.	<u>PRESENT REVISED PROPOSALS (1953).</u>	41-67
6.	Flood control in the Puri District.	41
6.1	Extension of Irrigation in Puri.	44
	6.11 Site for the new weir.	44
	6.111 Salient features of the proposed new weir above Naraj & the head regulator over the new canal.	46
6.2	Proposals for Remodelling of existing weirs, head-Regulators etc.	48
	6.21 Jobra weir.	48
	6.22 Birupa weir.	49
	6.23 Remodelling of Head Regulators for the existing canals.	50
	6.24 Syphons for Irrigating Island areas.	50

<u>Paras</u>	<u>Page.</u>
6.3 Intensity of Irrigation.	51
6.31 Crop Rotation.	52
6.4 Duties.	53
6.41 Water allowance per 1000 acres of C.C.A.	56
6.42 Water requirements for canals.	56
6.5 Transmission and Losses.	56
6.6 Design of canal sections.	57
6.7 Free Boards for Canal Embankments & width of Inspection paths for different discharges.	57
6.71 Free boards for masonry structures.	58
6.8 Berm widths at full supply level.	58
6.9 Design of River Embankments.	58
6.10 Salient features of the canal system.	59
6.101 Kendrapara canal.	59
6.102 Taldanda canal.	60
6.103 H.L.C. Range No.1	60
6.104 Salient features of the Existing Canal system.	61
6.105 New Canal system in the Puri District.	61
6.106 Salient features of the Existing and New canal system.	62
6.11 Field channels (Water courses).	62
6.12 Navigation (New Canals).	64
6.13 Design of Drains.	64
6.14 Additional production of Food Grains.	65
6.15 Alternate proposals.	66

<u>Paras.</u>		<u>Page.</u>
VII.	<u>FINANCIAL ASPECTS.</u>	68-73
7.	History of water rates.	68
7.1	Present water rates.	69
7.2	Water Rates proposed by Advisory Committee.	70
7.3	Water Rates and Rates for betterment Levy proposed for the delta areas.	70
7.4	Present Revenue Receipts on account of Irrigation.	70
7.5	Navigation and Revenue therefrom.	72
VIII.	<u>ESTIMATES OF EXPENDITURE.</u>	74-80
8.	Estimated cost of present proposals.	74
8.1	Cost of alternate proposals.	80
8.2	Cost of alternative arrangement for flood disposal and Irrigation suggested by the Mazumdar Committee.	80
IX.	<u>PROGRAMME OF CONSTRUCTION AND WORKS EXPENDITURE.</u>	81-85
9.	Establishment.	81
9.1	Construction programme.	83
9.2	Requirements of funds.	85

LIST OF APPENDICES.

	<u>Pages.</u>
Appendix I .. Statements accompanying the Report.	86-103
Appendix II. .. Extract from Administrative accounts for 1951-52 for Orissa Canal Project.	103-116
Appendix III. .. A note on the Inspection of Godavari & Krishna Delta, by Shri M.G.Hiranandani.	117-142
Appendix IV. .. Note by the Chief Engineer, Orissa on Advisory Committee's report on Hirakud Dam Project.	143-164
Appendix V. .. Report on the Soil Survey of the Mahanadi Delta by Dr.R.C.Hoon.	165-177
Appendix VI. .. A note on the Statistical examination of Gauge-Discharge Delta by Shri C.K.Kochukoshy, E.A.D., C.W.& P.Commission.	178-187
Appendix VII. .. Correspondence on Model Experiments Joint note and preliminary note on Model Experiments by the Director, C.W.& Power Research Station and subsequent correspondence.	188-211
Appendix VIII... A note on the study of sub soil water level observations in the Mahanadi Delta by Shri C.K.Kochukoshy.	212-217
Appendix IX. .. A note on the analysis of discharge data observed at Nafaj & Sambalpur by Shri C.K.Kochukoshy, E.A.D., C.W.& P.Commission.	218-240
Appendix X. .. Note on intensities, crop rotation etc. to be adopted on the Delta Canals, and copies of confirmation of minutes.	241-245
Appendix XI. .. Note on the Duty of Irrigation water proposed to be adopted for various crops in the Delta Area of the Mahanadi by Shri M.G. Hiranandani.	246-248
Appendix XII. .. Note on the areas, alignments and design of the New Canal system in Puri District by Shri K.S.Misra.	249-252
Appendix XIII... An extract from Chapter VII Volume I.A of the Revised Hirakud Dam Project showing the water rates adopted in other Projects.	253-255
Appendix XIV. Abstracts of costs.	256-273.

LIST OF PLANS.

1. Index map showing the existing canals and the Advisory Committee's proposals scale 1" = 4 miles.
2. Index plan showing proposals for irrigation and flood control for new areas in Puri District scale 1" = 2 miles.
3. Index plan showing existing Orissa canals and proposed extensions scale 1" = 2 miles.

REPORT ON THE INVESTIGATIONS FOR
EXTENSION OF IRRIGATION IN THE MAHANADI DELTA.

I. I N T R O D U C T I O N.

1. The 1947 report on the Hirakud Dam Project did not include the area to be irrigated in the Mahanadi delta which lies about 200 miles down-stream of the Hirakud Dam.

A note was, however, made on page 52 of the Project report that "A thorough enquiry into the existing irrigation in the delta, the reasons for its being non-productive and the possibilities of improvement and extension seems to be urgently called for."

The Advisory Committee on Hirakud Dam Project appointed by the Government of India in March 1948 in their recommendations to the Government stated as under:-

" Steps for over-hauling delta irrigation in the Mahanadi Valley to be taken up atonce as also the investigation to utilize the continuous supply of 8,000 to 10,000 cusecs in dry weather for extension of Rabi Crop cultivation and bringing new areas under irrigation".

The investigations in this connection which were to be originally undertaken by the Orissa Government could not be taken in hand as the latter expressed its inability to do so for want of funds. One Division was opened for investigations in October 1951.

A rough estimate of the cost of improvements to the existing irrigation and for extension of irrigation in the new areas both in Cuttack and Puri District was worked out in January 1952 and incorporated in the revised estimates of the Hirakud Dam Project Vol.1.A.

The Advisory Committee on the Hirakud Dam Project (March 1952) appointed by the Government of India to review the revised estimate scrutinised the rough proposals made in connection with the delta irrigation and revised the

cost of proposals to Rupees 11.0 crores. It further desired that the recommendations made by the Committee be thoroughly investigated before the final proposals for irrigation and flood control in the Puri District are formulated.

One more Division and a Circle with a Superintending Engineer Incharge were sanctioned by the Government of India in May'1952, to carry out investigations in connection with improvements to the existing canal system and for extension of irrigation and flood control in Puri District, and prepare an estimate of cost of these proposals. This report deals with the investigations carried out, proposals for improvements to the existing Delta Canal system and for irrigation of new areas coupled with measures for flood control.

II. MAHANADI DELTA.

2. PHYSICAL FEATURES.

The proposals for improvements to the existing canals system and for extension of irrigation are confined to the Mahanadi Delta the Northern part of which over-laps to some extent deltaic region of the Brahmani river.

The general coast line of the delta is of typical shape projecting into the sea in a sector of a circle. On the west side is the big depression known as the Chilka lake. It has been cut off from the sea partly by a strip of rising land adjoining the coast and partly by extending sand drift. It is very gradually silting up at its east end by flood deposits of the Daya and Bhargovi rivers and the silt driven east-ward by the prevailing high winds on the lake. Index plan No.I shows the above features.

2.1 RAINFALL.

Both Puri and Cuttack are districts with abundant rain-fall. The maximum rainfall of 89 inches has been recorded in 1936 and a minimum of 42.48 in 1918 and 47.57 in 1921 in Cuttack and Puri districts respectively. The average rainfall during the years 1912 to 1952 is 62 inches. During this period the rainfall has been less than 50 inches on 5 occasions.

" On the other hand the rainfall is precarious, and an untimely or unequal distribution is liable to cause a partial or complete destruction of the crop, even if the actual rainfall does not fall short of the quantity required. A heavy shower in February or March is necessary to enable the land to be ploughed, but the most critical months are May, September and October. If the May showers, which are precursors of the Monsoon rains, do not fall sowing may be prejudicially delayed; but deficiency in the rainfall in September and October is even more dangerous, as it affects

the maturing of the staple rice crop. The most terrible famine of 1866 was caused by the failure of the September and October rains, and in 1896 and 1907, with the rainfall very little below the normal serious loss was caused by the cessation of the rains early in September."

2.2 RIVER SYSTEM.

The most conspicuous feature of the coastal area in the Cuttack district is a system of three rivers, emerging from the hills in the west. The Southern most is the Mahanadi that debouches into the plains above Naraj 70 miles from the sea. Northern most is the Baitarni river traversing a less hilly country. The Brahmani river enters the district about half way between the two.

The scope of the present investigation of irrigation possibilities is confined to the Mahanadi delta area lying between Brahmani on the one side and the Chilka lake shore on the other.

The Mahanadi has a catchment area of 51,000 sq.miles above Naraj and is by far the largest of all the rivers which traverse the State of Orissa and receives the drainage of a number of tributaries in its course. It forms a great delta-head and divides into a number of branches. At Naraj it bifurcates, the southern branch being known as the Katjuri, while the northern retains the name of the parent stream. About 10 miles lower-down, opposite Cuttack, the Birupa branches off from the Mahanadi. Flowing in a north-easterly direction for about 12 miles, the Genguti takes off the Birupa on its left bank, the two streams enclosing between them the island of Kuhunda Jaipur; the Genguti meets the Kimiria, an off-shoot of the Brahmani, about 18 miles below the point of bifurcation, and rejoins the parent stream a mile lower down. After receiving the waters brought down by these streams, the Birupa discharges

itself into the main stream of the Brahmani a little above Indpur, and their united waters ultimately find their way into the Bay of Bengal by the Dhamra estuary.

After passing Cuttack, the Mahanadi divides into three branches, the Chitratola to the north, the Mahanadi in the centre and the Paika to the south. The Chitratola branch leaves the parent stream about 10 miles below the Birupa mouth, and soon bifurcates into the Chitratola and the Nuna. These streams unite after a course of about 20 miles, and under the name of the Nuna, fall into the Mahanadi estuary and the Bay of Bengal. About ten miles from the point of bifurcation the Paika and Mahanadi rejoin, but only to separate again into the Sukhpaika and Mahanadi; these branches reunite further down, and then dividing into a number of channels pass into the Bay of Bengal.

The Katjuri arm of the Mahanadi, after branching off at Naraj almost immediately divides into Kuakhai, a southern branch flowing through the district of Puri. It is a high level branch practically acting as a spill-channel of the main Katjuri. A short distance below Cuttack the main stream Katjuri throws off the Surua, which however rejoins it after a traversing a few miles. Lower down the Debi takes off and is a low level branch which carries the major discharge. During its course to the sea, the Debi divides itself into a great number of branches and minor channels all of which eventually reunite, and flow, under the name of the Devi, through the Puri District into the Bay of Bengal. As the Katjuri began to get enlarged and drew considerable volume of water from the Mahanadi at the bifurcation point, a weir and training embankments were constructed at Naraj between 1860 and 1865, in order to regulate the flow and divert the low supplies into the Mahanadi for feeding the channels lower down.

KUAKHAI RIVER:-

The Kuakhai branches into three important rivers namely Kushbhadra, Bhargovi and Daya. Except Kushbhadra which has a direct out-fall into the sea, the other two discharge their waters into the Chilka lake.

Kuakhai is embanked on both sides, except for the Mancheswar spill on the right bank situated nine miles below the head.

KUSHBHADRA:-

The Kushbhadra river has two rivected, high level flood escapes, one at Jogiāsahi on the right bank about 3 miles below the head and the other at Ramchandrapur a little below on the left bank.

It is embanked on both sides upto 2 miles above Gop village.

BHARGOVI:-

River Bhargovi has also two high level escapes, one about 5 miles from the head called the Achhootpur flood escape and the other known as the Kanchi off-take on its left bank.

The draw off by the Kanchi has increased during flood time due to the construction of the Sur lake sea cut which keeps the lake at a much lower level than previously throughout the flood season.

Another branch of Kanchi which falls into Somangpat is the bigger stream of the two. The draw off from Kanchi has resulted in the silting up of Bhargovi below its off-take and thus decreased its discharge capacity. Bhargovi is embanked on both sides.

DAYA:-

This river has developed generally at the expense of the Bhargovi, and carries major portion of the discharge flowing down the Kuakhai.

Daya is embanked in a length of 33 miles on the left and 11 miles on the right from its head.

It has three flood escapes at Belmora, Madhipur and Kanti.

The River system, main drainage lines, position of Escapes etc. are shown on the Index Plan No.I.

2.3 DRAINAGE.

There are 3 main natural drainage channels the Prachi, Dhanua and Nuna in the Katjuri-Kushbhadra, Kushbhadra-Bhargovi and Bhargovi-Daya doabs respectively in the Puri District.

Prachi, carrying the spill from Ramchandrapur and the drainage from the catchment area of its doab, has its out-fall into the sea. Dhanua, which carries the discharge from Jogiashahi and Achhootpur escapes, empties into Sur lake which has an out-let into the sea. Nuna carrying the overflow from the 3 Daya river escapes flows into Chilka Lake.

In the case of the Taldanda canal and Kendrapara canal systems in the Cuttack District, these doabs have Hansua and Gobri as their main drainage lines both of which discharge into the Sea.

2.4 FAMINES & FLOODS.

* " Previous to the construction of the Orissa canal system drought and famines were of frequent occurrence. Historical records show that terrible famines occurred in the 14th, 15th and the 16th centuries.

The years 1806, 1808, 1809, 1817 and 1828 were years of bad crops and scarcity, and in 1836, 1837 and 1842 Cuttack suffered severely from drought. The great catastrophe of the century were famines of 1865 and 1866.

During the last century Cuttack also, frequently suffered from inundation and though defensive works in the shape of embankments along the rivers prevented the devastation

of the District, a large proportion of the immense volume of water concentrated on the Delta periodically, spreads over the country. Since 1830, floods of a serious character have occurred not less than 28 times, namely in 1831, 1834, 1848, 1851, 1855, 1856, 1857, 1862, 1866, 1868, 1872, 1874, 1877, 1879, 1880, 1881, 1885, 1892, 1894, 1895, 1896, 1900, 1907, 1911, 1913, 1920, 1926 and 1927."

In order to tackle the flood problem the Govt. of Orissa appointed a number of Committees in 1927, 1937, 1938 and 1940. The Investigations were finally carried out by the Central Water and Power Commission. Previous reports and investigations indicated that the solution lay in the development of Mahanadi Valley for storage, irrigation and power.

The recommendations of the different Enquiry Committees mentioned are given in brief in Volume I.A of the general report of the Revised Estimate on the Hirakud Dam Project.

III EXISTING IRRIGATION:-

3. THE ORISSA CANAL SYSTEM:-

The first proposal to utilise the waters of the rivers of Orissa for irrigation, was made in the year 1858 by Sir Arthur Cotton who was invited to advise in the matter of control of floods of the Mahanadi.

*** He recommended the construction of a complete system of irrigation and navigation canals, following the principles then being carried out in the deltas of the Godavari and Kistna. He estimated that an area of 2½ millions of acres might thus be irrigated, and that navigation might be opened up between Orissa, Midnapur and Calcutta, for a sum of Rs.130 lacs. Here, as elsewhere, Sir Arthur Cotton attached special importance to making the canals navigable, and pointed out how completely Orissa was cut off from the rest of India, destitute as it was of roads, railways or harbours, and traversed by a succession of formidable and unbridged rivers. In 1860 the East India irrigation and canal Company was formed for the purpose of carrying out the works in Orissa, and water was first supplied for irrigation in 1865. The works, however, were not sufficiently advanced to be of any real use in the terrible famine of 1866, though they supplied an excellent form of relief labour in the distressed districts. Before this, it had become evident that the original estimate would be largely exceeded; and as the Company found it difficult to raise further funds, the Government of India purchased the whole of the works for the sum of Rs. 109 lakhs and in 1869 the Company ceased to exist".

" From the first, irrigation in Orissa made very slow progress. The works, however, proceeded, and in 1873 it was decided to provide for an irrigable area of 1,14,000 acres in Orissa at an estimated cost of Rs.441 lacs. This area was to

include 500,000 acres in the Balasore and Puri sections of the scheme, which had not then been put in hand and were soon after abandoned. The works sanctioned included the Taldanda and Machgaon canals for the irrigation of the lands between the Mahanadi and Katjuri rivers; the Kendrapara and Pattamunda canals for the irrigation of the area between the Chitratola and the Birupa, and three ranges of the high level canals for the irrigation of the strip ^{of} country lying at the foot of hills from Cuttack to Bhadrak. By 1874, the greater part of the scheme was completed but collections proved very disappointing and in 1884 a revised scheme was approved for the extension of the Taldanda and Machgaon canals and for the construction of new distributaries, bringing up the total estimate to Rs. 9,23,00,000 of which Rs. 2,02,00,000 had already been expended. The Project then approved has been completed, and besides this the Machgaon canal has been extended to the village of Nagpur".

The Government of India purchased the Orissa canals system from the East India Company in 1868 for a sum of Rs. 1,09,00,000. The total capital cost exclusive of interest charges incurred by 1951-52 was Rs. 2,75,94,105. The above cost is inclusive of the cost of L.C. ranges No. I, II, III, which are excluded from the scope of investigation undertaken at present. It has not been possible to obtain the capital cost, exclusive of the cost of Ranges II & III, as the Revenue accounts for these have not been kept separately vide Deputy Accountant General Orissa's letter of the 17th July '53, which along with an extract from the Administrative accounts for the year 1951-52 for the "Orissa Canal Project", is enclosed vide appendix II.

3.1 DIVERSION WORKS.

There are three weirs namely Naraj, Jobra & Birupa, which have been constructed on the Mahanadi and Katjuri rivers.

NARAJ WEIR.

The Mahanadi bifurcates into two branches at Naraj. In 1865 a weir was built across the Katjuri at a cost of Rs. 3.0 lacs to limit the flood flow in the river and divert low supplies into Mahanadi. The crest of the weir has been kept at R.L.72.6 (G.T.S). The length of this weir is 3833 feet. It has a few sluices on the right flank to regulate and draw water into Katjuri when required.

MAHANADI & BIRUPA WEIRS.

Mahanadi and Birupa Weirs, construction of which was commenced in 1864 were completed at a cost of Rs. 10.0 and 2.25 lacs respectively. These are 6,363 and 1,980 feet long between abutments and their crest levels have been kept at R.L.64.0 and 62.8 respectively.

The Mahanadi weir across the main branch of the Mahanadi at Jobra-Cuttack, diverts water into the Taldanda and the Machgaon canals. It has two sets of scouring sluices, one of which is at the south end of the weir, and serves to keep the approach channel to the canal head and the entrance to the Jobra lock, free from silt, while the other, which was situated in the centre of the weir serving the purpose to a certain extent of maintaining a deep water channel above the weir has since been closed.

The Birupa weir is situated across the Birupa branch almost in a line with the Mahanadi weir. It is also provided with two sets of under-sluices one on either side, and diverts water to the Kendrapara canal system and the H.L.C.Range No.1, which take off on its right and left flanks respectively.

Both the Mahanadi and Birupa weirs are fitted with falling shutters which are manually lifted.

All these weirs are of the same design and consist of a curtain wall founded on wells sunk in the sandy bed. This wall on the upstream and downstream sides, is protected by an apron of dry laterite blocks laid at a slope. Since the time of construction till now, in the course of about 80 years, serious damage has occurred to Mahanadi weir only once during a heavy flood in 1886. It caused a breach in the middle of the Central Sluice.

In the year 1942 again, a serious scour started causing a 25 feet deep scour-hole at the downstream toe of the Talus of the Central sluices of the Mahanadi weir. This was referred to the Poona Research Institute, which suggested combination of baffle walls and deflectors, which were constructed in the year 1948. Finally, the crest of the Central sluice section was raised by 5 feet in 1949.

3.2 CANALS.

There are three main canals:-

- i) High Level Canal Range No.1.
- ii) Kendrapara canal & two branches called the Gobri & Pattamundai canals & Gobri extension of the Pattamundai canal.
- iii) The Taldanda canal, with its branch Machgaon canal.

HIGH LEVEL CANAL RANGE NO.1

High level canal range No.1 takes off above the left flank of the weir across the Birupa and then runs along the foot of the hills north-east-wards through the Cuttack district. This is a navigation-cum-irrigation canal with a designed discharge of 600 cusecs. It is 33 miles long and is navigable in a length of 25.5 miles as the last 8 miles are choked with weeds. The total length of distributaries and minors, functioning at present is 75 miles. It commands an area of 44,639 acres.

KENDRAPARA CANAL.

The Kendrapara canal which was opened in the year

1869 is the oldest and the most important canal in the district. Taking off from the Birupa river at Jagatpur just above the anicut it skirts the northern embankment of the river and its tributary the Nuna, running nearly due east to Marasaghai. It has a length of 39 miles. The Kendrapara extension is a continuation of it, which runs between Marsa-ghai and Jamboo, a distance of about 15 miles. The total length of the canal and its extension is 54 miles.

The canal is navigable in its entire length.

It irrigates the country between the Mahanadi and the Gobri drainage channel, its right bank forming protected embankment as well as a thorough-fare for the people.

The Gobri canal is a branch of the Kendrapara canal and takes off at 28th mile of the latter. It is 16 miles long. This canal which was originally intended to be a distributary was afterwards made navigable in order to facilitate communication between Cuttack and Chandbali and it now forms part of the main route between the two places. The designed discharge of Kendrapara including Gobri is 1191 cusecs.

The Pattamundai canal branches off from the Kendrapara canal little less than a mile from the head, and skirts the southern bank of Birupa river and of the Brahmani river for a total length of 50 miles. It is designed for a discharge of 885 cusecs at the head, which is inclusive of the discharge for Gobri extension.

This canal is not navigable and irrigates some of the richest land in Orissa and its left bank protects a large area from the floods of Birupa and Brahmani rivers.

The Gobri extension, which is navigable, is a continuation of the pattamundai canal and derives its water from it, is only six miles long. It forms a connecting link between the terminus of the Gobri canal and the Gandakia river at Alva.

The total length of distributaries and minors on this system is 564 miles.

The Kendrapara canal system is designed to carry a discharge of 2076 cusecs at head, and commands a culturable area of 1,98,508 acres.

TALDANDA CANAL.

The Taldanda canal takes off from the right bank of the Mahanadi immediately above the anicut at Jobra, and runs in the south-eastern direction of Birabati, where the Machgaon canal branches off. It then runs along the southern bank of Sukhapaika and the Mahanadi for a total length of 52 miles. This canal which was designed for the purpose of irrigating the triangular piece of land between the Mahanadi and the Katjuri, is also navigable in its entire length and provides an alternative route from Cuttack to Chandbali via the Hansua creek.

The Machgaon canal branches off the Taldanda canal 7 miles south of Cuttack and runs along the north bank of the Katjuri for a distance of 32 miles. It carries a discharge of 776 cusecs at head. It was originally intended to carry this canal as far as Machgaon tailing into the tidal water of Debi river and establish a connection with the sea, but this scheme was not carried out. It stops 6 miles short of Machgaon and is not navigable.

This canal system has a total length of 400 miles of distributaries and minors and carries a total discharge of 1401 cusecs at head. It commands a culturable area of 1,62,829 acres.

All these canals which command a culturable area of 4,05,974 acres were designed to carry a total discharge of 4077 cusecs and start functioning during the month of June. Most of the area is irrigated during Kharif season i.e. from June to November, as the Mahanadi discharge at Naraj is

a widely variable one from December onwards as the following average monthly discharge during 1952-53 at Naraj would indicate:-

December	..	7,427	cusecs.
January.	..	3,613	"
February.	..	2,706	"
March.	..	1,029	"
April.	..	670	"
May.	..	305	"

Statement No.1, vide Appendix I shows the designed discharges, lengths of main canal, branches and distributaries, navigable length of canal and culturable commanded area for the three canal systems.

Position of weirs and the alignments of the existing canals etc. are shown on the Index Plan No.1.

3.3 IRRIGATION DEVELOPMENT.

From the very commencement, irrigation in Orissa did not make a satisfactory progress. According to the statistics collected from the records of Orissa Government the Orissa canal system excluding H.L.C. Range II and III was designed for a culturable commanded area of 4,06,000 acres.

Statement No.2 showing the areas and percentage of different crops irrigated on the three canal systems, for the 10 years 1942-43 to 1951-52 is attached vide Appendix I.

The average area irrigated during Kharif during the above period works out to:-

1. Kendrapara canal system	..	1,02,266	acres.
2. Taldanda.	..	67,657	"
3. H.L.C. Range I.	..	24,518	"
Total.	..	<u>1,94,441</u>	<u>acres.</u>
Say		1,95,000	acres.

This works out to 48% of the irrigable area of 4,06,000 acres.

There is a Rabi crop "Moong" of legume variety to the extent of about 76,000 acres. The total area under Rabi on the 3 canal systems is 77,000 acres. This works out to about 19 percent of the irrigable area. The average annual intensity of irrigated area during Kharif & Rabi amounts to 67%.

3.4 IRRIGATION ON GODAVARI CANALS.

In the case of the Godavari delta, the canal system for which also was designed and constructed by Sir Arthur Cotton immediately prior to the construction of the Orissa Canals system, the growth of irrigation from the very beginning to date, has been very satisfactory. From an irrigated area of 4,36,000 acres in 1869, the area irrigated in 1950-51 has increased to 8,70,000 acres, which is nearly 100 percent of the commanded culturable area, as compared to about 48 percent obtained on the Orissa Canals system. The annual Intensity of irrigation during both crops is nearly 140%. Total area irrigated annually is nearly 12.0 lac acres.

3.5 CANAL ADMINISTRATION AND METHOD OF ASSESSMENT:-

The Orissa canal system is under the control of a Superintending Engineer, who is assisted by one Executive Engineer. The latter is responsible for the maintenance of the canals and the conduct of irrigation operations; and a separate establishment is entertained for the collection of Revenue. For this purpose, a Revenue Division Incharge of a Deputy Collector, who sees to the assessment and Collection of water rates, works under the orders of the Superintending Engineer.

3.51 SYSTEM OF GRANTING LEASES.

The canal irrigated areas are divided into suitable blocks, each block consisting of a number of villages.

Drainage lines as a rule have been taken as the boundaries for these blocks. These blocks are serially numbered and are entered in block register which shows the gross and irrigable areas of the blocks and also actually leased areas.

There are different kinds of leases namely Long Leases, Seasonal Leases, Provisional Leases and Seasonal Leases for crops other than autumn rice etc.

3.52 LONG LEASES.

In case of long leases which are given for not more than 10 years, ordinarily the whole area of a village or villages situated within the block is included in the lease. Lands not irrigable by flow or which are so low as practically never to require water during the cultivation of the autumn (Sarad) rice crops are, at the discretion of the Divisional Officer excluded from the lease. Lands which grow an early variety of rice known locally as 'Biri-Biali' are also at the desire of the cultivators and at the discretion of the Divisional Canal Officer excluded from the lease, though irrigable, provided that the fields so excluded form a distinct group with defined boundaries, and that a channel does exist by which the water can be delivered to the leased field situated beyond or near to the fields so excluded without waste and without flowing on to or over the fields excluded.

In case of long leases the Divisional Canal Officer is authorised to grant a lease when not less than 95 percent of the net irrigable area of the block has been signed for. For areas less than 95 percent the lease is granted by the Superintending Engineer who records reasons in writing while granting such a lease.

3.53 SEASONAL LEASES.

The seasonal leases for the irrigation of rice are granted for the whole irrigable area of the rice cultivation of a block or of a definite part of a block. The

Divisional Canal Officer is authorised to grant at his discretion lease in such a case if not less than 90 percent of the net irrigable area has been signed for.

3.54 PROVISIONAL LEASES.

Applicants for a lease for a term of years or for a seasonal lease for the irrigation of autumn rice who may require water before the lease has been concluded, can obtain a supply on tendering an application for a provisional lease. The application for a provisional lease, which is sanctioned by the Sub Divisional Canal Officer must not be for an area less than 75 percent of the irrigable land within the block.

3.55 SEASONAL LEASES FOR CROPS OTHER THAN AUTUMN RICE.

In case of seasonal leases for crops other than autumn rice, the assessment for the irrigation effected is done according to the actual use made of water and no fixed percentages of irrigable area within a block is specified as in the case of other leases.

3.56 CLASSIFICATION OF LAND.

The lands are further classified into Mada, Dhoya and Khalpat for assessment by the Canal Officer. The Dhoya land pays only half the water rate and the Khalpat none at all although both these classes of land receive the benefit of irrigation supplies. It is only 'Mada' land that pays the full water rate.

3.57 DEFECTS OF THE LEASE SYSTEM.

It will be seen from the practice of awarding leases on the Orissa canal system that it has been left entirely to the discretion of the canal Officers to classify and exclude lands from assessment which are considered by him to be not irrigable by flow or to be so low as practically to require no water and lands which are cultivated with early variety of rice.

The area commanded by the Orissa Canal system is an area of abundant rainfall which averages to 62 inches per annum. There are no field channels to carry canal water to various fields according to requirements. Irrigation is done from field to field. Rain water also flows from field to field. Canal fed lands can be declared as rain fed.

The lease system in force, therefore, is liable to be misused, and it is understood such misuse is prevalent resulting in defrauding Government of the water charges.

Scrutiny of the leases registers in use shows that there is a vast difference between the irrigable areas and areas actually leased out in a block. Generally areas actually leased out are on the whole less than even 50 percent of the irrigable area while it looks as though there is no land left un-cultivated at all. So considerable extent of land actually irrigated probably escapes assessment due to the system of leases adopted.

Statement No.3 showing area under Long and Seasonal Leases on the three Canal systems for the years 1942-43 to 1951-52 is attached vide Appendix I.

The area under Lease works out to 41.8 percent, 55.7 percent and 52.3 percent of the culturable commanded area in the case of Taldanda, H.L.C.Range I and Kendrapara Canal systems respectively. The percentage of the total areas leased to the C.C.A. on the three Canal systems works out 48.4%.

3.6 REASONS FOR UNSATISFACTORY PROGRESS OF IRRIGATION.

The Indian irrigation Commission (1901-03) in para 386 of its report has advanced two reasons why the Orissa canals have fallen short of expectations. These are the smallness of the area for which water is taken and the low water rates charged. And in para 384 of the report, it is stated that "Those who had enthusiastically quoted success

of the Madras Delta seem to have forgotten that in those delta rain-fall did not exceed 40 inches, whereas in Orissa it amounted to nearly 60 inches per annum".

It may be pointed out that one of the reasons, which is responsible for the growth of irrigation, in the Godavari and Kistna deltas of the Madras State, is the system of field channels which is almost entirely absent in the case of the Orissa canals system. It appears that some field channels were excavated in the beginning but the system of field channels, was never developed as in the case of the Madras deltas with the result that the irrigation of lands had to be done from field to field resulting in tremendous wastage of water. This is clear from the fact that instead of a duty of 100 at the out-let head for which the canal system was designed by Sir Arthur Cotton, a duty of 60 only has been obtained in practice. Due to absence of field channels, the Ryots make innumerable cuts in the distributing channels to obtain quicker and larger irrigation supplies, with the result that water seldom reaches the tails of channels. Large areas are thus thrown out of command.

Thus the two important reasons for the unsatisfactory growth of irrigation appear to be the absence of field channels and the present system of giving leases, renewal of which also is optional at the expiry of the lease. The Irrigation Commission have rightly pointed out that the abundant rainfall has been partly responsible for lack of growth of canal irrigation. No ryot would care to take water in a year of even distribution of rainfall, as 60 inches is ample to mature a rice crop normally. It is only in years of uneven distribution and low rainfall that irrigation supplies will be necessary.

It has been shown vide Appendix XI that on an average there has been a year of low rainfall once every

5 years in Cuttack and every 4 years in Puri Districts.

Useful rainfall works out to about 75 % of the total rainfall during the period of 150 day paddy crop, and that nearly 50% of the delta will have to be supplemented by Irrigation supplies in a year of low rainfall of about 42 inches and 33% in case of an average year of about 55 inches, if the paddy crop is to fully mature and give a good yield.

A study of these and other allied matters, which are common to the Mahanadi, Godavari and Kistna deltas, was made and the results of the study have been recorded vide Appendix III.

IV. PREVIOUS PROPOSALS FOR EXTENSION OF IRRIGATION IN THE MAHANADI DELTA.

4. 1947 PROJECT PROPOSALS.

With the functioning of the Hirakud Dam Project a regulated discharge of about 8000 to 12000 cusecs will be available in the Mahanadi river from November to June as against a minimum winter flow of about 300 cusecs at present at Naraj.

The 1947 Project Report did not, however, include any proposals for extension of irrigation in the Mahanadi Delta.

4.1 PROPOSALS ACCORDING TO REVISED PROJECT REPORT (1952).

In the revised report on the Hirakud Dam Project (1952) following proposals were made for extension of irrigation in the Mahanadi Delta:-

- (1) Remodelling of the existing Orissa canal system consisting of H.L.C. Range No.1, Taldanda and Kendrapara canal systems.

The remodelled system would irrigate a culturable area of 4,00,000 acres and carry a combined discharge of 4,600 cusecs.

- (2) Introduction of irrigation in the new areas in Puri District. The new canal system would carry a discharge of 4,240 cusecs at head and irrigate a culturable area of 3,68,000 acres.

- (3) The existing head of Taldanda canal was proposed to be remodelled and the Canal section concrete lined to carry a total discharge of 6,000 cusecs for the new areas as well as areas to be irrigated from the Taldanda Canal system. The main canal for the new area which would bifurcate 2 miles below the head of Taldanda canal would cross Katjury river below the off-take of Kuakhai by means of a syphon.

It would then run parallel to Kuakhai upto the off-take of Bhargovi after crossing Kushbhadra

river on the way. The 3 Doabs in the Puri District were proposed to be irrigated by branch canals running parallel on either side of Kushbhadra, Bhargovi and Daya rivers.

- (4) In order to provide complete flood control Kuakhai was proposed to be closed at head.

According to the above proposals a total culturable area of 7,68,000 acres was proposed to be irrigated.

4.2 MAZUMDAR COMMITTEE'S PROPOSALS (MARCH, 1952).

The Advisory Committee appointed by the Government of India to review the revised estimates while agreeing with the proposals for the existing canals was of the opinion that the Kuakhai system should not be closed. It has made suggestions for alternative arrangements for irrigation and flood disposal in the delta area which are summarised below:-

4.21 DISPOSAL OF FLOODS.

(1) On account of flood moderation at Hirakud, the maximum flood of 15 lac cusecs at Naraj is expected to be reduced to 12 lac cusecs. This discharge will be distributed as under:-

Mahanadi	6.0 lacs.
Katjuri	4.5 "
Kuakhai.	1.5 "

Total.	12.0 lacs.

The discharge in Kuakhai is proposed to be distributed as under:-

Mancheswar spill.	0.75 lac cusecs.
Kushbhadra.	0.30 " "
Bhargovi.	0.20 " "
Daya.	0.25 " "
Total	<u>1.5</u> lac cusecs.

The flood discharge of 0.3 lac cusecs in Kushbhadra will be diverted into Dhanua escape through the Jogiasahi escape.

(ii) The flood discharge of 0.2 lac cusecs let into Bhargovi would also be diverted to Dhanua escape, through the Achhutpur escape also marked on the same plan. Thus Dhanua escape will carry a discharge of 50,000 cusecs in the doab formed by Kushbhadra and Bhargovi rivers.

(iii) The flood discharge of .25 lac cusecs let into Daya would be let into Nunan escape at the point of Kanti escape marked in the plan. The discharge of .75 lac cusecs through Mancheswar spill will also cross Daya at the point of Kanti escape, by means of a level crossing and made to flow into Nunan river. Thus Nunan escape will carry a discharge of 1 lac cusecs through the doab formed by Bhargovi and Daya rivers into Chilka Lake.

4.22 IRRIGATION SYSTEM.

The main canal for the new delta areas will take off upstream of Jobra weir as already proposed in the Revised Project Estimates (1952) and will have its outfall in the Katjuri upstream of a barrage to be built across Katjuri river. Another barrage will be constructed across Kuakhai. A level crossing will thus be provided from where one of the branches will take off for irrigating the left part of Katjuri-Kushbhadra doab.

Kuakhai will continue to function as a main canal from its head right upto the off-takes of Bhargovi and Daya. Regulators will be constructed in Kuakhai proper and at the off-take of Kushbhadra from the former. Kushbhadra will function as an irrigation channel and will irrigate area both on its right and left. Two more regulators will be constructed lower down one at the head of Daya and the other at the head of Bhargovi. Both Bhargovi and Daya will function as irrigation channels irrigating areas in the doabs.

Regulators will be provided on Kushbhadra and Bhargovi at points where the flood discharges are to be let through the escapes into Dhanua. A Regulator will be provided at the

head of Mancheswar spill to pass the discharge of 0.75 lac cusecs and a level crossing on Daya River at the off-take of Kanti escape to pass a discharge of 1.0 lac cusecs into Nunan.

The Advisory Committee's proposals are shown on the Index Plan No.1 attached.

The Committee desired that its proposals should be thoroughly investigated before the final proposals for irrigation and flood control in the Puri District are formulated, as these will have the advantage of keeping the river channels open to flushing without bringing in the problems arising from their complete closure.

4.3 CHIEF ENGINEER ORISSA'S PROPOSALS.

Mr. J. Shaw, Chief Engineer, Orissa, while offering his comments on the above proposals has disagreed with the suggestions of the Advisory Committee in regard to the diversion of discharge of 1.5 lac cusecs through the two doabs and on the west of Kuakhai. He considers that the unrestricted passage of heavy discharge of 1,00,000 and 50,000 cuses through two doabs is likely to cause colossal damage to very rich irrigable lands in these areas. An extract from Mr. Shaw's comments on the recommendations of the Advisory Committee is reproduced below:-

" The Committee have given suggestions in Appendix IV for disposal of a flood in the Mahanadi system reduced to 12 lakhs cusecs maximum by Hirakud control. Special reference is made to the Kuakhai river system flood disposal and alternative suggestions for irrigation channel. I shall discuss this in detail below but the suggestions in brief are that the Kuakhai system flood should be reduced to a maximum of 1.5 lakhs cusecs and the Hirakud Control distributed as below:-

	At present (in cusecs)	Proposed (in cusecs)	Reduction (in cusecs).
Mahanadi ..	6.75 lakhs.	6.0 lakhs.	0.75 lakhs.
Katjuri ..	5.50 "	4.5 "	1.0 "
Kuakhai. ..	2.75 "	1.5 "	1.25 "
Total.	<u>15.00 lakhs.</u>	<u>12.0 lakhs.</u>	<u>3.00 lakhs.</u>

They propose to reduce the proportion between the Katjuri and the Mahanadi by reducing Naraj Weir and experimenting with the Biranasi Gap which passes flood from the Katjuri to the Mahanadi at high floods. As regards the Kuakhai river system the figures for proportionate discharge appear wrong. The proposals are to divert half the Kuakhai discharge through the Mancheswar Gap flood escape to the Daya river, construct barrages across the Kushbhadra, Bhargovi and Daya rivers for crossing the canals and also controlling flood distribution, to divert the Kushbhadra and Bhargovi rivers into the interior doab drainage and to utilise the resultant river channels downstream as canals. It is claimed that since the river beds in the delta will continue to rise and eventually create an indefensible situation, it is better to anticipate this and divert the rivers into the lower interior drainage channels where they will eventually go. The Committee admittedly have said that these are only tentative proposals which need examination. These proposals certainly put forward original ideas which require serious consideration. After examination, however, I find myself unable to agree to these on practical considerations for the reasons given below.

First of all the Committee did not appear to have studied the Orissa Flood Advisory Committee's report and account of the investigations done in the delta. These investigations showed that the delta in the Kuakhai river system was for all practical purposes in a stable state and there was no sign of a general rise in river beds. The Orissa Flood Advisory Committee also recommended that double embanking should be extended towards the sea in these rivers and that high

level escapes be given to pass off excess floods. The Govt. of Orissa accepted these proposals combined with a certain degree of flood control by flood retention reservoirs in the river catchment areas. There is thus no good reason for assuming that the river beds will rise continuously with reference to this surrounding ground and therefore ^{there} is no necessity to divert these rivers into the interior drainage channel in the doabs. The Committee have stated that flooding conditions and flood damage would in the interior be no worse than before, if the Kuakhai discharge is reduced and the rivers diverted through the escapes to carry on more water than before. They do not seem to have considered the damage thus done by these escapes when running at full supply and there is a big difference between the occasional functioning of these escapes and the continued diversion of the entire river through these escapes during the flood season. A large tract of country on each side of these drainage channels would be devastated by continuous flooding and bed sand burdens. Also if this idea was carried to a logical conclusion, it would mean forming new rivers which would also have to be double embanked and because of their newness and the transference of all the bed sand would result in a speedy rise of these new rivers above the surrounding ground level and interference with local drainage. A considerable tract would be also flooded between these embankments and construction and maintenance of such embankments would be very expensive. If the intention is not to have such marginal embankments the resultant general flooding would interfere considerably with the proposed canal system as it would not be confined to a small area near the drainage channel. There is also the question of utilising the river beds as canals as suggested by the Committee. They have stated that in Sind this proceeding was carried into effect successfully and the River beds silted up quickly to the required canal section and discharged. I consider however, that the Orissa conditions

are somewhat different in that we have not the same heavy suspended charge as in Sind and it would be considerable time before these channels silted up purely by silt from the canal system. If they were flushed occasionally during flood time by sluices from the river this would help to silt them up more rapidly, but even then the process would be fairly slow.

I have examined the more detailed tentative proposals put forward by the Committee in Appendix IV and I do not consider these proposals practicable or desirable for the reasons above stated. I have prepared a flood distribution chart according to what I consider approximately the present flood distribution in the Kuakhai river for 15 lakhs and 12 lakhs in Mahanadi. I have also made a rough calculation of the reduction necessary in Kuakhai discharges in order to give full control of flooding using the existing rivers and shutting down or considerably reducing the flood escapes such that the canal system will not be interfered with. I am putting this up as a separate note for the consideration of the S.W.&P.C. I consider that there should be no interference with Naraj weir or the Biranasi spill but that the Banki road flood spill should be cut off and the head of the Kuakhai reduced a little width. It would also appear that some control is necessary in the Kushbhadra river near its off-take. This could be done by a barrage. For crossing the Bhargovi river, a barrage or a syphon may be given."

Full comments of Mr. Shaw on the Advisory Committee's report and his subsequent note are attached as Appendix IV to this report.

V. PRESENT INVESTIGATIONS.

5. PRESENT INVESTIGATIONS.

As the proposals made in the Revised Estimates of Hirakud Dam Project Volume No.1A, which were reviewed and revised by the Advisory Committee appointed by the Government of India (March 1952) were based on very scanty data, it was considered that the estimates in connection with the improvements to the existing canal system in the Cuttack District, and extension of irrigation and flood control in the Puri district should be framed on detailed investigations.

These investigations, which were started in October, 1951, with one Division were supplemented by the opening of a new Circle with one additional Division.

Before framing the programme of Investigations, it was found that hardly any records in regard to the Contour plans, Design and record plans for existing canals and canal structures, discharge observations on Canals and Rivers etc. was available with the Chief Engineer, Orissa.

The following Investigations were, therefore, planned to collect as much information as possible during the limited time available for framing a preliminary estimate for the proposals.

5.1 THE EXISTING CANAL SYSTEMS.

In case of the existing canal systems in the Mahanadi delta the investigations comprise of the following items:-

- i) Contour survey of the area proposed to be commanded by the 3 canal systems.
- ii) Collection of figures of gross & culturable areas, which can be commanded by the canal system, from the revenue records & their verification.
- iii) Collection of other Agricultural statistics namely irrigated areas, Gross & Net Revenue from irrigation, Receipts from Navigation etc.
- iv) Observation of discharge of main canal, branches & distributaries and collection of other Hydraulic data in connection with the working of the canals.

- v) Observation of Sub-soil Water levels (on existing Wells) every month to determine the fluctuations in water table.
- vi) Levelling along main canals, branches and distributaries and collection of data for completing longitudinal and cross sections of irrigation channels and as many drainage lines as possible.
- vii) Collection of details of all important masonry structures on main canals, branches & distributaries.
- viii) Collection of the details of existing weirs namely Birupa and Jobra for remodelling the same.
- ix) As the area commanded by the existing canals, is almost fully protected, investigations of the 3 island areas which are either unprotected or are partially protected have also been made, with a view to bring these areas under command.

5.2 NEW AREAS IN PURI DISTRICT.

In case of new areas to be brought under irrigation in the Puri district, which are unprotected and are liable to frequent flooding from the spill of Kuakhai and its 3 branches, investigations have been made both in regard to flood protection and extension of irrigation in these areas.

5.21 FLOOD CONTROL.

Investigations in regard to flood protection consist of:-

a) Gauge and discharge observations of river Mahanadi and its branches namely Birupa, Katjuri and Kuakhai and its 3 branches namely Kushbhadra, Bhargovi and Daya, with a view to determine the distribution of discharges between Mahanadi and its branches, discharges at Bankful stage and the maximum discharge for which the Kuakhai system could be designed without flooding the area to be brought under irrigation.

b) Survey of rivers Mahanadi, Katjuri and Birupa in head reaches and that of Kuakhai and its 3 branches from their head to tail.

(c) Survey of the escapes from the branches of Kuakhai and main drainage lines namely Dhanua, Prachi & Nuna with a view to determine their capacity to carry maximum flood discharges.

5.22 EXTENSION OF IRRIGATION.

Following investigations have been made in connection with extension of irrigation:-

- i) Contour survey of the area to be commanded by the proposed canals.
- ii) Collection of gross and culturable areas which will be commanded by the new canal system and their verification.
- iii) Observation of sub-soil water level in the areas proposed to be irrigated to see the fluctuations in Water table.
- iv) Survey work in connection with the proposals of the Advisory Committee particularly the sites for six barrages.
- v) Investigations for a new Weir site, upstream of Naraj and the alignment of the main canal which will take off upstream of the new weir and three syphon crossings under Kuakhai, Kushbhadra & Bhargovi rivers.

This investigation is an alternative to the Advisory Committee's proposals and has been discussed in detail in subsequent paragraphs.

- vi) Discharge observations at Naraj and their comparison with the observations at Hirakud to see if there are any transmission losses enroute.

5.3 SOIL SURVEY.

Soil survey to determine the agri-irrigational potentialities of soil of the Mahanadi delta comprising of the portions under the command of the existing canal system and the new areas in the Puri District has been carried out by Dr. R. C. Hoon, Deputy Director, Hirakud Research Station. The whole area covering about 13 lac acres has been divided into grid squares, each square measuring about 3,300 acres.

Soil sampling has been done at one representative site in each grid square by means of soil augers and sampling done at majority of sites between 6 to 8 ft. depth from ground surface on account of the sub soil water table and other conditions prevailing during the period when the field work was in progress. Soil samples have been collected at each 6 inch

depth in the top foot and at every subsequent foot depth along the remaining depth of profile at each site of bore. A total number of 3,228 soil samples have been collected.

The laboratory examination of the soil samples analysed so far indicate that:-

*(a) The area occurs as a deep alluvium and comprises of a number of 'Doabs'. The soil texture varies from clay loam to clayey with clay content ranging from 30 to 50 percent. The land at the head of the 'Doab'., i.e. near the bifurcation of channels and along the banks of streams is comparatively high level and lighter in texture with heavier soil in the valley. The latter continues till the sea sand belt is reached. The high-lying, intermediate and low lying land are known locally as 'Biali', 'Laghu' and 'Sarad' respectively.

(b) The total soluble salt content of the soil is generally low and seldom exceeds 0.2 percent except in areas which are located in proximity of the sea and within the effect of tidal creeks. The range of PH values lies between 6.5 and 8.5 for a major part of the area.

(c) Calcium is the predominant base in the exchange complex, the base exchange capacity figures range between 20 to 40 milli-equivalent.

(d) The soils are primarily deficient in nitrogen and to a slight extent in phosphorus and potassium and call for an enrichment by artificial fertilizers and or, green manuring, which can be introduced in the crop rotation."

A detailed note on the soil survey by Dr.R.C.Hoon is attached as Appendix V.

5.4 CONTOUR SURVEY.

Contour survey of the areas commanded by existing canal system measuring about 1100 sq.miles was entrusted to the survey of India, which was scheduled to be completed by May'1953.

*Extract from Dr.Hoon's preliminary report on Soil survey.

Although the aerial photographs have been taken, the field work has been completed for the H.L.C. Range I, Kendrapara Canal system and a part area on the Taldanda canal only. The remaining field work as intimated by the survey of India is expected to be taken up during 1953-54 and contour maps made available in early 1954.

As proposals for the Delta Area have to be finalised before October, 1953, the spot levels taken by the Survey of India have been transferred on to the command plans of H.L.C. Range No. 1 and Kendrapara canal systems and command boundaries fixed as best, as can be done under the circumstances. These will need to be verified and adjusted where necessary, after the receipt of the contour maps from the Survey of India.

In case of incomplete portions of the Taldanda canal system, Nuna-Chitratola and Beluakhai-Katjuri Island areas, levelling has been done along a few grid lines. The command boundaries of these areas will have to be carefully scrutinised on receipt of contour maps, as these may involve some adjustments. It is, however, expected that the total commanded culturable area is not likely to be materially affected.

Contour Survey of the new areas to be brought under irrigation, measuring about 1,200 sq. miles, which was undertaken by the Central Water & Power Commission has been completed, contour plans drawn and tentative alignments of channels and command boundaries fixed.

5.5 CULTURABLE AREAS.

Figures of gross and culturable areas have been collected from the Revenue records of the Collectors of Puri and Cuttack for the new areas in the Puri District and for the existing areas in the Cuttack District.

These areas have been discussed with the Collectors and got verified by them and their confirmation placed on record.

Subject to the remarks in para 5.4 above, the revised commanded culturable areas (C.C.A) both for the existing and new canal systems work out as under:-

(i) Existing Canal System.

S.No	Name of system.	C.C.A. in acres.	
		At present	Proposed.
1	2	3	4
1.	Kendrapara canal system.	1,98,500	2,93,914
2.	Taldanda canal system.	1,62,829	1,95,322
3.	H.L.C.Range No.1	44,637	51,554
	Total.	<u>4,05,966</u>	<u>5,40,790</u>

Areas in column 4 are perennial flow.

(ii) NEW CANAL SYSTEMS.

S.No	Name of canal.	C.C.A in acres proposed.			Total.
		Perennial flow	Non-perennial flow	Perennial Lift.	
1	2	3	4	5	6
1.	Katjuri-Kushbhadra Doab	1,58,387	15,190	-	1,73,577
2.	Kushbhadra-Bhargovi "	1,34,600	27,556	-	1,62,156
3.	Bhargovi-Daya "	1,00,000	15,190	-	1,15,200
4.	West of Daya river.	<u>56,884</u>	<u>980</u>	<u>27,570</u>	<u>85,434</u>
	Grand Total.	<u>4,49,881</u>	<u>58,916</u>	<u>27,570</u>	<u>5,36,367</u>

There will be 4 lifts varying between 10 to 50 ft.as under:-

	<u>Place</u>	<u>Area in acres</u>	<u>Lift in ft.</u>
1st Lift.	Main canal Right Mile 1	2,279	25.0
2nd Lift.	-do- Left Mile 1.	2,173	10.0
3rd Lift.	Daya Branch Right Mile 17	11,960	45.0
4th Lift	-do- Mile 23	<u>11,158</u>	<u>50.0</u>
	TOTAL AREA UNDER LIFT.	<u>27,570</u>	

The total culturable area which will be commanded by the existing and new canal areas would be 10,77,000 acres, against 7,68,000 acres assumed in Volume I.A. The present investigations therefore, record an increase of 3.1 lac acres which is nearly 40 percent.

Statement No.4 of Appendix I shows the proposed gross, culturable commanded areas, revised discharges, lengths of canals, distributaries etc.

The non-perennial area of 59,000 acres is situated towards the tails of the Doabs. It is possible that there may be no demand for water in this area in the beginning. In order to err on the safe side, it is proposed to omit this area while preparing the financial forecast for the Project, although it has been taken into account while designing the canal system.

5.6 DISTRIBUTION OF DISCHARGES IN MAHANADI & ITS BRANCHES.

As hardly any data in respect of river discharges of the Mahanadi and its branches was available prior to the commencement of these investigations, simultaneous discharge observations were undertaken during the monsoon season of 1952 on the rivers of Birupa, Mahanadi, Katjuri and Kuakhai. Similar discharge observations were also recorded on Kuakhai and its 3 branches, namely, Kushbhadra, Bhargovi and Daya rivers, with a view to determine the distribution of discharges on the Kuakhai system.

The discharge observations of Mahanadi and its branches were taken by means of current meters from the four Railway Bridges while those on Kuakhai and its branches were taken by means of boats and where this was not possible, from the existing road bridges over these rivers.

The maximum gauge recorded during 1952 at Naraj was 87.0 which gave a discharge of nearly 7 lacs cusecs with a corresponding discharge of 83,000 cusecs at the head of Kuakhai with a H.L. of 75.9 at Kazipatna gauge.

As the maximum observed discharge during 1952-53 did not exceed 7.0 lac cusecs the flood levels, the distribution of discharge into branches of Mahanadi for the maximum moderated flood discharge of 11.0 lacs had to be extrapolated at different points viz. Naraj, Kazipatna, Katjuri

Railway Bridge etc. for the design of barrages and a new pick-up weir upstream of Naraj weir and the design of embankments for Kuakhai and its branches.

Mr. Shaw's comments, particularly the "Separate Note" mentioned in his comments (which also forms a part of Appendix IV) were referred to.

It was seen from the correspondence between Mr. Shaw, Chief Engineer, Orissa and the Director, Central Water and Power Research Station, Poona, that the latter did not agree with the former's distribution of discharges in the branches of Mahanadi for discharge of 10, 12 and 15 lac cusecs at Naraj, for the reasons stated by him in his letter dated 17th April 1953, which had the approval of Sir Claude Inglis before he left India.

In absence of any reliable data for discharges more than 7.0 lac cusecs, the matter was referred to the Director, Central Water & Power Research Station, Poona, who had already been requested to perform model experiments as suggested by the Advisory Committee (March 1952) and he was asked to find out the distribution of discharges for 9, 10 and 11.0 lac cusecs at Naraj along with the corresponding water levels at Naraj, Bellevue, Kazipatna and Katjuri Bridge. A latest river survey of Mahanadi and its branches carried out in 1952 was supplied to him for the purpose.

5.61 STATISTICAL ANALYSIS OF THE GAUGE & DISCHARGE DATA.

Meanwhile as some beginning had to be made for the design of barrages proposed by the Advisory Committee, statistical examination for the discharge data collected during 1952 was carried out in the Statistical Section of the Central Water & Power Commission to derive the following relationships:-

- i) Naraj gauge for a discharge of 11.0 lac cusecs.
- ii) Co-relation between Naraj gauge and gauges at Kazipatna, Katjuri Railway Bridge & Bellevue gauge.

- iii) Value of Kazipatna gauge for a discharge of 1.0 lac and 1.25 cusecs at the head of Kuakhai.

It was realised that due to the paucity of data the conclusions arrived at, will have a limited validity, and will have to await confirmation of the corresponding results from the model experiments.

Statistical examination of the hydraulic data showed:

- i) That a R.L. of 89.13 (G.R. 90.5) will be obtained at Naraj for a discharge of 11.0 lac cusecs.
- ii) That with Naraj at R.L. 89.13, gauge reading of 25.0 (R.L. 80) will be obtained at Bellevue.
- iii) That for Naraj at R.L. 89.13, a R.L. of 80.28 (G.R. 17.58) will be obtained at Kazipatna.
- iv) That for discharges of 1.0 & 1.25 lac cusecs at Kazipatna the corresponding water levels would be 77.7 (G.R. 15.0) and 80.28 (G.R. 17.58) respectively.

A note on the statistical analysis of the data along with the gauge and discharge observations is attached vide Appendix VI.

The above results which are based on the moderated flood discharge of 11.0 lac cusecs at Naraj have been used for the design of barrages at Katjuri, Kuakhai (i.e. at Kazipatna), after allowing for an accretion of 2.0 ft. (i.e. R.L. 91.33 at Naraj) due to the construction of a Barrage across Katjuri.

Further hydrological studies carried out in the Central Water and Power Commission have since shown that the maximum moderated flood discharge, which may be expected at Naraj will be 10.0 lac cusecs instead of 11.0 lacs. It has also been decided that free boards for flanks of Barrages etc. should be provided for water levels corresponding to the maximum water level recorded at Naraj which is equivalent to R.L. 91.33 ft.

5.7 MODEL EXPERIMENTS.

The Director, Central Water & Power Research Station has since supplied the results of model experiments on *distribution of discharges for branches of Mahanadi for*

discharges of 9,10 and 11.0 lac cusecs at Naraj and the corresponding water levels at important sites. Correspondence with the Director etc. along with his preliminary report and subsequent results is enclosed vide Appendix VII of this report.

The following statement shows the comparison between the distribution of discharges and water levels obtained statistically and those by model experiments for a discharge of 11.0 lacs at Naraj.

Comparative figures for a discharge of 10.0 lac cusecs have also been included:-

S.No	Description.	Water	Water	W.L.at	Distribution of discharge		
		level	Level	Kazi-	Lac cusecs.		
		at	at	patna.	Mahanadi	Katjuri	Kuakhai
		Naraj	Belle-		& Birupa	below	(Kazipat-
			vue.			Kuakhai	'na Head).
1.	11.0 Lacs at Naraj (Statistical data)	89.13	80.0	80.28	5.1	3.5	2.4
2.	11.0 lac at Naraj (Model results).	88.65	81.30	80.20	6.64	2.86	1.5
3.	10.0 lacs at Naraj (Model results).	87.95	80.63	79.6	5.91	2.7	1.39

Further experiments on the distribution of discharges in the light of River discharges observed during August '53 are in progress at the Poona Research Station.

It will appear from the above that the water levels obtained by statistical relationships which have been used for the design of new weir and the barrages etc. before the model results became available are, if any, on the safer side. These may be checked and designs modified later on, if necessary, after further results of model experiments become available.

5.8 SUB SOIL WATER LEVEL OBSERVATIONS.

Observations regarding movement of water table in both the existing and new areas have been made by observing water levels in 66 selected wells, once every month from

October, 1952 to May 1953.

It is intended to study the fluctuation of water table in these areas which are proposed to be brought under intensive irrigation.

This data has been analysed in the statistical section of the Central Water & Power Commission and a note on the study of sub soil water level observations in the Mahanadi Delta is attached as Appendix VIII.

The analysis of limited data available indicates that:-

1. The sub soil water level in the existing irrigated area which varies between 7 to 13.0 ft. from ground surface is higher than that in the new areas proposed to be irrigated, where it fluctuates between 12 to 23.0 ft. between October and April.
2. The water table falls off at a faster rate in the new areas than in the existing areas already under irrigation.

The existing areas have been under irrigation for nearly 90 years and if the water table during winter months fluctuates between 7 to 13.0 ft. from ground surface, no danger due to water logging need be apprehended due to the introduction of perennial irrigation which is mostly dry except for wet Rabi to the extent of 12% of the C.C.A.

Similar inference may be drawn in respect of the new areas in Puri District, which are subject to about the same amount of rainfall and will have similar intensity of irrigation during Kharif & Rabi.

5.9 DISCHARGE OBSERVATIONS AT NARAJ.

Discharge observations at Naraj were started during the dry season of 1953 to find out the magnitude of transmission losses in the river as compared to the discharges observed at Hirakud.

These observations which are taken by current meters at both sites have been recorded almost daily from December, 1952 to May, 1953 at Naraj.

The comparison of discharges at the two sites

indicates that discharge at Naraj is greater than that at Hiraakud. There is thus an evidence of either regeneration or addition from the tributaries of the river or both, during the non-monsoon months, in the river Mahanadi.

For purposes of present proposals, discharges available at Naraj for irrigation have been taken to be the same as at Hiraakud, until more data is available.

This data has also been analysed in the Statistical Branch of the Central Water and Power Commission to determine what discharge over and above the one passing through the P.H.No.1 may be considered to be available at Naraj for irrigation purposes.

A note on statistical analysis of the data along with accompaniments is enclosed as Appendix IX.

5.10 DISCHARGE OBSERVATIONS ON EXISTING CANALS.

Current meter observations on main canals and important distributaries were recorded on all the existing canals, and slope measurements taken. Hydraulic elements viz: A.V.P.R.S. for the discharge sites observed have been computed and values of Kutter's 'N' and Lacey's 'f' worked out. These observations show at a glance the working of the canals. The data collected has been useful in remodelling the existing canals.

Statement No.5 showing discharges and other hydraulic data for the existing canals is attached vide Appendix I.

VI. PRESENT REVISED PROPOSALS (1953).

6. FLOOD CONTROL IN THE PURI DISTRICT.

Investigations carried out in the Delta Area show that in addition to the enormous cost of canalising drainages for high flood discharges, as recommended by the Mazumdar Committee, the flood proposals of the above Committee are subject to a further technical objection in regard to the efficient local drainage of the surrounding area, which will not be able to find out an out-fall into the main drain at the time the drainages are carrying the flood discharge. This has led to the revision of the Advisory Committee's proposals for flood control and irrigation for the new areas in the Puri District.

In order to afford complete flood protection to this area it is proposed to close all escapes from Kuakhai and its branches which used to over-flow and flood the areas in the 3 doabs and to canalise the remaining portions of those rivers by providing river embankments on either side upto the point of their out-fall.

These proposals briefly consist of:-

(1) Providing a river embankment on the right side of Katjuri from one mile below the downstream of the Naraj weir to the upstream of Kuakhai barrage at Kazipatna. This is an entirely new embankment which will close the Banki spill and prevent the river spill from over-flowing on the right side of Katjuri as that area is now proposed to be brought under perennial irrigation.

(2) Closing of Mancheswar spill. The spill from this escape used to run on the right side of Kuakhai along the west of Daya flooding a large area of land which is now proposed to be protected and brought under irrigation.

(3) Closing of Jogiasahi and Ramchandrapur escapes ex-Kushbhadra river, and providing embankment on either sides in the tail portion of this river i.e. from two miles above

village Gop right upto the sea. This will enable the flood water flowing into Kushbhadra to discharge directly into the sea without causing damage enroute, either through the 2 escapes or by spill at the tail in the unembanked portions.

(4) Closing one of the 2 escapes Ex-Bhargovi river namely Acchutpur escape. The water from Kanchi, the second escape, does not flood any area proposed to be brought under irrigation. It flows mostly into Samangpat (a local lake) and from there to Sur lake through Athar nala. The water from Sur Lake discharges into the sea by means of an existing cut.

The river Bhargovi which is already embanked on both sides has its out-fall into Chilka lake.

(5) Closing of Belmora, Madhipur and Kanti escapes ex-Daya river. Daya river is embanked in a length of 33 miles on the left and 11 miles on the right. It is proposed to extend the embankment on the right side also upto mile 35 which will be about two miles below the irrigation boundary in the area west of Daya. One mile length of Embankment on either side of Mandagine river from its entry into Daya along with a sluice for entry of Rajua drain has also been proposed. The waters of Daya will thus discharge into chilka Lake without causing any damage in the area proposed to be brought under irrigation.

Discharges which are likely to pass through Kuakhai and its branches have been calculated for a R.L.76.9 which is likely to be obtained at Kuakhai head for 10.0 lac cusecs at Naraj.

Statement No.6 shows that whereas a total discharge of 92,000 cusecs can be carried at the head of the three branches, the total discharge at the tail will not exceed 50,000 cusecs, at the maximum H.F.L. It is possible that discharging capacity of the branches in the tail portions may improve due to the proposed canalisation of the two branches

viz. Kushbhadra and Daya Rivers, in due course. It is, however, considered that the maximum discharge of 50,000 cusecs should be sufficient for flushing of Kuakhai and its branches and that the balance of 89,000 cusecs out of 1.39 lac cusecs may be diverted into Katjuri and Mahanadi by providing a structure for the purpose at the head of Kuakhai.

The effect of restricting the discharge of 50,000 cusecs into Kuakhai on various gauges and the distribution of discharge between Mahanadi and Katjuri has been studied on the model at Khadakvasla. The experiment showed a rise of 3.15 ft. at Kazipatna gauge (R.L.82.75) and a rise of 2.22 ft. in Bellevue gauge (R.L.82.85). The Naraj downstream gauge showed a rise of 5", whereas the Naraj upstream gauge did not show any rise. It was further observed that the discharge into Katjuri below Kuakhai head did not increase appreciably as the excess discharge was diverted to Mahanadi through the Biranasi spill. The results of this experiment are shown below:-

Discharge above Naraj.	Water Level at Bellevue	Water Level at Kazipatna	Distribution of discharge in lacs.		
	'	'	'Mahanadi & Birupa	'Katjuri below Kuakhai'	'Kuakhai.'
10.0 Lac cusecs.	82.85	82.75	6.8	2.7	0.5

The flood relief which would accrue to the branches of Mahanadi below Naraj as a result of flood moderation and the present proposals is shown vide column 5 of the following statement:-

S.No	Name of River.	Distribution for 15.0 lacs before flood moderation.	Distribution for 10 lacs flood after flood moderation.	Relief in Lac cusecs.
1.	Mahanadi & Birupa.	6.75	6.80	Nil.
2.	Katjuri.	5.50	2.70	2.80
3.	Kuakhai.	2.75	0.50	2.25
	Total.	15.00	10.00	

According to above proposals Kuakhai and its branches will continue to function as channels for disposal of flood water with a reduced discharge, instead of being used as irrigation channels, as recommended by the Advisory Committee, and will thus obviate the necessity of passing large quantities of water through the doabs at enormous cost and without inter-firing with the local drainage.

6.1 EXTENSION OF IRRIGATION IN PURI DISTRICT.

It has been found during the course of investigations that a large block of area of 85,000 acres of land can be irrigated on the right side of Katjuri, Kuakhai and Daya rivers from Naraj right down to Chilka Lake, if the area can be commanded.

It is, therefore, proposed to construct a weir on the Mahanadi upstream of Naraj with the canal taking off from its right bank. This canal which is 27 miles long will take off near Barmundli village on the right bank of the river Mahanadi three miles away from the existing Naraj weir, cross the Barang Road and Railway bridges at 7M-2244' and 7M-3364' respectively, and enter the syphon across river Kuakhai at mile 10. Two branches one upstream and the other downstream of this syphon will irrigate areas on the west of Daya and the eastern portion of the Katjuri-Kushbhadra Doab respectively. Thereafter it will go along the left bank of Kuakhai and cross the National Highway bridge on that river at mile 16, and the Kushbhadra river by a syphon at mile 19. Here also two branches will take off one on the upstream and the other on the downstream of the syphon which will irrigate the western portion of the Katjuri-Kushbhadra Doab and the east portion of Kushbhadra-Bhargovi Doab respectively. It will once again run parallel to the Kuakhai on left bank till it finally crosses the Bhargovi river at mile 27 near Sardaipur village, where the branch upstream will irrigate the west portion of the Kushbhadra-Bhargovi Doab, and the two branches downstream the Bhargovi-Daya Doab. These proposals are shown on the Index Plan No. II attached.

6.11 SITE FOR THE NEW WEIR.

Four sites have been considered. The first site was on the Mahanadi itself, opposite Naraj, where a Barrage could be provided to enable a canal to take off on the right side

(Contd).

of Mahanadi. As this would subject Naraj weir to extra head, which it may not stand due to its unsatisfactory condition and as the Chief Engineer, Orissa in his remarks and subsequently the Director, C.W.P. Research Station have advised against touching this weir, this proposal which may have eventually involved the construction of two major structures, was dropped. Two more sites, one immediately above Naraj in the gorge upstream and the other about 1 mile above the 1st site at the head of the gorge where rock foundations were expected to be met with were then investigated. Drill boring operations carried out at both the sites revealed that rock could not be met with upto 60 ft. below ground level in one case and about 40 ft. in case of the other.

The site for the new weir has, therefore, been fixed upstream of the gorge. The inspection of the river has shown that off-take of the main canal can be suitably located on the outside of the curve at or little below cross-section No.7 of Mahanadi river and the site of the weir between cross-sections 7&8. The exact locations for the weir and the off-take will be decided after a detailed river survey of the area to be undertaken during the cold weather of 1953-54 and after model experiments.

Pending, the final selection, the estimate for the weir has been prepared for a site between cross-sections 8&9.

The crest of the weir has been provisionally fixed at R.L.73.5. The weir will have 5.0 ft. falling shutters with their crest level at R.L.78.5. These shutters will be raised by means of a power-operated plough.

A navigation lock for country boats plying on the Mahanadi has been provided in the weir.

6.111 SALIENT FEATURES OF THE PROPOSED NEW WEIR ABOVE NARAJ & THE HEAD REGULATOR OVER THE NEW CANAL.

WEIR.

Maximum Discharge over Crest.	..	9,00,000 cusecs.
Maximum discharge through under-sluice.	..	1,00,000 cusecs.
Maximum discharge over crest & under-sluices.	..	10,00,000 cusecs.
H.F.L.	..	94.0
Afflux assumed.	..	3.0 feet.
Pond Level.	..	78.50
Length of weir.	..	3,230 feet.
R.L.of crest of weir.	..	73.50
size of falling shutters.	..	10'x5'
R.L.of top of shutters.	..	78.50
Top width of crest of weir.	..	12.0 feet.
Front slope of weir.	..	1 in 5
Rear slope of weir.	..	1 in 3
R.L.of U/S pavement.	..	60.0
Length of U/S pavement.	..	30 feet.
Cement concrete block protection U/S	..	50 feet.
Loose stone protection U/S in bed.	..	125 feet.
-do- on sides.	..	50 feet.
R.L. of pavement D/S.	..	58.00
Length of pavement D/S.	..	110 feet.
Cement concrete block protection in bed D/S.	..	115 feet.
Loose stone protection D/S- in bed.	..	170 feet.
-do- on sides.	..	48.75 "

SLUICES.

Number of sluices.	..	9 Nos.
Width of span of sluices.	..	30 feet.
Length of piers.	..	24 "
Thickness of piers.	..	7 "
Crest level of sluices.	..	R.L. 69.00
Size of gates.	..	30' x 10'

R.L. of top of gates.	..	79.00
Pavement level U/S.	..	R.L. 60.00
Pavement Level D/S.	..	R.L. 52.00
Length of pavement U/S.	..	30 feet.
Length of pavement D/S.	..	130 feet.
Cement concrete blocks U/S.	..	60 feet.
Cement concrete blocks D/S.	..	125 feet.
Loose stone protection U/S.	..	140 feet.
Loose Stone protection D/S.	..	205 feet.
<u>GUIDE BANKS.</u>		
Length of guide banks U/S, Right & Left.	..	3900 ft. each side.
Length of guide banks D/S, Right & Left.	..	900 ft. each side.
Top width of banks in straight reach.	..	30 feet.
-do- at Nose.	..	60 feet.
R.L. of top of guide banks.	..	(U/S 100.0 (D/S 97.0)
Side slopes, both sides.	..	2:1
<u>AFFLUX BUND IN RIVER.</u>		
Top width of bund-Right side.	..	20 feet.
Top width of bund-Left side.	..	30 "
R.L. of top bund.	..	100.0
Side slopes of bund.	..	2:1
<u>HEAD REGULATOR OVER NEW CANAL:-</u>		
Discharge.	..	6100 cusecs.
H.F.L.	..	96.00
Pond Level U/S.	..	78.50
F.S.L. D/S.	..	76.1
Number of spans.	..	6 Nos.
Width of span.	..	24 ft.
Length of piers.	..	86.5 ft.
Width of piers.	..	6 feet.
Crest level.	..	70.75
U/S Slope.	..	1 in 4
D/S slope.	..	1 in 3

U/S pavement length.	..	71.75 feet.
D/S pavement length.	..	50.0 feet.
U/S cement concrete block protection.		10 feet.
D/S cement concrete block protection.		10 feet.
U/S loose stone protection.	..	20 feet.
D/S loose stone protection.	..	30 feet.
Canal bed level U/S.	..	66.0
Canal bed level D/S.	..	65.5
Pavement level U/S.	..	66.0
Cistern level.	..	63.0
Stone protection U/S on sides.	..	48.45
Stone protection D/S on sides.	..	30 feet.
Top of gates.	..	R.L. 78.25

ROAD BRIDGE AT REGULATOR.

Class 'A' loading.	..	Two lane traffic.
Width of road way.	..	24 feet (with 5' & 3' side walks).
R.L. of road-way.	..	104.75

6.2 PROPOSALS FOR REMODELLING OF EXISTING WEIRS, HEAD REGULATORS ETC.

Important modifications which will require to be carried out to the existing weirs and the head-regulators of canals will be as under:-

6.21 JOBRA WEIR.

The crest of Jobra weir is fixed at R.L. 64.05 and the top of the falling shutters at R.L.67.55. These shutters are manually lifted. It is proposed to raise the crest of the shutters to R.L.69.05 and provide automatic falling shutters 5 feet high and 10 feet long, which will be operated by a suitably designed power plough of similar design as used on the Godavari anicuts.

These changes will make available an extra head of 1.5 feet which could be utilised when necessary and provide an efficient method of regulation at the weir, which at present

is extremely slow and inefficient.

Experiments by the Electrical analogy method on the model of Jobra weir carried out at the Central Waterways & Power Research Station at Poona, indicate that an impermeable apron 15.0 ft. long on the upstream of the weir will be necessary to dissipate the rise in pressure due to the increase in head of 1.5 ft.

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A further modification in case of this weir will consist of shifting upstream the central sluice portion of the weir which has been recessed downstream and bring it in alignment with the main weir to enable the power plough to function in raising the shutters, whenever required.

6.22 BIRUPA WEIR.

The Kendrapara canal takes off from the inside of the curve upstream of this weir. At present there are two heads for this canal carrying a total discharge of 2,076 cusecs. The revised discharge of this canal is 3,262 cusecs. The upstream head of the canal has been silting in the head reach. The Poona Research Station has been asked to suggest suitable alterations to free the canal from excess silt entry.

The existing crest of Birupa weir for a major portion of length is at R.L. 62.83 and 62.58 for a smaller length.

It is proposed to raise the crest to a uniform R.L. of 63.83 and raise the present crest of shutters from R.L. 67.83 to R.L. 68.83, by installing 5 feet high and 10 feet long falling shutters which will be power operated as in the case of Jobra Weir. These alterations will provide an extra head of 1.5 feet and more efficient regulation at the weir. As in the case of Jobra weir 15.0 ft. apron on the upstream is being provided to counteract the rise in pressure due to the increase in head of 1.5 ft.

The existing falling wooden shutters of the scouring sluices of both the weirs which are difficult to operate once these fall down will also be substituted by steel gates, and the masonry of the piers raised above maximum water level.

6.23 REMODELING OF HEAD REGULATORS FOR THE EXISTING CANALS.

Due to the increase in the commanded culturable areas of both the Paldanda and Kendrapara Canal systems the present capacity of 1401 and 2076 cusecs of these canals will have to be increased at head to 2168 and 3262 cusecs respectively. The revised discharge of H.L.C. Range No.1 will be 572 cusecs against the designed discharge of 600 cusecs.

The existing waterways of both the Paldanda and Kendrapara head-regulators have been tested. It is seen that the waterway is sufficient to pass the increased discharges. The existing regulating arrangement consisting of horizontal baulks on all the Head Regulators is proposed to be substituted by vertical screw steel gates, to obtain efficient regulation.

6.24 SYPHONS FOR IRRIGATING ISLAND AREAS.

It is proposed to bring under command the 3 new areas comprising of:-

i) Birupa-Gengudi Island	C.C.A	17,157	acres.
ii) Nuna-Chitartola Island	C.C.A	37,398	"
&			
iii) Biluakhai-Debi Island.	C.C.A	6,418	"

Total.		60,973	acres.

The first island will receive irrigation supplies from Pattamundai canal a little above Nurtang regulator by means of a syphon under Birupa river. The second will receive irrigation supplies from Kendrapara canal two miles below Kendrapatna regulator also by means of a syphon below the Nuna river, and third from Machgaon canal also by means of a syphon below Biluakhai river.

Both the Nuna-Chitratola and Biluakhai-Debi Islands are partially protected already by river embankments. There is no river embankment protecting the Birupa-Ganguti Island.

Necessary flood protection on moderated flood levels has been provided for the above islands.

6.3 INTENSITY OF IRRIGATION.

The Advisory Committee (March 1952) recommended the following intensities for the delta area:-

KHARIF.

Paddy.	...	60%
Sugarcane.	...	20%
Jute.	...	<u>20%</u>
Total.	...	100%

RABI.

Paddy.	...	33%
Cash Rabi crops, like Wheat, ground-nuts etc.	...	8%
Light Rabi crops, Moong, Kulti etc.	...	<u>7%</u>
Total.	...	48%
Total Annual Intensity .		148%

The question of intensities, crop rotation, depth of water required for different kinds of crops, periods of sowing, transplantation and maturing etc. has been discussed with the Director of Food & Agriculture, Orissa and the Director, Central Rice Research Institute, Cuttack..

Minutes of the meeting between the representatives of Director of Food & Agriculture, Orissa, Director, Central Rice Institute, Cuttack and the Central Water & Power Commission in which the decisions regarding intensities, crop rotations etc. were recorded along with confirmations from the above officers are attached vide Appendix X of the Report.

Except for the intensity of Dalua paddy which was fixed at 33 percent and which has been reduced to 12 percent, the

rest of the intensities as decided in the Conference have been adopted. These are briefly as under:-

KHARIF:-

Jute.	..	15 %
Aman Paddy.	..	80 %
Beali Paddy.	..	5 %
Sugarcane & garden crops.	..	<u>10 %</u>
Total.	..	110 %

RABI.

Dalua Paddy.	..	12 %
Wheat, Cotton & Ground nuts.	..	10 %
Cover crop Legume Variety.	..	40 %
Vegetables & potatoes.	..	<u>5 %</u>
Total.	..	67 %

Thus an annual intensity of 177 percent is proposed to be adopted against an intensity of 148 percent proposed by the Advisory Committee. Of the 177 percent, 40 percent will constitute a legume variety of crop requiring only one watering of 4 to 6 inches.

6.31 CROP ROTATION.

The following crop rotation along with the intensity of each and the period of each crop is proposed to be adopted:-

(a) KHARIF:-

- i) Jute. .. 15% - 15th April to 31st July followed by Aman Paddy in 2/3rd Jute area.
- ii) Aman Paddy. . 80% - 15th May to 30th November.
- iii) Beali Paddy. 5% 15th May to 30th September to be followed by potatoes and Vegetables.
- iv) Sugarcane & Garden. .. 10% -Whole year crop.

(b) RABI.

- v) Dalua Paddy .. 12% - 1st Jany. to 30th April
(Seedlings to be raised in December).
- vi) Wheat, Cotton & Ground-nut. 10% - 15th Oct. to 30th April.
- vii) Cover crop.. 40% - December to April. (in Aman Paddy area).
(Legume Variety)
- viii) Vegetables & Potatoes. .. 5% - October to March (in the area of Beali Paddy).

6.41 DUTIES.

The total depth of watering required for sowing, transplantedation and maturing the 3 important paddy crops and jute will be as under:-

Aman Paddy	..	59 inches.
Beali Paddy.	..	54 inches.
Dalua Paddy.	..	54 inches.
Jute.	..	40 inches.

The Advisory Committee appointed by the Government of India (March 1952) had suggested that the duties for the Delta area should be the same as recommended for canals in the Sambalpur area.

In case of the Sambalpur canals the Committee was of the opinion that duty of 100 for paddy in the month of July was a reasonable assumption and could be worked upto, except during abnormal breaks in the Monsoon during July & August.

In case of sugarcane, the Committee considered that the duty of 120 for November and December should be lowered to 60.

As the districts of Cuttack and Puri are areas of abundant rainfall, a further study of the duties to be adopted has been made and the same incorporated in the "NOTES ON THE DUTY OF IRRIGATION WATER PROPOSED TO BE ADOPTED FOR VARIOUS CROPS IN THE DELTA AREA OF THE MAHANADI RIVER" which is attached as Appendix XI.

In the calculation of duty for paddy and other crops, in an area of abundant rainfall, irrigation is fundamentally a practice of supplementing that part of the natural precipitation which is available for crop growth. An estimate of the extent of useful rainfall which contributes towards the growth of crops has, therefore, been made on the basis of the method adopted in the Madras State which is also described in Appendix XI.

Study of the rainfall figures for the years 1912 to 1947 has shown that the average maximum and minimum of the two districts works out to 89 inches and 45 inches respectively. The average rainfall during the period being 62 inches.

It is also observed from the rainfall data produced in Appendix XI that on average there has been a year of low rainfall almost once in every 5 years in case of Cuttack District between 1918 to 1942 and once every 4 years in case of Puri District between 1912 to 1939. The average rainfall of the 5 lowest years for both for Puri and Cuttack Districts works out to about 47 inches.

The study of the data has further shown that the percentage for the average rainfall during the Monsoon period (16th June to 30th November), for the five lowest years to the average rainfall for the whole year, works out to 88%.

Thus the average rainfall for the 5 low years from 16th June to 30th November works out to 41.6 inches.

The useful rainfall calculated on the Madras method amounts to 75 percent of the average rainfall. Therefore, the useful rainfall for the 5 low years which would go towards the growth of the crop would be $41.6 \times .75 = 31$ inches. The delta, that is the total depth of water required for the Aman paddy crop which is the major crop covering nearly 80 percent of the culturable area, is 59 inches. Thus nearly 50 percent of delta will have to be supplemented by irrigation supplies for full maturity of the crop.

Even if the requirements of irrigation supplies were computed on the basis of average rainfall of 62 inches the position would be as under:-

The average rainfall from 16th June to 30th November would be $62 \times .88 = 54.5$ inches.

Useful rainfall would be $= 54.5 \times .75$
 $= 39.8$ inches.

Say 40 inches.

The irrigation supplies in this case will have to be supplemented to the extent of $(59-40) = 19$ inches which will be nearly 33 percent of the water requirements needed for full maturity of the crop.

It may be pointed out that in the Phillipines which has an annual rainfall of nearly 100 inches, irrigation supplies have been made available which have increased the yield per acre by nearly 100 percent.

The duties proposed to be adopted at outlet heads for different crops in the delta area of the Mahanadi which have been worked out in Appendix XI will be as under:-

Month		DUTY FOR CROP.								RS
		Jute	Aman Paddy	Beali Paddy	Sugar cane & Gard-en.	Dalua Paddy	Wheat Cott-on & Ground Nuts.	Veg-table & Pot-atoes	Cover crop Legume Variety	
January	1-31	-	-	-	60	27	200	200	-	
February	1-28	-	-	-	60	90	200	200	-	
March	1-31	-	-	-	60	78	200	200	-	
April	1-15	-	-	-	60	76	200	200	-	
	16-30	45	-	-	60	76	200	200	-	
May	1-15	70	-	-	60	-	-	-	-	
	16-31	70	1800	-	60	-	-	-	-	
June	1-15	130	1800	1200	65	-	-	-	-	
	16-30	130	350	20	65	-	-	-	-	
July	1-31	180	100	-	120	-	-	-	-	
August.	1-31	-	125	-	120	-	-	-	-	
September.	1-30	-	240	220	120	-	-	-	-	
October.	1-31	-	130	120	120	-	-	-	-	
November.	1-30	-	145	-	60	-	-	200	-	
December.	1-15	-	-	-	60	-	200	200	150	
	16-31	-	-	-	60	1200	200	200	150	

In order to safe-guard against an abnormal failure of rainfall during the transplantation period, the main canals have, however, been designed to carry 1.0 ft. extra depth of water, to safeguard against the emergency. This will enable the canals to work to a duty of 80 against 100 as proposed, when required.

6.41 WATER ALLOWANCE PER 1000 ACRES OF C.C.A.

Water allowance has been calculated per 1000 acres of commanded culturable area for the intensities and duties proposed vide paras 6.31 and 6.34 of this report. It has been worked out for the 12 months of the year and is shown vide statement No.7 of Appendix I.

The maximum water allowance works out to 11.1 cusecs per 1000 acres of commanded culturable area for the month of July which is generally the period of maximum demand and is inclusive of 15 percent transmission losses from outlet to canal head.

Capacity of the canals has been designed for a discharge of 11.1 cusecs for 1000 acres of commanded culturable area.

6.42 WATER REQUIREMENTS FOR CANALS.

Water requirements for the 3 existing canal systems and the main canal for the new areas in the Puri District have been worked out vide statement No.8 of Appendix I. Column (12) of the Statement shows the total water requirements for all the canals and Column (13) the discharge available for use.

6.5 TRANSMISSION LOSSES.

In the case of Sambalpur canals Ex Hirakud transmission losses have been provided at 20 percent of the total discharge. As the soils in the delta area, which is proposed to be brought under perennial irrigation, are heavier it is proposed to restrict the transmission losses to 15 percent of the total discharge at outlet head.

In the case of Godavari and Krishna delta canals also the absorption losses have been limited to 15% of the discharge at the head of the canals.

6.6 DESIGN OF CANAL SECTIONS.

In the case of the existing canals, which are being remodelled for revised discharges, slope is obtained from Lacey's f-Q relationship by assuming values of Lacey silt factor 'f' varying between 0.8 to 1.0. Canal sections have been found from Kutter's equations by assuming the value of 'K' = 0.0225.

In case of new channels in the existing areas and the new canal system in the Puri District the channels have been designed entirely according to Lacey's theory with values of 'f' varying between 0.8 to 1.0.

6.7 FREE BOARDS FOR CANAL BANKMENTS AND WIDTHS OF INSPECTION PATHS FOR DIFFERENT DISCHARGES.

The following free boards and widths of inspection paths etc. which are in line with the general practice already in vogue on the existing Orissa canal system have been adopted for the new canal system also:-

Discharge.	Crest width of bank			REMARKS.
	Free Board	Non-Inspection side.	Inspection side.	
Below 25 Cusecs	1.5	4'	4	
25 to 50 "	2.0'	4'	4	
50 to 100 "	2.0'	5'	5	
100 to 150 "	2.0'	5'	5	
150 to 200 "	3.0'	5'	5	
200 to 350 "	3.0'	6'	10'	
350 to 500 "	3.0'	6'	15'	} Int'nded for wheeled traffic.
500 to 1000 "	3.0'	8'	15'	
1000 to 2000 "	3.0'	10'	15'	
Above.	"	3.0'	10'	15')

6.71 FREE BOARDS FOR MASONRY STRUCTURES.

Following free boards for masonry structures have been adopted.

- (1) Main Canal .. 2 ft.
- (2) Branches. .. 2 ft. On all cross regulators and all off-taking channels at a group.

For channels not taking off at a group free board has been limited to 1.5 ft.

- (3) For masonry structures on distributaries and for off-taking channels from the distributaries the free board to be 1.5 ft.

6.8 BERM WIDTHS AT FULL SUPPLY LEVEL.

The following berm-widths, which have been followed on the D.V.C. Canals have been adopted:-

- Channel below 100 cusecs. D or 5' whichever is more.
 - 100 to 1000 " (D+5) or 10' whichever is more.
 - 1000 to 2000 " (D+5) or 15' whichever is more.
 - Channel above 1000 to 2000 " (D+5) or 20' whichever is more.
- 5' extra berm on each side for each 10' extra depth over initial 10' depth is to be provided.

6.9 DESIGN OF RIVER EMBANKMENTS.

The following specifications which are already in use by the Orissa Government, Irrigation Department, for the construction of capital embankments have been proposed for remodelling and construction of new river embankments:-

- Crest width 10 feet.
- Crest 3 feet above M.F.L.
- River side slope 2 to 1.
- Country side slope from crest to 8 ft. below, slope 2 to 1.
- 5 feet wide berm at 8 feet below crest.
- From 8 to 15 feet below crest, slope 4 to 1.
- 5 feet berm at 15 feet below crest.
- From 15 feet below crest, slope 4 to 1.

The berm may be omitted in embankments only 9 feet high if the soil is good and well compacted.

In case of river embankments on the right side of Katjuri from Naraj to Kuakhai barrage and marginal bunds upstream of the new weir same specifications as above, except for a free board 4 feet and six feet respectively instead of 3 feet, have been adopted.

The H.F.L. in case of design of embankments of Kuakhai and its three branches has been fixed with respect to a flood level of 76.9 at Kazipatna gauge.

6.10 SALIENT FEATURES OF THE CANAL SYSTEMS.

The new canal system in the Puri District and the 3 existing canal systems have been designed to carry revised discharges according to the proposed intensities of irrigation and duties. Index Plans 2 and 3 show the proposals in regard to alignment of channels, Irrigation boundaries, main drains etc. for the existing and new canal systems respectively. The salient features of the canal systems are given below:-

6.101 KENDRAPARA CANAL SYSTEMS.

This system comprises of the Kendrapara canal, the Patamundai Canal, Gobri Extension and the Gobri canal:-

1. Gross commanded area	..	3,48,981 acres.
2. Culturable commanded area.	..	2,93,914 acres.
3. Designed discharge.	...	3,262 cusecs.
4. Intensity during Kharif.	..	110 %
5. Intensity during Rabi.	..	67 %
6. Area irrigated annually during Kharif.	..	3,23,305 acres.
7. Area irrigated annually during Rabi.	..	1,96,923 acres.
8. Total area irrigated annually.		5,20,228 acres.
9. Length of main canal.	..	126.5 miles.
10. Length of distributaries & minors.		674 miles.
11. Length of Navigable canals.	..	76.5 miles.
12. Full supply Level at head.	..	R.L. 67.32
13. Bed width at Head.	..	100 ft.
14. Full supply Depth at Head.	..	10.2 ft.

6.102 TALDANDA CANAL SYSTEM.

This system includes the Machgaon canal also:-

1. Gross commanded area	..	2,86,567 acres.
2. Culturable commanded area.	..	1,95,322 acres.
3. Designed discharge.	..	2,168 cusecs.
4. Intensity during Kharif.	..	110 %
5. Intensity during Rabi.	..	67 %
6. Area irrigated annually during Kharif.	..	2,14,854 acres.
7. Area irrigated annually during Rabi.	..	1,30,866 acres.
8. Total area irrigated annually.	..	3,45,720 acres.
9. Length of main canal.	..	83.9 miles.
10. Length of distributaries & minors.		441 miles.
11. Length of navigable canals.	..	51.7 miles.
12. Full Supply Level at head.	..	R.L.68.00
13. Bed width at head.	..	98 ft.
14. Full supply depth at head	..	8 ft.

6.103 H.L.C.RANGE NO.1

1. Gross commanded area.	..	78,930 acres.
2. Culturable commanded area.	..	51,554 acres.
3. Designed discharge.	..	572 cusecs.
4. Intensity during Kharif.	..	110 %
5. Intensity during Rabi.	..	67 %
6. Area irrigated annually during Kharif.	..	56,709 acres.
7. Area irrigated annually during Rabi.	..	34,541 acres.
8. Total area irrigated annually.	..	91,250 acres.
9. Length of main canal.	..	33 miles.
10. Length of distributaries & minors.		110 miles.
11. Length of Navigable canals.	..	25.5 miles.
12. Full Supply Level at head.	..	R.L. 67.83
13. Bed width at head.	..	56.00 ft.
14. Full Supply depth at head.	..	7.00 ft.

6.104 SALIENT FEATURES OF THE EXISTING CANAL SYSTEMS.

1. Gross area commanded	..	7,14,471 acres.
2. Culturable commanded area.	..	5,40,790 acres.
3. Designed discharge.	..	6,002 cusecs.
4. Area irrigated annually during Kharif.	..	5,94,808 acres.
5. Area irrigated annually during Rabi.	..	3,62,330 acres.
6. Total area irrigated annually.		9,57,198 acres.
7. Increase in annual irrigation (9,57,198 - 2,71,738)	..	6,85,460 acres.
8. Length of main canals & branches.		243.4 miles.
9. Length of distributaries & minors.		1225 miles.
10. Length of Navigable canals.	..	153.7 miles.
11. Total cost of Remodelling.	..	Rs. 4.08 Crores.
12. Cost per acre of C.C.A.	..	Rs. 75/-

6.105 NEW CANAL SYSTEM IN THE PURI DISTRICT.

This system will have 8 branches:-

1. Gross commanded area.	..	6,67,230 acres.
2. Culturable commanded area.	..	5,36,333 acres.
3. Designed discharge.	..	5,954 cusecs.
4. Intensity during Kharif.	..	110 %
5. Intensity during Rabi.	..	67 %
6. Area irrigated annually during Kharif.	..	5,90,004 acres.
7. Area irrigated annually during Rabi.	..	3,19,892 "
8. Total area irrigated annually.		9,09,896 "
9. Length of main canals & branches.		192.6 miles.
10. Length of distributaries & minors.		790 miles.
11. Length of Navigable canals.	..	Nil.
12. Full Supply Level at Head.	..	R.L. 76.1
13. Bed width at head.	..	138 ft.

14. Full supply depth at head.	..	9.9 ft.
15. Cost of construction of the New Canal system.	..	Rs.10.75 crores.
16. Cost of per Acre of C.C.A.	..	Rs. 200/-

A note on the areas, alignments, design of the new canal system in the Puri District and is attached vide Appendix XIII of the report.

6.106 SALIENT FEATURES OF THE EXISTING AND NEW CANAL SYSTEMS COMBINED

1. Gross commanded area.	..	13,81,701 acres.
2. Culturable commanded area.	..	10,77,157 "
3. Designed discharge.	..	11,956 cusecs
4. Area irrigated annually during Kharif.	..	11,84,872 acres.
5. Area irrigated annually during Rabi.	..	6,82,222 "
6. Total area irrigated annually.	..	18,67,094 "
7. Increase in annual irrigation (18,67,094 - 2,71,738).	..	15,95,356 "
8. Length of main canals and branches	..	436 miles.
9. Length of distributaries & minors.		2,015 miles.
10. Total cost.	..	Rs. 14.82 crores.
11. Cost per acre of C.C.A.	..	Rs. 138/-

6.11 FIELD CHANNELS (WATER COURSES).

In the 1947 estimates of the Hirakud Dam Project no provision was made for excavation of water courses in Sambalpur District where irrigation was proposed to be provided. It had been assumed that water-courses will be excavated by cultivators themselves. No provision for excavation of water courses was therefore made in the revised estimates, of the Hirakud Dam Project.

The position happens to be quite different in the case of the Delta areas a part of which is already under irrigation for the last 90 years.

In the case of Orissa canal system of the Mahanadi delta no field channels have been provided and irrigation is done from field to field. This has been one of the reasons for the unsatisfactory progress of irrigation on this system where the area irrigated during Kharif has not increased beyond 2 lacs for the last 50 years.

If perennial irrigation which is proposed to be introduced in the Delta area is to be a success and intensities of 110% during Kharif and 67% during Rabi which are expected to be achieved at full development are to be realised, it is necessary that an efficient system of water-courses be provided which should be ready along with the rest of the canal system so that water can be delivered directly on to the land as required.

"As a general rule water courses for irrigation Projects are not constructed by Government as an integral part of the Project, the liability of Government being confined to the provision of the main canal and of such branches and minors and distributaries as may be decided upon by competent authority from time to time", according to Appendix IV, of the Central Public Works Account Code. The said appendix also provides that "In the general interests of the cultivators, especially when a canal project, or an integral part of it, is launched in a new locality and it is desired to afford special facilities to the cultivators, with a view to the more rapid development of irrigation, it may sometimes be decided by Government to lay out and construct, at the cost of Government in ^{the} first instance, the entire system of the main water-courses required for a Project or a substantial section of it, at the outset. When this course is adopted, a scheme is simultaneously devised for effecting recovery, in a number of years, of the additional burden thus thrown on Government finances."

It is, therefore, recommended that a system of water-courses necessary for efficient distribution of water both in the existing and new areas be provided at Government cost and the recovery of cost incurred effected in 10 equal annual instalments as arrears of land revenue.

Typical estimate for water-courses has accordingly been made and the cost per acre of C.C.A. estimated. This works out to:-

- (a) New areas .. Rs. 13/8/- per acre of C.C.A.
- (b) Existing areas .. Rs. 17/- " "

The total cost to be incurred on the excavation of water courses will amount to Rs. 1.63 Crores.

Statement No.9 Appendix I shows the details of cost per acre of C.C.A. and the total cost of water courses.

6.12 NAVIGATION (NEW CANALS).

The position in regard to Navigation on the existing Orissa canals has been discussed vide para 7.5 of this report. It has been shown that navigation on these canals has not been a success.

As the conversion of Irrigation Canals into irrigation Cum-Navigation channels which require wider and deeper section and the construction of locks at all cross-regulators, involve a large amount of expenditure without commensurate return (as has been found in the case of existing canals), new canals in the Puri District have been designed as irrigation channels only.

Provision has however been in the case of New areas for development of communications to facilitate marketing of produce.

6.13 DESIGN OF DRAINS.

In an area of abundant rainfall where paddy is the predominant crop during Kharif an efficient system of drainage is essential for obtaining a good yield. In the area commanded

by the three existing canal systems in the Cuttack District, a system of internal drainage already exists. Some obstructions have been put across these drains. These are proposed to be removed and the drains cleared.

The main drains namely the Mansua and Gobri do not need any remodelling as they are already big enough to take the run-off from the surrounding catchments in their respective doabs.

In the case of new areas it is proposed to do some training and cleaning of the existing major and minor valley lines.

One main drain namely the Dhanua in the Kushbhadra-Bhargovi doab has been designed to carry the run-off from the local catchment of the doab. The cost of remodelling this main drain has been estimated in detail and works out to Rs. 3/12/- per acre of C.C.A. A lumpsum provision of Rs. 5/- per acre of C.C.A has accordingly been made in the Project estimates for the purpose.

6.14 ADDITIONAL PRODUCTION OF FOOD GRAINS.

Enquiries from the Director of Agriculture, Orissa, show that an average yield of 15 Maunds of Paddy is obtained at present from both the irrigated and non-irrigated areas of Cuttack and Puri Districts. On account of assured supplies which will be available on completion of the Delta Canal system and due to improved methods of cultivation, use of manure, better quality of seed etc., it is expected that an average yield of about 25 maunds per acre is likely to be obtained for the 150-day Kharif Paddy crop. The average yield for 150-day crop in Godavari Krishna Delta varies from 30 to 35 maunds per acre.

The average yield per acre for Rabi Paddy is expected to be less than for the 150 day crop as the former is a crop of shorter duration and its yield is likely of the order of about 20 maunds per acre.

The yields for wheat, ground-nuts and Jute crops have been assumed at 10 maunds per acre and that for Pulses etc. at 8 maunds per acre. The yield of sugar-cane will be about 500 maunds per acre which will give a jaggery yield of about 50 maunds per acre.

Additional production of food grains and other commodities which will be obtained as a result of introduction of perennial irrigation, the increase in yield, the areas of land under different crops etc. have been worked out vide Statement No.10 of Appendix I.

The additional annual production at full development of different commodities will be about 8,00,000 tons as under:-

i) Food grains.	..	5,59,278 tons.
ii) Jaggery.	..	1,92,348 tons.
iii) Jute.	..	<u>57,705 tons.</u>
Total =		8,09,331 tons.
Say. =		8,00,000 tons.

6.15 ALTERNATE PROPOSALS.

The following proposal which is alternative to the one described in the preceding paras, consists of irrigating the new areas in the Puri District, through the Taldanda canal taking of upstream of Jobra weir. This proposal will involve:-

- 1) Construction of a new Regulator at head to carry the combined discharge of 7200 cusecs for Taldanda canal & the new areas in Puri District.
- 2) Lining of Taldanda canal from the head upto the point of bifurcation of the new canal from the Taldanda canal; and the construction of a new channel carrying about 5,000 cusecs upto its out-fall into Katjuri river.
- 3) Construction of Katjuri Barrage, which is proposed to be combined with the existing road bridge.
- 4) Construction of a Barrage on Kuakhai at Kazipadna, which along with Katjuri Barrage will serve as a level crossing for the off-take of the new canal on the right side of Katjuri & for flood control.
- 5) Construction of a canal for 5,000 cusecs on the right side of Katjuri upto its meeting the alignment of the new canal on the downstream of the Kuakhai syphon.

The above proposals are marked in dotted red on Plan No.II.

Rest of the proposals for flood control and for irrigation below Kuakhai syphon, on the left side of the river will be the same as already proposed.

As the main canal will take off at Jobra weir with a F.S. level of 68.0 at head, as against, R.L. 75.5 for the canal taking off upstream of new weir above Naraj, the C.C.A will be reduced to 4,50,933 acres, due to loss of command, on the right side of Daya.

The cost of the alternate proposal amounts to Rs. 12.31 crores. cost per acre of C.C.A. works out to Rs. 124/-

During the monsoon months, the regulation for the main canal for the new areas will be done at the Katjuri Barrage. Due to a large fluctuation in the range of flood discharge, water level up-stream of the Barrage will have to be ponded upto the required F.S.L. for the canal for long periods. This is likely to result in deposition of silt and consequent accretion of river-bed upstream. An accretion varying between 2 to 4 feet has taken place above Barrages constructed across alluival rivers.

An accretion of 2.0 ft. in bed levels of Katjuri upstream may, therefore, reasonably be expected to occur on account of the construction of the Barrage.

This will have the effect of raising the Bellevue gauge from 27.8 to 29.8, which may not be safe for Cuttack Town. The maximum Bellevue gauge so far recorded has been 27.8 (R.L. 82.8).

VII. FINANCIAL ASPECTS.

7. HISTORY OF WATER RATES.

The following extract from the Cuttack Gazetteer gives the history of water rates since the commencement of irrigation on the Orissa canal system.

"The present practice is to give long-term block leases, which often extend to ten years, but in order to discriminate between the various classes of land forming a block, different rates are charged. Thus lands lying so low that they never require irrigation, although water may often flow into them, are excluded from assessment; while a special rate of Rs. 1/12/- per acre is charged on those lands which derive benefit from irrigation only in exceptionally dry years. The rate was originally 8 annas per acre, which was increased to 12 annas in the year 1912, was subsequently enhanced to Rs. 1/8/- per acre in the year 1920, was ultimately raised to Rs. 2/- per acre in the year 1922, and has recently been reduced to Rs. 1/12/-. The rate charged for other land, or the ruling rate, was formerly Rs. 1/8/- per acre, but it was raised to Rs. 1/12/- in the year 1902, to Rs. 2/- per acre in the year 1912; it was subsequently raised to Rs. 2/8/- in the year 1920. In the year 1922 the water rates were raised to Rs. 3/8/- for long term leases and Rs. 4/8/- for season leases, mainly because at that time the price of grain was high; but the effect of this rising of rates has been a decided reluctance to renew expired leases especially on the canals from the Baitarani, and it has now been decided to reduce the rates again to Rs. 3/4/- and Rs. 4/4/- on the canals of the Cuttack district".

According to the proposals now made it is intended to provide an assured supply during the summer months and a Rabi supply during the winter months, thereby, converting the existing non-perennial system into a perennial one, which would enable 2 or more crops being raised during the

year. It is also proposed to provide a system of field channel that would reduce the field to field supply and also improve and expand the drainage system so that distinction between the three classes of land is eliminated. To make the Project pay, it is necessary to legislate for a compulsory levy of water rates on C.C.As. whether the owner takes water or not.

In the adjoining deltas of Godavari and Kistna rivers of the Madras State compulsory levy of water rates has been enforced. This provides that a cultivator whose land is situated in the command of the irrigation channels will pay the water rate irrespective of the fact whether he takes water or not so long as he cultivates the land.

The existing lease system will, therefore, need to be substituted by either a compulsory levy as enforced in the Madras State or modified suitably by the Orissa Government never losing sight of the Principle that lands commanded must pay.

7.1 PRESENT WATER RATES.

The water rates ruling on the delta canals at present are as under:-

<u>Kind of crop.</u>	<u>Water rates per acre.</u>
Sugar-Cane.	Rs. 5/8/- to Rs. 7/8/- per acre.
Paddy (Long lease).	Rs. 3/- per acre for Mada Land.
	Rs. 1/12/- per acre for Dhoya Land.
(Seasonal)	Rs. 4/4/- per acre.
<u>Kind of crop.</u>	<u>Water rates per acre.</u>
Jute.	Rs. 2/-/- per acre.
Garden crops.	Rs. 2/-/- per acre.
Pulses, ground nuts.	Rs. 2/-/- per acre.

The above water rates are obviously extremely low as compared to the water rates prevailing in the other States of India or where similar projects are either completed or are in the course of completion.

7.2 WATER RATES PROPOSED BY ADVISORY COMMITTEE.

The Advisory Committee (1952) in its report has suggested the following water rates:-

		<u>RATES PER ACRE.</u>
Kharif Paddy.	..	Rs. 10/-
Rabi Paddy.	..	Rs. 15/-
Jute.	..	Rs. 15/-
Sugar Cane.	..	Rs. 40/-
Other Kharif.	..	Rs. 6/-
Cash Rabi crops like wheat, potato, cotton, ground-nuts.		Rs. 8/-
Light Rabi crop, like Mung, Kulti etc.		Rs. 6/-

The water rates, which have been levied in other States for similar crops are discussed in Chapter VII of Revised Hirakud Dam Project Report, Volume I.A. An extract from the above chapter is attached as appendix XIII for ready reference.

7.3 WATER RATES AND RATES FOR BETTERMENT LEVY PROPOSED FOR THE DELTA AREAS.

Hirakud Control Board has appointed a Committee on the "appraisal of Direct benefits from Hirakud Dam Project". This Committee which has made recommendations for levy of water-rates and rates of betterment levy for areas proposed to be brought under irrigation in the Sambalpur District has not yet finalised its proposals for the Delta area. It has not, therefore, been possible to include the proposed water rates and rates for betterment levy for the Delta area in this report.

7.4 PRESENT REVENUE RECEIPTS ON ACCOUNT OF IRRIGATION.

Once again an extract from the Cuttack Gazetteer is reproduced below to show the position of canal revenue from the very beginning:-

"When the Project was first mooted, the most sanguine expectations were entertained as to the revenue the canals

would yield; and in 1867 the Directors of the East India Irrigation and Canal Company estimated that the scheme would eventually return a net income equal to 21 percent of the out-lay. These hopes soon proved delusive. It was found that the receipts did not cover the working expenses, while the interest on the loan steadily accumulated and quickly amounted to a sensible addition to the capital out-lay. The hopes of a steadily increasing demand for water were dispelled, though the outlay was very large, the incomings were insignificant. Six years after water was first offered to the people, irrigation was as far from general adoption as it was at first. By steadily refusing the water on the terms originally offered, the peasantry succeeded in beating down the rate, and the use of canal water then gradually extended. The works have, however, never been a success financially, and even upto the present day the outlay has proved unremunerative. The average annual working expenses for the five years ending in 1900-01 were Rs. 4,91,830 and the average gross revenue from all sources was Rs. 4,67,913 so that the working expenses were not covered. The position has improved a little since, as the average annual expenses for the ten years ending in 1929-30 on the whole Orissa Project stand at Rs. 6,55,354 and the average gross revenue from all sources at Rs. 7,37,885, but the total net revenue realized upto the end of the year 1929-30 amounted to only .49 per cent of the capital out-lay".

During the year 1951-52, the gross Direct receipts for the Orissa canal system as a whole amounted to Rs. 13,54,296 and the gross expenditure to Rs. 13,79,545 giving a deficit of Rs. 25,249, against a deficit of Rs. 6,56,578 in the preceeding year. *The decrease of Rs. 6,31,329 in the net deficit is due to an increase of 3,49,813 in the gross receipts and a decrease of Rs. 2,81,516 in the working expenses.

* Extract from Administrative accts. 1951-52 Appendix II.

and maintenance charges (including indirect charges). Taking into account the interest on capital invested the working of the Project disclosed a net deficit of Rs. 9,27,227 during the year under review as against Rs. 15,58,759 in the proceeding year**.

Statement No.11 showing the gross annual revenue from Irrigation, Miscellaneous Revenue, Maintenance charges, Net Revenue excluding establishment charges for the 10 years ending 1951-52 for the three canals system only, is enclosed vide Appendix I.

It will be observed that the net revenue for three canal systems excluding establishment charges amount to Rs. 3,14,228. If the establishment charges, details of which are not available separately for irrigation, are taken into account, the net revenue is likely to become negative.

7.5 NAVIGATION AND REVENUE THERE-FROM.

All the three canals viz. Kendrapara, Taldanda and H.L.C.Range I. are Navigable. The total length of navigable canals is 154 miles (vide col.7, statement No.1, Appendix I).

In this case also an extract from Cuttack Gazetteer (1930) on the progress of Navigation is reproduced, which indicates the position of the revenue which has been realised from time to time from this source.

" A very large sum was expended in making the canals first class navigation lines, as great importance was attached to this source of income. It was confidently expected that there would be large traffic along these waterways, and that the receipts from tolls would give the State a profitable return for the money spent on them. It might, indeed, reasonably have been expected that, if navigation could be success any-where, it would be in Orissa. The country was in a terrible state of isolation without internal and external communications, and it was naturally anticipated that the canal would attract all the local trade and form cheap routes connecting all

parts of the country. It is clear, however, that after 60 years of a very fine system of navigable canals, the people have not taken to navigation. Carts and pack bullocks still constitute the Chief means of transport, and even when canals are available, the people seldom use boats. The navigation receipts have, therefore, always been an insignificant source of income, and since the opening of the Railway they have still further diminished, falling from Rs. 1,94,100 in 1897-98 to Rs. 78,153 in 1901-02. The tollage rates were reduced in the year 1903 and the tonnage borne along the canals increased, but even so the tollage only amounted to Rs. 68,489 in 1903-04. The rates for tollage were increased in the year 1923 but the average tollage for the five years ending in 1929-30 amounted to Rs. 87,301 only. There does not appear, therefore, to be any likelihood of navigation ever proving of much value as a source of income".

An average gross revenue from Navigation on Taldanda, High Level Canal Range and Kendrapara canals for the year 1946-47 to 1950-51 is Rs. 2,18,860/-.

Statement No. 12 showing the tonnage of traffic on each canal and the tollage collected from Navigation during each year is enclosed vide Appendix I. It will be observed that there has been a sudden increase in the collection of tollage, particularly on the Kendrapara canal during 1951-52 due to the increase of rates by nearly 50 percent from October, 1951.

If the figures of Tollage for the 1951-52 are excluded the average gross revenue from Navigation would amount to Rs. 1,42,217/- only.

VIII. ESTIMATES OF EXPENDITURE.

2. Estimated cost of present proposals.

The estimates for the extension of irrigation in the Mahanadi Delta which consist of remodelling the existing canal system and providing new irrigation in the Puri District, coupled with flood control amount to Rs. 14.82 Crores, vide abstract of cost No.1 of Appendix XIV.

The costs have been based on the rates prevailing in the Cuttack and Puri Districts.

Brief details regarding various sub-heads of the estimate are given below:-

DIRECT CHARGES.

1. Head-works.

(a) Existing Canal system.

Provision of Rs. 50.8 lacs under this consists of remodelling of Jobra and Birupa weirs including provision of steel gates for under-sluzes and replacement of existing shutters by new 10'x5' falling shutters which will be operated by means of a power plough. It also includes the cost of substituting the existing wooden shutters by vertical screw gates for H.L.C. Range No.1, Talanda and both heads of Kendrapara canal head regulators.

(b) New Areas.

An amount of Rs. 3.56 crores has been provided under this sub-head which includes the cost of construction of a new weir across Mahanadi above Naraj including the cost of head-regulator for the new canal etc. and the cost of a weir across Kuakhai river near Kazipatna for controlling discharge passing down the Kuakhai and its 3 branches in order to protect the area to be brought under irrigation from being damaged from floods.

2. Main Canal and Branches.

1. Works.

A- Preliminary.

The total provision under this sub-head amounts to

Rs. 18.39 lacs. This includes the cost of contour survey done by Survey of India and Hirakud Administration, Soil survey, model experiments, discharge and sub-soil water level observations etc.

B-Land.

The total provision under this head works out to Rs. 22.8 lacs which is inclusive of 15 percent compulsory acquisition charges for land to be acquired permanently.

An area of 3756 acres will be acquired permanently for extra strips of land required along existing canals and distributaries and for the land for excavation of new channels.

In addition some area will be acquired temporarily for 3 years for borrow pits. The rates of different categories of land to be acquired have been ascertained from the Orissa Government and are given below:-

- (i) Permanent acquisition in existing irrigated areas in Cuttack District .. Rs. 800/- per acre.
- (ii) Permanent acquisition in new areas in Puri District. .. Rs. 500/- "
- (iii) Temporary acquisition for 3 years both in the existing and new areas. .. Rs. 350/- "

D-Regulators.

A provision of Rs. 24.2 lacs has been made under this sub-head which consists of remodelling and construction of new regulators wherever necessary in case of existing canal system and the construction of entirely new regulators for the new canal system.

The cost of the Regulators has been worked out from a cost curve, which has been drawn from the cost of Regulators of varying discharges, designs and estimates for which have been prepared in detail.

E- Falls.

A provision of Rs. 1.8 lacs has been made under this sub-head for construction of 2 falls on the main canal for the new areas. The cost is based on plans and estimates prepared.

F-Gross Drainage works.

The amount of Rs. 39.53 lacs has been provided under

this sub-head. This consists mainly of the following items:-

- (1) Syphon under Kuakhai river.
- (2) Syphon under Kushbhadra river.
- (3) Syphon under Bhargovi river.

The above syphons have been provided to take water on the other side of the river for purpose of irrigation. Plans and estimates for these have been prepared in detail.

G-Bridges.

A provision of Rs. 8.55 lacs has been made under this sub-head. This consists mainly of additions and alterations to the Road and Railway Bridges for the crossing of the Main Canal in Puri District.

H-Escapes.

A provision of Rs. 1.99 lacs has been made under this sub-head.

K-Buildings.

A provision of Rs. 59.73 lacs has been made under this sub-head for construction of buildings. These comprise of both residential and office buildings for one Superintending Engineer, 5 Executive Engineers and their staff and also buildings for inspection of touring officers and for housing regulating staff.

L- Earth Work.

A total provision of Rs. 192.51 lacs has been made under this sub-head. This includes the cost of earth work for remodeling of the existing canal system and the excavation for the new canal system. Rate of Rs. 30/- and Rs. 20/- per 1000 cft. has been provided for earth work which is inclusive of all loads and lift, for main canals and branches respectively.

L 1 Service and Boundary roads.

A total provision of Rs. 15.32 lacs has been made under this sub-head.

L 2 Lining of Canal.

A provision of Rs. 2.99 lacs has been made for lining the main canal upstream of Kuchabadi crossing.

M-Plantation.

An amount of Rs. 1.12 lacs has been provided under this sub-head for the new canal systems only.

O-Miscellaneous.

A total provision of Rs. 32.21 lacs has been made under this sub-head which includes the cost of development of communications in the new areas, construction of boundary pillars, distance marks, discharge sites etc. It also includes the cost of vehicles for one Superintending Engineer and 5 Executive Engineers and other items.

O 1-Pumps and Pipe Lines.

A provision of Rs. 17.68 lacs has been made under this sub-head which accounts for the cost of pumps and pipe lines required for lifting irrigation supplies in the 4 lift area tracts on the new canal system.

O 3-Outlet Heads:-

A provision of Rs. 1.21 lacs has been made under this sub-head.

P-Maintenance.

A provision of one percent of total cost under all sub-heads excluding the cost of B-Land has been made to cover this item. This amounts to Rs. 4.13 lacs.

Note:- The above sub-heads for the new canal system include the cost of 8 branches which will be constructed in the above area. This cost has been calculated in detail for one branch, the same estimated per acre of C.C.A. and applied to other Branches.

3. Distributaries.

(a) Existing Canals.

A provision of Rs. 187.25 lacs has been made under this sub-head for remodelling, extension and construction of new distributaries in the existing canal systems. These are based on detailed estimates.

The above amount also includes the cost of remodelling of minors which has been estimated in detail for one distributary system and the cost worked out per acre of C.C.A., and the same included in the cost of distributaries.

(b) New Areas.

A provision of Rs. 221.27 lacs has been made for the construction of distributaries in the new areas. This amount has been arrived at by working out the cost of construction of one Distributary system in detail and applying the cost of per acre of C.C.A. there-from for the cost of the Distributary system required for the whole area. The cost per acre of C.C.A. works out to Rs. 41/4. The rate of earth work of Rs. 20/- per 1000 c.ft. has been taken in working out the cost of Distributaries.

4. Drainage and Protective works.

A system of drainage already exists for the existing canal system which will require only clearance. In the case of new areas, the minor and major valley lines are proposed to be trained and cleared. Cost of remodelling Dhanua drain works out to Rs. 3/12/- per acre of C.C.A. A lumpsum provision of Rs. 5/- per acre of C.C.A. has however, been made in the estimate for purpose of drainage.

A total provision of Rs. 144.46 lacs has been made for this item which mainly consists of providing marginal bunds upstream of the new weir, construction of the right river embankment from Katjuri below Waraj upto Kuakhai head, raising, strengthening and construction of new embankments wherever necessary along Kuakhai and its 3 branches, and raising, strengthening and construction of new embankments in the island areas proposed to be brought newly under irrigation in the area commanded by the existing canal, and the cost of drainage at Rs. 5/- per acre of C.C.A.

5. Water courses.

A provision of Rs. 163.33 lacs has been made under this sub-head. This is based on a typical estimate prepared for a water-course system of a distributary from which the cost of per acre of C.C.A. has been worked out both for existing and new areas. As the cost of water courses is proposed to be recovered from the land owners, this is accounted for under V-Receipts and Recoveries on capital account.

6. Special Tools & Plant.

A provision of Rs. 20.35 lacs has been made under this sub-head which has been assumed at 5 percent of the amount for I-Headworks. 90 percent of this has been charged to works for the probable depreciation etc. and the credit to the extent of 10 percent has been shown under V-Receipts on Capital Account on account of the residual value of Plant and Machinery at the completion of works.

7. Losses on Stock.

A lumpsum provision of 1.0 lacs has been made under this sub-head.

Unforeseen.

A lumpsum provision of Rs. 4.0 lacs has been made under this sub-head to cover the cost of such items which could not be fore-seen while framing the estimate.

II- Establishment.

Details of establishment have been worked out for one Superintending Engineer, 5 Executive Engineers with the necessary Sub-divisions and other technical and non-technical staff from the year 1954-55 to 1959-60 vide statement 13 Appendix I showing the schedule of establishment works out to Rs. 40.0 lacs.

III. Tools and Plant.

Provision under this sub-head has been made at 1 percent of the cost of I-Works which amount to Rs. 15.70 lacs.

V. Receipts on Capital Amount.

An amount of Rs. 165.58 lacs has been provided under this sub-head. This consists of Rs. 163.33 lacs on account of recovery of cost of water courses from land owners, 10 percent of the cost of 6-Special Tools and Plant viz. Rs. 2.03 lacs which is expected to be realised from the sale of machinery on the completion of the Project and an amount of Rs. 0.22 lacs to be realised from other miscellaneous revenue like rent etc.

VI. Indirect charges.

(i) Capitalisation of abatement of land revenue.

This has been provided at 5 percent of the cost of B-Land and amounts to Rs. 10.66 lacs.

(2) Audit charges.

Provision for these charges is usually made at one percent of cost of I-Works. In the case of Hirakud Dam Project costing Rs. 92 Crores, an amount of Rs. 7.5 lacs has been provided in the revised estimates for audit charges as intimated by the Financial Adviser and Chief Accounts Officer. A provision at 1 percent will be much in excess of the provision made in the revised estimates for Hirakud Dam Project, a provision for these charges is being made at $\frac{1}{2}$ percent instead of usual 1 percent of cost of I-Works. This amounts to Rs. 7.85 lacs.

Details of estimates on which the cost of Sub-heads is based are attached separately.

8.1 Cost of Alternate Proposals.

Cost of alternate proposals described in para 6.15 of the report has been worked out in detail and amount, to Rs. 12.31 crores vide abstract of cost No.II of Appendix XIV.

8.2 The cost of alternative arrangement for irrigation of new areas and disposal of floods in the Puri District suggested by the Mazumdar Committee vide Appendix IV of their report has also been worked out in detail and amounts to Rs. 22.3 crores vide abstract of cost No.III of Appendix XIV.

IX. PROGRAMME OF CONSTRUCTION & WORKS EXPENDITURE.

9. ESTABLISHMENT.

The entire work of construction will be under the Administrative charge of an Officer of the rank of a Superintending Engineer, who will work under the general directions of the Chief Engineer.

The Superintending Engineer will be assisted by a Personal Assistant of the rank of an Executive Engineer.

There will be 5 Divisions with the number of Sub-divisions in each divisions as shown below:-

- | | | | |
|--|-----|---|----------------|
| 1. Stores Division. | ... | 4 | Sub Divisions. |
| 2. Head Works Division. | ... | 3 | " |
| 3. New Canal Divn.No.1 | ... | 4 | " |
| 4. New Canal Divn.No.II. | .. | 4 | " |
| 5. Remodelling Divn.
(Existing canals). | ... | 3 | " |

Work is proposed to be started during the year 1954-55 when a Circle and the three Divisions namely Stores Divn, Headworks Division, and New Canal Division No.1 will be opened. The remaining two Divisions viz. New Canal Division No.II and Remodelling Division will start functioning from the 2nd year of construction viz. 1955-56. This full strength of 5 Divisions will continue during the years 1956-57 and 1957-58 after which Head Works Division will be closed and 4 Divisions will continue to work upto the year 1958-59 i.e. 5th or last year of construction. The Stores Division will however continue to function during the year 1959-60 also for the disposal of Plant and Stores, final payments and adjustments for accounts etc.

Besides the Engineer Officers there will also be one Medical and one Labour Welfare Officer.

Establishment required each year from the commencement of construction is given in the schedule of Establishment vide Statement No.13 of Appendix I.

The cost of establishment has been based on Orissa States Government scales of pay, taking the average pay into account, and comes to Rs. 43.3 lacs. Details for this have been separately worked out and are included in the file of detailed estimates.

9.1 PROGRAMME OF CONSTRUCTION.

1954-55.

HEADWORKS.

Preliminary operations, collection of materials for new weir.
Land acquisition for buildings etc. in work yard area.
Foundation for the head regulator for the new weir site.
Construction of buildings and workshop.
Construction of roads and conservancy works.
Purchase of vehicles.
Purchase of heavy tools and plant.
Construction of roads for development of communications.
Collection of materials etc. for Kuakhai weir.
Collection of materials etc. for remodelling of Jobra, Birupa Weirs, and head regulators.

Main Canal, Branches and Distributaries etc.

Alignment of canals.
Acquisition of land for main canals and branches.
Earth work 11.7 crores cft.
Construction of buildings along canals.

1955-56.

Head works.

Additions and alterations to Jobra & Birupa weirs including head-regulators over 3 existing canals.
Construction of remaining building.
Commencement of foundations and part super-structure of Kuakhai weir.
Construction of head-regulator over New Canal and under sluices for the new weir.
Purchase of heavy tools and plant.
Construction of roads for development of communications.

Main Canal, Branches & Distributary etc.

Alignments of canals and distributaries and water-courses.
Acquisition of land for main canal, branches and distributaries.
Masonry works on canals to be started.

Earth-work 32.6 crore C.ft.

Construction of buildings along canals.

Plantation along channels to be started.

1956-57.

Headworks.

Additions and alterations to Jobra and Birupa Weir and head regulators over 3 canals.

Construction of the main weir along with upstream and downstream protection and undersluices.

Construction of Head regulator over new canal.

Construction of Kuakhai weir.

Purchase of heavy tools and plant.

Starting work of construction of Marginal bunds.

Main Canal, Branches & Distributaries etc.

Alignment of distributaries and water-courses.

Acquisition of land for distributaries minors and water-courses.

40% of masonry works to be completed.

Earthwork 48.3 crore C.ft.

Plantation along channels.

1957-58.

Head Works.

Completion of additions and alterations to Jobra & Birupa weirs and head regulators over 3 existing canals including providing gates in the undersluices and the head-regulators.

Completion of new weir and head regulator over the New Canal including regulating gates in the head regulator over the new canal and in the under-sluices for the new weir etc.

Main Canal, Branches and Distributaries etc.

Land acquisition for water-courses.

75% masonry structures to be completed.

Earth work 59.4 crore c.ft.

Lining of portion of main canal near Kushbhadra crossing.

Plantation along channels.

Pumping plant and pipes for lift area tracts.

Work of construction of out-let heads on existing canals to be started.

1958-59.

Main Canal, Branches and Distributaries etc.

All masonry works to be completed.

Lining of Canal near Kushbhadra crossing to be completed.

Earth-work 56.2 crore c.ft.- all earth-work to be completed.

pumping plant including pipes to be completed.

Work of construction of outlet-heads on existing canal system to be completed.

1959-60.

Disposal of Plant, Machinery and stores.

Payment of remaining bills.

Completion of accounts.

9.2 REQUIREMENTS OF FUND FOR WORKS EXPENDITURE.

Requirements of funds have been worked out for different years from 1954-55 to 1959-60 vide statement No.14 of Appendix No.1

APPENDIX II.

Statements accompanying the
Report.

STATEMENTS.

- Statement No.1 ... Showing the existing culturable commanded areas, designed discharges, lengths of main canals, Branches & Distributaries & lengths of Navigable canals etc.
- Statement No.2 ... Showing areas irrigated and percentage of different crops on the existing canals for 10 years (1942-43 -1951-52).
- Statement No.3. ... Showing areas under long and Seasonal leases on the three canal systems for 10 years (1942-43 - 1951-52).
- Statement No.4 ... Showing the proposed, gross & culturable commanded areas, revised discharges and lengths of canals, branches and distributaries, areas to be irrigated etc.
- Statement No.5 ... Showing the discharge observations, and other hydraulic data for the various discharge sites on the existing canals.
- Statement No.6 ... Showing calculation of flood discharges through Kuakhai and its branches.
- Statement No.7 ... Showing the water allowance per 1000 acres of C.C.A. for 12 months.
- Statement No.8 ... Showing proposed water requirements for both the existing & new canals.
- Statement No.9 ... Showing the details of cost of water courses (Field Channels).
- Statement No.10 ... Showing areas under different crops, yields and additional production of food grains etc.
- Statement No.11 ... Showing gross annual revenue from irrigation, maintenance charges etc. for the existing canals from 1942-43 - 1951-52.
- Statement No.12. ... Showing tonnage of traffic and tollage collected from Navigation for 5 years ending 1951-52.
- Statement No.13. ... Showing schedule of Establishment .
- Statement No. 14 ... Showing requirements of funds for works expenditure.

STATEMENT No. 1

Showing the existing culturable commanded areas, designed discharge, length of Main Canals, Branches and distributaries, Length of Navigable Canal etc.

Name of Canal.	Culturable commanded area in acres.	Designed discharge in cusecs.	Length of Main canals in miles.	Length of Branches in miles.	Length of distributaries and minors in miles.	Length of Canals Navigable.	REMARKS.
Aendrapara Canal.	1,15,193)		54.5	-	384.5	54.5	
Gobri Canal.	14,234)	1,191	16.0	-	25.0	16.0	
Patamundai Canal.	57,997)	885	50.0	-	137.0	-	
Gobri Extension.	11,084)		6.0	-	17.0	6.0	
Total Aendrapara Canal system.	<u>1,98,508</u>	<u>2,076</u>	<u>126.5</u>	<u>-</u>	<u>563.5</u>	<u>76.5</u>	
Taldanda Canal.	42,857)	625	51.7	-	158.2	51.7	
Machgaon Canal.	1,19,972)	776	32.2	-	241.4	-	
Total Taldanda Canal system.	<u>1,62,829</u>	<u>1,401</u>	<u>83.9</u>	<u>-</u>	<u>399.6</u>	<u>51.7</u>	
H.L.C. Range I.	44,637	600	33.0	-	75.0	25.5	
Total of all Canals.	4,05,974	4,077	243.4	-	1,038.1	153.7	

"Chamanlal"
20.10

STATEMENT NO.2

Showing areas irrigated and percentage of different crops on the existing Canals for 10 years (1942-43 to 1951-52).

Year.	Kharif Paddy.				J u t e.				Beali Paddy.				Sugar-cane.			
	Kendrapara Canal system.	Taldanda Canal system.	H.L.C. Range I.	Total.	Kendrapara Canal system.	Taldanda Canal system.	H.L.C. Range I.	Total.	Kendra-para Canal system.	Taldanda Canal system.	H.L.C. Range I.	Total.	Kendra-para Canal system.	Taldanda Canal system.	H.L.C. Range I.	Total.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1942-43	99,636	66,426	24,523	1,90,585	171	-	-	171	-	-	-	-	-	3	10	13
1943-44	99,432	67,581	24,499	1,91,512	307	-	-	307	-	-	-	-	1	-	-	1
1944-45	99,685	66,426	24,531	1,90,642	176	-	-	176	-	-	-	-	-	3	-	3
1945-46	1,00,202	66,534	24,525	1,91,261	97	-	-	97	-	-	-	-	-	8	23	31
1946-47	1,00,519	66,845	24,543	1,91,907	-	-	-	-	-	-	-	-	-	-	48	48
1947-48	1,00,626	66,191	24,591	1,91,408	272	-	-	272	-	-	-	-	-	13	-	13
1948-49	1,00,754	67,408	24,695	1,92,857	3,492	-	-	3,492	-	-	-	-	-	5	34	39
1949-50	1,00,708	67,034	24,866	1,92,603	3,369	-	-	3,369	-	-	-	-	-	1	8	9
1950-51	1,01,385	69,569	24,866	1,95,820	5,606	49	-	5,655	-	-	-	-	-	-	46	46
1951-52	1,01,878	72,461	23,377	1,97,716	4,351	12	-	4,363	-	-	-	-	-	-	-	-
Total.	10,04,820	6,76,475	2,45,016	19,26,311	17,841	61	-	17,902	-	-	-	-	1	33	169	201
Average.	1,00,482	67,648	24,501	1,92,631	1,784	6	-	1,790	-	-	-	-	-	3	17	20
Percentage of cultivation to C.C.A.	50.6	41.6	54.9	47.4	0.9	-	-	6.4	-	-	-	-	-	-	-	0.3

"Chamen"
20.10

STATEMENT -2 (Contd).

K H A R I F.				R A B I											
Total Kharif.				Wheat Paddy.				Green Gram (Moong).				Potatoes.			
Kendrapara Canal system.	Taldanda Canal System.	H.L.C. Range I.	Total.	Kendrapara Canal system.	Taldanda Canal System.	H.L.C. Range I.	Total.	Kendrapara Canal system.	Taldanda Canal System.	H.L.C. Range I.	Total.	Kendrapara Canal System.	Taldanda Canal System.	H.L.C. Range I.	Total.
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
99,807	66,429	24,533	1,90,769	-	-	211	211	46,753	50,483	1,200	98,436	282	97	6	385
99,740	67,581	24,499	1,91,820	1,613	-	1,080	2,693	28,527	39,142	1,797	69,466	252	650	11	913
99,861	66,429	24,531	1,90,821	1,441	-	818	2,259	32,328	28,735	20	61,083	474	388	-	862
1,00,299	66,542	24,548	1,91,389	152	-	425	577	36,793	32,640	-	69,433	404	378	31	812
1,00,519	66,845	24,591	1,91,955	-	-	350	350	32,468	39,177	-	71,645	752	332	74	1,158
1,00,898	66,204	24,591	1,91,693	-	-	80	80	32,595	22,756	3,675	59,026	688	268	62	1,018
1,04,246	67,413	24,729	1,96,388	-	-	45	45	37,955	31,035	-	68,990	750	357	57	1,164
1,04,072	67,035	24,874	1,95,981	-	-	-	-	33,580	30,342	-	63,922	603	504	82	1,189
1,06,991	69,618	24,912	2,01,521	33	-	40	73	38,454	35,415	5,549	79,418	604	519	65	1,188
1,06,229	72,473	23,377	2,02,079	8	7	25	40	55,597	54,125	5,487	1,15,209	578	611	121	1,310
10,22,662	6,76,569	2,45,185	19,44,416	3,247	7	3,074	6,328	3,75,050	3,63,850	17,728	7,56,628	5,387	4,104	509	10,000
1,02,266	67,657	24,518	1,94,441	324	1	307	632	37,505	36,385	1,773	75,663	539	410	51	1,000
51.5	41.6	54.9	47.9	0.2	-	0.7	0.2	18.9	22.3	4.0	18.6	0.2	0.3	0.1	0.2

"Chaman"
16.9

STATEMENT NO. 2 (Contd).

R A B I.				Total Annual cultivation.									REMARKS.
Miscellaneous.				Total Rabi.									
Kendra-para Canal system.	Taldanda Canal system.	H.L.C. Range I.	Total.	Kendrapara Canal System.	Taldanda Canal system.	H.L.C. Range I.	Total.	Kendrapara Canal system.	Taldanda Canal system.	H.L.C. Range I.	Total exist- ing canal system.		
34	35	36	37	38	39	40	41	42	43	44	45	46	
-	-	-	-	47,035	50,580	1,417	99,032	1,46,842	1,17,009	25,950	2,89,801		
8	-	-	8	30,400	39,792	2,888	73,080	1,30,140	1,07,373	27,387	2,64,900		
-	-	-	-	34,243	29,123	838	64,204	1,34,104	95,552	25,369	2,55,025		
-	-	-	-	37,349	33,018	456	70,823	1,37,648	99,560	25,004	2,62,212		
-	-	-	-	33,220	39,509	424	73,153	1,33,739	1,06,354	25,015	2,65,108		
-	-	-	-	33,283	23,024	3,817	60,124	1,34,181	89,228	28,408	2,51,817		
-	-	-	-	38,705	31,392	102	70,199	1,42,951	98,805	24,831	2,66,587		
-	-	-	-	34,183	30,846	82	65,111	1,38,255	97,881	24,956	2,61,092		
-	-	-	-	39,091	35,934	5,654	80,679	1,46,082	1,05,552	30,566	2,82,200		
-	-	-	-	56,183	54,743	5,633	1,16,559	1,62,412	1,27,216	29,010	3,18,638		
8	-	-	8	3,83,692	3,67,961	21,311	7,72,964	14,06,354	10,44,530	2,66,496	27,17,380		
1	-	-	1	38,369	36,796	2,131	77,296	1,40,635	1,04,453	26,650	2,71,738		
-	-	-	-	19.3	22.6	4.8	19.0	70.8	64.2	59.7	66.9		

STATEMENT NO. 3

Showing areas under Long and seasonal lease on the three Canal systems for the 10 years (1942-43 to 1951-52).

Year.	Area of long lease.				Area of season Lease.				Total of long & seasonal lease.				Total.	remarks.
	Kendrapara Canal system.	Taldanda Canal system.	H.L.C. Range I.	Total.	Kendrapara Canal system.	Taldanda Canal system.	H.L.C. Range I.	Total.	Kendrapara Canal system.	Taldanda Canal System.	H.L.C. Range I.	Total.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1942-43	99,633	66,426	24,523	1,90,582	Not available	100	227	327	99,633	66,526	24,750	1,90,809		
1943-44	99,427	67,581	24,499	1,91,507	Not available.	650	1,091	1,741	99,427	68,231	25,500	1,93,248		
1944-45	99,685	66,426	24,531	1,90,642	1,164	391	818	1,209	1,00,849	66,817	25,349	1,91,851		
1945-46	1,00,301	66,534	24,525	1,91,360	934	386	479	865	1,01,235	66,920	25,004	1,92,225		
1946-47	1,00,519	66,845	24,543	1,91,907	727	332	472	804	1,01,245	67,177	25,015	1,92,711		
1947-48	1,00,622	66,191	24,591	1,91,404	3,436	281	142	423	1,04,058	66,472	24,733	1,91,827		
1948-49	1,00,754	67,408	24,695	1,92,857	4,035	362	136	498	1,04,789	67,770	24,831	1,93,455		
1949-50	1,00,703	67,034	24,866	1,92,603	5,517	505	90	595	1,06,220	67,539	24,956	1,93,198		
1950-51	1,01,385	69,569	24,866	1,95,820	6,990	519	151	670	1,08,375	70,088	25,017	1,96,490		
1951-52	1,01,878	72,461	23,377	1,97,716	Not available.	611	146	757	1,01,878	73,072	23,523	1,98,473		
Total.	10,04,907	6,76,475	2,45,016	19,26,398		22,803	4,137	3,752	30,692	10,27,710	6,80,612	2,48,768	19,34,287	
Average.	1,00,491	67,647	24,502	1,92,640		3,858	414	375	4,047	1,03,749	68,061	24,877	1,96,687	
						(Average of seven years).								

Percentage of leased Area to C.C.A.

52.3 41.8 55.7 48.4

"Chaman"
16.9

STATEMENT No. 4.

Showing the proposed Gross culturable commanded area, revised discharges and lengths of Canals, branches and distributaries, areas to be irrigated etc.

Name of canal system.	Gross commanded area (in acrs).	Culturable commanded area (in acrs.)				Total culturable commanded area.	Designed Discharge (in cusecs)	Area to be irrigated annually (in acrs).			Length of main canal (in miles)	Length of branches (in miles)	Length of distributaries & minors (in miles)	Length of Canals-navigable (in miles)
		Perennial Flow.	Perennial lift.	Total perennial	Non-perennial Flow.			Kharif	Rabi	Total.				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<u>EXISTING CANALS.</u>														
Kendrapara Canal.	1,71,807	1,42,913	-	1,42,813	-	1,42,813	1,585	1,57,094	95,685	2,52,779	54.5	-	431	54.5
Kabri Canal.	31,316	27,261	-	27,261	-	27,261	302	29,987	18,265	48,252	16.0	-	40	16.0
Katamundai Canal.	98,211	82,876	-	82,876	-	82,876	920	91,164	55,527	1,46,691	50.0	-	14	-
Kabri Extension.	47,647	40,964	-	40,964	-	40,964	455	45,060	27,446	72,506	6.0	-	63	6.0
Total Kendrapara Canal system.	<u>3,48,981</u>	<u>2,93,914</u>	<u>-</u>	<u>2,93,914</u>	<u>-</u>	<u>2,93,914</u>	<u>3,262</u>	<u>3,23,305</u>	<u>1,96,923</u>	<u>5,20,228</u>	<u>126.5</u>	<u>-</u>	<u>674</u>	<u>76.5</u>
Taldanda Canal.	1,39,909	73,273	-	73,273	-	73,273	813	80,600	49,093	1,29,693	51.7	-	179	51.7
Kachgaon Canal.	1,46,658	1,22,049	-	1,22,049	-	1,22,049	1,355	1,34,254	81,773	2,16,027	32.2	-	262	-
Total Taldanda Canal system.	<u>2,86,567</u>	<u>1,95,322</u>	<u>-</u>	<u>1,95,322</u>	<u>-</u>	<u>1,95,322</u>	<u>2,168</u>	<u>2,14,854</u>	<u>1,30,866</u>	<u>3,45,720</u>	<u>83.9</u>	<u>-</u>	<u>441</u>	<u>51.7</u>
L.L.C. Range I.	78,930	51,554	-	51,554	-	51,554	572	56,709	34,541	91,250	33.0	-	110	25.5
Total Existing Canals.	<u>7,14,471</u>	<u>5,40,790</u>	<u>-</u>	<u>5,40,790</u>	<u>-</u>	<u>5,40,790</u>	<u>6,002</u>	<u>5,94,868</u>	<u>3,62,330</u>	<u>9,57,198</u>	<u>243.4</u>	<u>-</u>	<u>1,225</u>	<u>153.7</u>
<u>NEW CANAL.</u>														
Katjuri-Kushbadra Doab.	2,06,276	1,58,387	-	1,58,387	15,190	1,73,577	1,927	1,90,935	1,06,119	2,97,054	-	50	250	-
Kushbadra-Bhargovi Doab.	1,91,523	1,34,600	-	1,34,600	27,556	1,62,156	1,800	1,78,372	90,182	2,68,554	27.6	55	230	-
Bhargovi-Daya Doab.	1,34,079	1,00,010	-	1,00,010	15,190	1,15,200	1,279	1,26,720	67,007	1,93,727	-	35	190	-
West of Daya River.	1,35,352	56,884	27,570	84,454	980	85,434	948	93,977	56,584	1,50,561	-	25	120	-
Total New Canal.	<u>6,67,230</u>	<u>4,49,881</u>	<u>27,570</u>	<u>4,77,451</u>	<u>58,916</u>	<u>5,36,367</u>	<u>5,954</u>	<u>5,90,004</u>	<u>3,19,892</u>	<u>9,09,896</u>	<u>27.6</u>	<u>165</u>	<u>790</u>	<u>-</u>
Total Existing & New Canals.	<u>13,81,701</u>	<u>9,90,671</u>	<u>27,570</u>	<u>10,18,241</u>	<u>58,916</u>	<u>10,77,157</u>	<u>11,956</u>	<u>11,84,872</u>	<u>6,82,222</u>	<u>18,67,094</u>	<u>271.0</u>	<u>165</u>	<u>2,015</u>	<u>153.7</u>

STATEMENT No. 85 (Continued)

KENDRAPARA CANAL SYSTEM.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	D-17			Below Hd. Regulator.			15.00	111.00	5,000		31.24		33.12		17.74				
	D-18			-do-			Not available.				36.70		28.65	2273	18.92				
	Kendrapara Main.	39		809 U/S Lock Marsaghai.			15.00	111.00	5,000		475.50		217.37	2730	92.22				

"Chaman"
21.9

STATEMENT No. 15 (Continued).
KENDRAPARA CANAL SYSTEM.

Date	Channel.	Mileage of main canal.		Position of discharge site	Gauge Readings.		Designed Data.			Discharge.	Observed Data.			Wetted perimeter	Hy. mean depth.	Value of N.	Value of F.	
		Mile	Feet.		U/S	D/S	F.S.L. U/S	D/S	Hydraulic Gradient 'l in.		Sectional area.	Mean Velocity.	Discharge.					Hy. Gradient 'l in.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5-11-52	Gobri Canal Main.			Below bifurcation.							175.75	0.975	171.31	4167	58.91	2.983	.0489	1.026
	D-1	1	3000		4.10	3.80					28.92	1.171	34.88	1064	17.28	1.674	.0548	1.952
	D-2	2	3420		4.70	2.90	24.78	24.40	5000	17.37	24.90	1.185	29.55	6250	15.57	1.599	.0216	0.675
	D-3	2	3480		No gauge.		24.5	22.00	5000		27.74	1.196	33.16	1739	22.50	1.233	.03196	1.471
	Gobri Canal Main.	2	4075	U/S D/S	6.40	7.10					322.25 216.50	0.671 1.001	216.36 216.77	4762 3704	73.72 66.17	4.372 3.272	0.0857 0.0547	.969 1.127
<u>KENDRAPARA CANAL BELOW DANPUR.</u>																		
5.11.52	Gobri canal Head.	--	500	Below Bifurcation of Kendrapara							17.75	0.975	171.31	4167	58.91	2.983	.0489	1.026
5.11.52	Kendrapara Canal.	27	2625	-do- of Gobri.							134.00	1.121	150.16	2273	51.29	2.075	.04525	1.456
5.11.52	D-15	29	3162	Below Hd. Regulator.	6.8	4.20					30.88	1.344	41.50	2778	19.30	1.60	.0454	1.497
5.11.52	Kendrapara Canal.	30	970	Above Basepur Lock.	6.9	5.80					128.75	0.901	115.97	5000	42.15	3.055	.06183	0.8844
5.11.52				Below Basepur Lock.	"	"					133.25	0.838	111.65	11111	54.78	2.435	.0304	0.3441
7.1.52	D-16					4.80					24.00	0.718	17.24	2500	16.93	1.418	.0657	1.108
7.1.52	Kendrapara Canal.	35	355	Above Kalpara Lock.	6.5						300.25	0.424	127.39	5263	65.52	4.583	1.332	0.8657
				D/S of Kalpara Lock.	9.2									14286				
	D-17			Below Hd. Regulator.							31.24	1.060	33.12		17.74	1.761		
7.11.52	D-18			-do-					scrapped.		36.70	0.781	28.65	2273	18.92	1.94	0.6209	1.234
7.11.52	Kendrapara Canal.	39	809	Above Marsaghai.	9.40						475.50	0.457	217.37	2730	92.22	5.168	0.1859	1.354

----- Not available -----

STATEMENT No. 5 (Continued)
TALDANDA CANAL SYSTEM.

Name of canal.	Date	Mileage.	Discharge site	Gauge readings.	G.T.S.R. of gauge readings.	Discharge in cusecs.		Area in sq.ft.	Mean velocity in ft. per sec.	Wetted perimeter in ft.	Hydraulic mean depth in ft.	S l o p e		Manning's n	Lacey's formula.
						Observed.	Designated.					Observed	Designated.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Taldanda Canal.	4.11.52	0M-1000'	1000' below the Head Sluice.	68.66	67.84	1224	1324	576	2.12	105	5.5	Lin 8482	Lin 10560	.024	0.711
Taldanda Canal.	4.11.52	7M-1000'	700' above the Biribati Lock.	64.40	63.36	438	Not available.	269	1.62	67	4.00	Lin 8482	Lin 10560	.025	0.73
Taldanda Canal.	4.11.52	7M-3000'	1000' below Biribati Lock.	55.48	54.87	453	-do-	269	1.68	73	3.7	Lin 10300	Lin 10560	.020	0.65
Taldanda Canal.	5.11.52	14M-4500'	1000' above Somepur Lock.	52.25	50.93	384	-do-	214	1.79	53	4.1	Lin 10300	Lin 10560	.021	0.64
Taldanda Canal.	5.11.52	15M-1500'	1000' below Somepur Lock.	42.25	41.85	313	-do-	194	1.61	58	3.3	Lin 14320	Lin 10560	.017	0.51
Taldanda Canal.	5.11.52	25M-3500'	1000' above Tarpur Lock.	38.38	37.87	223	-do-	153	1.45	43	3.6	Lin 14320	Lin 10560	.020	0.50
Taldanda Canal.	5.11.52	26M-720'	1000' below Tarpur Lock.	30.85	30.31	196	-do-	169	1.16	49	3.4	Lin 16300	Lin 10560	.022	0.48
Taldanda Canal.	5.11.52	34M-1480'	1000' above Tirtol Lock.	28.35	27.63	93	cusecs -do-	213	0.44	61	3.5	Lin 16300	Lin 10560	.006	0.43
H.L.C. Range No.1	1.11.52	0M-1000'	1000' below Head Lock of H.L.C. Range.	67.60	66.96	524	600	366	1.43	73	5.01	Lin 32600	--	.017	0.33

"Chaman"
23.9

STATEMENT No. 6

SHOWING "FLOOD DISCHARGE" CALCULATIONS ON KHAKHAI SYSTEM
 Corresponding to proposed M.F.L. after flood moderation.
 (76.90 R.L. of Flood at Kazipatna).

Name of river.	Slope.	N	M.F.L.	S.E.T.			P S.E.T.			R S.E.T.			Q S.E.T.			Total Q	Remarks.
				A 1	A 2	A 3	P 1	P 2	P 3	R 1	R 2	R 3	Q 1	Q 2	Q 3		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
<u>HEAD REACHES OF KHAKHAI BRANCHES.</u>																	
1. KUSHBHADRA (near Jogishahi)	1/4000	0.0336	59.25	9,301	328	-	900	98	-	10.3	3.35	-	30,900	515	-	31,415	20,000 cs. was observed on 13.9.53.
2. BHARGAVI (near sardeipur).	1/3,600	0.0320	48.750	9,749	-	-	1,362	-	-	7.14	-	-	28,000	-	-	28,000	24,000 cs. was observed on 13.9.53.
3. Daya (near sardeipur).	1/2,400	0.0367	50.00	840	6,221	126	220	420	111	3.32	14.80	1.13	1,550	31,000	112	32,662 92,077 Cs.	23,500 Cs. was observed on 13.9.53. Thus total of 67500 cusecs was observed in head reaches of the three branches during peak flood in 1952-53.
<u>TAIL REACHES OF KHAKHAI BRANCHES.</u>																	
5. DAYA (near Kanas).	1/2,640	0.0367	14.25	2,791	420	-	332	104	-	8.4	4.04	-	9,150	845	-	9,995	
6. KANCHI & BHARGAVI (below Kanchi off-take).	1/6,600	0.0320	24.25	240	2,922	-	100	240	-	2.4	12.4	-	250	8,900	-	9,150	
7. KUSBHADRA (below Gop).	1/4,800	0.0336	11.50	787.3	4,381.5	1,240.1	172	400	276	4.57	10.95	4.54	1,380	13,800	2,160	17,340	
																<u>50,512</u> cs.	

Note:- Discharge of 50,512 cusecs of the tail reaches is on the higher side to some extent. This is so because the value of "slope" has been presumed to be equal to "average slope" in the rivers between head and tail of each river. Actual slopes in the tail reach were not observed, they would be flatter than this average slope.

STATEMENT No. 7

Showing the Water allowance for 1,000 acres of C.C.A. for 12 months.

{ Jute	15%	150 acres.	{ Vegetable &		
{ Aman Paddy.	80%	800 "	{ Potatoes.	5%	50 acres
{ Beali Paddy.	5%	50 "	{ Dalua Paddy.	12%	120 "
{ Sugarcane & Garden.	10%	100 "	{ Wheat, Cotton & Groundnuts.	10%	100
Total.	110%	1100 acres.	{ Cover crop, Legumi.	40%	400
			Total.	67%	670 acres.

Month.	Description of crop and period	Duty	Acre- age.	Disch- arge requir- ed.	Trans- miss- ion loss @15%	Total dis- charge for the each crop.	Total dis- charge for the period.
	2	3	4	5	6	7	8
	Dalua Paddy.	1-31	27	120	1.44	0.67	5.11
	Wheat, Cotton & Groundnut.	"	200	100	0.50	0.08	0.58
	Vegetable & Potatoes.	"	200	50	0.25	0.04	0.29
	Sugarcane & Garden.	"	60	100	1.67	0.25	1.92
	Dalua Paddy	1-28	90	120	1.33	0.20	1.53
	Wheat, Cotton & Groundnut.	"	200	100	0.50	0.08	0.58
	Vegetable & Potatoes.	"	200	50	0.25	0.04	0.29
	Sugarcane & Garden.	"	60	100	1.67	0.25	1.92
	Dalua Paddy.	1-31	78	120	1.54	0.23	1.77
	Wheat, Cotton & Groundnut.	"	200	100	0.50	0.08	0.58
	Vegetable & Potatoes.	"	200	50	0.25	0.04	0.29
	Sugarcane & Garden.	"	60	100	1.67	0.25	1.92
	Dalua Paddy.	1-30	76	120	1.58	0.24	1.82
	Wheat, Cotton & Groundnuts.	"	200	100	0.50	0.08	0.58
	Vegetable & Potatoes.	"	200	50	0.25	0.04	0.29
	Sugarcane & Garden.	"	60	100	1.67	0.25	1.92
	Jute.	16-30	45	150	3.33	0.50	3.33
	Sugarcane & Garden.	1-31	60	100	1.67	0.25	1.92
	Jute.	"	70	150	2.14	0.32	2.46
	Aman Paddy.	16-31	1800	800	0.44	0.07	0.51

STATEMENT NO. 7 (Continued)

1	2	3	4	5	6	7	8	
June	Sugarcane & Garden.	1-15	65	100	1.54	0.23	1.77) 3.65
	Jute.	"	130	150	1.15	0.17	1.32	
	Aman Paddy.	"	1800	800	0.44	0.07	0.51	
	Beali Paddy.	"	1200	50	0.04	0.01	0.05	
	Sugarcane & Garden.	16-30	65	100	1.54	0.23	1.77) 8.60
	Jute.	"	130	150	1.15	0.17	1.32	
	Aman Paddy.	"	350	800	2.29	0.34	2.63	
	Beali Paddy.	"	20	50	2.50	0.38	2.88	
July.	Sugarcane & Garden.	1-31	120	100	0.83	0.12	0.95) 11.10
	Jute.	"	180	150	0.83	0.12	0.95	
	Aman Paddy.	"	100	800	8.00	1.20	9.20	
	Beali Paddy.	"	-	50	--	--	--	
August.	Sugarcane & Garden.	1-31	120	100	0.83	0.12	0.95) 8.31
	Aman Paddy.	"	125	800	6.40	0.96	7.36	
	Beali Paddy.	"	-	50	-	-	-	
September.	Sugarcane & Garden.	1-30	120	100	0.83	0.12	0.95) 5.04
	Aman Paddy.	"	240	800	3.33	0.50	3.83	
	Beali Paddy.	"	220	50	0.23	0.03	0.26	
October.	Sugarcane & Garden.	1-31	120	100	0.83	0.12	0.95) 8.50
	Aman Paddy.	"	130	800	6.15	0.92	7.07	
	Beali Paddy.	"	120	50	0.42	0.06	0.48	
November.	Sugarcane & Garden.	1-30	60	100	1.67	0.25	1.92) 8.56
	Aman Paddy.	"	145	800	5.92	0.83	6.35	
	Vegetable & Potatoes.	"	200	50	0.25	0.04	0.29	
December.	Dalua Paddy.	16-31	1200	120	0.10	0.02	0.12) 5.98
	Wheat Cotton & Groundnuts.	1-31	200	100	0.50	0.08	0.58	
	Cover Crop, Legumi-	"	150	400	2.67	0.40	3.07	
	Vegetable & Potatoes.	"	200	50	0.25	0.04	0.29	
	Sugarcane & Garden	"	60	100	1.67	0.25	1.92	

STATEMENT NO. 38

Showing proposed water requirements for both existing and new canals.

Period.	EXISTING CANAL.					NEW CANAL.					Total for existing and new canals. (Col. 6 + Col. 11)	Discharge available from Power House No. 1 at Nirakud	Remarks.
	Water allowance per 1000 acres of C.C.A.	Kendrapara Canal system (C.C.A.) acres.	Taldanda Canal system (C.C.A.) acres.	H.C.C. Range I (C.C.A.) acres.	Total existing canal (C.C.A.) acres.	Water allowance for perennial area.	Water allowance for Non-perennial area.	Perennial area C.C.A. acres.	Non-perennial area C.C.A. acres.	Total New Canals (C.C.A.) acres.			
1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Cusecs.	Cusecs	Cusecs	Cusecs	Cusecs	Cusecs	Cusecs	Cusecs	Cusecs	Cusecs	Cusecs	Cusecs.	
JANUARY.	7.90	2,322	1,543	407	4,272	7.90	1.92	3,772	113	3,885	8,157	8,750	
FEBRUARY.	4.32	1,270	844	223	2,337	4.32	1.92	2,063	113	2,176	4,513	9,100	
MARCH.	4.56	1,340	891	235	2,466	4.56	1.92	2,177	113	2,290	4,756	9,600	
APRIL.	8.44	2,481	1,648	435	4,564	8.44	5.75	4,030	339	4,369	8,933	10,400	
MAY.	4.89	1,437	955	252	2,644	4.89	4.89	2,335	288	2,623	5,267	11,020	
JUNE-1-15.	3.65	1,073	713	188	1,974	3.65	3.65	1,743	215	1,958	3,932	12,400	
JUNE 16-30	8.60	2,528	1,680	443	4,651	8.60	8.60	4,106	507	4,613	9,264	12,400	
JULY.	11.10	3,262	2,168	572	6,002	11.10	11.10	5,300	654	5,954	11,956	14,360	
AUGUST.	8.31	2,442	1,623	428	4,493	8.31	8.31	3,968	490	4,458	8,951	12,800	
SEPTEMBER.	5.04	1,481	984	260	2,725	5.04	5.04	2,406	297	2,703	5,428	10,900	
OCTOBER.	8.50	2,498	1,660	438	4,596	8.50	8.50	4,058	501	4,559	9,155	9,540	
NOVEMBER.	8.56	2,516	1,672	441	4,629	8.56	8.27	4,087	487	4,574	9,203	9,320	
DECEMBER.	5.98	1,758	1,168	308	3,234	5.98	1.92	2,855	113	2,968	6,202	8,340	

STATEMENT NO.9

Showing the details of cost of water courses
(Field Channels).

**

ANALYSIS OF RATES FOR WATER COURSES.

(I) NEW AREAS.

Abstract of cost for selected water-course system in
Kathjuri-Kushabhadra Doab.

C.C.A. = 652 acres.

Total Length of Water course. = 7.35 miles.

S.No.	Particulars.	Total cost.	Cost per acre of C.C.A.	2% work-charged Establishment + 3% contingen- cies = 5%.	Total cost per acre of C.C.A.
1.	A. Preliminary.	-	0-8-0	-	0-8-0
2.	B. Land.	8140-0-0	6-4-0	-	6-4-0
3.	C. Bridges.	1800-0-0	2-12-0	0-2-0	2-14-0
4.	L. Earthwork.	2267-0-0	3-8-0	0-3-0	3-11-0
				Total.	13-5-0

(II) OLD AREAS (Existing).

For existing areas, the cost per acre of C.C.A. on
all items, except "B-Land" will be the same as above.

On "B-land" the cost will be $6-4-0 \times \frac{8}{5} = \text{Rs. } 10/-$

∴ Cost per acre of C.C.A for existing areas

= Rs. 13-5-0 + Rs. 3-12-0

= Rs. 17-1-0

Say Rs. 17/-

COST OF WATER COURSE SYSTEM.

(1) Cost of water course in New areas	= 13-5-0 x 5,36,367 =	71,40,000
(2) Cost of water courses in Existing areas.	= 17-0-0 x 5,40,790 =	91,93,000
Total cost.	=	1,63,33,000.

STATEMENT NO. 10

Showing the areas under different crops, yields and the production of additional food grains etc.

Total C.C.A. 10,77,157 acres.

Sl No	Name of Commodity.	Intensity	Present yield in Maunds per acre.	Proposed yield in Maunds per acre.	Increase in yield in Mds. per acre.	Area of crop in acre.	Production of commodity in Maunds.	Production of commodity in Tons.
1	2	3	4	5	6	7	8	9
								10

FOOD CROPS.

1.	Aharif Paddy.	85%	15	25	10	9,15,583	91,55,830	3,26,994
2.	Rabi Paddy.	12%	-	20	20	1,29,258	25,38,160	92,328
3.	Wheat & Ground-nuts.	10%	-	10	10	1,07,715	10,77,150	38,470
4.	Pulses.	40%	8	8	-	* 3,55,200	28,41,600	1,01,486
						Total food grain =		5,59,278
5.	Sugarcane.	10%	-	50	50	1,07,715	53,85,750	1,92,348
6.	Jute.	15%	-	10	10	1,61,572	16,15,720	57,705
								Net increase in area = 75,662
								Net increase in = 355,200

*Area at 40% Intensity = 430,862
 Less existing area under irrigation. = 75,662
 Net increase in = 355,200 area.

This yield is for Jaggory per acre of sugarcane which yields about 500 Mds. of cane per acre. No account has been taken of this item while working out the additional production.

Total production of all Commodities. 8,09,331

Say = 8,00,000 tons.

5%
177%

7. Vegetables & Potatoes.

Showing gross annual revenue from irrigation, maintenance charges etc. for the existing canals from 1942-43 to 1951-52.

Year	Gross annual Revenue from Irrigation.				Miscellaneous Revenue.				Total Gross Revenue.			
	Kendrapara Canal System.	Taldanda Canal system.	H.L.C. Range I.	Total Cols. 2 to 4.	Kendrapara Canal System.	Taldanda Canal system.	H.L.C. Range I.	Total Cols. 6 to 8.	Kendrapara canal system. Col. (2+6)	Taldanda Canal system Col. (3+7)	H.L.C. Range I Col. (4+8)	Total Cols. (10 to 12)
1	2	3	4	5	6	7	8	9	10	11	12	13
1942-43	2,12,778	1,34,015	54,007	4,00,800	11,083	15,974	11,092	38,149	2,23,861	1,49,989	65,099	4,38,949
1943-44	2,12,010	1,36,729	52,708	4,01,447	13,125	16,735	12,623	42,483	2,25,135	1,53,464	65,331	4,43,930
1944-45	2,13,044	1,34,987	53,080	4,01,111	Not available.	19,116	17,742	36,858	2,13,044	1,54,103	70,822	4,37,969
1945-46	2,14,326	1,36,058	51,861	4,02,245	-do-	20,327	21,179	41,506	2,14,326	1,56,385	73,040	4,43,751
1946-47	2,14,126	1,37,078	52,941	4,04,145	14,987	20,741	17,544	53,272	2,29,113	1,57,819	70,485	4,57,417
1947-48	2,14,423	1,34,862	52,105	4,01,390	16,168	22,367	17,103	55,638	2,30,591	1,57,229	69,208	4,57,028
1948-49	2,18,671	1,39,863	54,478	4,13,012	17,061	24,862	21,607	63,530	2,35,732	1,64,725	76,085	4,76,542
1949-50	2,94,613	1,85,556	71,573	5,51,742	19,323	24,633	16,879	60,835	3,13,936	2,10,189	88,452	6,12,577
1950-51	2,90,971	1,97,995	73,288	5,62,254	21,265	25,043	46,123	92,431	3,12,236	2,23,038	1,19,411	6,54,685
1951-52	2,94,540	1,92,378	71,377	5,58,295	24,595	28,839	14,396	67,830	3,19,135	2,21,217	85,773	6,26,125
Total.	23,79,502	15,29,521	5,87,418	44,96,441	1,37,607	2,18,637	1,96,288	5,52,532	25,17,109	17,48,158	7,83,706	50,48,973
Average.	2,37,950	1,52,952	58,742	4,49,644	17,201	21,864	19,629	58,694	2,55,151	1,74,816	78,370	5,08,337
					(Average of 8 yrs) ✓							

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23.9

Maintenance charges excluding Estt. charges.				Net Revenue excluding Estt. charges.			
Kendrapara Canal system.	Taldanda Canal system.	H.L.C. Range I.	Total (Cols. 14 to 16).	Kendrapara Canal system. (Cols. 10-14)	Taldanda canal system (Cols. 11-15)	H.L.C. Range I Cols. 12-16	Total Cols. 18 to 20)
14	15	16	17	18	19	20	21
3,542	47,562	1,354	92,458	1,80,319	1,02,427	63,745	3,46,491
62,278	37,876	6,374	1,06,528	1,62,857	1,15,588	58,957	3,37,402
74,564	52,072	11,016	1,37,652	1,38,480	1,02,031	59,806	3,00,317
72,656	66,944	6,779	1,46,379	1,41,670	89,441	66,261	2,97,372
82,976	72,412	10,000	1,65,388	1,46,137	85,407	60,485	2,92,029
1,09,190	96,409	11,992	2,17,591	1,21,401	64,820	57,216	2,39,437
1,27,648	1,51,578	15,986	2,95,212	1,08,084	13,147	60,099	1,81,330
1,41,281	1,27,233	30,568	2,99,082	1,72,655	82,956	57,884	3,13,495
1,16,068	1,05,318	40,050	2,61,436	1,96,168	1,17,720	79,361	3,93,249
1,01,347	94,646	23,373	2,19,366	2,17,788	1,26,571	62,400	4,06,759
9,31,550	8,52,050	1,57,492	19,41,092	15,85,559	8,96,108	6,26,214	31,07,881
93,155	85,205	15,749	1,94,109	1,61,996	89,611	62,621	2,14,228

STATEMENT NO. 12

Showing tonnage of traffic and tollage collected
from navigation for 5 years ending 1951-52.

Year	Kendrapara Canal system.			Taldanda Canal system.			H.L.C. Range 1.			T o t a l.			R E M A R K S.
	Traffic in		Tollage	Traffic in		Tollage	Traffic in		Tollage	Traffic in		Tollage in	
	Tons	Cft.	Rupees.	Tons.	Cft.	Rupees.	Tons	Cft.	Rupees.	Tons.	C.ft.	Rupees.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1947-48	26,236	1,71,892	32,823	57,698	2,95,315	33,082	8,284	33,166	9,359	92,218	5,00,373	75,264	
1948-49	36,529	2,42,226	70,345	67,692	3,29,639	58,043	11,386	45,368	17,292	1,15,607	6,17,233	1,45,680	
1949-50	57,679	1,85,553	94,992	67,176	2,38,761	70,886	11,506	18,045	15,748	1,36,361	4,42,359	1,81,626	
1950-51	2,90,774	1,02,114	80,323	77,306	5,11,772	72,236	9,350	10,536	13,739	3,77,430	6,24,422	1,66,298	Tollage for the major portion of traffic on kendrapara canal during 1950-51 seems to have been recovered in the year 1951-52.
1951-52	60,469	1,59,332	4,33,638	74,617	2,82,149	77,714	8,076	9,746	14,082	1,43,162	4,51,227	5,25,434	
Total.	<u>4,71,687</u>	<u>8,61,117</u>	<u>7,12,121</u>	<u>3,44,489</u>	<u>16,57,636</u>	<u>3,11,961</u>	<u>48,602</u>	<u>1,16,861</u>	<u>70,220</u>	<u>8,64,778</u>	<u>26,35,614</u>	<u>10,94,303</u>	
Average.	94,337	1,72,223	1,42,424	68,898	3,31,527	62,392	9,720	23,372	14,044	1,72,955	5,27,122	2,18,860	

"Chaman"
25.9

STATEMENT NO.13

Showing schedule of Establishment.

Particulars.	Y E A R						REMARKS.
	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60	
1	2	3	4	5	6	7	8
Superintending Engineer.	1	1	1	1	1	-	
Personal Assistant to Superintending Engineer of the rank of an Executive Engineer.	1	1	1	1	1	-	
<u>EXECUTIVE ENGINEERS.</u>							
Stores Division.	1	1	1	1	1	1	
Head Works Division.	1	1	1	1	-	-	
New Canal Division No.I.	1	1	1	1	1	-	
New Canal Division No.II.	-	1	1	1	1	-	
Remodelling Division.	-	1	1	1	1	-	
TOTAL.	3	5	5	5	4	1	
<u>SUB DIVISIONAL OFFICERS.</u>							
For 5 Divisions.	11	18	18	18	15	4	
Personal Assistants to Executive Engineers.	2	3	3	3	3	1	
For Land acquisition work.	1	2	2	2	2	-	
TOTAL.	14	23	23	23	20	5	
<u>OTHER OFFICERS.</u>							
Sub-Assistant Surgeon.	1	1	1	1	1	-	
Assistant Labour Welfare Officer.	1	1	1	1	1	-	

STATEMENT NO.14

SHOWING REQUIREMENTS OF FUNDS FOR WORKS EXPENDITURE.

DESCRIPTION OF ITEM.	AMOUNT IN LACS OF RUPEES.						REMARKS.
	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60	
1. HEADWORKS.	40.70	101.75	122.09	122.09	20.35	-	
2. Main Canal & Branches.							
A-Preliminary.	*14.75	2.07	1.38	0.69	-	-	*This includes an amount of Rs.12 lacs already incurred on investigations during the year 1951-52 to 1953-54.
B-Land.	3.42	5.70	6.84	4.56	2.28	-	
D-Regulators.	-	2.42	7.26	8.47	4.84	1.21	
E-Falls.	-	0.18	0.72	0.90	-	-	
F-Cross Drainage works.	-	3.95	11.86	13.84	7.90	1.98	
G-Bridges.	-	0.38	1.16	1.35	0.77	0.19	
H-Escapes.	-	0.20	0.60	0.70	0.40	0.09	
I-Buildings.	29.87	14.93	14.93	-	-	-	
L-Earth Work.	19.25	38.50	48.13	48.13	28.87	9.63	
L 1-Service & Boundary road.	0.77	3.06	3.83	3.83	3.06	0.77	
L 2-Lining of Canal.	-	-	-	1.50	1.49	-	
M-Plantation.	-	0.22	0.22	0.28	0.34	0.06	
N-Miscellaneous.	3.22	6.44	8.05	8.05	4.83	1.62	
O 1-Pumps & Pipe Lines.	-	-	-	5.30	10.61	1.77	
O 3-Outlet heads.	-	-	-	0.54	0.61	0.06	
P-Maintenance.	-	0.41	0.83	1.24	1.65	-	
3. Distributaries and Minors.	20.43	81.70	102.13	102.13	181.70	20.43	
4. Drainage & Protective works.	7.22	14.44	36.12	43.34	36.12	7.22	
5. Water Courses.	-	8.10	24.30	64.81	56.71	9.41	
6. Special Tools & Plants.	8.14	6.10	5.09	1.02	-	-	
Less depreciation charged to works.	(-)0.91	(-) 1.83	(-) 4.58	(-) 5.50	(-) 5.50	-	
Net amount of special T&P.	7.23	4.27	0.51	(-) 4.48	(-) 5.50	-	
Losses on stock.	-	0.10	0.25	0.30	0.30	0.05	
Unforeseen.	-	1.00	1.00	1.00	1.00	-	
Total I Works.	146.86	289.82	392.21	428.57	258.33	54.49	

APPENDIX II.

EXTRACT FROM ADMINISTRATIVE ACCOUNTS
FOR 1951-52 FOR ORISSA CANAL PROJECT.

102
APPENDIX II.

OFFICE OF THE DEPUTY ACCOUNTANT GENERAL, ORISSA.

No. WM-13-1121 Dated, the Puri the 17th July, 1953.

To:

The Superintending Engineer,
Delta Irrigation Circle,
Hirakud Dam Project,
Camp-Bhubaneswar.

Sub:- Capital cost of the Orissa Canal system.

Sir,

With reference to your letter No. DIC/W-27/1079-camp dated 10.7.53, I am to state that the detailed information in respect of each canal as required in your letter No. DIC/W-27/836-camp of even date, is not available in my office. All the canals for which capital and Revenue accounts are kept are merged and styled as "Orissa Canal Project" which is exhibited in the Administrative accounts. An extract of the relevant portion of accounts for 1951-52 is enclosed.

Yours faithfully,
Sd.
(P.C. Mukherjee)
Deputy Accountant General,
ORISSA.

"Chaman"
23.9

ADMINISTRATIVE ACCOUNTS FOR THE YEAR 1951-52.

General Abstract of Financial Result showing the estimated cost of construction of productive and unproductive work outlay thereon, the revenue derived there from, the working expenses and interest on the Debt incurred in respect of these works for and to end of 1951-52.

Name of Project	ESTIMATED COST OF CONSTRUCTION.			Date of closure of construction estimate or in the case of work under construction. date of sanction.	Capital outlay inclusive of indirect charges during 1951-52.			To end of 1951-52			Accumulated arrears of simple interest to end of the year.
	Direct charges.	Indirect charges.	Total.		Direct charges.	Indirect charges.	Total.	Direct charges	Indirect charges.	Total	
1	2	3	4	5	6	7	8	9	10	11	12
Unproductive											
Orissa Project.	2,65,73,699	6,13,444	2,71,87,143	31st March, 1895	-	-	-	2,69,76,954	6,17,151	2,75,94,105	7,80,38,634

Total Capital invested to end of the year (Col.II & 12)	Gross receipts during 1951-52.			Working expenses and maintenance during 1951-52 inclusive of indirect charges.			Net Revenue Profit (+) Deficit(-)	Percentage on capital outlay col.11 Gain-G Loss-L	Simple interest during 1951-52	Net gain	Net Loss	Percentages of net revenue (Col.20) on capital involved (Col.13)			Prescribed rate of interest as test of productivity.	
	Direct receipt	Portion of Land revenue due to works etc.	Total	Direct charges	Indirect charges.	Total						During 1949-50	During 1950-51	During 1951-52		
13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
10,56,32,639	13,54,296	-	13,54,296	13,72,295	7,250	13,79,545	-25,249	.0915 L	9,01,978	-	9,27,227	-0.7514	-0.6271	-0.0239	4.00	

Orissa Project.

Part II- Detailed account of capital expenditure for & to end of 1951-52.

Heads of Accounts.	Direct charges.		Cost of construction as now estimated (construction estimate closed on 31st March 1895).	R E M A R K S
	During 1951-52	To end of the year.		
1	2	3	4	5
I. Works.				
head works.	--	47,36,748	47,36,748	
Main canals & Branches.	--	97,30,279	97,30,279	
Distributaries.	--	26,75,018	26,75,018	
Drainage and protective works.	--	25,33,391	21,62,667	
Irrigation Survey.	--	2,08,023	2,08,023	
Total.	--	<u>1,98,83,459</u>	<u>1,95,12,735</u>	
II. Establishment.				
Direction and Account. Executive.	--	48,59,178	48,41,693	
Medical.				
Survey.				
Total.	--	<u>48,59,178</u>	<u>48,41,693</u>	
III. Tools and Plant.				
New supplies.	--	20,09,342	20,09,342	
Repairs and Carriage.	--	65,478	65,478	
Lump sum charges other Governments, Departments.	--	19,409	4,364	
Total:-	--	<u>20,94,229</u>	<u>20,79,184</u>	
IV. Charges in England				
Loss by exchange.	--	2,68,071	2,68,070	
GRAND TOTAL:-	--	<u>2,71,04,937</u>	<u>2,67,01,682</u>	
V. Less receipts on Capital account.				
	--	1,27,983	1,27,983	
Net Total.	--	<u>2,69,76,954</u>	<u>2,65,73,699</u>	

ORISSA PROJECT.

Part III- Revenue Account for and to end of 1951-52 (date of closing construction estimate 31st March, 1952).

GROSS RECEIPTS.			GROSS WORKING EXPENSES.		
Head of Accounts.	Total. During the year 1951-52.	To end of the year.	Heads of Accounts.	Total. During the year 1951-52.	To end of the Year.
1	2	3	4	5	6
Direct receipts.			Post-War Development.		
Water rate.	6,98,548	3,00,35,536	(1) Extension and Improvement.		
Receipts from workshop.	26,630	2,19,364	Head Works.	1,952	27,298
Sales of water.	749	29,693	Main Canals and branches.	8,032	4,16,523
Water supply of Town.	-	(-) 1,766	Drainage and protective works.	-	4,84,996
Plantations.	8,053	5,02,642	Total.	9,984	9,28,817
Other canal produce.	39,769	3,10,110	(2) Establishment, Direction & Accounts.		
Owner rates.	111	18,425	Executive.	99	13,173
Water Power.	102	133	(3) Tools and Plant.	2,051	19,833
Navigation.	5,28,120	71,01,885	Lump sum charges creditable to other Govt. and departments-direct charges.	-	-
Rents.	2,930	3,22,072	(4) Charges in England.	Nil	62
Recoveries of expenditure.	7,608	41,046	Total.	12,134	9,61,885
Fines.	-	1,163	1A Extension and Improvement.		
Misc. & other receipts.	41,756	22,22,165	Head Works.	25,343	4,11,570
Total.	13,54,376	4,08,03,074	Main canals and branches.	26,071	10,35,021
Deduct Refunds.	80	61,101	Distributaries.	9,238	1,27,603
Direct Revenue raised in England.	-	38,686	Drainage and protective works.	16,967	8,02,123
Total-Direct receipts.	13,54,296	4,07,80,659	Total.	77,619	23,76,923
Portion of Revenue due to works.	-	1,263	1B. Maintenance and Repairs.		
Total Gross Receipts.	13,54,296	4,07,81,922	Head Works.	77,702	47,54,650
Net Deficit.	25,249	59,89,803	Main Canals and branches.	2,57,317	87,26,598
			Distributaries.	1,95,659	38,99,599
			Drainage and protective work.	1,04,645	23,59,983
			Loss on Stock.	-	1,457
			Total.	6,35,330	1,97,42,287
			1C Compensation.		
			Establishment.		424
			Direction and Accounts.		
			Executive.	1,92,557	94,09,553
			Revenue.	3,54,883	97,27,052
			Navigation.	30,091	13,97,962
			Total.	5,77,551	2,05,34,567

PART III (Contd.)

	1	2	3	4	5	6
B.F.		13,79,545	4,67,71,725		13,02,634	4,36,16,086
III. Tools and Plant.						
New Supplies.					804	4,25,839
Repairs and Carriage.					8,555	7,91,557
Lump sum charges.					29,695	1,62,818
Creditable to other Govts. and Deptts.						
Total.					<u>39,054</u>	<u>13,80,214</u>
IVA. Profit and Loss.					-	* 1,865
IV Suspense including stock account.					30,197	(-) 1,284
Refund to Revenue.					-	57,024
Deduct-Recoveries on Revenue account.					-	28,650
Total.					<u>13,71,885</u>	<u>4,50,25,255</u>
Direct expenditure in England.					410	21,816
Total Direct Charges.					<u>13,72,295</u>	<u>4,50,47,071</u>
Indirect charges as per part V.					7,250	17,24,654
Total Gross Charges.					<u>13,79,545</u>	<u>4,67,71,725</u>
Balance Net Revenue.					-	-
Grand Total.					13,79,545	4,67,71,725.

Orissa Project.Part IV- interest Account for and to end
of 1951-52.

Interest	Amount	Net Revenue	Amount.
Total interest charges to end of 1950 -51	7,11,46,753	Net Revenue realised to end of 1950-51	(-) 59,64,554
Interest charges for the year 1951-52	-	Total net revenue realised during 1951-52 as per part III.	(-) 25,249
Interest on Rs. 2,69,76,954 being outlay upto 1950-51.	9,01,978	Total net revenue realised to end of 1951-52 as per part III.	(-) 59,89,803
Total interest to end of 1951-52.	<u>7,20,48,731</u>	Balance-Net interest charges.	<u>7,80,38,534</u>
Total.	7,20,48,731	Total.	7,20,48,731.

PART V-Accounts of Indirect charges.

Particulars.	During the year 1951-52	To end of the year.
Capital Account.	--	6,17,151
Revenue Account.	7,250	17,24,654

Particulars.	Charges against closed sanction.			Charges against open canal sanction.			Charges against old and current sanction.		
	1	2	3	4	5	6	7	8	9

Direct charges.

Works.	1,85,91,015	9,21,720	1,95,12,735	3,70,724	-	-3,70,724	1,98,83,459
Establishment.	46,26,782	2,14,911	48,41,693	17,485	-	-17,485	48,59,178
Tools and Plants.	20,65,399	13,785	20,79,184	15,045	-	-15,045	20,94,229
Suspense Account.	-	-	-	-	-	-	-
Loss by Exchange	2,68,070	-	2,68,070	-	-	-	2,68,070
Charges in England.	-	-	-	1	-	-1	1
Total.	2,55,51,256	11,50,416	2,67,01,682	4,03,255	-	-4,03,255	2,71,04,937

Less receipts on Capital account.
Net Total.

	1,00,926	27,057	1,27,983	-	-	-	1,27,983
	2,54,50,340	11,23,359	2,65,73,699	4,03,255	-	-4,03,255	2,69,76,954

Indirect charges.

Capitalised abatement of land revenue.	33,233	5,831	39,064	-	-	-	39,064
Leave and pension allowances.	5,43,875	30,155	5,74,030	-	-	-	5,74,030
Audit and Acct. Establishment.	-	350	350	3,707	-	3,707	4,057
Total.	5,77,108	36,336	6,13,444	3,707	-	3,707	6,17,151
Grand Total.	2,60,27,448	11,59,695	2,71,87,143	4,06,962	-	-4,06,962	2,75,94,105

Review of the Administrative
Accounts for 1951-52.

1. The Orissa Canal Project:- During the year 1951-52, the gross receipts on account of this Project fell short of working expenses and maintenance charges by a sum of Rs. 25,249 as against Rs. 6,56,578 in the preceding year. The decrease of Rs. 6,31,329 in the net deficit is due to an increase of Rs. 3,49,813 in the gross receipts and a decrease of Rs. 2,81,516 in the working expenses and maintenance charges (including indirect charges). Taking into account the interest on capital invested, the working of the Project disclosed a net deficit of Rs. 9,27,227 during the year under review as against Rs. 15,58,759 in the preceding year.

"Chaman"
23.9

APPENDIX III.

A NOTE ON THE INSPECTION OF GODAVARI
& KRISHNA DELTAS.
BY SHRI M.G. HIRANANDANI.

117
APPENDIX III

No. DIC/W-41/200
Government of India,
Central Water & Power Commission.

Camp Cuttack.
Dated 5th Jan.1953.

From:-

M.G.Hiranandani,
Superintending Engineer,
Delta Irrigation Circle,
Curzon Road, Barracks 'A',
New Delhi.

To:

Shri Kanwar Sain,
Member (Designs) & Chief Engineer,
Hirakud Dam Project,
Burla.

Subject:- Inspection of Godavari and Krishna deltas in the
Madras State.

Sir,

I am forwarding herewith a report of my visit to Godavari and Krishna deltas in the Madras State for favour of further disposal.

Para 28 of this report gives the summary of salient features observed during the inspection of both the deltas. Some of the important points on which the orders of the Hirakud Control Board and Orissa Government are required are dealt with in para 29 of the report.

It is requested that the points raised in para 29 of the report may be put up to the Hirakud Control Board at its 4th Meeting proposed to be held from 28th to 30th January '53.

Yours faithfully,
Sd.

M.G.Hiranandani,
Superintending Engineer,
Delta Irrigation Circle (H.D.Project)
C.W.& P.Commission.

D.S.S.
1 report
with ac-companiments.

REPORT ON THE VISIT TO GODAVARI AND
KRISHNA DELTAS IN THE MADRAS STATE.

BY

M.G. HIRANARDANI, B.A., B.Sc. Eng. (London)
SUPERINTENDING ENGINEER, DELTA IRRIGATION
CIRCLE, CENTRAL WATER & POWER COMMISSION.

With a view to study the problems connected with irrigation and flood control in the delta area of Mahanadi it was desired by Shri Kanwar Sain, Member (Designs) and Chief Engineer, Hirakud Dam Project, that the adjoining areas of Godavari and Krishna deltas may be inspected and studied in regard to the existing practice of irrigation and flood control in these areas.

A programme of visits to both the deltas which was arranged through the Chief Engineer, Madras State, was framed by the Superintending Engineer, Godavari & Krishna deltas copies of which are enclosed as Annexure 1 to this report.

BRIEF DESCRIPTION OF THE GODAVARI DELTA.

2. The River Godavari which has a catchment area of 1,15,000 miles rises 50 miles from the Arabian SEA. and flows across the Peninsula generally in the south-east direction for a distance of nearly 900 miles and merges into plains of the deltas at Polavaram, a village about 25 miles up-stream of Dowleshwaram.

The maximum discharge which occurred in 1942, was 21,07,660 cusecs. The minimum discharge of 1050 cusecs was recorded in May 1952.

Above the anicut the river is called Akhand Godavari. At the anicut it divides into 2 main branches called Gautami Godavari and Vasist Godavari.

The Gautami branches flows in the south easterly direction and throwing off two minor branches called the Vrindha Godavari and Goringa river, joins the sea near the village called Goringa.

2.1 systematic irrigation from the Godavari started with the construction of the anicut i.e. a masonry diversion weir about 4 miles long, at Dowleshwaram (about 5 miles

south of Rajahmundry Railway station on the Southern Railway. It owes its conception and construction to Sir Arthur Cotton. It was constructed during the years 1847 to 1852.

2.2. Godavari delta consists of three sections, the Eastern, the Central and the Western, and extends for Forty miles from the head-works to the Bay of Bengal. The three sections of the delta forming coastal portions of east and west Godavari districts and lying east of the Railway line, are developed almost to the full extent, excepting a few dry patches and these are being gradually brought under cultivation under the Grow More Food Campaign launched by the Government, since the last few years.

Each of these sections has an independent head-sluice and canals ^{with its main canals} system and branches. These main canals are navigable for their full length. Annexure II gives the extent of lands irrigated under the three sections, and the lengths of canals. The Godavari Eastern, Central and Western canals were designed for discharges of 3,205, 2573 and 6266 cusecs respectively. The discharges actually carried at present are about 10% more than their designed capacities. The contours of the delta vary from about 40.00 at head to almost sea level at end. The soil is alluvial clay except in a belt of 5 or 6 miles width near the coast where it is pure sand to sandy loam and is covered by patches of scrub jungle. Irrigation is being extended to these areas also with protective bunds to prevent tide from submerging these lands.

An Index plan showing the Godavari and its branches and the three sections of the delta etc. is enclosed.

MONSOONS.

3. The delta is subject to both south-west (May-September) and North-east Monsoons (October-December). About 75 per-cent of the rainfall is due to the south-west and 25 percent due to the north-east monsoons. The coastal strip receives a larger share of N.E. Monsoon than the interior with a corresponding decrease in the south-west Monsoon. The floods in the river

syachoronise with local rains of south-west monsoon period and consequently irrigation is concentrated and is intense in the first crop season. There are 29 rainfall recording stations in the delta. The statistics of recorded rainfall at all these stations from 1943 to 1951 give an average annual rainfall of 45 inches per year.

CROP SEASONS.

4. There are two irrigation seasons in this delta, namely the first crop (Kharif) and second Crop (Rabi) seasons. The first crop (Kharif) season begins in June and ends November, the second crop (Rabi) season begins in January and ends in April. In the first crop season, seedlings are raised in patches of land from the beginning of May onwards. The seedlings are in ground for about six weeks, and are transplanted from 15th June to middle of August. The crop gets to maturity by third week of November and then harvesting begins. The second crop seed beds are raised in December and January and the transplantation done in February and harvesting done towards the ends of April and early in May. The second crop is not raised immediately after the first crop as the prevailing breeze in this period is not considered conducive to the growth of the crop. During the second crop season about half the lands which do not get second crop turn are cultivated with dry crops as gingelly, chillies, grams and pulses, green manure crops, which are well harvested by 15th March. Generally the flow of water over the fields is altered to suit the various stages of the crop mentioned above and varied in accordance with the incidence of rain.

INTENSITY.

5. The entire ayacut is irrigated during the first crop (June to December) mainly with different varieties of paddy except for small patches where commercial crops like sugar-cane, plantains, Betals etc. are grown.

During the second crop period (January to April) the water supply in the river is not sufficient for irrigating the whole ayacut. On an average 40% of the ayacut is irrigated during the second crop, the intensity for the whole year working out to 14% for the entire delta, it was stated by the Superintending Engineer of the Godavari Canal Circle that if water was available the intensity would increase to 200% in the entire delta.

The statistics of gross area and actual cultivation during the year 1948-49 are as under:-

(a) Gross	14,00,000 Acres.
(b) Total irrigation in the first crop period.	8,48,387 "
(c) Total irrigation in the second crop period.	3,39,558 "

PERCENTAGE OF SUGARCANE GARDEN AND OTHER DRY CROPS.

5.1 Areas under sugar-cane and garden crops and dry crops as compared to the ayacut in the Western Godavari delta were collected to see the development of the above crop in the latter delta which is one of the highly developed delta in this area. The cultivation figures were as Under:-

(a) Ayacut.	4,68,000 acres.
(b) Sugar-cane & Garden crop.	33,000 "
(c) Dry crops.	26,000 "

Thus the sugar-cane, gardens and other dry crops forms roughly 12% of the total ayacut in the Godavari delta.

Enquiries at the Agricultural Research Station Maruter showed that it had not been possible to grow either wheat or cotton as ^asecond crop in the same area where rice was grown during the first crop.

Experiments carried out at the above station gave a maximum yield of 500 lbs per acre for cotton and 400 lbs. per acre for wheat which was considered a low yield and was

attributed to the nature of soil in Godavari delta which is considered to be heavy. A typical soil sample has been collected and is being analysed in the Hiraakud Research Station.

It is, however, understood that cotton is being successfully grown in the same area in which paddy had been raised as the first crop in Tanjore delta of the Kaveri basin.

YIELD OF CROPS.

6. The average yield of different crops in the Godavari delta is found to be as under:-

1. Paddy first crop	--	30 maunds per acre.
2. Paddy second crop.	--	24 maunds per acre.
3. Sugar-cane.	--	40 tons per acre.
4. Gingelly (Til).	--	4 Maunds per acre.
5. Ground-nuts.	--	12 Maunds per acre.

Average yield of Paddy in upland area (unirrigated) was stated to vary between 10 to 12 Maunds per acre.

DUTIES:

7. The percentage of useful rainfall which goes towards the maturing of the crop is generally taken as 60 to 70 percent in years of normal rainfall. The method usually adopted for calculating the useful rainfall in the Madras State is described in the Madras Engineering Association P.W.D. Diary 1944, page 495, and is reproduced below.

"It is desirable to ignore during transplation of rainfall less than $\frac{1}{4}$ in 24 hours, or exceeding 3" in 24 hours or 5" in any 10 days period. After transplantation period, all falls less than 1/10th of an inch in 24 hours or 3" in any 10 days period shall be ignored. Useful rainfall for at least 10 days before the assumed duty of transplantation shall be included:-

The following rainfall is omitted while considering the useful rainfall before transplantation period:-

1. Below 0.25" in 24 hours.

2. In excess of 3" in 24 hours.

3. In excess of 5" in 10 days.

In the Godavari Delta a duty of 70 for the first crop and duty of 50 for the second crop is adopted. These duties do not take account of the precipitation of rainfall and are exclusive of that.

BRIEF HISTORY OF THE ANICUTS.

8. The anicut over the Godavari have a total length of 11,849 feet and are built in 4 sections with intervening islands with embankments which have an aggregate length of 7,365 feet. The embankments are about 21 feet high above the anicut crest. The construction of these anicuts was completed by Sir Arthur Cotton in 1852.

Prior to 1866 the anicut crests had been kept at R.L.38.00 Due to expansion of irrigation in the delta it was found necessary to maintain 2 to 3 feet depth of water above the crest level of the anicut. In 1898, the crests were raised by 9 inches and falling shutters 2 feet, high fitted on top. These shutters were originally designed to fall when water rose to 2.5 feet above the anicut. Subsequently in 1916 the pivots of shutters were raised so as to make them fall when water rose to 2.75 feet. The pivots were further raised subsequently so that shutters may stand up to 3 feet depth of water over the crest and this was the maximum which could be achieved by adjusting the pivots. When the shutters fell down, they were raised by manual labour.

As the lifting of shutters by manual operation took long the anicut was equipped with power driven machines running over rail tracks on anicut crests to lift the gates. These machines which are called "PLOUGHS" were designed by Messrs. Ransome & Repiers.

PARTICULARS OF SHUTTERS AND MACHINES.

1. Length of shutters.	10'
2. Height of shutters.	3.25'
3. Head required for the shutters to fall.	6"

- | | |
|--|--|
| 4. Gauge of rail track. | 6'-6" |
| 5. Rail section..(Top rail 50 lbs. Per Yard
Bottom "41½lbs. per yard. | |
| 6. Power unit for shutters
lifting machines. | 4 Cylinder Petrol
engine 30 D.H.P. |
| 7. Speed of engine. | 1000 R.P.M. |
| 8. Speed of travel over
the track. | 1 mile per hour. |
| 9. Fuel consumption. | 1 Gallon per hour. |
| 10. Establishment required
for the plough' | 1 Driver.
1 Assistant.
4 Khalasis. |

Sketches of the falling shutters, the shutters lifting machine and the cross section of Dowleshwaram anicut showing the position of the shutters etc. have been obtained and kept on record.

DESIGN OF CHANNELS.

9. The canals and channels are designed according to Kutter's formula with the value of $n = 0.0225$.

The channels are generally designed for a velocity of 2.5' per second. Except the head reaches of some channels others were reported to be non-silting.

For remodelling of some of the canals in this system and Chief Engineer, Madras, has ordered that, these may be re-designed by adopting Lacey's design with $f = 0.7$.

Channels in cuttings are excavated with sides slopes 1 to 1, and the spoil banks are formed with side slope of 1½ to 1.

Sections of canal embankments, width of berms and free boards etc. adopted for different discharges are given vide Annexure III attached to this note.

GENERAL SLOPE OF THE COUNTRY AND POSSIBILITY OF WATER LOGGING

10. The average slope of the country is not uniform and it varies from 0.65' to 1' per mile. There is not water logging due to intensive cropping. Some trouble due to rise

in water table is experienced at the tails of the channels due to submersion on account of heavy raise and tidal action. There is no such trouble during the second crop.

11. An elaborate system of drainage has been developed in the Godavari delta where the lines of natural drainage have been cleared and canalised and out-fall sluices provided where the drainage line is near the Sea and is subject to tidal action.

Kutter's formula is adopted for designing the sections of the drains.

The longest drain is the Yenamadurru drain in the Godavari western delta which has a catchment of 900 sq.miles in up land delta areas and carries a maximum flood discharge of 16,400 cusecs.

The high yield of paddy crop in this delta is attributed to be efficient system of drainage which is well maintained.

ABSORPTION LOSSES.

12. The absorption losses in canals and distributaries generally vary 10 to 15 percent of the designed capacity of the canal depending upon the nature of the soil.

WATER COURSES.

13. The water courses are called field Bodhis in the Madras State. The policy in regard to Bodhis as adopted in Godavari delta is as under:-

1. All Bodhis upto 150 acres blocks are excavated and maintained by Govt.
2. Between 150 to 25 acres blocks the land is acquired by Government and handed over to Ryots for constructing the Bodhis which are looked after by the latter.
3. For 25 acres blocks and below the land is acquired by the Ryots and the excavation is also done by the latter.

In case where it is feared that the development of irrigation is likely to be affected due to delay in the excavation of the Bodhis, in case of 150 to 25 acre blocks, the excavation of the Bodhis is done by the Public Works Department after obtaining the approval of the Government.

There is no system of modules or masonry out-lets. The water in the Bodhis is supplied through hume pipes which are not laid in masonry.

COST OF MAINTENANCE OF CANALS.

14. The cost of maintenance of Canals works out to about Rs. 2/- per acre of cultivable commanded area.

WEED GROWTH.

15. There is trouble due to the growth of weeds in certain head reaches of the main canals. There are 3 kinds of weeds:-

1. Spreading creeper variety similar to corks crew.
2. Sword blade type.
3. The casurina leaf type.

The weeds are stated to spring from the seeds which are carried by floods from some up land pools and drains emptying into these canals. The seeds are deposited in the sides of the canals. ~~Along with the~~ silt in the red water season, which turns clear from November on-wards. They lie here till the red water becomes clear and sunlight reaches the bulbs and roots. Then they put forth shoots (ie) in November and December. The leaves become long and profuse enough in January and February and prevent free flow of water. In the next red/clear water catch further seeds, and then ~~and then~~ go on multiplying till entire waterway is closed.

Their presence is not noticeable till they come upto the surface. They never grow above the surface but always keep to within an inch or two of the water surface. Their removal by hand, after closing the canals temporarily for a few days, has become an annual operation involving thousands of rupees. But it is neither a permanent nor satisfactory remedy. Chemical treatment

is prohibitive in cost in large volumes of running water and necessarily bound to be in-effective as the chemical will spread to the root of the growth so to say. The weeds have been identified as:-

1. Hydrills verticillation Royks.
2. Vallisuria spira is Lime.
3. Petomogeton Pietamatics Lime.

An effective remedy tried has been to be to remove the soil among the wetted border by at least 9" and even this has proved to be a temporary pallivative and a costly one.

NAVIGATION.

16. The main canals and branch channels of Godavari delta are mostly irrigation-cum-navigation canals. The velocities for these channels range from $1\frac{1}{2}$ to 2' per second.

The designs of structure, gates, locks and lock gates are same as on the Orissa Canals.

There is no levy of separate charges for different commodities transported by navigation. The income from navigation the canal system accrues from the registration of the boats which pay licence fee. Total incoeome from navigation on Godavari canals was stated to be about Rs. 2 lacks per annum.

17. Water rates for different crops are compulsorily levied irrespective of the fact whether water is used or not. Following water rates are in force:-

1. Water rate for paddy first crop. Rs. 6/4/- per acre.
2. Water rate for paddy second crop. Rs. 3/2/- per acre.
3. Water rate for garden crops such as sugarcane, Betels, plantain etc. Rs. 12/3/- per acre.

FINANCIAL RESULTS.

18. Annexure IV showing the financial results of irrigation, navigation, embankments and drainage work for Godavari delta system upto the end of 1948- 49 is enclosed.

The Godavari delta canal system has a total length of 2.434 miles of main canals branches and distributaries which

were constructed at an estimated cost of Rs. 2,60,14,187/-. The gross receipts both direct and indirect amount to Rs. 63,28,354/- and working expenses to Rs. 20,30,492/- giving a net revenue of Rs. 39,97,872/- This gives a percentage return of 15.86 on the Capital out-lay.

BRIEF DESCRIPTION OF THE KRISHNA DELTA.

19. The Krishna river after a long course of about 400 miles in the Nizam's dominion, turns sharply south east wards when it reaches the chain of the eastern ghats, flows for about 100 miles between the Krishna & Guatur districts and empties itself into the Sea by two principal mouths to the south of the town of Maslipatam, the headquarters of the Kistna district. The enormous mass of silt it carries, which has been calculated to be sufficient in flood time to cover daily an area of 5 square miles to a depth of 1' has in the course of ages been deposited in the form of wide alluvial delta extending far into the Sea and sloping gradually away from the banks of the river.

It has a catchment area of 97,000 sq. miles and descends into the plains at a point 200 miles above Berwada anicut.

The maximum discharge so far recorded has been 11,90,000 cusecs in 1903.

Two canals take off from either side of the anicut totalling about 11,000 cusecs which irrigate an ~~ay~~acut of 11.6 lac acres, in eastern and the western deltas between which the Krishna river runs.

MONSOONS.

20. This delta like the Godavari delta is subject to both the south west and north-east Monsoons. The rainfall based on the average for last 60 years is of the order of 41.8" per annum. July to November is regarded as the heaviest Monsoon period whereas during January to April the rainfall is generally nominal. The season is judged

by the rainfall from June to November. The south west monsoon is the more important one as its failure will affect the field of crops.

CROP SEASONS.

21. The crop seasons are the same as in the Godavari delta except that there is only one irrigation season in this delta due to the non-availability of the supply during the Rainy season. Thus only one crop is raised in this delta as against 2 crops in the Godavari delta.

INTENSITY.

22. Intensity during the first crop season is 100 percent, there being no second crop.

PERCENTAGE OF SUGARCANS, GARDEN AND OTHER DRY CROPS.

23. The percentage of sugar-cane garden and other dry crops is hardly 2.5 percent of the total ayacut .

DUTIES AND YIELD OF CROP.

24. These are about the same as in the case of Godavari delta.

BRIEF HISTORY OF THE ANICUT.

25. The construction of the Krishna anicut was begun by Sir Arthur Cotton in 1852 and completed in October 1855. The total length of the anicut including the under sluices is 3785 feet. The length of the weir is 3198 feet from wing. Its crest is 6 feet wide and is placed $15\frac{1}{2}$ feet above level of the top of the foundations. The total width of apron below the crest wall is 257 feet. The foundations consist of a double row of wells 7 feet deep and $4\frac{1}{2}$ feet in diameter. There is a set of under sluices at each end having a total of 30 vents of 6 feet.

The spillway portion of the anicut consists of 29 sets of 110 feet each. Each set consists of 11 shutters 110 feet long and 6 feet high. The total length of falling shutters is 3190 feet.

In the case of Krishna anicut the shutters do not fall automatically when the water level above the shutters exceeds a particular limit as in the case of shutters on the Godavari anicut, but are made to fall by hydraulic operation under a pressure of 1500 lbs per sq. inch which is transmitted through $\frac{3}{4}$ " steel pipes are carried in ducts which are laid below the weir crest and remain submerged and are thus inaccessible for repairs during the period the water is flowing over the anicut.

The shutters are raised by means of a steam driven plough which has been manufactured by Messrs. Ransome & Rapiers specially for the purpose. The cost of the hydraulic equipment and the plough when fitted on the Krishna anicut amounted to Rs. 1.5 lacs. The speed of the travel of the plough is 1 mile per hour as in the case of the power driven plough for the shutters on the Godavari anicut.

Details of the plough, the arrangement of hydraulic pipes etc. have been outsined and are placed on record.

OTHER DETAILS.

26. Other details regarding the design of channels, water-courses, maintenance of canals etc. are practically the same as in the case of the Godavari delta canal and as such need no specific mention.

LIFT IRRIGATION.

27. Two pumping schemes, the patamata and Undavali were under execution on the Eastern Krishna canal system.

In the patamata pumping scheme a discharge of 7 cusecs was proposed to be lifted by 10 feet to irrigate an area of 500 acres. The cost of pumping charges amounted to Rs. 24/- per acre which the Tyots have agreed to pay in addition to the water rate of Rs. 6/4/- per acre for Paddy.

In the case of Undavali pumping scheme in which a discharge of 20 cusecs had to be lifted by about 15 feet to irrigate an area of 1,450 acres, the pumping charge per acre amounted to Rs. 17/8/- in addition to the water rate which also the Tyots have agreed to pay.

SUMMARY OF SALIENT FEATURES OBSERVED DURING THE
INSPECTION OF BOTH THE DELTAS.

28. The salient features which will have a bearing on the design and preparation of the scheme of introducing perennial irrigation in the Mahanadi Delta may be briefly described as under:-

(i) MONSOONS.

There are two monsoons South-West and North East. The average annual rainfall varies between 42 to 45 inches, nearly 3/4th of which is obtained during the South-West and the balance during the North-east Monsoons.

(ii) CROP SEASONS.

There are two irrigations seasons in the Godavari Delta. The first crop season (Kharif) begins in June and ends in November and the second crop season (Rabi) begins in January and ends in April.

There is only one irrigation season (Kharif) in case of the Krishna Delta, due to want of irrigation supplies during the second crop season.

Except for a small percentage of commercial crops like the sugar-cane plantains, Betal etc. almost the entire culturable commanded area is irrigated with different varieties of paddy in both seasons in the Godavari Delta and in one season in the Krishna Delta.

(iii) (a) INTENSITIES.

An intensity cent percent has been attained during the first crop season in case of both Krishna & Godavari deltas and 40% in the case of second crop in the case of latter. The intensity for the whole year works out to 140% in the case of the Godavari Delta.

It was understood that the intensity for the whole year in case of both the deltas would increase to 200% if adequate supplies were available during the second irrigation season.

(b) PERCENTAGE INTENSITIES OF DIFFERENT CROPS.

On an average more than 9% of the culturable commanded area is irrigated with paddy in both the deltas. The maximum percentage of commercial crops, like sugarcane & other garden crops and dry crops has been obtained in the case of the western Godavari delta:-

- | | | |
|--------------------------------------|----|------|
| (i) Sugar cane & other garden crops. | .. | 7.0% |
| (ii) Dry crops. | .. | 5.0% |

It has not been possible to grow either wheat or cotton as a second crop in the same area, where rice is grown during the first crop, in either of the deltas.

(iv) YIELDS CROPS:

The average yield of different crops both wet and dry in both the deltas is as under:-

- | | | |
|-------------------------|----|--------------------|
| (i) Paddy first crop | .. | 30.Mads. per acre. |
| (ii) Paddy second crop. | .. | 24 " " " |
| (iii) Sugar-cane. | .. | 40 tons per acre. |
| (iv) Ground nuts. | .. | 12 Mds. per acre. |
| (v) Gingelli (Til) | .. | 4 Mds. per acre. |

Average yield of paddy in up-land unirrigated tracts is about 10 to 12 maunds per acre.

(v) DUTIES.

About 60 to 70% of the annual rainfall is considered useful and taken into consideration while working out duties. Duties of 70 & 50 for the first and second crop seasons have been adopted. These do not take account of the incidence of rainfall during both the seasons.

(vi) Water Courses.

The policy in regard to excavation of water courses called Bodhis in Madras State is as under:-

1. All Bodhis upto 150 acres blocks are excavated and maintained by Government.

2. Between 150 to 25 acres blocks the land is acquired by Government and handed over to Ryots for constructing the Bodhis which are looked after by the latter.
3. For 25 acre blocks and below the land is acquired by the Ryots and the excavation is also done by the latter.

(VII) (a) WATER RATES.

Water rates for different crops are compulsorily levied irrespective of the fact whether water is used or not.

Following water rates are in force.

1. Water rate for paddy field crop. .. Rs. 6/4/- per acre.
2. Water rate for paddy second crop. .. Rs. 3/2/- per acre.
3. Water rate for garden crops such as sugar-cane, Betels, plantain etc. .. Rs. 12/8/- per acre.

(b) In two cases of lift irrigation where water is pumped to height of 10 to 15 feet, the Ryots have agreed to pay the pumping charges of Rs. 24/- and Rs. 17/8/- per acre in addition to the water rates in force.

(VIII) DRAINAGE.

An elaborate system of natural and artificial drainage has been developed in both the deltas during the last 100 years since the anicuts were made. This is considered essential both in regard to the high yield of paddy and development of high intensity of cultivation.

IMPORTANT POINTS ON WHICH THE ORDERS OF THE HIRAKUD CONTROL BOARD ARE REQUIRED.

29. (1) CROP SEASONS.

It is proposed to introduce perennial irrigation both in the puri and Cuttack districts. As such there will be 2 crops seasons.

Except for the small percentage of commercial crops like sugar-cane, Garden and other dry crops, the entire commanded culturable area is irrigated with different varieties of paddy in the Godavari delta. The maximum

percentage of sugar-cane and other garden crops and dry crops in the case of Western Godavari delta amounts to 7 percent only.

The Advisory Committee on Hirakud Dam Project appointed by Government of India (March 1952) has suggested a pattern of crop rotation for the delta areas in consultation with the Director, Central Rice Research Institute, Cuttack, vide pages 11 & 12 of its report.

The Director of Agriculture, Orissa State, vide his No. 18360/Agri-9S-100/52, dated 19th December, 1952, has suggested the following crop rotation.

HIGH LAND.

1. Jute & Biali paddy, followed by Potato, wheat, or early Rabi Pulses & Oil seeds.

LOW LAND.

Winter paddy followed by Mung.

2. Jute followed by transplanted winter paddy followed by Mung.
3. Jute and paddy followed by Mung.

It is suggested that the Orissa Government may be requested to recommend the rotation of crops which it considers most suitable to be adopted.

(ii) ANNUAL INTENSITIES.

An annual intensity of irrigation of 140% has been attained in the case of Godavari delta. This would increase to 200 percent if sufficient irrigation supplies were available in Godavari during the second crop season.

The suggestions of the Advisory Committee in regard to the percentage intensities of different crops during the 2 seasons are given on page 17 & 18 of its report.

The Director of Agriculture in his No. 18360/Agri-9S-100/52, dated 19th December, 1952, has suggested the following cropping programme for 100 acres both for Kharif and Rabi seasons.

MAHADI.

Sugar-cane	..	5 acres.
Jute	..	15 acres.
Beali Paddy.	..	5 acres.
Garden crops.	..	5 acres.
Winter paddy.	..	80 acres.

110 acres.

RABI.

Sugar-cane.	..	5 acres (old)
-do-	..	5 acres (New)
Wheat.	..	3 acres.
Garden crops.	..	7 acres.
Jnain mung.	..	40 acres.
2nd paddy.	..	<u>10</u> acres.
		<u>70</u> acres.

Orissa Government may be requested to give its decision on the proposals for the annual intensities to be adopted for the delta areas of the Mahanadi.

(iii) WATER COURSES.

In both the original and revised reports of the Hirakud Dam Project it has been assumed that water courses i.e. field channels, will be excavated by the ryots themselves at their own cost. As such no provision under this item exists in the estimate except for surveying and levelling off the alignments of the water courses at annas Eight per acre.

The policy in regard to the excavation of these channels, which are called bodhis in the Madras State as adopted, in the Godavari and Krishna deltas has been stated vide para 13 of this report.

It is requested that orders of the Hirakud Control Board may be obtained as to the policy to be followed in connection with the excavation of the field channels.

In case the procedure laid down in the Madras State is followed it may be decided whether the cost of the field channels should be included in the revised estimate or a separate estimate be prepared by the Orissa Government which may be submitted by the latter to the Government of India for sanction and allotment of funds.

(iv) COMPULSORY LEVY OF WATER RATES.

In the Godavari and Krishna deltas water rates for different crops are compulsorily levied irrespective of the fact whether water is used or not provided the land is cultivated. In case of Mahanadi delta it is only those who apply for a lease have to pay the water rate. It is suggested that the Orissa Government may be approached in the matter and requested to agree to the compulsory levy of water rates in the case of delta areas to be brought under perennial irrigation as a result of the Hirakud Dam Project.

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ANNEXURE 1 (a)

DRAFT TOUR PROGRAMME FOR THE VISIT OF SHRI M.G.HIRANANDANI,
SUPERINTENDING ENGINEER, DELTA IRRIGATION CIRCLE, HIRAKUD DAM.

OCTOBER, 1952.

1. Godavari Delta.

(28th) Thursday. Arrival Dowleshwaram.

Study of records and plans of the Godavari Delta system, and discussion with the Executive Engineers.

29th (Wednesday). Inspection of anicut and head-works of the 3 deltas.

Trip to Polavaram and back.

Enroute inspection of flood banks above the anicut and river sets.

30th (Thursday). Inspection of Godavari Central Delta.

Dowlaishwaram to Gannavaram and back to Amalapuram.

Inspection of Delta, 1st crop paddy area, drains in the locality, and the aqueduct across Vynatheyan river and other irrigation works.

31st (Friday). Amalapuram-Annampalli Aqueduct-Head of

P.I.P system and back to Dowlaishwaram.

Inspection of Lolla and Kalli regulators of Godavari Central Delta main canal.

Evening:- Discussions.

NOVEMBER, 1952.

1st (Saturday).

GODAVARI EASTERN DELTA:

Dowlaishwaram-Ramachandrapuram-Kakinada and back.

Inspection of Delta system, Teki drain, Corrianga Island Project under execution, Biccavole drain and Samalkota canal system.

2nd (Sunday).

GODAVARI WESTERN DELTA

Dowlaishwaram-Narsapur-Bhimavaram.

Inspection of Delta Irrigation, drains enroute-Nakkala drain, Kaza drain and Gonteru drain, etc.

3rd (Monday)

II. KRISHNA DELTA.

4th to 7th

Inspection of Krishna Delta. Details to be furnished by the Superintending Engineer, Vijayawada Circle.

8th

Leave vijayawada.

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ANNEXURE 1 (b).

Draft Tour Programme for the visit of Shri Hiranandani,
Superintending Engineer, Delta Irrigation Circle, Hirakud Dam.

November, 1952.

3rd (Monday)	..	..	Arrival (in evening).
4th (Tuesday).	..	..	Study of records and plan of the Krishna Delta System and Discussion with Executive Engineers.
5th (Wednesday).	..	..	Inspection of Krishna Eastern Delta.
			<u>Trip to puligadda and back</u>
			Enroute inspection of flood bank below Anicut and River sets, K.E.B. Can and Campbell aqueduct.
6th (Thursday).	..	..	Inspection of K.W. Delta.
			<u>Vijayawada-Seethanagaram- Dugrialala, Bapatla & back.</u>
			Inspection of the Delta system, Romperu and Nallamada drains.
7th (Friday).	Leave Vijayawada.

Sd.N.Padmanabha Ayyar, 11/10
Superintending Engineer,
Jayawada Circle.

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ANNEXURE II.

CANAL-WORK PARTICULARS OF THE GODAVARI DELTA.

No.	Name of canal.	Length M F.	Bed width at head. in ft.	Depth at head. in ft.	Awaout or Irrigated extent in acres.	Duty of supply.	Discharge at F.S.L. (Cusecs).
1	2	3	4	5	6	7	8
<u>Godavari Eastern Delta.</u>							
1.	Main Canal.	4--1	184	8.15	2,24,307	70	3,205
2.	Bank Canal.	40--0	95	8.39	41,675		595
3.	Coringa Canal.	23--0	51	7.08	37,942		542
4.	Kandapeta canal.	14--0	29.34	7.91	36,258		518
5.	Kakinada canal.	25--0	73	8.54	46,319		662
6.	Samalkot canal.	34--0	69	8.63	30,964		442
7.	Injarani canal.	12--0	22	6.02	18,988		271
<u>Godavari Central Delta.</u>							
1.	Main canal.	8--0	96	9.5	1,67,267	65	2,573
2.	Bank Canal.	39--0	59.5	8.02	62,649	65	963
3.	Amalapuram canal.	32--0	50	7.8	53,492	65	823
4.	Benda canal.	7--0	21.5	6.25	12,289	65	189
5.	Ganavarani canal.	37--0	50.0	7.6	49,999	65	769
<u>Godavari Western Delta.</u>							
1.	Main canal.	5--7	170	10.7	4,25,116	70	6,266
2.	Bank canal.	24--0	45	6.5	37,345		534
3.	Kakaraparru canal.	10--0	105	9	1,82,094		2,611
4.	Narasapur canal.	30--0	72	7	80,145		1,142
5.	G & V Canal.	33--0	54	6	52,154		749
6.	Undi canal.	20--0	80	6.5	62,400		891
7.	V & W canal.	32--0	84	8.5	1,16,985		1,680
8.	Junction canal.	3--0	41	5.5	24,428		349
9.	O.W. Canal.	5--0	35	3.5	5,585		80
10.	Elluru canal.	40--0	140	8.7	2,41,094		3,503
11.	Attili canal.	16--0	49	7	42,814		612

1.
ANNEX 111
 Standard for canal Cross-Sections.

Type	Main Branch Canals		or Distributaries		Minor Distributaries.	
	5,000 to 1,000 Cusecs.	1,000 to 300 Cusecs.	300 to 150 Cusecs.	150 to 25 Cusecs.	25 to 10 Cusecs.	Below 10 Cusecs.
Maximum crest width of widest bank.	15	6	6	6	4	3
Free board.	3	3	3	2	1½	1½
Width of berm	$4 + \frac{1}{1000} + \frac{d}{2}$	$4 + \frac{d}{2}$	$4 + \frac{d}{2}$	$2 + \frac{d}{2}$	$2 + \frac{d}{2}$	$2 + \frac{d}{2}$ Occasionally no berms are provided.
Depth of earth over saturation gradient.	4	3	1	1	1	1
Width of land to be acquired clear of banks when canal is in cutting deeper than balancing depth.	15 Half the height of the bank above ground subject to a minimum of 5 feet.					
Width of land to be acquired clear of banks when canal is in less than balancing depth of cutting.	Full height of bank plus 15 feet. Full height of bank above ground plus 5 feet.					

- NOTE
- (1) Q = Discharge in cusecs.
 - (2) d = depth of excavation in feet.
 - (3) Land widths are to nearest whole foot of width.
 - (4) The side slopes of banks are assumed as 1½ to 1 and of cuttings as 1 to 1 and the widths of berms are computed on this assumption.
 - (5) A saturation gradient of 1 in 4 is usually suitable.
 - (6) Where the tops of banks are used for wheeled traffic they must not be less than 15 feet wide and must be metalled or gravelled.

ANNEXURE IV.

STATEMENT SHOWING THE FINANCIAL RESULTS OF IRRIGATION, NAVIGATION, EMBANKMENTS & DRAINAGE WORK FOR GODAVARI DELTA SYSTEM UPTO THE END OF 1948-1949.

No. of works.	Name of work.	General financial results to end of 1948-49					Total capital out-lay Direct & Indirect.	Accumulated areas of interest.	Accumulated surplus of revenues.	Total sum-at-charge (Columns 7 & 8).	Gross receipts Direct and indirect).	Working expenses (Direct and indirect).
		Mileage in operation. Main Canals & Branches.	Distributaries.	Estimated cost of construction (Direct & Indirect)	Date of completion of work.	Date when the system came into operation.						
1	2	3	4	5	6	7	8	9	10	11	12	13
A. 1	Irrigation Works. Productive works. Godavari Delta system.	Miles 509-5/8	Miles 1,925 1/2	Rs. 2,60,14,187		Rs. 31-3-1980	Rs. 1877-78	Rs. 2,52,07,259	Rs. 16,95,44,447	Rs. 2,52,07,259	Rs. 63,28,354	

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General Financial results of the year 1948-49.							
Net Revenue.	Percentage on capital out-lay (Column 7)	Percentage on sum-at-charge (Column 10)	Interest	Net Profit.	Net loss.	Area irrigated	Percentage of working expenses to receipts (Column 12 to 16).
14	15	16	17	18	19	20	21
39,97,872	15.86	15.86	9,90,368	30,07,504	1,10,000	12,37,715	36.83

APPENDIX IV.

Note by Chief Engineer, Orissa on
Advisory Committee's report on
Hirakud Dam Project.

NOTE BY THE CHIEF ENGINEER, ORISSA, ON

Report of Advisory Committee on Hirakud Dam Project (March 52)

I have examined the above report and also have to hand for my reference Volume 1 of the Hirakud Dam Project Report (Revised Jan: 52) of CWPC. I remark on this Advisory Committee's report and proposals as below, reference being to the paragraph numbers throughout. Where I am in agreement no remarks are given except where I have to implement the recommendations and give further reasons.

Page 9 para 2.14 Duty. I consider that the duties assigned by CWPC are too high. As stated by the Committee I had reported to them that on heavy soils with an improved and efficient irrigation system a duty of 100 would be maximum to be assumed except for abnormal demands in case of breaks in the monsoon when about 80 would be the maximum and a strict "5:1" or alternate supply to different areas would have to be enforced. I therefore consider that the Committee's original suggestion to consider 90 as the duty instead of 100 is certainly necessary. Since some canals have already been designed and constructed the Committee have suggested that the canals be overloaded 5 inches when required in order to meet the demand. It seems there is no alternative for canals already constructed but for canals not constructed the design should be changed. In volume 1 of the Revised Hirakud Project report in para 4.33 details of how the discharge is calculated are not shown. This should be made clear in order to check the assumption made and apparently not stated.

Page 10 para 2.16 Water Table. Since there is a good slope on the ground in general and the subsoil water table is low I do not think that there will be much trouble from water logging but in flatter areas drainage channels should be provided. Wet rabi crops will naturally go to the lower areas which may not be so suitable for the dry rabi crops.

Page 11 para 2.17 crop Rotation. The showing of jute followed by rice is a custom in Kenduapatna and Kendrapara jute irrigated areas where they seem to manage even without a green manure crop. However the rotation proposed seems better.

page 12 para 2.18. Irrigation in the Delta Areas. Before conducting another model experiment on the Mahanadi- Kuakhai, it seems desirable to study the results seen from the previous model experiment showing the effect of closing the Banki spill and the restriction of Naraj Weir. The model experiment lay out for the Mahanadi at Poona has been dismantled some years ago and will be expensive to do again. That model experiment showed the rise in flood levels in the Katjuri at Cuttack town which might be expected by cutting off the Banki road spill then taken as 1 lakh cusecs, which flowed into the Kuakhai. I am not in favour of reducing the length or raising Naraj Weir as the effects would be partly cancelled by flow coming from the Mahanadi to the Katjuri through the Biranasi gap unless that was closed. The model experiment also showed the effect of closing that Biranasi gap. Moreover the Naraj Weir is a primitive weir of dry rubble with deep masonry or modern protection against weir dangers. Consequently if the head on the Weir is increased by raising the crest or reducing the length then it will surely give way unless removed or protected by expensive works. In my opinion, taking all this into consideration the Naraj Weir as a flood weir should not be interfered with.

As regards the proposals to conduct model experiment to reduce the silt entry to the canals this also in my opinion is scarcely necessary. When we have proper control gates on the channel near the head sluice we can easily provide the usual proper methods of silt exclusion and also put into effect the improvement already suggested and stopped for lack of funds. Also the silt

trouble in our canals is not serious because we close the canals when the river becomes too turbulent and sand laden, and our trouble is with fine suspended silt which by a slow process gradually reduces the channel sections and for which we got insufficient funds for clearance. The trouble is not serious. Even with the silt excluding devices it would probably be possible to keep open the canals only at a river level little higher than at present considered, as the river is then too turbulent with lots of suspended heavy matter.

Pages 13-15: In the revised Hirakud Report of Jan:52 at page 78 para 4.47 the proposals is to take off the canal for the Kuakhai system from above Naraj Weir and follow the Barang Nallah and cross the Kuakhai. Subsequently however, CWPC have preferred to improve the Taldanda canal head sluice and line the canals to increase the discharge then take off the canal for the Puri District and syphon it below the Katjuri river. C.W.&P.C. however apparently still recommended closing the Kuakhai river. If the improved Taldanda canal is to be relied upon for the large discharge then necessary, it will be very necessary to study the vagaries of the channels in the Mahanadi river upstream of the anicut as at present there is a bad development of an almost continuous strip of land from Jobra near the anicut, upstream for about the four miles which has affected the navigation channel along the Cuttack river frontage. This has been compensated by a channel near Jobra from mid-river channel but it would seem necessary to have at least the present full length of sluice way at the Jobra and of the anicut with improved sluice gates in order to pass a good controlling flow here during floods and keep a good channel open. Presumably CWPC have considered data and costs before rejecting the Naraj Weir and Barang river site for the river canal off take."I should like to see the data on this, as unless there are contrary data, it would seem that deeper sluices could be given at Naraj on the weir and a lower level channel developed which with the higher water levels in the Mahanadi at Naraj from the *Hirakud*

flow, should give satisfactory discharge conditions. If the Kuakhai river is kept open now with a reduced discharge as I propose, a syphon across the Kuakhai river at the narrows down stream of the railway bridge would be much shorter and cheaper than across the Katjuri near Cuttack as proposed by C.W.P.C. Also if the barrage across the Katjuri river as suggested by the Committee on page 16 is adopted than with deeper sluices at Naraj it is probable that even hot weather flow could be brought down the Katjuri at Naraj from the Mahanadi and directed into the Puri Canal at the barrage. These alternatives should be examined against the cost of the proposal to bring from the Taldanda Canal.

I agree with the Committee that the Kuakhai river must not be closed off from the floods. The sluice discharge of 5,000 cusecs proposed by CWP-C for the Kuakhai and branches is too small. The Committee give the following reasons for not agreeing to closing the Kuakhai.

- (1) Bad effect on the Chilka lake and fisheries.
- (2) Stagnation and malaria in the old river beds.

(Apparently CWPC proposals for flushing with 5,000 cusecs is not considered enough).

- (3) Loss of flushing lands with silt laden flood leading to reduction in fertility.
- (4) Closing of the Kuakhai flood discharge would largely negative the Hirakud flood reduction for the other areas in the Mahanadi delta ie. Puri district would benefit at the expense of most of Cuttack District.

I agree on all these points.

(1) I wrote to the Director of Fisheries in February 1952 explaining that the Chilka Sea mouth would close and probably could not be kept open without the Kuakhai floods and that salinity in the lake would also increase. He replied among other things that the present brackish water with no great salinity was a

very important factor, that an open sea mouth was most important for bringing in the fish and spawn and that the fish yield was particularly good after a big flood year. The Chilka fisheries are most important and valuable. Compensation for their destruction would be enormous. Although a lot of reclamation of land for cultivation could be done at the east end of the lake this eventually would be bad land if the lake became saline. My proposal for the reduced discharge would meet the fishery and reclamation cases satisfactorily.

(2) My fear is that drainage is already difficult in places and if the river and river mouths are not kept in good order at present levels by passing floods, then the beds will rise, the mouths close and have to be dug open regularly, the tidal range will decrease and the low lands with their drainage channels may not be able to drain as effectually as at present. As mentioned by the Committee there is also the serious matter of stagnant pools and malaria in the lower reaches of the rivers and the drainage channels. Moderated floods are therefore considered essential.

(3) Since it is proposed to irrigate most of the Puri area from canals, this area will have to be flood protected and cannot be exposed to silt laden general flooding. The areas not included under the canals however should get this benefit by controlled flooding and the present system of irrigation through sluices in the flood embankments. The canal water also carried a certain amount of silt.

(4) There will be strong objection from the rest of the Mahanadi Delta area if they do not get good benefit from Hirakud. This is specially so in the large island areas on the Debi river. A 21-mile long flood embankment has been constructed on the right bank of the Debi-Kandal-Taunla river which has resulted in temporarily higher flood levels in the island areas between this embankment and the previous embankment on the Debi left bank. This was done because the reduction of flood level by Hirakud Control, then

expected by 1954, would lower flood levels in the island areas and permit major flood embankments and flood protection with irrigation for sluices. It is essential that this promise be fulfilled. There are many other areas also in which such benefit is expected and promised. It is therefore essential to continue to pass a fairly large flood discharge down the Kuakhai river system, say such as to be 2 ft. above river bank level when the system is double embanked throughout.

Page 15. The Committee have given suggestion in Appendix IV for disposal of a flood in the Mahanadi system reduced to 12 lakhs cusecs maximum by Hirakud Control. Special reference is made to the Kuakhai river system flood disposal and alternative suggestions for irrigation channel. I shall discuss this in detail below but the suggestion in brief are that the Kuakhai system flood should be reduced to a maximum of 1.5 lakhs cusecs and the Hirakud Control distributed as below:-

	As present (in cusecs)	Proposed (in cusecs)	Reduction. (in cusecs).
Mahanadi ..	6.75 lakhs.	6.0 Lakhs.	0.75 Lakhs.
Katjuri. ..	5.50 "	4.5 "	1.0 "
Kushbadra. .	2.75 "	1.5 "	1.25 "
Total.	<u>15 Lakhs.</u>	<u>12 Lakhs.</u>	<u>3.0 Lakhs.</u>

They propose to reduce the proportion between the Katjuri and the Mahanadi by reducing Naraj Weir and experimenting with the Biranasi Gap which passes flood from the Katjuri to the Mahanadi at high floods. As regards the Kuakhai river system the figures for proportionate discharge appear wrong, the proposals are to divert half the Kuakhai discharge throughout the Muncheswar Gap flood escape to the Daya Rivers, construct barrage across the Kushbadra, Bargovi and Daya Rivers for crossing the Canals and also controlling flood distribution, to divert the Kushbadra and Bargovi rivers into the interior doab drainage and to utilize the resultant river channels downstream as canals. It is claimed that since the river beds in the delta will continue to rise and eventually create an indefensible situation, it is better to anticipate this and divert the rivers into the lower interior drainage channels.

where they will eventually go. The Committee admittedly have said that these are only tentative proposals which need examination. These proposals certainly put forward original ideas which require serious consideration. After examination however, I find myself unable to agree to these on practical considerations for the reasons given below.

First of all the Committee did not appear to have studied the Orissa Flood Advisory Committee's report and account of investigation done in the delta. These investigations showed that the delta in the Kuakhai river system was for all practical purposes in a stable state and there was no sign of a general rise in river beds. The Orissa Flood Advisory Committee also recommended that double embanking should be extended towards the sea in these rivers and that high level escapes be given to pass off excess floods. The Government of Orissa accepted these proposals combined with a certain degree of flood control by flood retention reservoirs in the river catchment areas. There is thus no good reasons for assuming that the river beds will rise continuously with reference to this surrounding ground and therefore there is no necessity to divert these rivers into the interior drainage channel in the doabs. The Committee have stated that flooding conditions and flood damage would in the interior be no worse than before, if the Kuakhai discharge is reduced and the rivers diverted through the escapes to carry on more water than before, they do not seem to have considered the damage thus done by these escapes when running at full supply and there is a big difference between the occasional functioning of these escapes and the continued diversion of the entire river through these escapes during the flood season. A large tract of country on each side of these drainage channels would be devastated by continuous flooding and bed sand burdens. Also if this idea was carried to a local conclusion it would mean forming new rivers which would also have to be double embanked and because of their newness and

the transference of all the bed sand would result in a speedy rise of these new rivers above the surrounding ground level and interference with local drainage. A considerable tract would also be flooded between these embankments and construction and maintenance of such embankments would be very expensive. If the intention is not to have such marginal embankments then the resultant general flooding would interfere considerably with the proposed canal system as it would not be confined to a small area near the drainage channel. There is also the question of utilising the river beds as canals as suggested by the Committee. They have stated that in Sind this proceeding was carried into effect successfully and the river beds silted up quickly to the required canal section and discharged. I consider however that the Orissa conditions are somewhat different in that we have not the same heavy suspended discharge as in Sind and it would be considerable before these channels silted up purely by silt from the canal system. If they were flushed occasionally during flood time by sluices from the river this would help to silt them up more rapidly, but even then the process would be fairly slow.

I have examined the more detailed tentative proposals put forward by the Committee in Appendix IV and I do not consider these proposals practicable or desirable for the reasons above stated. I have prepared a flood distribution chart according to what I consider approximately the present flood distribution in the Kuakhai river for 15 lakhs and 12 lakhs in Mahanadi. I have also made a rough calculation of the reduction necessary in the Kuakhai discharges in order to give full control of flooding using the existing rivers and shutting down or considerably reducing the flood escapes such that the canal system will not be interfered with. I am putting this up as a separate report not for the consideration of the CWPC. I consider that there should be no interference with Naraj Weir or the Biranasi spill but that the Banki road flood spill should be cut off and the head of the Kuakhai reduced a little in width. It would also appear that some control is necessary in the Kusbhadra river near its off-take. This could be done either by a barrage. For crossing the Bhargovi

river a barrage, or a syphon may be given.

Page 19 para 2.25 Growth of weeds in the north Orissa canals. We have difficulty with weeds from the end of December to March, when weed growth in certain slow flowing lengths is very considerable and holds up water such that the required discharge cannot be passed without overtopping the banks. Where canals are purely irrigation canals then as noted by the Committee the only solution is to dry out the canals at specific fixed intervals in order to kill weed growth, but our canals are all navigation canals or supply water for navigation in the canals and navigation is at its greatest within these months. We have to put up with the weed growth except for occasionally scaring away in bad cases. In the case of the proposed Puri system of canals these will be purely for irrigation purpose and so we ought to be able, to dry them out at intervals and stop weed growths.

Page 49 Para 4.9. As regards water rates proposed by the Committee, I consider that a rate of Rs. 8/8/- per acre would be acceptable to cover irrigation for the whole year in low lying areas including all crops except sugarcane. For low lying areas i.e. those only practically benefited, the rate may be reduced to Rs. 5/12/-. The sugarcane rate for the whole year may be Rs. 11/8/-. As regards the rabi crops for all seasons I recommend Rs. 5/- per acre for potatoes and Rs. 4/- per acre for all other rabi crops harvested in the rabi season.

Page 50-53 para 4.10-Betterment Levy. On consideration I do not think that the advantage possible by irrigation will be so great as anticipated by the Committee I recommend that the betterment levy will be Rs. 100/- for Sambalpur flow irrigation and for the Delta area under irrigation at present. For the Delta area now being given flood protection and irrigation I recommend Rs. 150/- per acre and for the delta area being newly irrigated only Rs. 130/-. This amount may be recovered in 15 years instalments starting after the third year as recommended by the Committee.

Page 66 para 5.4. Compulsory water rates. I agree with the proposal to get powers to include all areas which can be satisfactorily irrigated and require irrigation for compulsory leasing and charge of water rates.

"Chaman"
18.9

Office of the Chief Engineer, U.P. Irrigation, D.I. Circle,
Banda, U.P.

No. A(1)-Irg-2-52-20

Dated, the 13th November, 1952.

From

C.M. Bennett., Esqr., O.B.E., I.S.E.,
Chief Engineer, I.M. Office,

To:

The Secretary of Government of Orissa,
Works Department.

Subject:- Revised project of the Advisory Committee of
Birkud-Delta Irrigation and flood control.

Sir,

With reference to your P.O. letter No: 114-65/
52-13 dated 3-9-52 to Mr. Shaw on the subject noted above, I
forward herewith a copy of report and chart as prepared by him.
A copy of this note and chart is also being forwarded to Mr.
Kiranandani, Superintending Engineer, Delta Circle as desired
by Mr. Shaw, the late Chief Engineer.

Yours faithfully,
Sd: C.M. Bennett,
Chief Engineer,

Encl:-
Copy of note and chart.

Copy with a copy of the note and chart referred
to above is forwarded to Mr. Kiranandani, Superintending Engineer,
Delta Circle for information.

Yours faithfully,
Sd: C.M. Bennett,
Chief Engineer.

Encl:-
Copy of note and chart.

Mija

The proposal is to reduce the present 15 lakhs cusecs flood of the Mahanadi river by Hirakud Dam control to a maximum of 12 lakhs cusecs. This means that the Naraj gauge will be reduced to 89.85 on the Naraj gauge according to the discharge chart for Naraj. CWPC however, guarantee that the Naraj gauge will not be allowed to exceed 89.00 which from the discharge chart shows 11,10,000 cusecs. However, CWPC choose to take into consideration 12 lakhs cusecs as maximum to be permitted so we may assume 12 lakhs maximum flood and maximum Naraj gauge 89.00 since there is a margin of further storage control at Hirakud. This means that the H.L.L at Naraj is reduced by about 3 ft. and at Bellevue by 3.8.ft.

Naraj gauge 89.00 gives 24.00 on Bellevue gauge. Bank full level for the Katjuri-Mahanai river system is about 24.00 on Bellevue gauge and the Kuakhai system flood escapes start working at about 21.00 on Bellevue gauge.

Trying for distribution for 12 lakhs flood:- Mancheswar escape with length of 1766 ft. against the present length of 1600 ft. passed 50,750 cusecs on 80.8.39 with Bellevue gauge at 26.25 with Bellevue reduced to 24.00 the discharge will be reduced roughly to $50,750 \times \frac{1600}{1766} = 46,000$ cusecs say 6,500 cusecs for a 1600 ft. length. Further deduction = 1600×2.25 reduction $\times 2.7$ velocity = 9,750 cusecs.

Net discharge is $46,500 - 9,750 = 36,750$ cusecs approximately.

Say 37,000 cusecs.

This checks roughly with the Kushabhadra reduction the 1939 discharge below Mancheswar Gap was 1,16,600 . The 12 lakhs flood discharge is 1,48,000 or 31,400 more.

Add Kushabhadra	14,400	giving	67,000
Bhargovi.	10,500	giving	48,100
Daya.	6,500	giving	35,900
	<u>31,400</u>		<u>1,48,000</u>

With above distribution for a 12 lakhs flood, compare river discharge at head with former maximum below escapes.

River	Former Maximum.	12 L Lks Flood.	Areas.
Kushabhadra	1,35,000	1,48,000	(-) 37,000
Dharjovi.	40,000	45,000	(+) 5,000
Daya upper, below Belmore escape.	32,000	35,900	(+) 2,900
Daya lower below all escape.	72,000	72,900	(+) 900
			40,800 cuacs.

The position would be that if all escapes were closed to protect the areas to be irrigated we would have 40,800 cuacs more in the rivers downstream of the escapes that we had before. This will not do. We have to reduce not only by this amount but also by a further amount to give lower flood levels downstream than at present and permit further embankment & control in the Kushabhadra and Daya. The Dharjovi can be diverted to a greater degree to the Sur Lake. The Kushabhadra can be given an escape along with Dal Lake to the Sur Lake and the Kunda, reduced to an interior drainage within river flood, can have a slice into the Dal Lake. From

Kushabhadra below Madhara 450 x 3 = 1350 wide between embankments	marginally rough calculations about another 36,000 cuacs should be added
Reduce by 3 ft. dikes	on this account. The total reduction
1350x3x5.5 = 22,300 cuacs	cuacs are therefore on the Kunda
Reduce Dharjovi by 1' - 0"	for a 12 lakhs cuacs flood in the
500x1x5.5 = 4,950 cuacs	Kunda in the present distribution
Say 5,000 cuacs.	will be about 49,000 + 36,000 = 85,000
Reduce Daya 2' - "	say 77,000 cuacs. The total discharge
1000x2x4 = 8,000 cuacs.	discharge could be reduced by shutting
Say 35,900 cuacs.	ing off the sand Road spill which
Say 30,000 cuacs.	would give about 50,000 cuacs in a

15 lakhs flood and about 25,000 cuacs in a 12 lakhs flood. The amount of 52,000 cuacs will have to be met by reducing the width of the head of the Kunda by a strong embankment, 3 on the left or east bank

and this would assist matters since we expect a rise in the Bhatkai bed and lowering of the Kutjuri river bed consequent on the increased low tide charge. This will counterbalance the scour of the Bhatkai head created by the narrowing of the entry and consequent temporary extra head. If this process will be too slow then the effect of a flood or action to be given by closing the escapes can be delayed by only partly closing the escapes since this reduced flood can pass down the central doab drainages without affecting the canal and distributary system. The canals can be syphoned past the escape heads.

Sd: J. Shaw

P.W.D. Orissa.

Muja

DISCHARGES OF MAHANADI RIVER SYSTEM AND KUAKHAI.

Discharges recorded so far are:-

	Upper Mahanadi	Mahanadi	Main Ratjuri	Ratjuri	Total
1937	14,65,000	6,45,000	8,21,000	5,86,000	2,24,000
1940	14,51,000	6,48,500	8,11,000	5,58,000	2,53,000
1939	13,61,000	5,85,000	7,73,000	5,50,000	2,25,000

Flood of 20.6.39- Kuakhai system.

Mancheswar gap and breach	13750 + 3910 = 17,660 cft.	52,750
Mushabhalra	-	52,600
Chirgovi	-	31,600
Daga (Lower Dya)	31,400	29,400
		<u>1,67,350</u>
		Cusecs.

Flood of 12.9.39-

Bellevue gauge- 85.52 ; Ratjuri below Mahai - 5,12,150 cusecs.

Palit	Main Mahanadi	-	11,20,000	
	Ratjuri 7.5%	1,75,000	(	6,75,000
	Kuakhai 29.5%	2,00,000)	
	Mahanadi	-	33,55,000	1,45,000
	Birupa	-	80,000)

Poona says vide letter No. 50/853 of 17-1-45 from Director, Indian Waterways Experiment Station, Poona (Copy enclosed).

Shaw says Bunki spill starts at 20 to 21 on Bellevue i.e., 86.2 or so at Bura when flood is 8.1 lakhs to 9 lakhs. Say 8.5 lakhs.

Biranasi spills also at 8½ lakhs flood level. Discharge below Waraj and above Biranasi, Ratjuri 70% at 8½ lakhs:

60% at 15.

For 11.2 lakhs flood record and the distribution as below:-

Mahanadi Below Biranasi	4,45,000	40%
Kuakhai-2.00	1,75,000	60%
Ratjuri below Mahai 1.75	<u>11,50,000</u>	

Waraj gauge for 12 cusecs flood in 89.85 corresponding to Bellevue 85.00

Assume for 15 lakhs flood at present - For 12 lakhs.

Kuakhai.	-	2,53,000	2,00,000	7,00,000
Ratjuri	-	5,97,000	5,00,000	
Mahanadi		<u>6,50,000</u>	5,00,000	<u>5,00,000</u>
		15,00,000		12,00,000
		cusecs.		Cusecs.

RAJASTHAN GOVT. ENGINEERING COLLEGE, JAIPUR.

There were done assuming a spill at maximum floods (15 lakhs cu. ft.) of 1 lakh over Banki Road into the Bunkhi. Actually at present only about 1/2 lakh goes this way into the Bunkhi at one time but there is a vast reservoir at the Bunkhi which fills up so in practice at a peak flood, this balance the rise is the result may be about say 1/2 lakh discharge assumed. Still this means an alteration in the experiment result to some extent. The experiment extended.

	15 lakhs Flood.	12 lakhs Flood
Banki spill of 1 lakh cut off.	Rise in Balleve ft. e. 1.4	2.3
-do- reduced to 1/2 lakh	-do- 2.0	1.1.
-do- 1/3 lakh.	-do- 3.0	2.0
Birnasasi cut off	-do- 1.0	0.8
Both Banki and Birnasasi cut off.	-do- 4.7	3.0
(Gives extra 1.8 lakhs cu. ft. in Hattari below Bunkhi)		

With alteration of error in Banki spill from 1 to 1/2 lakh we might expect at a 12 lakh flood controlled flood by cutting off Banki spill about 1.8 ft. rise.

Sd:- J. Shaw.
13-7-52.

Raja

No. 80/358 of 1945 part, 17th April 45

To:

The Superintendent, Baginara, Orissa Circle,

BUMH.

Sir,

I have the honour to send you herewith a note on discharge analysis of Mahanadi prepared from the data of discharges of individual branches, handed over to Mr. Ghoshkar when you visited Madakwala, for perusal and remarks. I may mention that this note was approved by Shri Glauco Ince before he left.

Sds D.V

Director Indian R.ways,
Experiment Station, Bonga.

Copy with compliments to S.K. Mitt, Esq.,
Executive Engineer, Flood and Drainage Division, Cuttack.

Muja

Indian Waterways Experiment Station, Poona.

LIST OF DISCHARGES OF THE NATURI BRANCHES OF THE MATTAI RIVER AT VARIOUS STAGES OF FLOODS.

When Mr. Shaw visited this station in January, 1945 he handed over the following:

- (1) Discharges of Matkhai and Banti Road spill at various stages of floods.
- (2) Discharges of Katjuri below Matkhai head at various stages of floods.
- (3) Discharges of Sarua at various stages of floods.
- (4) Discharges of Berupa at various stages of floods and
- (5) Khid's Baraj discharge for Mhaadi (above Baraj) (Interpolated and corrected curve)
- (6) Discharge of Mhaadi at Jobra - curve supplied in 1943.

He also gave the information that the Bank road spill begins to flow when Bellevue gauge = 20 to 21.

Bellevue gauge 20 means Baraj gauge 86.2 i.e., a flood of 7.1 lakhs and 21 means 9 lakhs. It was therefore, concluded that the spill begins to flow with a flood of 8¹/₂ lakhs cusecs.

From the flood slope of Katjuri this figure appears to be correct. Table 1 below shows the individual discharges of the Naturi branches as given by Mr. Shaw.

Muja

1. 1000 ...	81 L. Hrs.	10 L. Hrs.	12 L. Hrs.	15 L. Hrs.
2. 1000 ...	86.5	88	89.85	92.5 (extrapolation)
3. 1000 ...	21.0	22	24.5	28.7
4. 1000 ...	70.1	71	72.6	75
5. 1000 ...	0.10 L. Hrs.	.93 L. Hrs.	1.89 L. Hrs.	3.26 L. Hrs.
6. 1000 ...	3.62 L. Hrs.	3.80 L. Hrs.	4.0 L. Hrs.	6.80 L. Hrs.
7. 1000 ...	3.00 L. Hrs.	3.98 L. Hrs.	3.45 L. Hrs.	4.21 L. Hrs.
8. 1000 ...	-	-	1.15 L. Hrs.	2.56 L. Hrs.
9. 1000 ...	0.21 L. Hrs.	0.345 L. Hrs.	0.55 L. Hrs.	0.96 L. Hrs.
10. 1000 ...	2.23 " "	2.75 " "	3.8 L. Hrs.	6.2 " "
11. 1000 ...	4.7 L. Hrs.	4.91 L. Hrs.	5.7 L. Hrs.	9.03 L. Hrs.
12. 1000 ...	11	1.15 L. Hrs.	2.28 L. Hrs.	0.70 L. Hrs.
13. Total of 1 ...	7.17 L. Hrs.	10.01 L. Hrs.	11.05 L. Hrs.	16.22 L. Hrs.

Note:- The observed data was for discharges greater than 4 lakhs but the curve was extrapolated by Mr. Shaw. The extrapolation appears incorrect as discharge is greater than at Matjuri below 12 lakhs flood which is impossible.

Item 12 was worked out from the fact that Siranasi spill max. Q = 70,000 cusecs and it begins flowing with 8 lakhs flood.

From items 11 and 12 it will be observed that the discharge of Matjuri below 12 lakhs including Siranasi spill is only 55%; 50.5%; 58.6% and 64.6% with 8, 10, 12 and 15 lakhs flood. Though correct at about 14 lakhs floods the data show a **wrong** trend. Actually as shown by the model and accepted by Mr. Shaw, the percentage discharges of Matjuri should be 70% at 8 lakhs flood and gradually reduce to 50% at 15 lakhs. Adding items, 9, 10 and 11 the total which is shown in col. 13 does not agree with the flood Q in col. 1 - the discharge for floods below 12 lakhs being under-estimated and at 15 lakhs being over-estimated.

To conclude, the discharge data of individual branches is not correct and as the Director has instructed, we now propose to let the model tell us the discharges rather than to use wrong data on it.

Mr. Talit, Executive Engineer, Flood and Drainage Division wired the data of discharges of Bhakhai and Ranki spill separately whereas Mr. Shaw has combined discharges of these branches to other. The data from the two sources is as follows shown in table 2.

Flood (lakhs)	Mr. Shaw.		Table 2.		Mr. Talit	
	Ranki Spill	Bhakhai	Bhakhai	Ranki Spill	Bhakhai	Ranki Spill
10 lakhs	98,000	cusecs.	85,000	Nil	85,000	
12 "	180,000	"	106,000	20,000	126,000	
15 "	326,000	"	163,000	90,000	253,000	

It will be seen that Mr. Shaw's figures are much higher than those of Mr. Talit. Under these circumstances it is a problem as to which data should be accepted.

As in the case of Mahandi side, it is proposed that we should go by flow condition and ranges rather than accept any

data of discharges which will lead us astray.

In the experiments carried out since Mr. Shaw's visit, the procedure followed was that the initial condition of the river branches with 6 lakhs flood was adjusted according to the visual inspection of Mr. Shaw and higher floods were run without changing the regulation.

The Director considered from inspection that this gave wrong conditions in that with 9.3 lakhs flood, Banki Road spill was assumed to be taking 22,000 cusecs whereas Kakhai was taking only 16,000 cusecs. In view of Mr. Talbot's data, the opinion of the Director appears to be confirmed.

In carrying out further experiments it is proposed to regulate downstream water levels so as to give distribution of discharges with 15 lakhs flood as observed in 1872 by Mr. Rhind (it should be noted that this is practically the same as observed by Mr. Shaw in 1939-40). The 1872 data gives percentage Q of each branch which is shown below:-

Q Mahanadi atobra excluding Sironasi spill	36.30	%
Q Barupa.	7.46	%
Q Sironasi spill	4.25	%
Q Banki Road spill	8.20	%
Q Kakhai.	13.45	%
Q Katjuri loop	10.60	%
Q Sirva.	<u>19.14</u>	<u>%</u>
	100.00	%

Programme of further experiments.

As has been discussed at Chachvala, the experiments with closing the spills either singly or both together will be repeated to find out the effect on gauges at Cutback and Kazipatna between Kakhai head and the Katjuri. As the Bellowe gauge will be in back water, after constructing the proposed embankment on Katjuri left bank, the collectorate gauge, which is further downstream will be used in the model. The regulation of various channels and spill will give correct levels and hence necessarily correct discharges in the experiment with existing conditions will be kept identical for all other experiments for distribution of Q with closed spills. The

order of this revised series of experiments will be shown below:-

Experiment 1. With existing conditions, the model will be run to stability and final cycle only will be run up to 15 lakhs.

Experiment 2. With Banki Road spill and Biranasi spill open.

Experiment 3. With Biranasi spill and Banki Road spill closed

Experiment 4. With both spills closed.

in experiments 2,3 and 4 two cycles will be run, first one representing a 12 lakhs flood & the second one 15 lakhs flood.

Experiment 5. In this experiment the Banki Road spill will be kept closed and the length of Maraj in will be gradually reduced at its right end till the gauges at Cuttack give the same water levels as obtained in experiment with existing conditions.

Having done this much the model will be run to stability under the imposed conditions of restricted water way at Maraj but the Banki spill will be opened .

Experiment 6. With conditions obtained in experiment 5 embankment ending with a spur will be constructed on left bank of Katjaru & the right bank of Mahanadi below Dhavalwar. Sluicse will be provided as shown at A.S.&C in fig7 to admit muddy water for silting up the Biranasi gap

Experiment 7. In this experiment with conditions obtained at the end of experiment 6, the northern(i.e.Mahanadi side) end of the Biranasi gap will be banded off as shown in fig.7 . The object being to see if the Mahanadi channel along the Cuttack bank could be made to develop below Chakana-Ghat. Vide Fig.7- and also to help silting up of the Biranasi gap.

Experiment 8. In this experiment, the proposal of constructing bridge across the Mahanadi opposite Cuttack fort will be tested. The model will initially be laid according to condition obtained in experiment 1 and with the bridge in, it will be run with 12 lakhs flood cycle till stability is obtained and finally with a 15 lakhs flood cycle. Condition of flow, velocities, water levels etc. will be noted.

APPENDIX V.

Report on the Soil Survey of the
Mahanadi Delta

by

Dr. R.C.Hoon.

APPENDIX V.

REPORT ON THE
PRELIMINARY SOIL SURVEY OF THE MAHANADI DELTA AREA
BY

Dr. R.C.Hoon, M.Sc., Ph. D.

assisted by

Sarvashri K.N.Talwar & Tarasingh Sidhu
HIRAKUD RESEARCH STATION, HIRAKUD (ORISSA).

1. INTRODUCTORY.

When the hydro-electric plant installed at the Hirakud Dam starts functioning, about nine thousand cusecs of water shall discharge through the generating sets from the Hirakud reservoir and flow down the Mahanadi river. Thus the discharge of that river would be considerably augmented during the lean discharge period in dry season. It is intended to utilise that increased water supply in the Mahanadi river for irrigating a much large area, than at present, in the Cuttack and Puri districts of Orissa. For achieving the latter object, it is proposed not only to strengthen the existing canal system but also to extend it considerably particularly in the Puri District.

The existing canal system in the Mahanadi Delta Area was completed as early as 1866. The present command of those canals comprises hardly about 2 lac acres. The proposed strengthening of the existing canals coupled with extension of irrigation would increase the extent of the commanded area considerably to over 11 lac acres in the Cuttack and Puri districts and moreover make perennial irrigation possible in that area instead of the present restricted irrigation.

2. PURPOSE AND SCOPE.

It was intended that, to assess the agri-irrigational potentialities of land, a soil survey of the gross commanded area in the Cuttack and Puri districts to be served by the proposed canal system be carried out. The Bureau of Flood Control, ECAFE, in its report on the extension of irrigation and flood control of the Mahanadi Delta Area, had also recommended the carrying out of a soil survey of the area, as none had been

carried out in the past. Moreover, a suggestion was made in that report that, as the area was even in comparison to the uneven terrain of the commanded area of the Hirakud Canal System, one sampling site per four thousand acres would suffice for soil survey.

That soil survey was included in the Programme of Investigations for the Mahanadi Delta Area to be carried out under the auspices of the Chief Engineer, Hirakud Dam Project. It was undertaken by the Soil Survey Section of the Hirakud Research Station and took two working seasons to complete. The field work was undertaken by Sarvashri K.N. Talwar and Tarasingh Sidhu, Research Assistants and they were assisted by Sarvashri C.L. Sharma and D.D. Soni, Analysts. The laboratory analyses of soil samples was carried out by Sarvashri Talwar, Tarasingh and Sharma.

3. GEOGRAPHICAL FEATURES OF THE AREA SURVEYED.

The area, soil surveyed, lies between N. Latitudes $19^{\circ}45'$ to $20^{\circ}55'$ and E. Longitudes $85^{\circ}35'$ to $86^{\circ}45'$. It is bounded by river Brahmani on the north, the river Daya on the West, and Bay of Bengal on the east, south-east and south. It is cut up into five major portions by the different streams into which the Mahanadi river divides below Naraj, the proposed weir site.

The climate, on the whole, is tropical. During the summer season, which lasts from end of March to mid-June, the part of the area along the sea coast enjoys the effect of cool sea breeze, that towards the interior is hot and sultry. Winter season lasts from November to February and is very mild. The rainy season comprises the period June to mid-October and rains are fairly ample due to monsoons; the average maximum and minimum rainfall for the two districts works out to 91 and 45 inches respectively, the average rainfall being of the order of about 62 inches. There has been, on the average,

a year of low rainfall almost once every five years in the case of Cuttack district and once every four years in the case of Puri districts. The major portion of the rainfall is confined to summer months, a small amount of rainfall i.e. about 12 percent comes off during the period, December to mid-June. That latter part of rainfall is, however, quite precarious and more often than not untimely from the point of view of crop production and hence the necessity of assured supply of irrigation water for agricultural practice is that area.

4. FIELD WORK.

The entire area has been divided into 419 grid squares each of about 3300 acres. The area, falling between High Level Canal on the north-west and the Machhgaon Canal on the south, comprises of 252 grid squares (8.34 lac acres) and the proposed extension area lying mostly in the Puri district of 166 squares (5.47 lac acres); the gross area thus works out to 13.81 lac acres. However, on account of the inclusion of certain incomplete grid squares and such area, as comprises of the bed of the various streams and drainage channels, the total area has been figured out as 11.41 lac acres. The division of the area surveyed into grid squares is shown in Fig.1.

5. SOIL SAMPLING.

Soil sampling was done at one site representative of each grid square with the help of soil auger to a depth of six to eight feet from the surface. Soil samples were collected at each of the sampling sites at each 6 in. depth in the top foot and at every subsequent foot depth along the profile to the depth sampled; a total number of 3228 soil samples were thus collected. The details of the soil samples along with the number of sampling sites and the extent of area they are supposed to represent is given below:-

	<u>No. of grid squares sampled.</u>	<u>Area in lac acres.</u>	<u>No. of soil samples collected.</u>
1) Area under High Level Canal Range I.	29	0.95	246
2) " between Birupa & Mahanadi Rivers (Patamundai & Kendrapara canals).	114	3.76	928
3) " between Mahanadi & Katjuri rivers (Machhgaon-Taldanda Canals).	110	3.63	778
4) " between Katjuri and Kushbhadra rivers.	55	1.81	482
5) " between Kushbhadra and Daya rivers.	111	3.66	794
	<u>419</u>	<u>13.81</u>	<u>3228</u>

Besides collecting samples of soil, samples of sub-soil water were also collected from some open wells in the area.

6. LABORATORY EXAMINATION.

All the soil samples have been analysed for their percentage content of total soluble salts, pH and textural characteristics. A selected lot of soil samples (about 10 percent of the total and representative of the whole area) have been analysed for the percent calcium carbonate content, exchangeable bases and base exchange capacity and their nutrient status, the latter comprises the estimation of their NPK contents. The water samples have been analysed for their chemical constituents to define their suitability for purposes of irrigation. The results of the various analyses of soil and water sample are presented in Tables 1 to 4.

7. PREDOMINANT SOIL FEATURES.

(a) pH . - Soil pH , which is a measure of the acidity of alkalinity of soils, is a very important factor effecting crop production. The results of pH of all the soil samples are given in Table I. For the sake of convenience, in the diagrammatic representation of results in Fig.2, however, the sites have been divided under three heads i.e. having pH (i)

below 6, (ii) from 6 to 8 and (iii) from 8 to 9.5.

A division of the area on the basis of those limits of P^H values laid down above is given below:

P^H range.	No. of sampling sites.	Approximate area (lac acres).
Below 6	43	1.42
From 6 to 8	320	10.56
From 8 to 9.5	56	1.85

Further, with respect to the trend of variation of soil P^H manifested along the depth of the soil profile at those sites, the area can be classified as follows:-

Trend of soil P^H with depth.	No. of sampling sites.	Approximate area (lac acres).
P^H increases with depth.	166	5.48
P^H decreases " "	73	2.40
P^H remains uniform.	64	2.11
P^H is irregular.	116	3.83
		<u>13.82</u>

From the above two tables it is apparent that the P^H of soil over a major part of the areas lies between 6 and 8. The Soil P^H below 6 is associated generally with excessive soluble salt content of those soils. High salt content in soils is known to depress the P^H and clay soils as are predominantly met with in this area, have a more pronounced buffering effect in this respect than light soils. The soil of such areas is likely to revert to normal P^H conditions if that land is subjected to reclamation operations to get rid of excessive salts.

The extent of areas with soil P^H above 8 constitutes a small fraction of the total area and is localised mostly in Taldanda-Machhgaon Canal areas. No adverse effect of high soil P^H was observed in the course of field work from the moong crop standing in fields at that time. However, this effect shall have to be investigated further by undertaking soil survey at a more intensive rate in such areas with particular reference to the crops intended to be grown and/or for effective soil amelioration.

With respect to the trend of soil P^H variation with depth, it is seen that the soil P^H over the major part of the area either increases with depth or is irregular but the extent of variation does not seem to be very pronounced or significant. Although on the bases of the existing conditions little aggravation of soil alkalisation can be expected but this aspect shall have to be watched with the introduction of perennial irrigation to such lands.

The aspect of soil P^H in relation to its soluble salt content is dealt with further under section (b) below.

(b) Total Soluble Salt Content:- The soluble salt content of soil has a very important bearing on its productivity. A salt content above a certain limit depending upon the textural characteristics of soil affects crop production adversely. From that point of view, all the soil samples collected from the various sites were tested for their total soluble salt content. The results are given in Table 1. Generally speaking, a salt content of above .2 percent in soil is known to affect crop production. The soils have, therefore, been classified tentatively in two main groups, i.e. having salt content below .2 percent and above that limit. The classification of the area on that basis has been diagrammatically presented in Fig.2

A division of the area on that basis works out as follows:-

T.S.range	No.of sites.	Approximate area (lac acres).
Below and upto .2%	350	11.55
Above .2%	69	2.28

The variation of soluble salt content of the soil along the depth of the profile is given in the following table:-

Variation of T.S.along the depth of the profile.	No. of sites.	Approximate area (lac acres).
T.S. increases with depth.	113	3.73
" decreases " "	17	.56
" irregular.	184	6.07
" uniform.	105	3.46

13.82

It is further seen that generally speaking the area bordering the sea manifests a relatively higher salt content. This is but natural and can be attributed to the effect of creeks leading inland from the sea. The area bordering the Chilka Lake, which again is connected to the sea has high salt content. The remaining area which forms the major part (83.5%) has, however, an inappreciable salt content. Moreover, in view of the fact that salt content remains appreciably low right along the depth of soil profile over the major part of the area, there seems little chance of further salinisation at a later stage. The soil with high salt content should be amenable to amelioration by the application of soil reclamation technique.

An analysis of the soluble salt content of soil in high salt containing patches brings out that the preponderating salts are those of chlorides and the sulphates are present in smaller proportion in comparison (Table 3). This seems to be a desirable feature of such high salt containing areas from the point of view of their reclamation with the advent of canal irrigation as the chlorides are amenable to quicker removal on leaching out than sulphates.

It may be of interest to consider the effect of P^H of soil in conjunction with that of its soluble salt content.

It is seen from Fig. 2 that a fair number of sampling sites in the Doab between Mahanadi and the Katjuri rivers and to some extent in the land strip on the north and south of Paika river have soil with relatively high P^H . It is all the more interesting because the doab area has had the benefit of irrigation from the Taldanda and Macpherson canals. There are again sites having soil of high P^H in the strip north of Berupa river receiving irrigation from the High Level Canal. The soil with high T.S. manifests low P^H . That has been explained earlier under sub-section (a). However, the presence of areas with high P^H soil with corresponding low soluble

salt content shall have to be investigated further by carrying soil survey at a more intensive rate, than the present soil survey, to demarcate such areas more definitely. An intensive soil survey shall also have to be carried out to localise areas of high salt content particularly from the point of view of soil reclamation operations.

(6) Textural Characteristics of Soil:- All the soil samples have been analysed for the percentage contents of clay, silt and sand to obtain an idea of their textural characteristics as that has an important bearing on soil tilth. The results of mechanical analysis are given in Table 1 and the classification of area on the basis of textural characteristics of soil is diagrammatically represented in Fig.3. It is seen that the major part of the alluvium consists of clayey soil with clay content varying from 30 to over 50 percent. Patches with lighter soil are scattered here and there and seem to have been formed as a result of deposition of heavier silt from the various streams.

From the point of view of variation of soil texture with depth along the profile the following classification seem feasible:-

<u>Change of texture</u>	<u>No. of sites.</u>	<u>Approximate area (lac acres).</u>
Becomes heavier with depth	70	2.31
" lighter " "	65	2.15
Remains uniform.	206	6.80
Irregular.	78	2.57

It is seen from the above that land over 50 percent of the area manifests a uniform texture along the depth of the profile.

(d) Base Exchange capacity and Exchangeable Bases:-

A knowledge of the bases in the exchange complex of the soil is extremely important for defining soil of any area. For this purpose about 10 percent of soil samples derived from sites distributed over the entire area and representing almost

all the soil textures were analysed for their exchange capacity and exchangeable bases. The results of these analyses are given in Table 2. It is shown that:-

- (1) That total base exchange capacity mostly varies from 20 to 40 milli-equivalents.
- (2) Calcium is the predominant base in the exchange complex and its content generally ranges from 10 to 25 milli-equivalents.
- (3) The content of exchangeable sodium and Potassium is generally low and ranges mostly from 2 to 6 milli-equivalents.
- (4) Exchangeable magnesium is not significant and ranges from 1 to 3 milli-equivalents.

It is rather interesting that the top soils are not fully saturated with respect to the bases, the saturation capacity increasing with depth. It is attributable to the rainfall concentrated within a short period and its leaching effect. This feature of the soil may have to be considered when the manurial requirement of soil is considered. The preponderance of calcium in the exchange complex of soil is a desirable feature as it contributes to good tilth and crumb structure of soil on ploughing and watering.

(c) Calcium Carbonate Content:- The same soils as taken for the base exchange characteristics were also analysed for their CaCO_3 content. The results of CaCO_3 contents of soil are given in Table 2. It is seen from the results that in general the CaCO_3 content of soils is below 1 percent.

(f) Manurial Content of Soils:- The selected soil samples were analysed for their percent contents of nitrogen, phosphorus and Potassium. The results are given in Table 2. It is seen that the nitrogen content varies from .02 to .06 percent, the phosphorus from .05 to .10 percent and potassium from .4 to .6. From a comparison of the above figures with the general standards laid down for the NPK status of soils it is brought out that the soils have got low status particularly with respect to N and P falling under the category of

poor with respect to N and poor to medium with respect to P. It is interesting that soils of High Level Canal and those of Kendrapara and Patanundai Canals and Katjuri Kushbhadra Doabs are richer in their P Content than soils from other areas. The soils of the area along Machhgaon-Taldanda Canal are particularly poor with respect to their manurial status; that might be due to the relatively higher intensity of cropping in that area and less deposition of silt through floods, the latter due to more efficient flood control measures in that area.

The requirement of supplementing the nitrogen and Phosphorus content of soils of the area in general, are brought out clearly.

8. SUB SOIL WATER SAMPLES.

The results of the chemical analysis of sub-soil water samples collected from open wells in the area are given in Table 4. It is shown that the waters in majority of the wells have low dissolved solids and thus indicate a low salt content in the soil crust at lower depths. There are two water samples which manifest a high salt content. They are from wells which are affected by the tidal creek and/or proximity to the sea.

9. CROP PATTERN.

At present the cropping scheme is governed by the annual rainfall in the non-irrigated area and on the availability of canal water in the irrigated area. The entire Delta Area is yielding one major crop of rice and that is followed by rabi pulses like moong and Kulthi. This rabi crop of pulses flourishes well in the irrigated area due to the availability of canal water but in the non-irrigated areas its sowing and maturity is entirely dependent upon the timely sequence of winter rain. Sugarcane is grown in the non-irrigated area at localities in close proximity of the streams which can serve as perennial source of water supply for the cultivation of that crop. The benefit of fresh silt depositions

through floods is an added benefit of the location of sugarcane fields near the streams. The cultivation of jute is practised in the irrigated areas.

With the introduction of perennial irrigation the crop pattern will be altered. It is premature to lay down specific crop rotations, their time of sowing and harvesting, dosage of various manures, etc. without carrying sufficient trials on experimental farms. On the basis of existing agricultural practice and climatic conditions prevalent in the area, however, the following tentative recommendations seem possible:

- (i) Rice and moong will continue to be the major Kharif and Rabi crops respectively. Their time of sowing and harvesting will have to be modified somewhat; for instance transplantation method of sowing rice can be adopted in place of the prevalent broadcast method. The Japanese method of rice cultivation is expected to become popular with the cultivators.
- (ii) Areas near the sea with high salt content which at present are unfit for any rabi crop, will be able to give a second rice crop (Dalu).
- (iii) The area under money crops like sugarcane and Jute which at present have restricted cultivation on account of lack of irrigated facilities shall increase.
- (iv) Cotton cultivation may also find favour in areas where heavy soils occurs.
- (v) Juar and maize crops will fit in fairly well where jute cannot be grown.
- (vi) The major advantage of perennial irrigation shall consist in growing a green manuring crop which can be used for supplementing the organic matter and nitrogen content of soil.
- (vii) In view of the mild and short winter rabi crops like wheat, barley etc. may not find favour when compared to the crops suggested under item V and VI but still a small area may come under these crops as people do require these cereals for their consumption. Early maturing wheat varieties shall find favour in this respect.

9.a (Plus see page 172)
10. SUMMARY AND CONCLUSIONS.

The soil survey of about 11 lac acres of land in Cuttack and Puri districts of Mahanadi Delta Area has been carried out on a more or less broad-basis to assess the agri-irrigational potentialities of that land. The area is expected

to receive the benefits of perennial irrigation water after the proposed strengthening and extension of the present Delta Canal System to receive the water let out from the hydro-electric installation at the Hirakud Dam when the latter starts operating.

The whole area has been divided into 419 grid squares of about 3300 acres each for purposes of carrying the field work in connection with the soil survey. 3328 soil samples have been collected and analysed for their main physical and chemical characteristics. A tentative classification of the area has been done on the basis of the textural characteristics of soils and their soluble salt content and P^H . The main features of the soil of the area may be summarised as follows:-

- (a) Soil over a major part of the area (76 percent) has P^H ranging from 3 to 8 and that of about 83 percent has low total soluble salt content.
- (b) Soil is fairly clayey (with clay content ranging from 30 to 50 percent) over a greater part of the area, that near the bank of the streams and drainage channels is of a lighter type.
- (c) There is a preponderance of calcium in the exchange complex of soils, the monovalent alkali bases being low in comparison. The calcium carbonate content of soils is low and rarely exceeds 1 percent.
- (d) With regard to their manurial status, the soil can be classed as poor and poor to medium with respect to the N and P contents respectively.

Thus a major part of the area surveyed has soil which is going to benefit immensely by the extension of perennial irrigation facilities and by the strengthened and expanded canal system visualized in the near future.

The present soil survey has revealed some areas which have soil containing an excessive salt content and/or high P^H . Such soil may require amelioration to obtain maximum agricultural benefits. It is suggested that further soil survey at a more intensive rate, than done for the present report, be carried out to indicate such deteriorated soil areas requiring reclamation more definitely.

Although the crop pattern can be indicated more definitely after actual field experiments, but the present indications are that it should be possible to have two major crops and also to grow green manure crops, the latter to be employed for enriching soil further.

The sub-soil waters have a low dissolved solid contents and thus signify a low salt content in soil crust even at lower depths.

Note:- Tables and Blue Prints accompanying the Note have been enclosed.

"Chaman"
8.10

9.a QUALITY OF THE MAHANADI RIVER WATER.

It may be of interest to discuss the quality of the Mahanadi river water from the point of view of its suitability for irrigation purposes. In that connection the results of chemical analysis of water samples collected during 1951 and 1952 at Kaimundi (representing the weir site of the proposed Delta Canal System) are presented in the following table:-

Results of Chemical Analysis of Water Samples
Collected during 1951 and 1952. *

Chemical constituents.	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Cond.	(195 (240	210 250	200 280	185 260	240 240	- 270	140 92	110 112	150 110	160 190	230 245	- 205
T.S.	(16.5 (21.6	16.9 22.6	16.3 24.2	15.4 22.4	18.6 20.2	- 20.0	9.6 7.6	8.8 9.2	11.0 10.2	12.4 17.8	17.8 21.4	- 18.6
CO ₃	(- (-	-	-	-	-	-	-	-	-	-	Trace	Trace
HCO ₃	(10.98 (13.3	10.98 13.2	10.98 13.3	9.76 13.7	12.56 14.8	- 16.1	5.64 6.4	5.02 6.6	6.91 6.8	8.76 12.0	10.68 15.1	- 12.2
Ca.	(1.84 (2.60	1.54 2.89	1.84 2.43	1.69 2.31	2.34 1.98	- 2.02	1.26 0.89	0.90 0.89	1.44 0.86	1.80 1.84	2.54 2.21	- 2.01
Mg.	(- (1.24	- 1.14	- 1.20	- 1.08	- 1.01	- 1.28	- 0.40	- 0.43	- 0.46	- 0.86	- 1.40	- 1.30
Cl	(0.50 (1.14	0.60 1.08	0.40 1.00	0.50 1.12	1.00 0.96	- 1.06	0.80 0.48	0.80 0.32	0.70 0.50	0.70 0.68	0.70 0.80	- 0.70
SO ₄	(1.04 (1.32	1.48 1.28	1.08 1.36	1.23 1.30	0.84 1.23	- 1.26	0.64 0.41	0.54 0.61	0.60 0.44	0.72 0.70	1.28 1.00	- 0.90

* figures in the upper line indicate results for 1951 samples and those in the lower line for 1952 samples.

It is seen from the results in the above table that the content of dissolved solids per 100 thousand parts of water varies from 7.6 - 11.0 parts during high discharge periods, to 18.6 - 24.2 parts during the period of lean discharge in the river at that site. Out of the acidions, the bicarbonates are by far the most predominant, sulphates and chlorides being less in comparison; calcium is the main basic ion.

The irrigation water containing less than 60 parts dissolved solids per 100 thousand parts of water is generally considered safe for irrigation purpose. Judged on that standard the order of dissolved solids content in the Mahanadi river is very low and the salts are mainly bicarbonates of calcium and therefore it shall cause little salinisation of land irrigated by it. This receives confirmation from the fact that the use of the Mahanadi water for irrigation, since the inception of the present delta canal system for the past over 80 years, does not seem to have caused any marked deterioration of soil of the area.

APPENDIX VI.

A NOTE ON THE STATISTICAL EXAMINATION OF
GAUGE-DISCHARGE DATA BY SHRI C.N.ROCHUKSHI,
B.A.D. C.W.& P.COMMISSION.

APPENDIX VI.

A NOTE ON THE STATISTICAL ANALYSIS OF GAUGE- DISCHARGE DATA BY
SHRI C.K.KOCHUKOSHY. B.A.D., C.W.& P.C.

Certain gauge and discharge data at various sites in Mahanadi Basin were supplied and the following problems were posed by Superintending Engineer, Delta Irrigation Circle to be examined in the statistics Branch vide his letter No. DIC/W-1/1050 dated 28.11.52. The results of the studies made are given below for each of the 5 questions. The Superintending Engineer has been consulted on the studies to be made and it may be pointed out that due to paucity of data, the conclusions arrived at may have only limited validity.

1. To find out R.L. of flood discharge for undivided Mahanadi when discharge is 11 lakhs cusecs at Naraj.

This was treated as a question of gauge-discharge relationship and the data of the gauges and discharges at Naraj pertaining to the period 11/8/52 to 22/9/52 was utilized to derive an equation. Only 13 observations were available and hence the validity of the results cannot be assumed to be universal.

The relation is $Q = 0.00003 d^{13.8}$

where $Q =$ discharge in lakhs cusecs.

$d =$ depth, taking average bed level of Mahanadi river at Naraj to be 60.00. The above relation has been represented in graph No.1 herewith attached. It has been computed that when the discharge at Naraj is 11 lakhs cusecs the depth is 30.5 which is forming the reduced level is 90.5 minus 1.37 for adjustment of zero value of the gauge.

II. The second question relates to the derivation of correlation between Naraj gauge and the gauges and discharges at Mahanadi Railway Bridge, Katjuri Railway Bridge, Kazipatna and Sardeipur gauge sites. This question has been divided into two parts.

i) Four correlations to be found out between gauges at Naraj and of other sites viz. Sambalpur (for Mahanadi Railway Bridge) Katjuri Railway Bridge, Kazipatna and Sardeipur (Daya).

2) The relationship of four gauges to be derived between the gauges at Naraj and discharges of Mahanadi, Katjuri, Khakhai and Birupa.

11(A) 78 observations of gauges at Naraj were made available and they cover a period of 2 1/2 months from 15/7/52 to 30/9/52. For purpose of calculations the average of the daily reading at 6 A.M. and 6 P.M. were taken. The gauges at Sambalpur were also available for 78 days corresponding to the above period. But, for Katour and Kaziapna the gauges were available only for 54 and 63 days respectively whereas for Baraieur (Daya) were available for 61 days. Four regression equations connecting the gauges were derived and are shown in the following table. Coefficients of correlations worked out between Naraj gauge and the other 4 gauges are also shown in the following statement.

STATEMENT A

S.NO.	Regression Equation	Correlation Coefficient	River	Gauge reading at site corresponding to	90.5 at Naraj.	88.0 at Baraj.
1. Y =	(0.585) x + 69.87	0.86	Mahanadi (Sambalpur)	35.26	32.70	
2. Y =	(0.638) x + 72.91	0.90	Katjuri (Lalbag)	27.58	25.23	
3. Y =	(0.725) x + 77.75	0.95	Kaziapna.	17.58	15.51	
4. Y =	(0.639) x + 77.42	0.87	Daya.	20.48	18.13	

It will be seen from the above that there is very high correlation between gauges at Naraj and those at Katjuri and Kaziapna. The regression equations given above can be used in arriving at the gauge figures for the different sites against Naraj.

11.(B) This is a problem of connecting Naraj gauge with corresponding discharges in the 4 rivers. The data was available only for 13 days from 11/8/52 to 23/9/52 at regular intervals. The following statement gives the gauge discharges corresponding to 11 lakhs cuacs at Naraj.

STATEMENT II.

S.No.	Equation	Locality of river	Correlation coefficient	Discharge corresponding to R.L.90.5 Naraj	Discharge corresponding to Naraj R.L. 89.00
1	2	3	4	5	6
1. Y =	(10) $1.59(X) - 0.063$	Mahanadi Discharge.	0.98	4.46(4.0)	3.48
2. Y =	(10) $1.47(X) - 0.086$	Katjuri	0.97	3.86(3.5)	3.17
3. Y =	(10) $1.78(X) - 0.032$	Kuakhai.	0.97	2.7(2.4)	1.58
4. Y =	(10) $1.75(X) - 0.038$	Birupa.	0.95	$\frac{1.10(1.1)}{12.12(11.0)}$	$\frac{.71}{8.94}$ lac cusecs.
			Total.	12.12 lac cusecs.	8.94 lac cusecs.

Note:- This total 12.12 as against 11 lacs shows an error of about 10% which is due to the fact that 4 separate equations had to be referred to. For practical purposes, this can be proportionately adjusted.

N.B. The coefficient of correlation in column (4) was calculated between the logarithm of the gauges and discharges in conformity with the nature of relationship that exists between them. The last column gives discharges corresponding to Naraj R.L.89.111. To find the R.L. of flood at Hazratnagar when the discharge in Kuakhai is 1 lakh and 1.25 lakh cusecs respectively.

13 observations of gauges and discharges were available out of these, two zero values of gauge were omitted for purposes of calculation because of the following reasons:-
 1) The zero values are not susceptible to logarithmic treatment
 2) Even the inclusion of zero values as minute quantities did not give a functional relation which could afford satisfactory values for discharge.

Hence a gauge discharge relationship based on the 12 items of data was derived. The relationship is graphically represented in a linear form in the graph herewith attached (Graph No.2) The actual values of discharges and the calculated values based on the derived relations are tabulated in the following statement. The R.L. of flood at Hazratnagar corresponding to 1 lakh and 1.25 lakh cusecs discharges in Kuakhai

have been calculated and are also given as items 12 and 13 in the table below:-

ANNEXURE 111

S.No.	Average Gauge d	Observed Discharge Q	Calculated Discharge
1.	1.4	3675	3368.22
2.	7.0	33660	33538.2
3.	8.2	41560	42039.7
4.	10.25	50820	37816.3
5.	4.1	17269	155.23.6 Equation.
6.	3.4	9214	11958.6 $Q = 2083(d)^{1.428}$
7.	10.2	63530	57414.3
8.	12.95	82930	80734.65
9.	9.70	55390	53437.9
10.	10.3	54195	58221.0
11.	8.15	46890	41674.5
12.	15.04		100000
13.	17.59		125000

IV. To find the distribution of discharge between Kushabdra, Bharavi and Daya rivers when the discharges at Kazipatna are 1 lakh and 1.25 lakh cusecs respectively.

The data for the solution of this problem has been particularly meagre, there being only 4 sets of observations available. However, since some estimates of distribution had to be made, a venture was made to solve the problem however unsatisfactory it might be. Accordingly, the three rivers Kushabdra, Bharavi and Daya were taken as 3 units into which the Kuakhai River had disintegrated, so to say, after Kuakhai Railway Bridge and the problem was to see how the water of Kuakhai were going to be distributed between the 3 riverlets. In other words the discharge of Kuakhai, if placed as a dependent variable on the Left Hand Side of an equation would have 3 variables on the right, respectively representing the 3 minor rivers Kushabdra, Daya and Bharavi.

In symbolic form it will be $Y = A + BX_1 + CX_2 + DX_3$ where the different Xs represent each small river and Y standing for Kuakhai. There are 4 constants to be solved and we had 4 equations for the purpose. The equation thus representing the distribution of the discharges worked out to be $Y = 0.20 X_1 - 3.59 X_2 + 1.33 X_3 - 22.84$. But this equation is not recommended as useful. It does not help us either in finding out the figures of discharges for each riverlet when the discharge in Kuakhai is given. Since it was known that the purpose of determining the nature of distribution was to know the discharges of each minor river once the discharge in Kuakhai was given, a series of separate regression equations were derived between Kuakhai discharges on one hand and the discharge in the 3 riverlets on the other. The discharges for Kuakhai being the same for corresponding discharges in other rivers, the 3 straight lines representing the regression equations are plotted in the same graph (Graph No.3) herewith attached against discharge figures of Kuakhai in the Y-axis. For any particular figure of discharge for Kuakhai (Y-axis) we have 3 corresponding X values on the 3 straight lines which give the discharges in the 3 respective minor rivers. The discharges of the 3 rivers against 1 and 1.25 lakh cusecs of Kuakhai discharge are given in the following statement.

STATEMENT IV.

S.No.	Kuakhai discharge	'Kushabhadra' Daya cusecs.	'Bhargavi' cusecs.	'Bhargavi' cusecs.
1.	100000	36470	80280	52300
2.	125000	47840	110240	70390

It is seen from the above values of distribution that they are disproportionately large and hence should not be taken at their face values. This is due to the extreme paucity of data and the necessity of extrapolating very much beyond the limits of available data.

The 3 equations showing relation-ship between discharges of Kuakhai and the other 3 rivers are

1. $Y = 2.18 X_1 + 20.49$ Khushabadra.
2. $Y = 0.835X_2 + 32.995$ Daya.
3. $Y = 1.382X_3 + 27.695$ Bhargavi.

V. To establish a correlation between Maraj and Bellevue gauges for purposes of forecast. For this, 72 observations were available and a direct relation between the two gauges were worked out. The line of regression is.

$$Y = 1.18 X - 81.94$$

The coefficient of correlation between the two gauges was calculated to be 92 which is indeed a high figure. The regression line and the given 72 points are plotted in the graph herewith attached. (Graph No.1) it will be seen from the graph that when Maraj discharge is 11 lakh cusecs i.e., when the gauge is 90.5 we have the corresponding gauge depth at Bellevue very nearly 25.

Sd - C.K.Kochukoshy.

Huja

FIG. 9 DISTRIBUTION OF RIVER DISCHARGES AT SURABAYA.

Date of observation	Name of river.	Corresponding gauge at Surab.	Discharges C.S.	Total Discharges.	Remarks.
1. 11.8.52	1. Mahanadi.	78.40	56,360	42.0	134782 Rising Floods
	2. Katjuri.		70,784	52.4	
	3. Kuakhai.		3,675	2.7	
	4. Birupa.		3,963	2.9	
2. 13.8.52	1. Mahanadi.	83.20	1,51,392	40.0	1330874 Rising Floods.
	2. Katjuri.		1,79,554	47.0	
	3. Kuakhai.		33,360	9.0	
	4. Birupa.		16,268	4.0	
3. 14.8.52	1. Mahanadi.	83.60	1,76,425	42.3	117046 Steady condition of Floods.
	2. Katjuri.		1,66,018	43.1	
	3. Kuakhai.		41,560	10.0	
	4. Birupa.		19,983	4.6	
4. 16.8.52	1. Mahanadi.	85.20	2,24,740	43.0	1525091 Falling Floods.
	2. Katjuri.		2,23,896	42.6	
	3. Kuakhai.		50,820	9.4	
	4. Birupa.		25,635	5.0	
5. 27.8.52	1. Mahanadi.	80.55	90,264	33.6	1271375 Steady Condition of Floods.
	2. Katjuri.		1,52,202	55.6	
	3. Kuakhai.		17,269	6.4	
	4. Birupa.		11,640	4.4	
6. 31.8.52	1. Mahanadi.	77.30	61,619	38.6	1259959 Falling Floods.
	2. Katjuri.		90,350	56.8	
	3. Kuakhai.		5,450	3.4	
	4. Birupa.		2,440	1.2	
7. 3.9.52	1. Mahanadi.	80.00	82,549	35.0	1234336 Falling Floods.
	2. Katjuri.		1,32,610	53.5	
	3. Kuakhai.		9,214	3.9	
	4. Birupa.		10,493	4.6	
8. 6.9.52	1. Mahanadi.	77.70	48,444	35.9	113,5124 Rising Flood.
	2. Katjuri.		80,444	59.5	
	3. Kuakhai.		2,534	1.9	
	4. Birupa.		3,688	2.7	

Date of observations	Name of river	Concession- 'dmg. Canals' 'at Bara'	Discharges C.C.	Total Discharges	Remarks
9. 12.9.52	1. Mahanadi.	35.0	2,31,670	42.0	(551777 Run ing File od)
	2. Katjuri.		2,32,942	42.0	
	3. Kuakhai.		63,530	11.5	
	4. Birupa.		23,635	4.5	
10. 12.9.52	1. Mahanadi.	37.00	3,14,000	46.0	(582927 Run ing File)
	2. Katjuri.		2,44,552	36.0	
	3. Kuakhai.		82,930	12.0	
	4. Birupa.		41,445	6.0	
11. 14.9.52	1. Mahanadi.	31.75	1,36,000	40.0	(460183 Run ing File)
	2. Katjuri.		1,82,854	39.8	
	3. Kuakhai.		55,390	12.2	
	4. Birupa.		35,939	6.0	
12. 20.1.52	1. Mahanadi.	34.73	1,97,000	38.2	(513417 Run ing File)
	2. Katjuri.		2,24,830	43.5	
	3. Kuakhai.		54,195	11.0	
	4. Birupa.		39,392	7.3	
13. 22.9.52	1. Mahanadi.	31.16	1,56,800	36.0	(434365 Run ing File)
	2. Katjuri.		2,02,360	40.50	
	3. Kuakhai.		46,890	11.5	
	4. Birupa.		28,915	6.0	

Sd/- K.S. Misra,
Executive Engineer,
Delta Irrigation Division.

Huja

REGISTRATION OF FLOOD IN RIVERS AND CANALS

Date of observation	Name of river	Corresponding gauge at No. of	Discharges in Cusecs.	Percentage of ratio with respect to Kuchhal.	Remarks.
1. 14.8.52	1. Kuchhal river at Kuchhal road bridge.	83.60	39,600	100	
	2. Kusbhadra above Jorisahi.	83.60	10,600	26.4	
2. 17.8.52	1. Kuchhal river at Kuchhal road bridge.	83.10	53,765	100	
	2. Kusbhadra river above Jori shahi.	83.10	11,900	28.4	
3. 1.9.52	1. Kuchhal river at Kuchhal road bridge.	77.15	3,512	100	
	2. Kusbhadra river above Jori shahi.	-do-	-	-	
4. 11.9.52	1. Kuchhal river at Kuchhal road bridge.	85.10	52,160	100	
	2. Kusbhadra river above Jorisahi.	-do-	14,393	27.4	
5. 13.9.52	1. Kuchhal river at Kuchhal road bridge.	86.20	63,480	100	
	2. Kusbhadra river above Jorisahi.	-do-	20,078	31.6	Sd/- V.S. Mirra, Executive Engineer, Dabra Irrigation Division.

Huja

Observed siltage

Date of observation	Name of river	Crossing (Name of bridge in case of bridge)	Change in siltage		Remarks
			of Rural	of Govt.	
1	2	3	4	5	6
1. 14.7.1952	1. Daya at Daya Road Bridge.	83.60	14,177	54.2	
	2. Sher ovi at Sar-Jolpur.	83.60	11,835	45.8	
2. 18.8.1952	1. Daya at Daya Road Bridge.	83.10	14,590	54.0	
	2. Bhargovi at Sar-Jolpur.	83.10	12,403	43.0	
3. 1.9.1952	1. Daya at Daya Road Bridge.	77.15	3,069	75.4	
	2. Bhargovi at Sar-Jolpur.	77.15	1,000	24.6	
4. 11.9.1952	1. Daya at Daya Road Bridge.	85.10	23,511	53.8	
	2. Bhargovi at Sar-Jolpur.	85.10	20,300	46.2	
5. 13.9.52	1. Daya at Daya Road B idge.	86.20	36,421	60.00	
	2. Bhargovi at Sar-Jolpur.	86.20	24,300	40.00	

Sd/- I. S. Misra,
Executive Engineer,
Delta Irrigation Division.

APPENDIX VII.

CORRESPONDENCE ON MODEL EXPERIMENTS- JOINT NOTE AND
PRELIMINARY NOTE ON MODEL EXPERIMENTS BY THE
DIRECTOR, C.W.& POWER RESEARCH STATION AND
SUBSEQUENT CORRESPONDENCE.

Recapitulation of observations to be made on Mahanadi model.

It is suggested that the following studies may be made on the Mahanadi model.

1. NARAJ WEIR.

(a) Reduction of width of Naraj weir from left side.

(b) Reduction of width in sections through out the length of the weir.

(These suggestions were made by the Advisory Committee and communicated to the Research Station vide this office No.4/DIC/HDP, dated 30th June ' 1952).

In this connection the moderated flood discharge at Naraj may be taken as 11 lacs cusecs instead of 12 lacs cusecs. (c) Distribution of discharge into Mahanadi, Barupa, Natjuri and Auakhai system with Naraj gauge at R.L.89, and the corresponding gauges at Bellevue, Jobra, Sirupa and Kasipatna.

In this connection discharge observations taken by current meter during the monsoon of 1952, showing the distribution of discharge in the Mahanadi and its branches for different gauges at Naraj and the standing wave data at Naraj weir which have been forwarded to the Director may please be referred to. It may be interesting to see whether the gauges observed at Naraj Bellevue, Jobra and Kasipatna, and the position of standing wave for different gauges at Naraj are reproduced on the model.

(d) To investigate effect of the increase in head on the stability of Naraj weir due to the reduction in its length while performing model experiments.

(e) Deepening of existing sluices in Naraj weir with a view to develop a low level channel which would pass the required discharge of about 5000 cusecs for the new delta areas into Natjuri on account of higher water level which would now be obtained in Mahanadi at Naraj due to a regulated discharge of about 9000 cusecs flowing below the power house. If this is possible it would obviate the necessity of carrying this discharge by widening and concrete lining the Maldanda canal which takes off up-

2. JOBRA WEIR.

(a) The investigation whether due to the development of an almost continuous island from jobra near the anicut to about 4 miles up-stream, Taldanda canal would be able to draw an increased discharge of about 5000 cusecs from the river up-stream of the anicut on account of the deterioration of river- regime in this reach.

(b) Measures for exclusion of silt from Taldanda canal as the head reach of the canal has been silting.

(c) The central sluices of the jobra weir are closed and the crest in that portion of jobra weir which is not in a straight line with the two portions on either side, is at a lower level than the rest of the weir. This will make it difficult to operate a power driven plough for raising the falling shutters.

It may be investigated whether the Central portion of the weir could be brought in a straight line and its crest raised to the same level as the rest of the weir. In this connection it may be remembered that the maximum flood of 15.0 lacs will now be moderated to 11.0 lacs at Naraj.

(d) The scouring sluices for Taldanda canal on the right side get submerged during high flood. It may be investigated whether the masonry of the piers may be raised and a divide wall provided with a view to provide a still pond regulation to decrease the entry of silt into Taldanda canal.

3. BIRUPA WEIR.

(a) The Kendrapara canal on the upstream of the Birupa weir takes off on the inside of a curve and silts in the head-reach. Measures to reduce silt entry may be investigated on the model. If it is not found feasible to improve the existing head, the possibility of taking a new head up-stream of jobra weir on the left side of Mananadi may be investigated.

Alternatively the feasibility of passing more silt into patamundai canal which takes off from Kendrapara canal about 2 miles below its head may be investigated as the latter channel has a steep slope and has been securing both the bed and sides of the existing section.

4. NEW WEIR UPSTREAM OF NARAJ.

It is proposed to construct a new weir upstream of Naraj the section of which will be supplied. The following investigations may be made in connection with this.

- (a) Protection for weir.
- (b) Position of lock, securing sluices, the angle of off-take of the head regulator for the new canal, length and width of approach channel etc.
- (c) The effect of the new weir on the hydraulic conditions on Naraj weir.

5. OTHER INVESTIGATIONS:-

- (a) Investigation of afflux due to the construction of barrages on Katjuri and Kuakhal on Cuttack town, in case Kuakhal is not closed and the value of the Bellevue gauge with Naraj at 89.0
- (b) Kuakhal and its three branches, survey for which will be supplied may be reproduced on the model and the following studies made:-
 - (i) The bankful stage for the three branches. This was observed to be obtained at R.L. 86 at Naraj.
 - (ii) The discharges which will flow through the three branches and their escapes with Naraj at R.L. 87.0, 88.0 and 89.0.

GOVERNMENT OF INDIA,
CENTRAL WATER AND POWER RESEARCH STATION.

D.O.No.Hirakud/1

Camp Hirakud, 10th Jan.1953.

Dear Hiranandani,

I send herewith a note of our discussion at Cuttack. The date as mentioned in the note may please be sent early.

Many thanks for the hospitality and the perfect arrangements made to make our stay very comfortable.

I have already had discussion with Shri Kanwar Sain at Hirakud about the various points.

Yours sincerely,

Sd.

D.V. Jogalekar.
Director.

Encl.
1 Note.

Shri M.G.Hiranandani,
Superintending Engineer,
Delta Irrigation Circle,
Central Water and Power Commission.
New Delhi.

Copy with a copy of the note, forwarded, with compliments to:-

Shri Kanwar Sain, I.S.E.,
Member(Designs) and Chief Engineer,
Hirakud Dam Project, Hirakud.

Shri A.S.Misra, Executive Engineer,
Delta Irrigation Division,
Bhubaneswar(Orissa)

(D.V.Jogalekar)
Director.

Hija
18/9

Points discussed in brief with the Superintending Engineer, Delta Irrigation Circle, on Monday the 5th January 1953 at Cuttack.

The following officers are present.

1. Shri M.G.Hiranandani, Suptg. Engr.) Delta Irrigation
2. Shri K.S.Misra, Executive Engineer.) Circle.
3. Shri S.Nagrani, Executive Engineer.)
4. Shri D.V.Joglekar, Director,)
5. Shri S.C.Desai, Chief Res. Officer) Poona Research
6. Shri S.D. Phansalkar, Asstt. Res. Officer.) Station.

The composite model No.1 will have to be proved in the following respects:-

- (a) Distribution of discharges between Mahanadi and Katjuri:
- (b) Katjuri and Kuakhai:
- (c) Katjuri and Sarua, and
- (d) Mahanadi and Birupa.

This should be done after maintaining the gauges as given by the Superintending Engineer, Delta Irrigation Circle, for the year 1952.

At present discharges are observed at the four railway bridges viz. Birupa, Mahanadi, Katjuri and Kuakhai by means of current meters. Surface velocities are observed in each span and coefficient 0.89 is used to work out the mean velocity on the vertical.

Soundings are also taken from which discharges are worked out and the total of these will be the total at Naraj.

It was reported that there were no spills during 1952 observations.

It is desirable to plot the cross sections observed by soundings during the peak flood and also the two values on either side and this should be compared with the cross-sections after the flood season. Corresponding details of velocity observations should be supplied by the Superintending Engineer. This information will be very useful for proving the model.

A statement of gauges along with an index plan and corrections to be applied to get the G.T.S. values is being prepared by the Superintending Engineer. This should be analysed

Statistically to get G. Q. graph for various places and this graph may be used for extra-polation. Data of observed gauges and discharges at Naimundi are available for the last 6 years. Data of gauge and discharge for the maximum flood hydrograph for each year will be supplied by the Superintending Engineer. G. Q. relationship for this data analysed by statistical Directorate, if available should also be sent.

The model experiments will give us the distribution of sand charges. Lines of flow etc, will be carefully observed at various places after making corrections in the rigid structures to suit river model scales like Naraj Weir, Jobra Weir etc.

In proving the model we should observe the length of the Naraj weir over which a standing wave forms for various flood stages as observed in the prototype.

Biranasi gap spill and Banki Road spill will also be tested.

After proving the model the following proposals should be tested:

Proposal No.1(original)

Kuaknai should be closed and with 11 lac cusecs the Naraj water levels in various branches of Mahanadi and Katjuri and other gauges are to be observed. If the Bellevue gauge exceeds the permissible limit as would be the case, the Katjur discharge should be reduced correspondingly so as to bring the Bellevue gauge within permissible limits by reducing the Naraj waterways.

As regards the permissible limit of Bellevue gauge it is reported that the damage occurs in Puri District when this exceeded 24 in the past and 23 at present.

safe flood gauge at Naraj.

The following passage from the preliminary report of the Orissa Flood Advisory Committee 1938-Appendix II gives an idea of the safe flood gauge at Naraj and states the flood problems of the delta.

"Bellevue gauge on the Katjuri at Cuttack town is the warning gauge for Puri district... The maximum gauge reading was 27.80 in 1892 and the 1937 flood was 27.25. The amount of flood passing with 24.0 gauge, I should consider as the safe limit beyond which it would be desirable to restrict floods, if possible. From a study of the past record of damage, it would appear that some slight damage is to be expected after the gauge reaches 23.00 and bad damage when over 26.00. With a gauge of 24.5 as happened on 27th July 1937, water passed over the countryside filling up all low lands and interfering with communications but causing no damage to houses. A prolonged flood at this height will of course cause damage to crops in low lying areas and affect houses."

"FLOOD VOLUME TO BE CONTROLLED: With Bellevue gauge at 24.00 Naraj gauge above weir on a rising flood has an average reading of 89.0 and according to Rhind's discharge table for this site the discharges would be about 1,140,975 cusecs. The 1855 and 1834 floods with Naraj gauge 93.36 and possibly 93.60 (unknown) are the highest floods on record, but are too extraordinary to be designed for.... Considering the highest floods from 1872(92.10), 1892 and 1896(92.10) 1920 (91.88), 1933 (91.45) and 1937 (91.50) we may take 92.10 as, being the maximum, not likely to be exceeded."

In the present Project, the maximum gauge for purpose of flood moderation has been taken as 93.60 with a peak discharge of 1,571,000 cusecs."

So far as the safety of the Cuttack town is concerned the Bellevue gauge should not exceed 27. As regards the damage in the lower reaches the gauge should not exceed 23. It was reported that Mahanadi flood levels have risen by about 2 ft. in the last 10 years. The data about this will be supplied by the Superintending Engineer.

The effect of reducing Naraj weir in order to reduce the discharge in Katjuri will be studied in the model. The discharge over the Naraj should be reduced either by closing the weir from the right side or by raising the crest above H.F.L. at intervals (i.e. by providing rectangular notches). In this connection attempt may be made to study by electrical analogy method and pressure observations to see the effect of afflux on the increase in pressures on the weir foundations. Safety of this old weir cannot be tested by a hydraulic model.

The proposal of deepening the undersluices of Naraj weir in order to draw 5,000 cusecs into the Katjuri for

developing a low level channel is considered not feasible as the bed level of the Mahanadi channel is reported to be 10 ft. lower than the present sill of the undersluices. Besides, the undersluices are on the sanding side and by the lowering the sill the low level channel will not get that discharge unless we excavate every year through the huge sand bank both above and below. Also the slope required will not be available for this channel because the difference in levels from Naraj to Katjuri bridge is only of the order of about 10 ft. which means the channel will be horizontal. Naraj is a primitive weir and has been damaged several times. Those damages have been repaired from time to time ; a note describing the repairs which have been carried out may please be sent.

It was also reported that there is a seep-age varying from 50 to 200 cusecs even during the winter months. a note on the seepage should also be supplied. It was observed that the high flood levels for some of the very high floods have been marked on the left bank abutment both for upstream and downstream. These levels should be supplied. Similar high floods levels for Jobra and Birupa should also be supplied, River surface slope data, if available, should be supplied.

It is also proposed that the Taldanda Canal should take a discharge of 1240 cusecs as against the present discharge of 1400 cusecs by widening and concrete lining. It would take this water across the Katjuri through an inverted syphon. The question was raised in this connection whether it will be possible to increase the discharge of Taldanda canal in view of the deterioration of Mahanadi upstream of Jobra due to the formation of islands etc, and also in view of the Taldanda Canal drawing a huge amount of sand and silt. The silting of Taldanda canal appears due to the slope of 1 in 10,000 which is too flat.

(2) Committee's proposal

According to this proposal the flood discharge of 15 lacs cusecs has to be moderated to 11 lacs cusecs and the distribution will be approximately as under:-

Mahanadi	5.5	Lacs.
Katjuri	4.1	"
Kuakhai	1.4	"

With the discharge of 11 lacs cusecs at Naraj. Water levels for various channels should be found out with these discharges.

Instead of siphoning below the Katjuri and closing the Kuakhai, the Committee suggested the construction of barrages on the Katjuri, Kuakhai, Kushabhadra and **Bhargovi** the object being to carry the water from Tladanla across these rivers by level crossings to irrigate the lands in the Doabs.

It is stated that the discharge through the Mancheshwar gap was of the order of 10,000 cusecs when the Naraj gauge was 87. According to the Committee's proposals the Mancheshwar Gap is to be designed to carry 75,000 cusecs. When the area was inspected it appeared that it can never carry that much discharge without causing severe damage. This will be quite apparent when the contour survey is available.

The data of bore-holes on the Katjuri and Kuakhai for the bridges should be obtained. The barrages will be tested in the model to find out the immediate afflux but the long term effect on accretion under the post barrage conditions cannot be tested in the model (The designs of barrages will be supplied by the S.E) The correct positions of road and railway bridges should be marked on the plan 2" to a mile and details of these bridges as regards plan, across section and elevation may be supplied, In the general plan the exact positions of rock, stiff clay and erodible clay islands should also be marked.

(3) Latest CW&PC Proposals.

The latest CW&P Commission proposal is to construct a weir on the Mahanadi above Naraj roughly half a mile upstream of Naraj weir (at cross section 12) and take off a 5,000 cusecs canal on the right to irrigate areas on the left bank of Kuakhai by providing cross drainage works (mostly siphons) across the rivers Kuakhai, Kushabhadra and Bhargovi.

To control the discharge entering Kuakhai up to a maximum of 1 lac cusecs a barrage is proposed in a stable rock.

of Kuakhai (at cross section 12). A complete layout and all the details of this proposal will be supplied by the Superintending Engineer.

In this connection, condition as regards ~~canal~~ entry into the new canal should be looked into carefully. The proposed canal takes off from a sanding side. Besides the weir will be in a gorge, therefore the conditions will be very turbulent and there is a great possibility of coarse bed sand being drawn into the canal. The only alternative to overcome this difficulty is to provide ejectors. The design of the weir, canal, head regulator, scouring sluices, navigation lock and ejector should be supplied by the Superintending Engineer. The effect of the new weir on the distribution of discharges and charges below Naraj should also be investigated.

The barrage across the Kuakhai will be constructed only if model experiments show that Kuakhai draws more than 1 lac cusecs without barrage. The effect of the barrage on Bellevue gauge will be carefully studied. This barrage will be in addition to the siphon.

Jobra Weir.

The following points should be investigated.

1. The crest of the oblong weir is 64.05 (G.T.S.) and the top of the shutters is 67.55- It is proposed to raise the crest of the shutters to R.L. 69.05 (G.T.S.) The stability of the structure will be found out by electrical analogy method and pressure observations in models.
2. The Central sluices of the Jobra Weir caused very heavy scour downstream and actually the crest curtain wall has collapsed. This scour occurred with a low discharge of the order of 50,000 cusecs when the downstream water level was very low with the result that a standing wave formed at the end of pucca pavement resulting in the above mentioned damage. At the request of the Chief Engineer, Orissa, experiments were carried out to see how these unsatisfactory conditions could be set right. On the recommendations of the Station the central sluices were blocked and a weir 5 ft. high was provided.

downstream. This was followed by 2. baffle walls and a deflector. Not only the scour was completely eliminated but silting actually took place. It may be noted that the Central Sluice portion has been recessed downstream of the main alignment of the weir. It is now proposed to straighten the whole weir and raise the crest to the same level as that of the weir i.e., R.L. 64.05 with 5 ft. high shutters. This will facilitate the operation of the shutters by a power plough.

3. The feasibility of providing the undersluices on the left of the weir to improve silt control into Birupa should be investigated. The dissipation of energy below right bank undersluices should also be investigated.

4. The Taldanda canal is silting badly and sand control devices are required. These should be tested both for 3,000 cusecs and 4,000 cusecs.

A statement of silt removed from the Taldanda from year to year will be supplied by the Superintending Engineer.

BIRUPA WEIR.

Kendrapara canal takes off from the inside of the curve. At present there are 2 heads for this canal, the old head carrying a discharge of 1400 cusecs takes off immediately upstream of Birupa weir on the right and the second head takes off further upstream and its discharge is 750 cusecs. The discharge for this canal is proposed to be increased to approximately 2400 between the 2 heads. As the canal takes from the inside of the curve it has silted very badly. It may be noted that the high level canal on the other side being on the outside of the curve is sand free. An alternative proposal is to provide a direct head from the Mahanadi above Jobra weir and if this proves to be too costly, then to divert the sand drawn by the Kendrapara canal into the Patamundai canal. This latter canal has a very steep slope and can take more sand without any trouble. To improve conditions with the present off-takes is almost impassible and would be very expensive.

One of the devices to exclude sand from Kendrapara canal into the Patamundai is King's vanes (Bombay T.P.59). These work

quite alright provided there is not much variation in the discharges ratios of the two canals. For this the designed discharges of these canals month by month will be supplied by the Superintending Engineer.

The existing crest of the Birupa Weir for a major portion of the length is at R.L. 62.83 (G.T.S) and 62.58 (G.T.S.) for a smaller length. It is proposed to raise the crest and make it uniform to 63.83 (G.T.S) The present crest of shutters is 67.33 and they are proposed to be raised to 68.83. The effect of increase in head on stability of the weir should be checked by pressures and electrical analogy models, measures to dissipate energy below right and left aprons should be tested in the hydraulic models.

The above investigations will require separate models for which estimate will be prepared for approval.

Muja

New Address:-
No.20, Bombay Road,
Poona-3.

Government of India,
Central Water and Power Research
Station, Poona-3

No.50/2670

Dated 6th May' 1953.

To:

The Superintending Engineer,
Mahanadi Delta Irrigation Circle,
Central Water and Power Commission,
New Delhi.

Subject:- **Preliminary** report on the Mahanadi River
Model near Cuttack.

Sir,

A reference is invited to your letter No.
DIC/W-26/C-320 dated 6th February 1953 and D.O.No.DIC/
W-26/1078 of 23rd April '1953. A preliminary report on
the work done on the Mahanadi River model for determining
the values of gauges at various places for discharges of
9,10 and 11 lacs cusecs at Naraj is enclosed herewith.

The values given in the report may be considered
as tentative as the full data of observed cross-sections
at the various ridges discharge sites and also the
details of spills with various discharges are still
awaited from the Executive Engineer. After the receipt
of these data- the tests will be repeated after
replenishment of Khadakwasla lake in July .

The supply of these data may please be
expedited.

Yours faithfully,

(Signature)
A. Sd.

D.V.Joglekar,
Director, C.W.P.R. Station

DA
1 Report.

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MAHANADI RIVER MODEL NEAR CUTTACK.

Preliminary report on the work done in March and April '1953

The Model:- The model has been prepared starting from Gail bank ie. about 5 miles upstream of Naraj Weir up to 2 miles below the Mahanadi railway bridge and upto about 2 miles below the bifurcation of the survey from Katjuri and up to the Kuakhai railway bridge. The following scale ratios are used.

Length Scale	1/400
Depth Scale.	1/66.
Discharge Scale.	1/1,60,000
Vertical Exaggeration.	6.06

Hydraulic Data:- The Hydraulic data available is very meagre and consists of gauge registers for the 1952 flood seasons only with corresponding discharges measured at the four railway bridges for a few of the gauge values. During this season the highest flood recorded had a very low value of 6,80,000 cs.

A scrutiny of the data shows that the values of the Naraj gauge downstream of the weir(i.e. on the Katjuri) are too high with submergence ratios from 90 to 95%. The formation of a clear standing wave shows that the submergence ratio must be somewhat lower ie. the value of this gauge must be lower than the recorded values. The recorded higher values of this gauge might be due to its faulty location or error in the zero value of the gauge.

Model Experiments:- A few hydrograph cycles were run to stabilize the bed and reproduce the known discharge distribution under a total flood of 6.8 lac cs. Then higher discharges of 9.0, 10.0 and 11 lacs cs. were let in and the discharge distribution and the various gauges were observed after controlling the tail and gauges at Kuakhai, Katjuri, Mahanadi and Birupa railway bridges at the values obtained by extrapolating the relations between these gauges and the Naraj gauge upstream of the weir by statistical methods. The results obtained are shown in the accompanying table.

During these preliminary runs it was observed that

there was a big return flow region opposite Naraj Weir, along the Mahanadi left bank deep channel, as shown in figure No.1. This needs to be confirmed from the prototype observation during this flood season.

Discussion of results:- For the various discharges the tail end gauges have to be controlled to predetermined values. In the experiments for 9, 10 and 11 lacs cusecs discharges the extrapolated gauges were maintained and they may have to be verified on the prototype. These controlled gauge values were as follows:-

Total Discharges.	Mahanadi	Birupa	Katjuri	Kuakhai
	rly. bridge.	rly. bridge.	rly. bridge.	rly. bridge.
	R.L.	R.L.	R.L.	
9.0 L.Cs.	68.75	65.95	74.05	73.80
10.0 L.Cs.	69.03	66.23	74.57	74.36
11.0 L.Cs.	69.30	66.53	75.11	74.94

The prototype data available upto a maximum discharge of 6.8 lacs only, it is also reported that Bank road spill begins to flow at floods of about 9 lacs cusecs of discharge. With this spill operating the general relations between the extrapolated gauges will naturally change. The survey data of the spill is still awaited from Executive Engineer and therefore the experiments so far conducted have been limited to the no-spill conditions.

The model has correctly shown that the silt charges entering Kuakhai is very heavy. Further it was found that the Kazipatna gauge is likely to show values upto approximately 1'-0" higher than shown in the accompanying table for 9.0, 10.0 and 11.0 lac cusecs during the rising flood stage.

The gauges and discharge distribution given as a result of these preliminary experiments may show variations to some extent. These can only be confirmed after full data about the flood cross-sections of the rivers and the details about spills are received from the Executive Engineer.

Total discharge in Mahanadi Lac Cs.	Water level at Naraj gauge (U/s of weir)	Water level at Bellevue Naraj gauge.	Water level at Naraj gauge (U/s of weir)	Water level at Naraj gauge (U/s of weir)	Water level at Naraj gauge (U/s of weir)	Discharge taken by Mahanadi & Birupa.	Discharge taken by Kunkhadi	Discharge taken by Katjuri & Kunkhadi	Discharge taken by Katjuri & Kunkhadi			
						Lac Cs. % of total	Lac Cs. % of total	Lac Cs. % of total	Lac Cs. % of total			
9.0	86.5	79.3	74.05	76.71	5.06	56.2	1.22	13.6	2.72	30.2	3.94	43.8
10.0	86.9	79.7	74.57	77.11	5.77	57.7	1.80	13	2.93	29.3	4.23	42.3
11.0	87.15	80.51	75.11	78.85	6.55	59.5	1.36	12.4	3.09	28.1	1.45	40.5

* This gauge was controlled at predetermined value.

Note:- All the gauge values given above are reduced levels with reference to G.T.S. Bench Marks.

"Reply to be addressed to
Post Box 18, Poona-I, please.

Government of India,
Central Water and Power Research
Station.

Poona 9th June 1953.

D.O.No.50/284

Subject:- Mahanadi River Model.

My dear Hiranandani,

Since sending you the preliminary note on 6th May '53 I have got the stage-discharge curve for Mahanadi at Naraj, extrapolated upto a maximum discharge of 15.00 lac cusecs. This is really a very high range for extrapolation. This curve gives a level of R.L. 88.38(G.T.S) at Naraj for a maximum discharge of 15.00 lac cusecs. According to the Rhinds curve(as corrected by Mr.Shaw) this value should be R.L.91.33(G.T.S). Further it was reported by you that the Mahanadi flood levels have risen up by about 2.0 ft. during the last 10 years. This fact has also been corroborated by a comparison of the present data with the Rhind's curve shown in Fig.1. It is also known that in 1940 the highest water-level had reached a value of R.L.90.48(G.T.S) at Naraj for which discharge was estimated at 14,50,000 cusecs which however is open to question. Under these circumstances I would like to have your estimate of the probable value of the Naraj gauge water level for the maximum discharge of 15.0 lac cusecs and also the corresponding water levels, at the four Railway bridge gauges below. The value of these gauges will determine the nature of the stage-discharge curve in the extrapolated region, which in its turn will affect the intermediate gauge levels for intermediate discharges.

Yours sincerely,

Sd/-

D.V.Joglekar,
Director, CW&PR Station.

To:

S-hri M. G. Hiranandani,
Superintending Engineer,
Delta Irrigation Circle,
Curzon Road, Barracks 'A',
New Delhi.

CENTRAL WATER AND POWER RESERVOIR STATION, PUNE.

MINUTES OF DELTA EXPERIMENTS NEAR CURRIER.

(Minutes of the Joint Discussions on the
18th and 19th August, 1953 at Khadakwasla).

1. The following officers were present:-

1. Shri M.G. Hiranandani, S.E.,
Delta Irrigation Circle.
2. Shri D.V. Joglekar, Director, CW&PR Station.
3. Shri S.C. Desai, Chief Research Officer (Hyd.)
CW&PR Station.
4. Shri S.D. Phansalkar, Asstt. Res. Officer, CW&PRS

2. An experiment with 10 lakhs cusecs flood at Naraj was conducted and discharge distribution in the various branches was observed. In another experiment the discharge passing into Kuakhai system was restricted to 50,000 cusecs and effect of this restricted discharge on various gauges at Kazipatna, Lal-Bag and Bellevue was observed. This experiment showed a rise of 3.15 ft. in Kazipatna gauge i.e., from R.L.79.60 to R.L.82.75, a rise of 3.50 ft. in Lal -Bag gauge i.e. from R.L. 79.50 to R.L.83.00, a rise of 2.22 ft. in Bellevue gauge i.e. from R.L.80.63 to R.L.82.85. The Naraj downstream gauge showed a rise of about 5" whereas the Naraj upstream gauge did not show any appreciable rise.

During the experiment it was also observed that the discharge in the Katjuri below Kuakhai head did not increase appreciably as the excess discharge was diverted to Mahanadi through the Birnasi Spill.

3. The experiment was carried out rather hurriedly, hence this is required to be repeated after reproducing the barrage at Kazipatna and also alternatively a weir restricting the waterway width in the Kuakhai. The object of this experiment is to see the effect of such a restriction on the various gauges i.e. Lal Bag, Bellevue and Naraj, to see whether there is an increase in the discharge of the Katjuri below Kuakhai head and also increase in the discharge of Mahanadi through Birnasi Spill or from above Naraj.

If in the experiment which is to be repeated the Bellevue gauge exceeds 27 i.e.(R.L.82) the experiment has

to be conducted to find out the value of Kuakhai discharge which would keep down the value of Bellevue gauge at 27 i.e. R.L. 82.

In this experiment lines of flow and velocity observations ups reach of Kuakhai head should be made. The slopes in all the channels should be observed particularly in the Katjuri system and this should be checked up by the calculations of back-water curves.

4. Statement No.1 shows the water levels at the various gauges with discharges at Naraj varying from 9 to 11 lakhs cusecs under existing conditions. This statement supercedes the previous statement included in the preliminary note sent under our letter No.50/2670 dated the 6th May, 1953.

Statement No.2 shows the discharge distribution under existing conditions for floods varying from 9 to 11 lakhs cusecs at Naraj and also with Kuakhai discharge restricted to 50,000 cusecs with Q at Naraj = 10 lakh cusecs.

5. Experiments in connection with new weir and canal off-take above Naraj:-

Detailed river survey from cross-section No.1 up to cross-section No.13 near Naraj weir will be made and supplied by the Superintending Engineer, D.I.C. After receiving these survey details and also the design details of the proposed weir, proper site and orientation of the weir, location of the canal head regulator should be found out from the present model. The weir will be located roughly between cross sections 7 and 9 (Mahanadi) and the head regulator will be located upstream at a point where favourable curvature is available.

6. Experiments for proposed modifications to Jobra Weir on the Mahanadi by the electrical analogy method and hydraulic models.

In the experiments already carried out for the Jobra Weir by the electrical analogy method the following assumptions were made:-

1. The weir masonry is impermeable.
2. The upstream apron was also considered to be impermeable.

These assumptions were made as it was felt that silt and

sand would have filled up the interstices in the stone filling forming the body of the apron as well as the weir.

It was decided to test this weir in an hydraulic model in the new soil chamber. In this experiment an attempt will be made to represent both the apron and the masonry of the weir to reproduce the correct prototype conditions as far as possible. The approximate cost of the model will be about Rs .8,000. A detailed estimate will be prepared and sent for sanction.

It is also desirable to observe pressures in the prototype. Shri Hiranandani will arrange to install 4 to 5 pressure pipes beginning from just downstream of the crest shutters to the end of the apron. Observations will be taken during the dry weather season and reported so that model and prototype conditions can be compared.

7. In the previous experiments carried out during 1943-47 at this Research Station, it was observed that reducing the Naraj weir by about 35% from the right bank would reduce the discharge in the Katjur below Naraj by 1.5 lakhs cusecs. The conditions of flow at Naraj have considerably changed since then. During the present experiments it was observed that even blocking the Naraj weir by 45% from the right side there was practically no reduction in the discharge entering the Katjur. This was a result of practically still water conditions near the right bank and a high concentration of flow towards the left flank. If, however, a reduction in discharge in the Katjari below Naraj is to be achieved it has not to be done by closing a part of the Naraj weir from the left or by raising the crest level of the Naraj weir. This weir is about 100 years old and is in a bad condition, hence it is felt that no modifications of any nature should be done to the Naraj weir from the left side or even by raising the crest. Shri Hiranandani is also of the opinion that the Naraj weir should not be touched.

8. The model showed the existence of return flow in the Mahanadi left channel. Also it was seen that with total discharge at Waraj exceeding about 5.0 lac cusecs, a major portion of the Mahanadi discharge flowed through the right channel of the Mahanadi (i.e. channel D in fig.1 accompanying letter No. 50/2674 dated 3rd August, 1953) It may be investigated if there is stiff material like boulders, rock etc. in the bed of channel D. Borings may be taken, if necessary.

9. Taldanda canal head regulator does not appear to be correct in the model. Detailed surveys may please be made as per letter No.2527 dated 11th May, 1953, and supplied.

10. It is desirable to have an aerial survey covering the part of the river from cross section No.1 near Goel bank down to one mile below the Railway bridges on the four branches namely Birupa, Mahanadi, Katjuri and Kuakhai. This aerial survey should be connected with some of the important traverse stations on ground. Fresh cross sections should be taken and their ends be connected with the traverse (which should be closed).

11. The estimate for the existing Mahanadi model costing Rs.35,488/- was prepared in July 1952 and subsequently as a result of discussions- additional experiments had been found necessary and have been carried out. It is anticipated that in order to complete the present programme of experiments in this model, additional amount of Rs.8,000 will be required. The estimate for the same will be prepared and sent to Shri Hiranandani, Superintending Engineer, Delta Irrigation Circle.

12. Shri Hiranandani, Superintending Engineer, Delta Irrigation Circle, in his D.O. letter No. DIC/W-26/22 dated 27th December 1952 had anticipated

us to conduct a number of additional experiments in connection with the proposed modifications to the structures in the Mahanadi delta in connection with the Delta Irrigation Scheme which is under preparation. It is suggested that a provision of about 1% for hydraulic models may please be made in the estimate.

"Chaman"

MIRANADI RIVER (NUMBER CUTBACK)

Statement No.1

Showing water levels (G.T.S) at different gauge stations for different flood discharges.

Total discharge at Rajahmundry (Upstream of weir)	Harad	Gaule	Kezapatna	Lalbag	Baliovue	Matjuri Bridge.	Kusabhai Bridge.	Mahanadi Rly Bridge	Birupa Rly Bridge.
9.0	87.30	73.74	77.90	79.54	75.30	74.80	70.30	66.20	
10.0	87.95	79.60	79.50	80.63	76.15	75.70	70.95	66.75	
11.0	88.65	80.20	80.17	81.30	77.10	76.60	71.55	67.30	

MUMBAI MODERN (GENERAL PURPOSE)

Statement No.2

Showing flood distribution under various flood discharges.

Total discharge above Naraj Lac cusecs.	Mahanadi discharge.		Bhruva discharge		Total discharge of Mahanadi & Bhruva	Kathnai discharge	Kalyani discharge	Total discharge of Mahanadi and Kathnai				
	%	Lac cusecs	%	Lac cusecs					%	Lac cusecs	%	Lac cusecs
1	2	3	4	5	6	7	8	9	10	11	12	13
Under existing River conditions	9.0	52.8	4.78	5.5	0.19	58.3	5.27	13.3	1.20	28.4	2.53	41.7
	10.0	52.9	5.29	6.2	0.62	59.1	5.91	13.9	1.39	27.0	2.70	40.9
	11.0	53.6	5.89	6.8	0.75	60.4	6.64	13.6	1.50	26.0	2.86	39.6
	10.0	60.7	6.07	7.3	0.73	68.0%	6.80	5%	0.50	27.0	2.70	32.0

****(With Kathnai discharge controlled at 50,000 cusecs in a rough test)

Muja

APPENDIX VIII.

A NOTE ON THE STUDY OF SUB-SOIL WATER LEVEL
OBSERVATIONS IN THE MAHANADI DELTA. BY
SHRI C.K.KOCHUKOSHY, E.A.D.
C.W.&P. COMMISSION.

APPENDIX VIII

A NOTE ON THE STUDY OF GROUND WATER LEVELS IN THE CUTBACK DISTRICT AND PROPOSED IRRIGATED AREAS OF PURI DISTRICT.

Observations for 66 wells in the region which includes existing irrigation and proposed irrigation were analysed after dividing the group into 2 parts. There were 47 wells for observations in the area where irrigation exists at present and in the other group in the Puri District there were 19 wells. The data extends from October, 1952, to April, 1953.

Arithmetic means of the observations were found out separately of each group for the 7 months from October to April. Because the specific area which each well represents was not known for the purpose of giving weightage to the observations in the process of calculation, the results obtained may have only limited validity. Of course, there is considerable variation in the water levels from place to place for the same months, and it was assumed that for the purpose of examining the fluctuation of water tables from month to month in each area as a whole mean figures would suffice. For the sake of abbreviation we may refer to these two sets as Set I and Set II standing for existing irrigated areas of Cutback District and proposed irrigated areas of Puri District respectively.

S.No.	Months	Set I Mean Sub-soil Water level.	Set II	Percentage decrease for Set No. I	Percentage decrease for Set No. II.
1.	October	7.18	12.18	-	-
2.	November.	8.24	15.52	14.76	27.42
3.	December.	9.25	18.08	12.26	16.49
4.	January.	9.90	19.38	7.03	7.19
5.	February.	10.28	20.36	3.84	5.08
6.	March.	11.67	21.01	13.52	3.19
7.	April.	12.96	22.68	11.05	7.95
			Mean	10.5	11.25 (say)

The first obvious conclusion is that where-as the average water level in Set No.1 is higher than in Set No.11 both follow a particular pattern of increase with the rate markedly high in the beginning months and less so towards the end. In Set No.1 the average water level starts with 7.18 ft. While in Set No.11 it starts with 12.18 which means the Sub Soil Water Level in the second set is much lower as a rule. When we come to the question of the depth by which the water level falls we find that in Set No.11 with a water level high is already very low the fall is greater in depth. When these decreases in Sub Soil water Level were changed into percentages as shown in the above table, the rates of fall shows only a smaller variation with 10.5 percent in Set No.1 and 11.25 in Set No.11. When mean percentages were found.

In order to assess on a statistical basis the nature of these two sets of decreases, 2 straight lines were fitted to the data and are herewith attached. The equation of the straight lines are:-

$$\begin{aligned} Y &= 0.9X + 6.3 \\ &\& \\ Y &= 1.6X + 12.06 \end{aligned}$$

respectively for Set No.1 and 11. As can be seen from the slopes of the straight lines Set No.11 has got a higher slope than Set No.1. If these slopes were to be expressed as tangents of particular angles and if these angles could be taken as indicative of the slopes the degrees of slopes are 42 and 58 respectively for the 2 Sets, which means that the rate of fall in Sub Soil Water Levels in Set No.11 is faster than the 1st Set.

It is difficult to predict how the Sub Soil Water Level in the proposed area will change after irrigation is introduced because we do not have Sub Soil Water Level Observations of the existing areas prior to the introduction of irrigation. If we assume that the Sub Soil Water Level in the entire area (Including the New and the existing areas) is of a homogeneous nature and that pre-irrigation Sub Soil Water Level pattern in the Cuttack District might have been approximately the same as that in the Puri District (New Areas proposed) then we may expect a rise in level of Sub Soil Water in the Puri District corresponding to that which we noticed in the Cuttack Distt.

It may vary between say 13.ft and 7 ft. Perhaps an equally important deduction would be that the rate of decrease in water level would be smaller than at present in the new areas after introduction of irrigation, corresponding to what we have noticed in the existing irrigated areas in the Cuttack District.

The main conclusions will be as follows:-

1. Sub Soil water Level in the existing irrigated areas are markedly higher than those of the new areas proposed for irrigation.
2. Sub Soil Water Level falls off from October to April at a faster rate in the Puri District compared to the Cuttack District.
3. The amount by which water Level falls off in the new areas is most generally higher in the case of the areas where there is no irrigation at present (i.e. Set No.11) compared to the irrigated areas i.e. Set No.1.
4. A glance at the graph herewith attached and the table given above shows that during the months of January and February water level shows some resistance against fast decrease in Set No.1 i.e. areas irrigated at present. In case of Set No.11 which consists of area which are not irrigated at present this tendency is noticed during the months of February and March.
5. If the assumption that the areas to be irrigated will have a pattern of Sub Soil Water Level similar to the one in the existing areas that pattern will roughly be on the basis of equation No.1 herewith attached as graphical representation.

It may be added that the paucity of data which extends to only 7 months from October, 1952 to April 1953 and the limitation of our assumptions may be considered as factors restricting the validity of our interpretation.

Sd.C.K.Kochukoshy,
Extra Asst. Director (State & P.W.)
Central Waterpower Irrigation
& Navigation Commission.

D.A/

Huja

Statement showing the sub-sill water level observation of wells.

S.No. as shown in the plan.	Location of the well.	Actual depth below top of parapet.							REMARKS.	
		October, 1952.	November, 1952.	December, 1952.	January, 1953.	February, 1953.	March, 1953.	April, 1953.		May, '53.
1	2	3	4	5	6	7	8	9	10	11
		EXISTING IRRIGATED AREA.								
1.	Jagatpur.	3'-7½"	4'-2½"	4'-9½"	5'-6"	5'-9"	6'-0"	8'-4½"		
2.	Barberia.	7'-2"	8'-7"	10'-0"	11'6"	12'-1½"	13'-0"	Not observed.		
3.	Kendupatna.	17'-0"	19'-5"	21'-9"	23'-4"	Not observed.	24'-4½"	25'-5"		
4.	Pubhansa.	13'-0"	15'-3"	15'-10"	15'-6"	17'-10"	18'-3"	19'-9"		
5.	Danpur.		5'-9"	6'-1"	5'-3"	6'-10½"	7'-7½"	8'-1½"		
6.	Basepur.		3'-1½"	4'-1½"	4'-6"	5'-2½"	3'-4"	5'-2"		
7.	Kalpara.		5'-6½"	6'-1"		7'-1"	8'-4"	7'-10"		
8.	Marsaghai.		5'-5½"	6'-3"		5'-5½"	3'-7"	6'-9"		
9.	Chakrada.		6'-4½"	9'-4"	8'-3½"	8'-1½"	7'-7"	8'-5"		
10.	Kendrapara.	6'-4½"	6'-8"	7'-10"	7'-7½"	7'-11"	6'-7"	8'-4"		
11.	Garapur.	3'-11½"		8'-5"	9'-7"	10'-4½"	11'-3"	11'-8"		
12.	Bara.	4'-3"	6'-1½"	7'-5½"	7'-1½"		9'-3½"	10'-6"		
13.	Gogua.	5'-2"	6'-9½"	8'-4"	8'-4"	9'-10"	9'-10½"	11'-8"		
14.	Patamundai.	11'-4½"	12'-11½"	14'-0"	15'-2"	15'-2"	15'-9½"	15'-11½"		
15.	Chandakulat.	8'-11½"	9'-11½"	10'-2"	10'-6½"	10'-7"	11'-6"	12'-1"		
16.	Ghagra.	4'-1"	5'-11"	6'-3"	7'-9"	7'-10"	9'-3½"	Not observed.		
17.	Indipur.	7'-4"	13'-½"	14'-4½"	15'-11"	16'-6½"	16'-10½"	17'-8"		
18.	Benipur.	10'-4"	16'-1½"	17'-1"	18'-9½"	19'-11"	19'-11"	20'-7"		
19.	Gopalpur.	5'-9½"	8'-2½"	9'-1½"	9'-4"		11'-2"	12'-6"		
20.	Balichandrapur.	6'-6"	9'-4½"	10'-2"	7'-8"		10'-8½"	11'-7"		
21.	Kuanpal.	9'-1"	11'-6½"	13'-1"	13'-5½"		14'-2½"	14'-4½"		
22.	Nurtang.	2'-4½"	4'-4"	2'-1"	8'-3"		3'-4½"	4'-5"		
23.	Bheda.	7'-9½"	9'-7½"	10'-4"	11'-6½"		13'-2½"	14'-4"		
24.	Lekhanpur.	9'-5"	11'-4"	13'-6"	13'-6½"		15'-11"	16'-8"		

Contd. on page 2.

Statement showing the sub-soil water level observation of wells.

S.No. as shown in the plan.	Location of the well.	Actual depth below top of parapet.								Remarks.
		October 1952.	November, 1952.	December, 1952.	January, 1953.	February, 1953.	March, 1953	April, 1953	May, 1953.	
<u>EXISTING IRRIGATED AREA (CONTD).</u>										
25.	Gopinathpur.	6'-8½"	7'-10½"	9'-½"	9'-8½"	10'-5½"	11'-½"	11'-4"	13'-4½"	
26.	Padampur.		5'-11½"	6'-11"	7'-10"	8'-10"	9'-8"	10'-6"		
27.	Bahugram.	13'-9½"	15'-2½"	16'-9"	18'-4"	20'-0"	21'-6"	22'-1"		
28.	Sisua.		3'-7"	5'-11½"	6'-4"	6'-9"	8'-1"	8'-2"		
29.	Salipur.		5'-9½"	8'-5½"	9'-7"	10'-7"	11'-6"	12'-2½"		
30.	Nischintkoili.		4'-8½"	7'-4"	7'-7"	7'-10½"	9'-½"	9'-8"		
31.	Sukarpara.	5'-3½"		7'-2½"	7'-10"	8'-2"	9'-1½"	9'-7"		
32.	Chandole hat.		5'-3"	7'-7½"	8'-1½"	8'-7"	9'-5"	9'-11"		
33.	Bhagabatpur.		5'-9½"	8'-3½"	9'-7"	10'-3½"	12'-0"	12'-5"		
34.	Tilotamadeipur.			6'-7"	4'-9½"	5'-4½"	7'-4½"	18'-1"		
35.	Aithpur.	5'-10"								
52.	Gopinathpur (Balua I.B)	8'-8"	9'-11"	10'-3"	9'-10½"	10'-8½"	11'-8½"	12'-7½"		
53.	Alipingal.	3'-6"	4'-7"	5'-5½"	5'-2½"	7'-8"	26'-7½"	28'-3½"	28'-6½"	
54.	Balikuda.	6'-10"	8'-6"	9'-0"	8'-7"	9'-5"	10'-3"	11'-4½"	12'-3½"	
55.	Jagatsinghpur.	4'-10½"	7'-2½"	8'-6"	9'-4"	10'-10½"	11'-8"	13'-3½"	13'-10½"	
56.	Nuapara.	3'-2"	6'-6½"	7'-7½"	7'-4"	8'-½"	8'-10½"	9'-1½"	9'-11½"	
57.	Manijanga.	5'-2"	7'-11"	8'-8"	9'-10½"	10'-3½"	11'-2"	12'-7½"	13'-2"	
58.	Kulusahi.	4'-2"	4'-6"	3'-10"	4'-4½"	4'-10½"	5'-3½"	5'-9"	8'-4"	
59.	Jagatpur (Same as S.No.1)	5'-4"	-		5'-6"	5'-10"	6'-0"	8'-6½"	9'-5½"	
60.	Tangi.	6'-9"	9'-3"	11'-2½"	17'-4½"	24'-4½"	26'-1½"	30'-½"	29'-1"	
61.	Bayree.	5'-3"	7'-3½"	8'-1½"	8'-8"	10'-½"	10'-11"	11'-8"	12'-9½"	
62.	Badachana.	13'-1"	9'-7"	11'-7½"	12'-10"	11'-10½"	16'-½"	15'-2½"	13'-2"	
63.	Jenapur.	9'-3"	10'-10"	11'-5½"	12'-11"	13'-2½"	13'-10½"	14'-10½"	18'-5"	

Contd. on page 3.

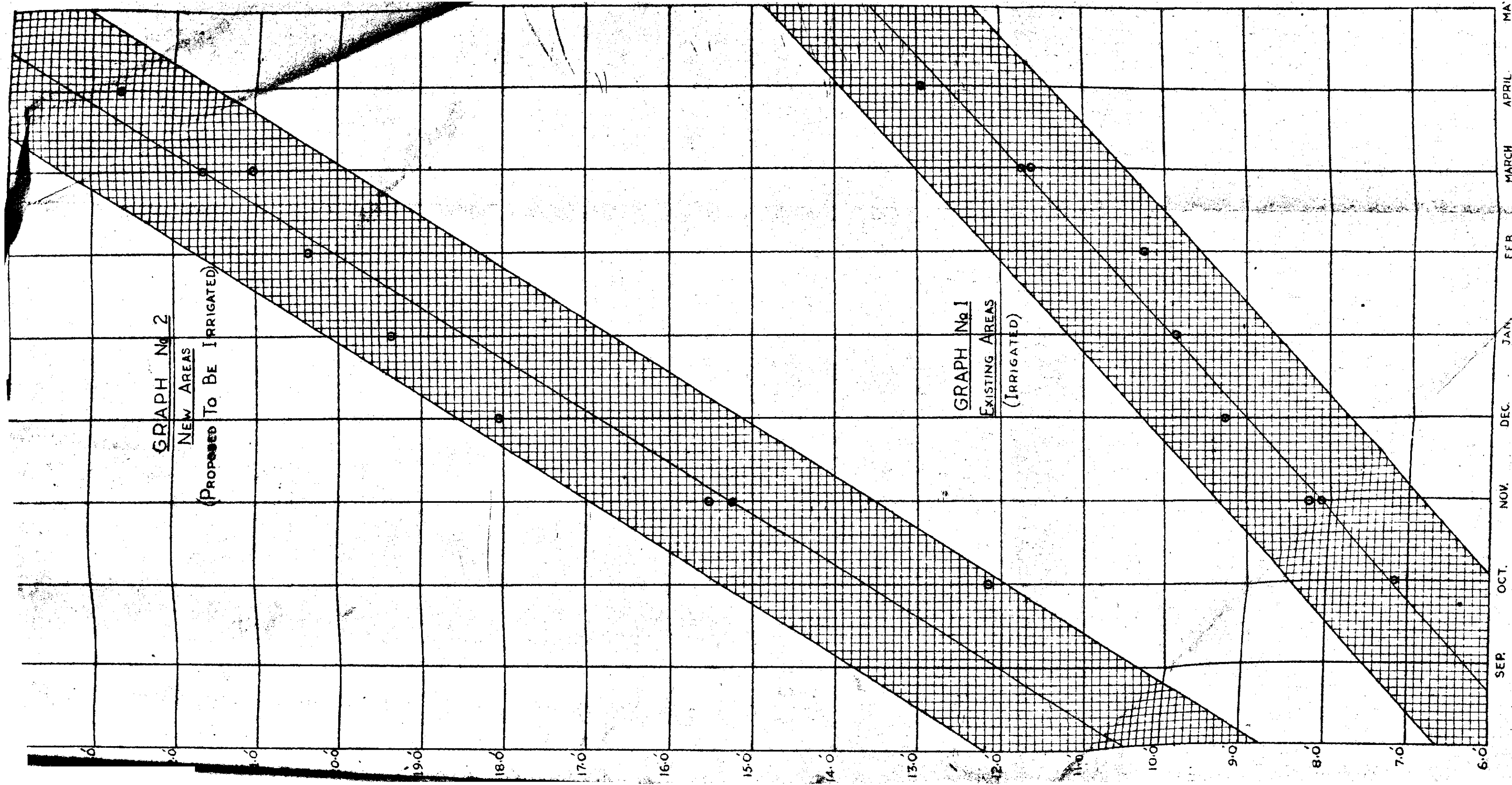
STATEMENT SHOWING THE SUB-SOIL WATER LEVEL OBSERVATION OF WELLS.

S.No. as shown in the Plan.	Location of the well.	Actual Deptt. below top of parapet.							
		October, 1952.	November, 1952.	December, 1952.	January, 1953.	February, 1953.	March, 1953.	April, 1953.	May, 1953.
		<u>N E W A R E A.</u>							
35.	Bhubaneswar.	16'-8"	21'-2"	25'-3"	31'-7½"	32'-10½"	37'-10¼"	42'-2¼"	38'-9½"
36	Sardaipur.	15'-0"	15'-8"	15'-10½"	16'-4½"	16'-8½"	17'-1½"	17'-4½"	17'-7"
37	Pipli.	10'-2"	12'-2"	13'-5"	15'-5"	16'-2"	16'-7½"	18'-4½"	19'-0"
38	Dhanmukandpur.	5'-4"	6'-11"	8'-7½"	11'-1½"	13'-7½"	14'-5½"	15'-3½"	15'-10"
39	Satyabadi.	7'-5"	9'-2½"	10'-1¼"	11'-2½"	12'-3"	14'-1"	25'-6"	25'-11"
40	Puri.	16'-11½"	19'-0"	20'-0"	20'-10"	21'-4"	21'-8½"	21'-6"	21'-5"
41	Khandgiri.	24'-10"	29'-8½"	34'-1"	37'-6"	38'-7"	40'-½"	42'-11½"	41'-3"
42	Chattabara.	21'-8½"	26'-9"	30'-11"	32'-8"	33'-9½"	35'-11½"	37'-3"	37'-5½"
43	Khurda.	14'-1"	18'-9"	23'-5½"	25'-10½"	27'-3½"	30'-½"	34'-2½"	33'-7½"
44	Jatni.	13'-5"	25'-10"	28'-10"	31'-0"	32'-7"	36'-10"	37'-2½"	38'-11"
45	Jankia.	5'-3"	7'-6"	8'-1"	8'-8"	9'-3"	9'-10"	10'-4½"	10'-3½"
46	Kanti.	7'-4"	-	11'-9½"	13'-4½"	14'-1½"	15'-½"	15'-5"	15'-7½"
47	Nimapada.	10'-4"	9'-9"	11'-2½"	12'-7"	13'-1"	13'-9½"	14'-2½"	14'-6"
48	Konark.	4'-2"	6'-7"	7'-5"	8'-3½"	8'-9½"	9'-6½"	9'-9½"	9'-7"
49	Niali	11'-0"	20'-2"	20'-9½"	21'-9"	22'-5"	23'-1"	23'-7½"	2'-1"
50	Naraj.	-	4'-½"	-	7'-11"	8'-4"	10'-1½"	9'-9"	1'-0"
51	Nakhara.	6'-2"	8'-2"	10'-1½"	11'-1"	12'-½"	13'-6½"	13'-11½"	14'-4½"
65	Chandka.	14'-1½"	25'-7"	31'-1½"	34'-2"	35'-2½"	35'-9"	36'-3½"	36'-2½"
66.	Gopa	15'-2"	12'-4"	14'-5½"	16'-10½"	17'-11"	18'-5½"	18'-11"	19'-5"

K B M A H A S.

GRAPH No 2
NEW AREAS
(PROPOSED TO BE IRRIGATED)

GRAPH No 1
EXISTING AREAS
(IRRIGATED)



SEP OCT NOV DEC JAN FEB MARCH APRIL MA

1952 1953

MONTHS

TRACED BY Sarah Pollock COMP. BY M. M. 11-1

APPENDIX IX.

A NOTE ON THE ANALYSIS OF DISCHARGE DATA OBSERVED
AT NARAJ AND SAMBALPUR
BY SHRI C.K.KOCHUKOSHY E.A.D.CW&PC.

APPENDIX IX.

A note on the analysis of Discharge data observed at Naraj and Sambalpur.

The discharge data of Mahanadi at Naraj and Sambalpur had to be analysed with a view to finding out the relation existing between the two sets of discharges.

For purposes of the study there were 85 observations available and the co-efficient of co-relation between two sets was first of all found out. This co-efficient is quite high and one is lead to believe that there is a considerable degree of concomitant variation between discharge at Naraj and that at Sambalpur. It has also been found that discharges at Naraj were almost invariably greater than those at Sambalpur. While a statistical explanation for this phenomenon cannot be validly given it may be remarked that explanation for this may have to be derived from engineering considerations.

An effort has been made to find out whether a regression equation could be found out which would enable us to forecast satisfactorily the discharges at Naraj from those of Sambalpur. A linear equation in the form $N = 1.65S - 41.16$ was fitted to the entire data consisting of 85 sets of observations. This has been plotted in the graph herewith attached. A glance at the 85 points plotted in the graph shows that there is considerable dispersion round this straight-line and hence it is doubtful whether we can make use of this linear relationship for purpose of forecasting discharges. As a matter of fact this regression equation has actually been applied and discharges at Naraj are calculated. It was found that there is too much discrepancy between the actual and the calculated values, sometimes extending to the tune of over 2000 cusecs. An examination of the graph shows that distribution of points is extremely close to the line at the beginning of the line whereas discrepancies abruptly start from about 2,500 (Naraj) & 1,500 (Sambalpur). Also the majority of the points namely 51 lie within this span

and hence it was considered desirable to have a separate regression equation for this part of the graph. Accordingly a straight line was fitted for these 51 points exclusively and its equation was found out to be $N = 1.59S - 33.17$. This straight line gives a very good fit. For the sake of study, another straight line was fitted for the remaining 34 points and its equation was found to be $N = 1.57S + 194.67$. Naturally it was found that this straight line does not give values agreeable with the observed discharges.

It may be pointed out that the data available extends to only a very small period and hence its behaviour and reliability of results obtained from their study, are all uncertain. However, subject to such limitations the following conclusions can be made:-

1. There appears to be a change in the pattern of discharges & their variation above the limits of 2,500(N) and 1,500(S)
2. While the relationship between the two sets of discharges obey a particular law as enunciated by the equation $N = 1.59S - 33.17$ up to the above mentioned limits, the distribution of discharges above the limits seem to be influenced by extraneous factors. (Because the inter-play of these extraneous factors are only for comparatively higher discharges they might be due to augmentation or otherwise of discharges due to Run-off from the places intermediary to Naraj and Sambalpur)
3. Subject to the validity of the available data it may be surmised that discharges at Naraj are likely to be generally greater than those at Sambalpur. But there have been actually two observations when Naraj discharge was found to be less than Sambalpur. These were on the 22nd and 23rd of January, 1953. These two observations will have to be looked into for their veracity.

Sd/- C.K.Kochu Koshy)

Superintending Engineer,
Delta Irrigation Circle.

APPENDIX X.

NOTE ON INTENSITIES, CROP ROTATION ETC. TO BE
ADOPTED ON THE DELTA CANALS, AND COPIES
OF CONFIRMATION OF MINUTES.

ANNEX

MINUTES OF THE MEETING HELD ON 12-2-1953 AT 3-30 P.M. IN THE OFFICE OF THE DIRECTOR, GENERAL RICE RESEARCH INSTITUTE, CUTTACK.

The following were present:

1. Dr. N. Parthasarathy, Director, Central Rice Research Institute, Cuttack.
2. Dr. Vacchani, Agronomist, " "
3. Shri D. Misra, Deputy Director of Agriculture and Food Production, Orissa.
4. Shri M. G. Hiranandani, Superintending Engineer, Delta Irrigation Circle, CWB-Commission.
5. Shri S. D. Nanagrani, Executive Engineer, Delta Investigation Division, Bhubaneswar.
6. Shri K. S. Misra, Executive Engineer, Delta Irrigation Division, Bhubaneswar.

The questions regarding intensities, crop rotation and delta (depth of watering) required for various crops, were discussed and following decision were arrived at:

INTENSITIES.

(a) KHARIF.

- (I) Jute 15%
- (II) Aman Paddy. 80%

This includes 10% of the land in which Jute will be sown and Aman Paddy done from 15 August to 30th November, sowings of this will be realised July, transplantation from 15 August to 15th August and maturing from 16th August to 30th November.)

- (III) Beali Paddy. 5%

To be followed by vegetables & potatoes in winter.

- (IV) Sugar cane & garden. 1%
- Total. 100%

(b) RABI.

- (V) Dalua Paddy. 3%

- (VI) Wheat Cotton & ground nut. 10%

- (VII) Cover crop 40% (Legumi variety)

- (VIII) Vegetable & Potatoes 5%
- Total. 88%

These will be grown in Paddy area:

Total intensity during the year

CROP ROTATION.

(a) K. AREA.

(i)	Jute	15%	15th April to 31st July followed by Aman Paddy in 2/3rd Jute area.
(ii)	Aman Paddy.	80%	15th May to 30th November.
(iii)	Beali Paddy.	5%	15th May to 30th September; to be followed by Potatoes and vegetables.
iv)	Sugar Cane & Garden.	10%	whole year crop.

(b) LABI.

(v)	Dalua paddy.	33%	1st Jany, to 30th April, (seedlings to be raised in Dec)"
(vi)	Wheat Cotton & Groundnut.	10%	15th Oct. to 30th April.
(vii)	Cover crop Leg- umi variety.)	40%	December to April.
(viii)	Vegetable & Potatoes.	5%	Oct. to March (In the area of Beali Paddy)

DELTA (E. TR. OF HARRING).

(i)	June.	40"	1st watering 8" and their are 8 irrigations of 4" each.
(ii)	Aman Paddy.	59"	(excluding raising of seedling) 22" during transplantation and 37" during maturing.

The above deltas of 22" and 38" will be spread over as under

(a) TRANSPLANTATION

15th June to 30th June.	20% of area.
1st July to 31st July.	55% of area.
1st August to 15th August	25% of area.

(b) MATERING OF CROP:

This will be spread over in the ratio of 3/4, 1, 1 1/4, 1 1/4 during the month of July to November respectively:-

July	.. 5.55"
August.	-- 7.4"
September.	.. 9.25"
October.	.. 9.25"
November.	.. <u>5.55"</u>
Total.	37.0"

	-223-	
(111) Beali paddy	-54"	(excluding nursery period) -22" during transplantation and 32" during maturing (Raising of seedling to be done from 16th May to 15th June)
(a) Transplantation	-22"	from 16th June to 30th June,
(b) Maturing	-32"	This will be spread over as under:
June 16-30	-5.5"	
July	-7.5"	
August.	-9.5"	
September	-8.5"	
Total.	<u>32.0"</u>	
(1v) Dalua Paddy-		Same as in case of Beali Paddy.
Raising of seedling		16th Dec. to 15th Jany.
Transplantation-		1st Jan. to 31st January.
Maturing. -		16th Jan. to 30th April.

- (v) Cover crop
(Legumi variety) One wat ring of 4" to 6" during Dec.

These crops will be grown in which
Raman Paddy is done.

Government of India,
Central Water and Power Commission.
Camp :Cuttack.
Dated 13-2-1953.

No. D.I.C/W-23.A/C-412

Copy forwarded to:

1. The Director of Agriculture and Food Production, Orissa.
2. The Director, Central Rice Research Institute, Cuttack.

The above minutes may kindly be confirmed.

Sd/- M. G. Hiranandani)
Superintending Engineer,
Delta Irrigation Circle.

Huja

No.F25-5/52-Estt-0855
Central Rice Research Institute,
Cuttack-4,Orissa.

25th Feb: 1953.

From:

Dr.N.Parthasarathy,ph.D(Lond),F.M.I,
Director.

To:

The Superintending Engineer,
Delta Irrigation Circle(H.D.Project)
C.&P. Commission, Carzon Road Barracks 'A'
New Delhi.

Sub:- Minutes of the meeting held on 12-2-53 at Central
Rice Research Institute, Cuttack.

Sir,

With reference to your office endorsement
No.DIC/W-23/A/C-412 dated 13-2-53 forwarding a copy of
the minutes of the meeting held on 12th February, 1953,
at this Institute, I endorse the recommendation adopted
at the meeting and confirm the minutes.

Yours faithfully,

Sd: N.Parthasarathy,
Director.

Huja

OFFICE OF THE DIRECTOR OF AGRICULTURE AND FOOD PRODUCTION,
ORISSA.

No.3044/Agri.2M(A)-115/52. Dated Cuttack, the 10th March, '53

To

The Superintending Engineer,
Delta Irrigation Circle,
CW&PC, Curzon Road Barracks 'A',
New Delhi.

Subject:- Duties.

Sir,

Minutes of the meeting furnished with your
letter No.DIC/W-23/A/C-412 dated 13th February, 1953
on the subject noted above are confirmed.

Yours faithfully,

For Director of Agriculture
Food Production, Orissa.

Mija

APPENDIX XI.

NOTE ON THE DUTY OF IRRIGATION WATER PROPOSED TO BE
ADOPTED FOR VARIOUS CROPS IN THE DELTA AREA OF THE
MAHANADI
BY SHRI M.G.HIRANANDANI.

NOTE ON THE DUTY OF IRRIGATION WATER PROPOSED TO BE ADOPTED
FOR VARIOUS CROPS IN THE DELTA AREA OF THE MAHANADI
RIVER

BY

M.G. HIRANANDANI, B.A., B.Sc. (Eng) LONDON,
SUPERINTENDING ENGINEER,
DELTA IRRIGATION CIRCLE,
CENTRAL WATER & POWER COMMISSION.

INTRODUCTION.

1. It is proposed to improve the existing canal system in the Cuttack District and extend Irrigation in the Puri District of the Orissa State on account of the water which will be available through-out the year as a result of construction of the Hirakud Dam Project.

The existing Orissa Canal system in the Cuttack District was completed in the year 1866 by Sir Arthur Cotten who designed these canals for a duty of 120. Ordinarily, experience of nearly a century's working of these canals should indicate the optimum duty which should be adopted for remodelling the existing and designing a new canal system.

1.1 Actual working of these canals has, however, shown that a duty of 60 has been obtained at the head of out-lets of the existing Orissa canal system for Paddy which is the principal crop raised during the Kharif season.

1.2 In the calculation of duty for paddy in an area of ample rainfall, irrigation is fundamentally a practice of supplementing the part of the natural precipitation which is available for crop growth. An estimate of the extent of useful rainfall which contributes towards the growth of crops, is therefore essential.

RAINFALL.

2. Statements 1 and 2 enclosed contain the figures of yearly rainfall for the years 1912 to 1947 in the descending order for stations which fall within the proposed command both in Puri and Cuttack districts.

As will be observed both these districts have an ample rain-fall, the average maximum and minimum for the two districts working out to 91 and 45 inches respectively. The average rain-fall during the period is of the order of about 62 inches.

2.1 For purpose of working out the extent of useful rainfall the following 5 years of lowest rainfall have been selected in case of each district:-

<u>DISTRICT CUTTACK</u>		<u>DISTRICT PURI</u>	
<u>Year</u>	<u>Rainfall in inches.</u>	<u>Year</u>	<u>Rainfall in inches.</u>
1942	47.39	1927	50.03
1927	47.00	1935	49.44
1921	46.34	1926	49.42
1939	44.52	1939	47.69
1918	42.48	1921	47.59
Total	227.73		244.17
Average.	45.55		48.83

It will be seen that on an average there has been a year of low rainfall almost once every 5 years in case of Cuttack district between 1918 to 1942 and once every 4 years in case of Puri district between 1921 to 1939.

2.2 Daily rainfall data has also been collected for each of the 5 years of lowest rainfall for only those stations which fall in the areas to be commanded by the existing and proposed canals.

It is seen that the percentage of the average annual rainfall of the 5 lowest years to the average rainfall during the Monsoon period (16th June to 30th November) works out to an average of 88 percent in the case of both the Puri and Cuttack districts. Thus almost the entire rainfall is confined to the summer months leaving small amount of 12 percent from 1st December to 15th June. This small percentage of rainfall which is untimely and precarious has not been taken into consideration while working out duties for crops in the latter period.

ESTIMATE OF USEFUL RAINFALL.

3. Useful rainfall has, as a rule, been assumed as a certain percentage of the total annual rainfall, varying between 50 to 70 percent, on various projects. As this is very approximate, it is proposed to use the following method described in the Madras Engineering Association P.W.D. Diary 1944, page 495 for working out useful rainfall which, it is understood, is based on results of experiments on water requirements in the Madras State:-

" It is desirable to ignore during transplantation of rainfall less than $\frac{1}{4}$ " in 24 hours, or exceeding 3" in 24 hours or 5" in any 10 days period. After transplantation period, all falls less than 1/10th of an inch in 24 hours or exceeding 2" in 24 hours or 3" in any 10 days period shall be ignored."

3.1 Useful rainfall for the years mentioned in para 2.1 above has been worked out on the Madras method.

The average rainfall for the 5 low years from 16th June to 30th November works out to 41.6 inches.

The useful rainfall calculated on the above method during the same period amounts to 31.0 inches which works out to 74.5% of the average rainfall.

No. 3 statement³ and 4 showing the daily rainfall figures for Cuttack District from June to November for the year 1927 and the useful rainfall for the same year have been attached as specimens.

WATER REQUIREMENTS AND ITS DISTRIBUTION FOR DIFFERENT CROPS:

4. Water requirements of crops proposed to be raised both during Kharif and Rabi were decided at a conference of the Director, Central Rice Research Institute, Cuttack, representative of Director of Agriculture, Orissa State, and representatives of the Central Water and Power Commission.

These are briefly described below:-

JUTE- 15th April to 31st July..	First watering of 8" & thereafter 8 waterings of 4" each.
	Total Delta 40"
AMAN PADDY-15th May to 30th November.	22" for transplantation and 37" for maturing. Total delta excluding nursery period = 59 inches.
BEALI PADDY-15th May to 30th September.	22" for transplantation and 32" for maturing. Total Delta excluding nursery period = 54 inches.
BALUA PADDY-15th Dec. to 30th April.	Same as for Beali Paddy.
COVER CROP , BEGUNE VARIETY:-	One watering of 4" to 6" during December.

4.1 Before working out the duties it is necessary to determine how the water requirements for different crops will be spread out during the period of raising the crop.

A note showing how this has been done in case of Aman Paddy crop, which will cover 80 percent of the commanded culturable area during the Kharif season, is attached, duties for Aman Paddy have been worked out in this note taking 1927 as a specimen year.

COMPUTATION OF DUTIES OF CROPS.

DUTIES FOR AVERAGE YEARS.

5. Duties for Jute, Aman Paddy and Beali Paddy based on water requirements mentioned in para 4 and the useful rainfall as calculated on the Madras method for 5 low rainfall years both for Cuttack and Puri districts have been worked out vide statements 5, 6 and 7, on the lines of the above note.

5.1 The duties so arrived at for Jute, Aman and Beali Paddy and the average duties proposed to be adopted are given below

Month	JUTE			AMAM PADDY			BEALI PADDY.		
	Distt. 'Cutt-ack.	Distt. Puri	'As 'pro-'pos-'ed 'to be 'adopt'ed	'Distt 'Cutt-ack	'Distt 'Puri	'As 'pro-'pos-'ed 'to be 'adop-'ted.	'Distt. 'Cutt-ack.	'Distt. 'Puri	'As 'pro-'pos-'ed 'to be 'adopt'ed
April	45	45	45						
May.	70	70	70	1800	1800	1800			
June 1-15)	135	132	130	1800	1800	1800	1200	1200	1200
16-30)				288	424	350	19	20	20
July	196	174	180	94	97	100	-	3720	-
August.				121	126	125	1950	709	-
September.				224	256	240	208	235	220
October.				123	144	130	122	137	120
November.				160	133	145			

Note:- All duties are at out-let heads.

A duty of 100 for paddy in July instead of an average of 96 has been proposed, as this is considered reasonable from the experience on the canals in the Ganjam district of Orissa State.

DUTIES FOR NON-MONSOON MONTHS.

5.2 Duty for cover crop, leg-ume variety, which requires only one watering 4 to 6 inches in December, works out to 150.

5.3 Duties for remaining crops including sugar-cane and garden which is a yearly crop, have not been calculated but have been taken as already proposed for these crops on the Sambalpur canals Ex. the Hirakud Dam. These duties are shown vide Statement No.8. A sheet showing how the duties of Dalma Paddy have been arrived at is enclosed as statement No.9.

6. As Madras, Bengal Bihar and Madhya Pradesh are predominantly rice growing states with ample rainfall, it would be appreciated if officers of these and other States would kindly offer their comments on their experience on the method of assessing the duty on rainfall, water requirements for crops and computation of duties dependent on this note.

STATEMENT 1.

SHOWING AVERAGE ANNUAL RAIN FALL FOR THE YEAR
1912-1947 DISTRICT CUTTACK.

S.No.	Year	Average Rainfall.	S.No.	Year	Average Rainfall.	Remarks.
1.	1925	92.01	26	1930	56.70	
2.	1936	89.21	27	1913	56.66	
3.	1944	81.42	28	1932	55.08	
4.	1917	77.95	29	1938	53.51	
5.	1933	77.74	30.	1912	51.94	
6.	1928	73.55	31.	1935	48.24	
7.	1937	68.86	32.	1942	47.39	
8.	1926	68.56	33.	1927	47.00	
9.	1947	68.21	34.	1921	46.34	
10.	1940	66.78	35.	1939	44.52	
11.	1919	66.48	36.	1918	42.48	
12.	1941	66.30	Total:		<u>2229.15</u>	
13.	1915	66.14	Average of 36 years :		61.92:	
14.	1920	65.58				
15.	1943	62.77				
16.	1934	62.20				
17.	1929	61.09				
18.	1916	60.27				
19.	1946	59.76				
20.	1914	59.51				
21.	1931.	58.05				
22.	1924	57.56				
23.	1923	57.35				
24.	1945	57.01				
25.	1922	56.93				

STATEMENT 2:

SHOWING AVERAGE ANNUAL RAINFALL FOR THE YEAR
1912-1947

DISTRICT PURI.

S.No.	Year	Average Rainfall:	S.No.	Year	Average Rainfall: F.A.KS
1.	1936	89.48	25	1929	56.06
2.	1943	85.04	26.	1913	55.79
3.	1925.	80.86	27.	1918.	54.53
4.	1917.	78.96	28.	1924	53.93
5.	1944	73.76	29.	1947	52.09
6.	1919	69.67	30.	1942	51.79
7.	1940	68.82	31.	1941	50.89
8.	1933	67.93	32.	1927.	50.03
9.	1928.	67.22	33.	1935	49.44
10.	1946	66.78	34.	1926	49.42
11.	1922	66.70	35	1939	47.69
12.	1916	66.07	36	1921	47.59
13.	1912	65.35	Total:		<u>2221.69</u>
14.	1938.	63.21			<u>Average of 36 years: 61.71:</u>
15.	1937.	62.11			
16.	1920	60.80			
17.	1930	60.67			
18.	1915	60.00			
19.	1932	59.76			
20.	1934	59.34			
21.	1914	58.19			
22.	1923	58.11			
23.	1931	57.14			
24.	1945	56.38			

Month & Date.	Jagatsingh pur.	Dharamsalla.	Cuttack.	Kendrapara	Salepur	Patamundai	Barachana	Total.
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August, 1927.

1	0.67	0.20	1.97	0.81	1.15	0.75	1.61	7.16
2	0.14	-	-	-	-	-	0.27	0.41
3	0.15	0.15	1.15	0.38	0.70	0.63	0.71	3.87
4	0.40	-	-	-	0.08	-	-	0.48
5	-	-	-	-	-	-	-	-
6	0.38	-	0.03	-	-	0.05	0.11	0.57
7	0.37	0.65	1.55	0.17	0.80	0.20	0.98	4.72
8	0.03	0.12	0.26	-	-	0.01	0.17	0.59
9	-	0.15	-	0.07	0.15	-	-	0.37
10	0.35	0.25	0.04	0.25	-	0.78	-	1.67
11	0.26	0.41	0.42	0.18	0.30	0.06	0.20	1.83
12	1.86	0.27	3.15	0.43	0.65	0.60	0.57	7.53
13	0.54	0.42	0.90	1.58	0.85	2.20	0.30	6.79
14	0.02	0.02	-	-	-	-	-	0.04
15	0.10	-	0.13	0.13	-	0.22	0.09	0.67

Total from 1st to 15th August.

16	0.57	0.57	0.39	0.88	0.30	0.88	0.30	3.89
17	0.39	0.37	0.04	0.74	0.13	0.32	0.24	2.23
18	0.28	0.72	2.22	1.68	0.70	0.50	0.60	6.70
19	0.42	0.72	1.35	-	0.27	-	0.48	3.24
20	0.03	0.15	0.67	0.06	0.17	-	0.04	1.12
21	0.95	-	-	-	0.15	-	-	1.10
22	0.73	-	1.24	-	-	-	-	1.97
23	0.27	0.41	3.08	0.10	-	0.30	-	4.16
24	0.44	0.23	0.49	0.42	-	0.35	-	1.93
25	0.36	0.25	0.70	0.12	0.48	0.12	0.40	2.43
26	0.01	-	0.04	-	0.37	-	-	0.42
27	-	1.40	0.05	0.09	-	0.47	0.03	2.04
28	0.97	0.34	0.02	0.39	-	0.51	-	2.23
29	0.41	-	0.22	0.96	0.24	0.25	0.09	2.17
30	0.62	-	-	-	-	-	0.40	1.02
31	0.01	0.40	-	0.05	-	0.27	0.46	1.19

Total from 16th to 31st August.

Total for the month.

September, 1927.

1	0.02	0.52	-	0.02	-	0.37	-	0.93
2	0.22	1.10	1.90	1.49	0.69	1.27	0.98	7.65
3	0.09	-	0.03	0.03	-	-	0.05	0.20
4	0.97	-	0.58	0.92	2.00	1.15	0.05	5.67
5	0.80	0.72	0.52	1.56	0.30	0.36	0.60	4.86
6	0.28	-	-	-	-	-	0.40	0.68
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	0.09	0.02	1.45	0.44	-	0.87	0.08	2.95
11	-	-	-	-	-	0.06	-	0.05
12	-	-	-	-	-	-	-	-
13	-	-	0.02	-	-	-	-	0.02
14	-	0.30	1.64	-	-	-	0.07	2.01
15	-	-	0.05	0.20	-	0.17	-	0.42
16	0.21	-	-	-	-	0.16	-	0.37
17	1.61	-	0.08	0.05	-	0.08	-	1.82
18	0.16	0.20	0.05	-	-	-	0.88	1.29
19	0.35	0.62	1.08	-	1.20	-	0.08	3.33
20	0.01	-	0.20	-	-	-	-	0.21
21	-	0.14	0.02	-	-	-	-	0.16
22	-	-	-	-	-	-	-	-
23	0.26	-	-	-	-	-	0.25	0.51
24	0.27	0.95	1.19	1.81	1.15	0.76	1.14	7.27
25	-	0.09	-	0.50	-	0.20	-	0.79
26	1.92	0.20	2.39	0.26	0.70	0.81	0.78	7.06
27	-	-	-	-	-	0.17	-	0.17
28	-	-	-	0.39	-	0.70	-	1.09

Total for the month.

STATEMENT NO. 3 (CONTD).

Month & Day	Jagatsinghpur	Dharamsala	Cuttack	Kendrapara	Salepur	Patamundai	Barchana	Total	Average	Useful rainfall
1	2	3	4	5	6	7	8	9	10	11

October 1927.

1	..	0.07	..	..	..	..	..	0.07	0.01	
2	..	..	..	..	..	..	..	..	..
3	..	..	..	..	..	..	..	..	..
4	1.60	0.67	0.02	..	0.15	0.18	1.15	3.77	0.54	
5	3.95	5.42	2.64	1.21	1.70	0.88	2.29	18.09	2.58	
6	0.30	0.37	0.63	1.03	..	0.51	0.12	3.06	0.44	
7	0.05	0.06	..	0.04	..	0.07	..	0.22	0.03	
8	..	0.25	..	..	..	..	..	0.25	0.04	
9	..	..	..	..	..	0.13	..	0.13	0.02	
10	..	..	..	..	..	..	..	..	..
11	..	2.87	..	..	..	..	..	2.87	0.41	
12	..	..	..	..	..	..	..	..	..
13	..	..	..	..	..	..	..	..	..
14	..	..	..	..	..	..	..	..	..
15	..	..	..	..	..	..	..	..	..
16	0.34	..	..	..	..	..	..	0.34	0.05	
17	..	..	..	..	..	..	..	..	..
18	..	..	..	..	..	..	..	..	..
19	..	..	..	..	..	..	..	..	..
20	..	..	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..	..	..
22	..	..	..	..	..	..	..	..	..
23	..	..	..	..	..	..	..	..	..
24	..	..	..	..	..	..	..	..	..
25	..	..	..	..	..	..	..	..	..
26	..	..	..	..	..	..	..	..	..
27	..	..	..	..	..	..	..	..	..
28	..	..	..	..	..	..	..	..	..
29	..	..	..	..	..	..	..	..	..
30	..	..	..	..	..	..	..	..	..
31	0.38	..	..	..	..	..	..	0.38	0.05	
Total for the month.										<u>4.17</u>

November 1927:

1	0.07	..	0.26	0.53	0.40	0.38	..	1.64	0.23	
2	..	..	..	..	..	..	..	..	..
3	..	..	..	..	..	..	..	..	..
4	..	..	..	..	..	..	..	..	..
5	..	..	..	..	..	..	..	..	..
6	..	..	..	..	..	..	..	..	..
7	0.04	..	..	..	..	..	..	0.04	0.01	
8	..	..	..	..	..	..	..	..	..
9	..	..	..	..	..	..	..	..	..
10	..	..	..	..	..	..	..	..	..
11	..	..	..	..	..	..	..	..	..
12	..	..	..	..	..	..	..	..	..
13	..	..	..	..	..	..	..	..	..
14	..	..	..	..	..	..	..	..	..
15	..	..	..	..	..	..	..	..	..
16	..	..	..	..	..	..	..	..	..
17	..	..	..	..	..	..	..	..	..
18	..	..	..	..	..	..	..	..	..
19	..	..	..	..	..	..	..	..	..
20	..	..	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..	..	..
22	..	..	..	..	..	..	..	..	..
23	..	..	..	..	..	..	..	..	..
24	..	..	..	..	..	..	..	..	..
25	..	..	..	..	..	..	..	..	..
26	..	..	..	..	..	..	..	..	..
27	..	..	..	..	..	..	..	..	..
28	..	..	..	..	..	..	..	..	..
29	..	..	..	..	..	..	..	..	..
30	..	..	..	..	..	..	..	..	..
31	..	..	..	..	..	..	..	..	..

for the month.

0.24

SHOWING THE USEFUL RAINFALL WORKED OUT ON MADRAS METHOD FOR THE YEAR 1927.

Date	June-1927.			July-1927.			August-1927.			Sept' 1927.			October-1927.			November-1927.		
	Average rain-fall.	Useful full daily rainfall.	Useful rain-fall during the period.	Average rain-fall.	Useful daily rain-fall.	Useful rain-fall during the period.	Average rain-fall.	Useful daily rain-fall.	Useful rain-fall during the period.	Average rain-fall.	Useful daily rain-fall.	Useful rain-fall during the period.	Average rain-fall.	Useful daily rain-fall.	Useful rain-fall during the period.	Average rain-fall.	Useful daily rain-fall.	Useful rain-fall during the period.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1				0.02	-	-	1.02	1.02		0.13	0.13		0.01	-		0.23	0.23	0.23
2				1.05	1.05	1.05	0.06	-		1.09	1.09		-	-		-	-	-
3				0.77	0.77		0.55	0.55		0.03	-		-	-		-	-	-
4				0.58	0.58		0.07	-		0.81	0.81		0.54	0.54		-	-	-
5				0.07	-	0	-	-		0.69	0.69		2.58	2.00		-	-	-
6				0.13	-		0.08	-		0.10	0.10	3.00	0.44	0.44		-	-	-
7				-	-		0.67	0.67		-	-		0.03	-	3.00	0.01	-	-
8				0.56	0.56	5.00	0.08	-	4.55	-	-		0.04	-		-	-	-
9				-	-		0.05	-		-	-		0.02	-		-	-	-
10				-	-		0.24	-		0.42	0.42		-	-		-	-	-
11				3.67	3.00		0.26	0.26		0.01	-		0.41	0.41		-	-	-
12				2.19	2.19		1.08	1.08		-	-		-	-		-	-	-
13				0.69	0.69	0.69	0.97	0.97		-	-		-	-		-	-	-
14				0.14	-		0.01	-		-	-		-	-		-	-	-
15				0.20	-		0.10	-	4.55	0.29	0.29	0.29	-	-		-	-	-
							5.24											
16	0.15	-		-	-		0.36	0.56		0.06	-		0.05	-		-	-	-
17	0.45	0.45		-	-		0.56	0.32		0.05	-		-	-		-	-	-
18	0.26	0.26		0.11	-		0.96	0.96		0.26	0.26		-	-		-	-	-
19	0.20	-		0.21	-		0.46	0.46		0.18	0.18		-	-		-	-	-
20	0.01	-		0.32	0.32		0.16	0.16		0.48	0.48		-	-		-	-	-
21	0.03	-		1.28	1.28		0.16	0.16	3.00	0.03	-		-	-		-	-	-
22	0.62	0.62		0.31	0.31		0.28	0.28		0.02	-		-	-		-	-	-
23	0.12	-	2.78	0.67	0.67	4.82	0.59	0.59		-	-		-	-		-	-	-
24	0.13	-		0.67	0.67		0.28	0.28		-	-	3.24	-	-		-	-	-
25	0.40	0.40		0.08	-		0.35	0.35		0.07	-		-	-		-	-	-
26	0.20	-		0.14	-		0.06	-		1.04	1.04		-	-		-	-	-
27	-	-		0.17	-		0.29	0.29		0.11	0.11		-	-		-	-	-
28	0.39	0.39		0.15	-		0.32	0.32	1.24	1.01	1.01		-	-		-	-	-
29	0.36	0.36		1.20	1.20		0.31	0.31		0.02	-		-	-		-	-	-
30	0.30	0.30		0.07	-		0.15	0.15		0.16	0.16		0.05	-	3.00	0.24	-	0.23
31				0.37	0.37		0.17	0.17					4.17	-				
	<u>3.62</u>		<u>2.78</u>	<u>15.82</u>		<u>11.56</u>	<u>5.42</u>		<u>4.24</u>	<u>7.06</u>		<u>6.53</u>						
							10.66		<u>8.79</u>									

-236-

"Chaman"
17.9

Note showing the water requirements and the method of working out duties during various periods for "AMAN PADDY" Crop

For working out duties the following assumptions are made:-

1. Seedling will be raised from 16th May to 30th June and the percentages during each month are taken as under:

May 16-31:	33 1/3 %
June:	66 2/3 %
2. The useful rainfall that can be utilised for the growth of crop has been worked out on the method adopted in Madras which is as under:-

Transplantation period :-

- a) Rainfall below quarter of an inch or exceeding three inches in 24 hour period has been ignored;
- b) Rainfall exceeding 5" in any 10-day period has been ignored;

Maturing period:

- a) Rainfall below 0.10" or exceeding 2" in 24 hour period has been ignored;
- b) Rainfall exceeding 3" in any 10 day period has been ignored;

3. Total quantity of rainfall required including useful rainfall for raising on good Aman Paddy crop is:-

a) Raising of seedling:	0.60"
b) Ploughing and transplantation.	22"
c) Maturing of crop:	37"
	59.6"

4. About 20% of water intended for ploughing and transplanting will be used from 16th June to 30th June, 50 % in the month of July and 30 % from 1st to 15th August:
5. The quantity of water required for maturing of crops in the 6 months period from July to November will be in the proportion ~~July~~ of $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, $\frac{3}{4}$ respectively:
6. The requirements during different periods will be as under:

May 16-31:	Raising of seedling:	0.20"
June 1-15:	-do-	0.20"
June 16-30:	-do-	0.20"
	Ploughing and Transplantation.	
	20% of 22"	4.40"
July 1-31:	Ploughing & transplantation	
	50% of 22"	11.00"
	Maturing of crop $\frac{3}{4} \times 1/5 \times 37$	5.55"
August 1-31:	Ploughing and transplantation	
	30% of 22"	6.60"
	Maturing of crop $1 \times 1/5 \times 37$	7.40"
September 1-30	Maturing of crop $5/4 \times 1/5 \times 37$	9.25"
October 1-30:	-do- $5/4 \times 1/5 \times 37$	9.25"
November 1-30:	-do- $\frac{3}{4} \times 1/5 \times 37$	5.55"
	Total.	59.60"

Duties for Aman Paddy during the year 1927 are worked out in the following table:-

AMAN PADDY:

Period:	Details of requirement	Depth on the field in inches:	Duty at outlet head.
May 16-31:	Raising of seedling:	0.20	1800
June 1-15:	-do-	0.20	1800
June 16-30:	-do-	0.20	1800
	Ploughing and Transplantation:	<u>4.40</u>	
	Total	<u>4.60</u>	
	Deduct useful rainfall:	2.78	
	Balance required:	1.82	198
July 1-31:	Ploughing and Transplantation:	11.0	
	Maturing of crop:	<u>5.55</u>	
	Total	<u>16.55</u>	
	Deduct useful rainfall:	<u>11.56</u>	
	Balance required.	4.99	149
August 1-31	Ploughing & Transplantation:	6.60	
	Maturing of crop.	<u>7.40</u>	
	Total:	<u>14.00</u>	
	Deduct useful rainfall:	<u>8.79</u>	
	Balance required:	5.21	143
Sept:1-30	Maturing of crop:	9.25	
	Deduct useful rainfall.	<u>6.53</u>	
	Balance required.	2.72	265
OCT.1-31:	Maturing of crop:	9.25	
	Deduct useful rainfall.	<u>3.00</u>	
	Balance required.	6.25	119
Nov.1-30	Maturing of crop:	5.55	
	Deduct useful rainfall.	<u>0.23</u>	
	Balance required	5.32	135

SHOWING THE DUTIES FOR JUNE FOR CUTTACK AND PURI DISTRICTS FOR 5 LOWER YEARS OF INFANTS

Year	April	Duty:	May	Duty	Depth of waterings required	Depth of waterings required	Useful rain-fall.	June	Duty	Depth of waterings reqd.	Useful rain-fall.	July	Duty.
	16-30: Depth of waterings required.		Balance reqd.					Balance required.					
<u>DISTRICT CUTTACK.</u>													
1918	8.00	45	10.67	70	10.67	7.14	3.53	204	10.67	5.94	4.73	157	
1921	"	"	"	"	10.67	5.56	5.11	141	10.67	6.34	4.33	172	
1927	"	"	"	"	"	5.12	5.55	130	10.67	7.72	2.95	252	
1939	"	"	"	"	"	4.52	6.15	117	10.67	6.76	3.91	190	
1942	"	"	"	"	"	4.27	6.40	112	10.67	7.58	3.09	241	
							26.74	-			19.01		
							5.35	135			3.80	196	
<u>DISTRICT PURI:</u>													
1921	8.00	45	10.67	70	10.67	6.79	3.88	186	10.67	4.51	6.16	121	
1926	"	"	"	"	"	2.73	7.94	91	10.67	6.02	4.65	160	
1927	"	"	"	"	"	6.00	4.67	154	10.67	7.10	3.57	208	
1935	"	"	"	"	"	4.91	5.76	125	10.67	9.00	1.67	446	
1939	"	"	"	"	"	5.60	5.07	142	10.67	6.06	4.61	161	
							27.32				20.66		
							5.46	132			4.13	174	
Note: No rainfall taken into account:													
Duty proposed.		45		70				130.					180

showing the duties for Aman Paddy for Cuttack and Puri Districts for five low years of rainfall.

Year	June 16-30				July				August				September				October				November			
	Depth of waterings required.	Useful rain-fall.	Balance required	Duty	Depth of waterings reqd.	Useful rain-fall.	Balance required	Duty	Depth of waterings reqd.	Useful rain-fall.	Balance reqd.	Duty	Depth of waterings reqd.	Useful rain-fall.	Balance reqd.	Duty	Depth of waterings reqd.	Useful rain-fall.	Balance reqd.	Duty	Depth of waterings reqd.	Useful rain-fall.	Balance reqd.	Duty
<u>DISTRICT CUTTACK.</u>																								
1918	4.60	3.33	1.27	283	16.55	5.23	11.32	66	14.0	8.46	5.54	134	9.25	5.03	4.22	171	9.25	0.38	8.87	84	5.55	-	5.55	130
1921	4.60	4.74	-	-	16.55	7.36	9.19	81	14.0	6.38	7.62	98	9.25	6.80	2.45	294	9.25	2.71	6.54	114	5.55	-	5.55	130
1927	4.60	2.78	1.82	198	16.55	11.56	4.99	149	14.0	8.79	5.21	143	9.25	6.53	2.72	265	9.25	3.00	6.25	119	5.55	0.23	5.32	135
1939	4.60	2.65	1.95	185	16.55	9.46	7.09	165	14.0	5.91	8.09	92	9.25	4.71	4.54	159	9.25	6.62	2.63	283	5.55	0.40	5.09	141
1942	4.60	3.37	1.23	293	16.55	9.75	6.80	109	14.0	9.62	4.38	170	9.25	7.07	2.18	330	9.25	3.39	5.86	127	5.55	4.63	0.92	783
Total.			6.27				39.39				30.84			16.11			30.15					22.43		
Average.			1.25	288			7.88	94			6.17	121		3.22	224			6.03	123			4.49	160	
<u>DISTRICT PURI.</u>																								
1921	4.60	5.18	-	-	16.55	6.16	10.39	72	14.0	6.50	7.50	99	9.25	6.58	2.67	270	9.25	5.52	3.73	199	5.55	-	5.55	130
1926	4.60	1.92	2.68	134	16.55	5.59	10.96	68	14.0	12.91	1.09	683	9.25	7.20	2.05	351	9.25	3.91	5.34	139	5.55	-	5.55	130
1927	4.60	5.40	-	-	16.55	10.25	6.30	118	14.0	10.78	3.22	231	9.25	7.20	2.05	351	9.25	3.25	6.00	124	5.55	0.16	5.39	134
1935	4.60	4.01	0.59	610	16.55	14.94	1.61	462	14.0	5.61	8.39	89	9.25	6.22	3.03	238	9.25	0.86	8.40	89	5.55	-	5.55	130
1939	4.60	3.60	1.00	360	16.55	7.54	9.01	83	14.0	4.78	9.22	81	9.25	4.98	4.27	169	9.25	6.86	2.39	311	5.55	0.47	5.08	142
Total.			4.27				38.27				29.42			14.07			25.86					27.12		
Average.			0.85	424			7.65	97			5.88	126		2.81	256			5.17	144			5.42	133	
Duty proposed.				350				100				125			240					130				145

SHOWING THE DUTIES FOR BEARLPADDY FOR CUTTACK AND PURI DISTRICTS FOR FIVE LOW YEARS OF RAINFALL.

Year	June 16-30				JULY				August				September				October			
	Depth of waterings reqd.	Useful rain-fall.	Bala-nce reqd.	Duty	Depth of waterings reqd.	Useful rain-fall.	Bala-nce reqd.	Duty	Depth of waterings reqd.	Useful rain-fall.	Bala-nce reqd.	Duty	Depth of waterings reqd.	Useful rain-fall.	Bala-nce reqd.	Duty	Depth of waterings reqd.	Useful rain-fall.	Bala-nce reqd.	Duty.
<u>DISTRICT CUTTACK.</u>																				
1918	22.30	3.33	19.97	19	5.50	5.94	-	-	7.50	7.74	-	-	9.50	5.03	4.47	161	9.50	0.38	9.12	82
1921	22.30	4.74	17.56	21	5.50	6.34	-	-	7.50	6.59	0.91	818	9.50	6.80	2.70	267	9.50	2.71	6.79	110
1927	22.30	2.78	19.52	18	5.50	7.72	-	-	7.50	8.30	-	-	9.50	6.53	2.97	242	9.50	3.00	6.50	114
1939	22.30	2.65	19.65	18	5.50	6.76	-	-	7.50	6.55	0.95	783	9.50	4.71	4.79	163	9.50	6.62	2.88	258
1942	22.30	3.37	19.93	19	5.50	7.58	-	-	7.50	7.99	-	-	9.50	7.07	2.43	296	9.50	3.39	6.11	122
Total:			94.63	95			-	-			1.90				17.36				31.40	
Average.			18.93	19							0.38	1950			3.47	208			6.28	119
<u>DISTRICT PURI:</u>																				
1921	22.30	5.18	17.12	21	5.50	4.51	0.99	752	7.50	6.42	1.08	689	9.50	6.58	2.92	247	9.50	5.52	3.98	187
1926	22.30	1.92	20.38	18	5.50	6.02	-	-	7.50	9.41	-	-	9.50	7.20	2.30	313	9.50	3.91	5.59	133
1927	22.30	5.40	16.90	21	5.50	7.10	-	-	7.50	8.28	-	-	9.50	7.20	2.30	313	9.50	3.25	6.25	119
1935	22.30	4.01	18.29	20	5.50	9.00	-	-	7.50	5.61	1.89	394	9.50	6.22	3.28	220	9.50	0.85	8.65	86
1939	22.30	3.60	18.70	19	5.50	6.06	-	-	7.50	5.20	2.30	323	9.50	4.98	4.52	159	9.50	6.86	2.84	282
Total.			91.39	99			0.99				5.27				15.32				27.11	
Average.			18.28	20			0.20	3720			1.05	709			3.06	235			5.42	137
Duty proposed.				20												220				120

"Chaman"
17.9

STATEMENT NO. 8

SHOWING DATES OF SUGAR CANE, GRADES AND
OTHER NON-MONSOON CROPS- ON THE
ORISSA CANALS;

Month	Sugar-cane & garden.	Wheat Cotton & G. nuts.	Vegetable & Potatoes.	Dalua Paddy.
November.	60	-	200	-
December.	60	200	200	1200
January.	60	200	200	27
February.	60	200	200	90
March.	60	200	200	78
April.	60	200	200	76
May.	60	-	-	-
June.	65			
July.	120			
August.	120			
September.	120			
October.	120			

"Chaman"
17.9

STATEMENT 9:

DALUA PADDY.

Period.	Details of requirements.		Depth on the field in inches.	Duty at outlet head.
December 16-31	Raising of seedling.	0.30	0.30	1280 say 1200
January 1-31	Raising of seedlings	0.30		
	Ploughing & transplantat- ion.	22.00		
	maturing of crops.	5.50		
		27.80	27.80	27
February.	Maturing of crop:	7.50	7.50	90
March.	Maturing of crop.	9.50	9.50	78
April.	Maturing of crop.	9.50	9.50	76

"Chaman"
17.9

APPENDIX XII.

Note on the areas, alignments and design
of the New Canal system in Puri District.

By

Shri K.S.Misra.

APPENDIX XIII.NOTE ON THE AREAS, ALIGNMENT & DESIGN OF THE
NEW CANAL SYSTEM.

BY
SHRI K.S. MISRA, EXECUTIVE ENGINEER,
DELTA IRRIGATION DIVN.

AREAS.

The Districts of Puri and Cuttack have got 5.36 lac acres of the C.C.A. (in Deltaic region) requiring New Canal Irrigation. This area lies in the Delta of the Mahanadi river system and consists of Doabs between 'Kathjuri-Kushbhadra', Kushbhadra-Bhargavi' and 'Bhargavi-Daya rivers' and area on the west of the Daya river.

HEAD WORKS:-

For irrigating these areas the required canal has to take off from the Mahanadi river and an evident site is some where near Naraj, so that, the highest areas above mentioned (i.e. on the west of Daya river) may be easily commanded, and then the canal can proceed on to the other three Doabs lower down.

To feed this canal, a weir across the Mahanadi is essential. At Naraj, the river throws off a branch on the right called Katjuri across which a solid weir already exists. So, it would have been enough to construct a weir across the left branch only at Naraj.

USE OF EXISTING NARAJ WEIR.

If the existing Naraj weir was capable of being repaired, and strengthened for perennial irrigation, then the above site for the new weir would have been most economical.

As it is, the existing Naraj weir across the Katjuri is in a very bad condition and it is not found capable of being repaired for perennial irrigation.

So, it is necessary to propose a weir higher up across the undivided Mahanadi river.

NEW WEIR IN THE GORGE AT NARAJ ON ROCK FOUNDATIONS:-

Cost of weir would have been low if rock foundations, could be located for it in the Naraj Gorge which is narrow being about half the width of the normal river. Trial borings were done but, satisfactory rock could not be met with at economical depth.

So, finally, the site of the proposed weir has been selected further up just upstream of Sidheshwar Temple, above the Naraj Gorge. Here the river runs in a straight reach and the bed is uniform- its width being about 6,000 ft.

HEAD REGULATOR OF MAIN CANAL:-

The site of head regulator for the canal has been selected about one mile above the weir site, near Baramandali village on the right bank of the Mahanadi, where the deepest bed is permanently situated due to curvature in the course of the river.

THE MAIN CANAL ALIGNMENT.

(1). The Main canal starts from the Head Regulator above mentioned and runs in the valley line to minimise the depth of excavation. It crosses the existing Cuttack-Banki road at its 7th mile from Cuttack. Here no bridge crossing has been provided because, it is proposed to construct an approach road from the 10th mile of Cuttack-Banki Road upto the Head Regulator of the canal, where the road will cross over the head regulator. Then, the first 3 miles of the Inspection paths on the left bank of the canal will be metalled i.e. till the Cuttack-Banki road is met with at 7th mile from Cuttack as above mentioned.

Further below, the canal runs on lowest possible ground again (to minimise the depth of excavation) near the Barang Nullah.

CANAL CROSSING UNDER ROAD AND RAILWAY LINE AT BARANG.

(2) The Road Bridge at Barang has got 12 spans. All of these will be used for passing the canal discharge.

There are two more road culverts near-by on the south of the Barang Road Bridge, which will be utilised for passing the small discharge of two thousand cusecs of Barang Nullah (previously when Banki Road Spill used to flow, the main Barang Bridge was required for passing that big discharge. Now, the Banki road spill has been proposed to be completely closed). A masonry wall combined with "Stone pitched" earthen embankment would be constructed between the Barang Road Bridge and the Barang Railway Bridge and also further below the latter for taking out the main canal under the railway line. Thereafter, the main canal will go towards the Kuakhai river. The Masonry wall above mentioned will form a partition under the Barang Railway Bridge between the Canal and the Barang Nullah, which goes to join the Kuakhai river.

FROM BARANG CROSSING TO KUAKHAI SYPHON.

(3) After passing Barang the canal will go in suitable ground towards the Kuakhai syphon site, where Branch No.8 off-takes for irrigating areas to the West of Daya river.

Just before entry of the canal into the Kuakhai syphon a 'low level' escape has been provided. The escape channel will join the Kuakhai river on its right bank within the shortest possible distance of about a thousand feet. In order to make this Escape function satisfactorily at the time when Kuakhai river is in high flood it may be necessary to create working head. This will be possible by "Heading up" of the canal water upstream of the syphon site by means of regulator on the upstream side of the syphon. If necessary, for a few hours that the Escape has to function, the flood level in the Kuakhai river would also be lowered by adequate regulation at the Kuakhai river "Off-take" at Kazipatna.

KUAKHAI SYPHON TO BALIANTA SYPHON.

(4). On the downstream side of the Kuakhai syphon (which is situated on the canal, 10½ miles away from its Head) a regulator will be constructed for off-taking the left branch of Kushbhadra-Katjuri Doab and other distributaries. The main canal thereafter, will run 'ditch to the Kuakhai river wherever

possible, upto the crossing under the National High-way Road Bridge. The canal will go through the extreme left span of the Bridge. One span of this bridge will become surplus for the canal crossing because the flood moderated discharge of Kuakhai river will be far less than the previous maximum floods, for which the entire water-way of this bridge had been designed.

After the National High-way Bridge, the canal will take a curve and pass round Balianta Village. Finally, it will take a turn again to enter the Kushbhadra river syphon at right angles to the river. To minimise land width required by the canal in the inhabited area, just near the Kushbhadra Syphon, "Lined Section" of the canal has been provided in a small length through Balianta Village.

On both sides of the Kushbhadra syphon, Regulators will be made for taking off distributaries and branches for irrigating Kathjuri-Kushbhadra Doab and Kushbhadra-Bhargavi Doab.

BALIANTA TO SARDEIPUR.

(5) Below Kushbhadra Syphon the main canal will run 'ditch' to the Kuakhai river upto Sardeipur, where the Bhargavi river branches off. At this place, the canal will be syphoned under the Bhargavi and come out on its right side, where the main canal will terminate at the twenty-seventh mile.

On the upstream and downstream sides of this syphon, Branches and Distributaries will take off to irrigate the Doabs between "Kushbhadra and Bhargavi" and "Bhargavi and Daya" rivers respectively. An escape will also be constructed on just upstream of the Bhargavi Syphon to pass surplus water of the canal into the Bhargavi.

DESIGN.

The Design of the Canal is done by Lacey's Formulae. The entire canal is non-Navigable. Total length of the canal is 27 miles. Its maximum discharge is 5954 cusecs. Slope provided varies from 1 in 10,600 to 1 in 9,090. The maximum and the minimum Bed width and water depth vary from " 188 ft.

to 112 ft." and " 9.9 ft. to 7.4 ft." respectively.

To obtain most economical results the canal has been taken in lowest possible lands from its head upto Kuakhai syphon. Thereafter, it runs "ditch" to the river Kuakhai, upto Sardeipur and the section of the canal has been designed for "balancing depth" as far as possible.

III. BRANCHES.

There are eight main branches, two for each of the following tracts to be irrigated:-

ALIGNMENT.

- i). Katjuri-Kushbhadra Doab.
- ii). Kushbhadra-Bhargavi Doab.
- iii). Bhargavi-Daya Doab and
- iv). Area on west of Daya river.

In the centre of each of these tracts, there is a deep drainage channel for discharging flood water of rivers from escapes. Banks of the rivers are situated on the highest ridge lines in the Doabs. So, all the main branches are proposed along both banks of the three rivers Kushbhadra, Bhargavi and Daya. One branch will also be situated along the right bank of the Katjuri river and another branch will run on Contour Alignment in the Khurda area on the west side of the tract. Thus, in all there will be eight main branches for the irrigation system running on the extreme boundaries of the areas for irrigation. Some channels in addition to the above will also be constructed for intermediate portions of the areas.

DESIGN:-

In all the branches running 'ditch' with rivers the design has been kept such as to minimise the cost of Earthwork and land. The channels are proposed to be kept in 'Balancing Depth' as far as possible.

ESTIMATE:-

One branch namely, Gop Branch has been estimated in complete details and its cost per acre of C.C.A. has been worked out to estimate the cost of all the branches (on basis of this rate per acre of C.C.A.) for irrigating the entire new Delta Area.

DESIGN & ESTIMATE OF GOP BRANCH CANAL.

It takes off at 19.8 Miles of Main canal.

Total length equals to 25½ miles.

It runs by the side of River with a common embankment, as the ridge line is by the side of the river.

Total C.C.A equals to 77,794 Acres, and Discharge equals to 864 Cusecs.

It is given in a slope of one in six thousand.

Bed width varies from 64.0 to 35.0 feet.

F.S. depth varies from 5.2 to 3.65 feet.

Velocity varies from 2.5 feet to 2.0 feet/Sec.

Four distributary systems (Viz. L 1 at 4th mile, L2, L3 at 14th mile and L 4 at 25½ mile) take off. There are 3 regulators at 4th, 14th & 25½ miles combined with drops and Road Bridges for class B.(I.B.C). Loading Rate per acre of C.C.A. comes to Rupees 16/-.

IV. DISTRIBUTARIES.

One distributary system (R1 distributary system of Kakatpur Branch) has been designed in complete detail applying 'Lacy's Formulae' and estimated. Its cost has been distributed on the C.C.A. irrigated by it. Then this cost per acre of C.C.A. irrigated has been applied to work out the cost of entire distributary system for the new Delta Areas. All distributaries as usual, have been aligned on the ridge line as far as possible and they have been kept in 'balancing depths' to get maximum economy.

R1 Distributary system which takes off at 2½ miles of Kakatpur Branch of Katjuri-Kushbhadra Doab has been selected as a typical distributary system for estimate purposes. This system consists of the R1 Distributary, & 4 minors viz. R1A,

R1B, R1C and R1D. Total length is 23.75 mile with a C.C.A. of 12,027 acres.

Slopes vary from $1/3000$ to $1/5000$.

Bed width varies from 24.0 to 2.6 feet.

F.S. depth varies from 3.1 to 1.5 feet.

Velocity varies from 1.7 to 1.0 feet.

There is one regulator at $1\frac{1}{4}$ mile from which R1A takes off.

There is another at $3\frac{1}{4}$ mile from which R1B, R1C and R1D take off. Both the regulators are combined with falls and road bridges for Class B; (IRC) loading. There is one drop of 3.6 feet in R1C minor and another of 1.81 Ft in R1 Distributary. The latter has been provided with a road bridge. Cost per acre of C.C.A. comes to Rs. 41/4/-.

WATER COURSES.

A small tract of land has been designed for lay-out of water courses in full detail and cost per acre of C.C.A. of the irrigated area has been analysed. With this the entire cost of water-course system in the new Delta Areas has been calculated. Design of water-courses has been done by Kennedy Formulae (Garrett Diagrams) because Lacey Diagrams do not show such small sections.

An area of 6.86 acres with a C.C.A. of 652 acres has been selected for the layout and design of typical W.C. system.

The system consists of 6 water-courses with a total length of 7.35 miles. On an average, discharge of each water-course is 1 cusec, its length about one mile and area irrigated about 100 acres. In case of water-courses which branch off into one or more units, the discharge has been kept at one cusec only as these will run by rotation. Each water course irrigates on either side a distance of about 600 feet. The alignment runs adjoining the field boundaries. Slopes are taken following general ground slopes. Bed width is kept as 1 foot.

Cost per acre of C.C.A. is Rs. 13/5/-.

V. DRAINAGE:-

Cost of Drainage per acre of C.C.A. has been provided as 5/-/-. This will comprise of improving the existing main and subsidiary drainages.

PROTECTION WORKS.

Necessary embankments have been designed and estimated for Mahanadi above Naraj, Katjuri Right bank below Naraj upto Kuakhai off-take, Kuakhai right Embankment upto Mancheswar, Kushbhadra river from '2 miles above Gop' upto its out-fall into the sea and Daya river Right bank from its 11th mile to 35 miles where the existing embankments are situated to check saline water.

NOTE ON THE ALTERNATE PROPOSAL (off-take from Taldanda Canal.

An alternative proposal for taking off the main canal for new Delta Areas is by taking off from the Taldanda Canal near National High Way Bridge over the Taldanda Canal at Cuttack. This will necessitate the present Head Regulator of Taldanda Canal at Jobra to pass a discharge of 7,200 cusecs.

In addition, the capacity of the existing Taldanda canal in the town of Cuttack will have to be increased by providing a lined section for a length of about two miles. At National High Way Bridge over Taldanda Canal a bifurcation will have to be provided. Canal for new Delta Areas will take off from here with a discharge of 5,000 cusecs. It will run in between the Railway line and the National High Way till the Kathjuri river where a barrage combined with existing National High Way Bridge will be constructed. Two double acting Regulators have been provided at entry and exit of the main canal from the Katjuri River.

The canal will emerge out on the right side of Kathjuri and join the first alignment above mentioned (from Naraj Weir) downstream of the Kuakhai siphon. Thereafter, further canal alignment will be the same as per first proposal.

This alternative will not be able to irrigate 86,000 acres of C.C.A., situated on the West of Daya river, which the first proposal would be able to do. The cost per acre of C.C.A. irrigated by this alternative is slightly cheaper (cost per acre of C.C.A. by first proposal is Rs. 200/- whereas in this alternative of the alignment from Taldanda, it comes to Rs. 183/-).

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APPENDIX XIII

AN EXTRACT FROM CHAPTER VII VOLUME I.A. OF THE
REVISED HIRAKUD DAM PROJECT SHOWING THE WATER
RATES ADOPTED IN OTHER PROJECTS.

APPENDIX XIII

An extract from Chapter VII Volume I.A of the Revised Mirakud Dam Project showing the water rates adopted in other Projects.

7.3 MYSORE

In Mysore, under the Irwin Canal system, the owner executes an agreement to pay a contribution (capital levy) of Rs.150/- per acre either by instalments or in a lumpsum, a rebate of 7% being given in the latter case.

In addition to the above contribution, the land owner pays the water rate of :-

- Rs 4/- during the 1st year;
- Rs.6/- during the 2nd year;
- Rs.8/- during the 3rd year;
- Rs.10/- per acre from 4th year onwards.

Water rates on some of the Projects, which are under the process of construction are as under:-

7.4 TUNGABHADRA PROJECT:

On the Tungabhadra Project, a betterment fee of Rs.50/- per acre or one acre of land to Government in lieu thereof or payment of Rs.62/8/- in 10 instalments of Rs.6/4/- each, have been assumed in working out the financial statements, The water rates levied are:-

Sugar-cane	Rs.12/- per acre
Other perennial crops.	Rs.12/- -do-
8 months crops.	Rs. 9/- -do-
Kharif Paddy.	Rs. 6/- -do-
Rabi Paddy.	Rs. 6/- -do-
Wheat	Rs. 4/- -do-
Other Kharif crops	
other rabi crops.	

7.5 MOR PROJECT:-

A betterment fee for rabi at Rs.100/- per acre has been recommended to Government for legislation and approval. A Kharif water rate of Rs.10/- and rabi water rate of Rs.15/- per acre have been recommended.

7.6 D.V.C.

In the case of D.V.C Project, the water rates have not yet been finalised, but those recommended are Rs.10/- for Kharif

and Rs.15/- for rabi. In addition a betterment fee of Rs.100/- per acre of non-perennial and Rs.150/- per acre for perennial areas are proposed to be levied

7.7 BOMBAY.

In the Bombay Presidency, different water rates are levied for major and minor irrigation works. These are:-

Major Irrigation Works.

- | | | |
|----|---|----------------------------|
| 1. | Sugarcane crop in 'Block' and on volumetric basis of sugar factories. | Rs.60/- per acre per annum |
| 2. | Sugarcane out of 'Block' | Rs.80/- " |
| 3. | Perennials other than sugarcane. | Rs.30/- " |
| 4. | Two season crops(15th June to 14th October). | Rs.10/- " |

Minor Irrigation Works.

- | | | |
|----|--|-----------|
| 1. | Sugarcane. | Rs.37/- " |
| 2. | Other perennials. | Rs.18/8/" |
| 3. | Two season crops(15th June to 14th October). | Rs.10/- " |

The following water rates it is understood, are to come in force from 15th February 1952 on the flow major canals in Daccan Irrigation Circle of the Bombay State.

- | | | |
|-------------------|---------|-----------|
| Sugarcane. | Rs.90/- | per acre. |
| Other Perennials. | Rs.45/- | -do- |
| 8 months drops. | Rs.15/- | -do- |
| Kharif seasonal. | Rs. 6/- | -do- |
| Rabi Seasonal. | Rs. 9/- | -do- |

7.8 SHAKRE NANGAL PROJECT;

In the case of Shakre Nangal Project, a uniform water rate of Rs.6/- per acre for all crops on the areas which will receive perennial irrigation and Rs.3/12/- per acre for non-perennial irrigation were proposed to be levied. These have since been increased by 10% Enhanced Land revenue of Rs.3/- and Rs.1/- per acre respectively for perennial and non-perennial areas are proposed. Levy of a betterment fee is also under consideration, on this project.

7.9 INDORE.

Following water rates are prevalent on one of the Storage Projects in Indore:-

Sugarcane.	Rs.45/-	per acre.
Gardens.	Rs.22/-	-do-
Rabi.	Rs. 5/-	-do-
Hot weather crops.	Rs. 8/-	-do-

7.10 Madras:

Water rates in force in the Godavari, Kistna, and Kanheri Delta systems in the Madras State are as under:-

Sugarcane.	Rs.7/8/- to Rs.17/8/-	per acre.
Rice.	Rs.6/4/-to Rs. 10/-	-do-
Oil seeds.	Rs.3/- to Rs. 10/-	-do-
Milletts pulses & Gram.	Rs.3/2/-to Rs. 10/-	-do-

7.11 U.P.

In the United Province, water rates as given in the Irrigation Administration Report for the year ending 31st March 1940, are as under:-

Sugarcane.	Rs.5/- to 12/-	per acre.
Rice.	Rs.4/- to 7/8/-	-do-
Oil seeds.	Rs.4/4/-	-do-
Wheat.	Rs.3/- to 5/-	-do-

These have since been increased by 150 percent and the question of further revision is under consideration.

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APPENDIX XIV

Abstracts of Costs.

APPENDIX XIV.

Abstract of Cost No. 14.

(Present revised Proposals).

Sub-head.	Existing canal system (vide 'separate sheet' attached).	New Canal system.	Total amount in Lakhs of Rupees.	REMARKS.
1. <u>Head Works.</u>	50.80	356.18	406.98	
2. <u>Main Canal & Branches.</u>				
A-Preliminary.	6.62	12.27	18.89	
B-Land.	1.66	21.14	22.80	
D-Regulators.	7.70	16.50	24.20	
E-Falls.	0.21	1.59	1.80	
F-Cross Drainage works.	0.86	38.67	39.53	
G-Bridges.	0.10	3.75	3.85	
H-Escapes.	0.49	1.50	1.99	
K-Buildings.	12.47	47.26	59.73	
L-Earth work.	36.24	156.27	192.51	
L 1-Service & boundary roads.	6.91	8.41	15.32	
L 2-Lining of canal.	-	2.99	2.99	
M-Plantation.	-	1.12	1.12	
O-Miscellaneous.	2.35	29.86	32.21	
O 1-Pumps and pipe lines.	-	17.68	17.68	
O 3-Outlet heads.	1.21	-	1.21	
Total.	76.82	359.01	435.83	
P-Maintenance 1% of items 'A' to 'O3' excluding cost of B-Land.	0.75	3.38	4.13	
Total 2 Main canal and branches.	77.57	362.39	439.96	
3. Distributaries & Minors.	187.25	221.27	408.52	
4. Drainage & protective works.	71.57	72.89	144.46	
5. Water-courses.	91.93	71.40	163.33	
6. Special Tools & Plant.	2.54	17.81	20.35	
Less depreciation charged to works.	(-) 2.29	(-) 16.03	(-) 18.32	
Net amount of special Tools & Plant.	0.25	1.78	2.03	

Abstract of cost No.I(continued)

Sub-head.	Existing canal system-(vide separate sheet attached.	New canal system.	Total amount in Lakhs of Rupees.	REMARKS
7. Losses on stock.	0.50	0.50	1.00	
Unforeseen:	2.00	2.00	4.00	
Total I-Works.	481.87	1088.41	1570.28	
II-Establishment.	6.43	36.85	43.28	
III-Tools & Plant at 1% of I-Works.	4.82	10.88	15.70	
IV. Suspense.		-	-	
V- Receipts on capital Account.				
(a) Resale value of special Tools and plant on completion of work.	(-)0.25	(-)1.78	(-)2.03	
(b) Other Miscellaneous receipts.	(-)0.12	(-)0.10	(-)0.22	
(c) Recovery of cost of water courses.	(-)91.93	(-)71.40	(-)163.33	
Total R&R on capital account.	(-)92.30	(-)73.28	(-)165.58	
Total Direct charges.	400.82	1068.86	1463.68	
VI- <u>Indirect charges.</u>				
(i) Capitalization of abatement of Land Revenue at 5% cost of B-Land.	4.46	6.20	10.66	
(ii) Audit charges at 1% of I-Works.	2.41	5.44	7.85	
Total Indirect charges.	6.87	11.64	18.51	
Total Direct & Indirect charges.	407.69	1074.50	1482.19	
Cost per acre of C.C.A.	Rs.75/-	Rs.200/-	Rs. 138/-	

Accompaniment to Abstract of Cost No. I
Showing the cost of the Existing Canals
separately.

Sub-head.	Kendrapara canal system.	Taldanda canal system.	H.L.C. Range 1.	Total.	REMARKS.
1. <u>Head Works.</u>				50,30,00	
2. <u>Main Canal & Branches.</u>					
A- Preliminary.	4,55,700	2,02,500	4,000	6,62,200	
B-Land.	74,700	50,700	40,000	1,65,400	
D-Regulators.	3,53,300	2,41,000	1,76,000*	7,70,300	
E-Falls.	-	21,000	-	21,000	
F-Cross Drainage works.	16,000	33,500	36,800	86,300	
G-Bridges.	6,000	3,500	-	9,500	
H-Escapes.	29,000	15,300	4,200	48,500	
K-Buildings.	12,24,700	22,300	-	12,47,000	
L-Earth work.	22,12,500	10,78,500	3,33,300	36,24,300	
L 1-Service & boundary roads.	5,42,100	32,500	50,500	6,25,100	
M-Plantation.	-	-	-	-	
O-Miscellaneous.	1,13,400	1,16,000	5,400	2,34,800	
O 3-Outlet heads.	95,600	25,100	600	1,21,300	
Total.	51,29,000	19,01,900	6,50,800	76,81,700	
P-Maintenance at 1% of above excluding B-Land.	50,600	13,500	6,100	70,200	
Total 2. main canal & branches.	51,79,600	19,15,400	6,56,900	77,51,900	
3. Distributaries & Minors.	1,08,64,100	61,31,400	16,29,400	1,86,24,900	
4. Drainage & Protective works.	50,42,800	15,76,900	5,33,600	71,53,300	
5. Water courses.	49,96,500	33,20,500	8,76,400	91,93,400	
6. Special Tools & Plant.				2,54,000	
Less Depreciation charged to works.				(-) 2,28,600	
Net amount of special T&P.				25,400	
7. Losses on Stock.	1,30,000	15,000	5,000	50,000	
Unforeseen.	1,20,000	60,000	20,000	2,00,000	
Total I-works.				4,81,17,300	

Sub-head.	Kondrapara 'canal system	Taldanda 'canal 'system.	H.L.C. 'Range I	Total.	ARRS
II-Establishment.				6,43,300	
III-Tools & Plant at 1% of I-Works.				4,81,900	
IV-Suspense.					
V-Receipts on capital Account.					
(a) Resale value of spl. Tools & Plant on com- pletion of work 25400.					
(b) Other Miscellane- ous Revenue. 12000					
(c) Recovery of cost of water-courses. 919340					
Total R&R on Capital Account. 9230800				(-) 92,30,800	
Total Direct charges.				400,82,300	
VI. <u>Indirect charges.</u>					
(i) Capitalisation of abatment of Land Revenue at 5% cost of B-Land.				4,45,900	
(ii) Audit charges at 1/2% of I-Works.				2,40,900	
Total indirect charges.				6,86,800	
Total Direct and Indirect charges.				4,07,69,100	

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APPENDIX XIV

Abstract of cost No. II.

(Alternate Proposal)

Sub-head	Existing canal system	New canal system	Total amount in Lakhs of Rupees	REMARKS
1. <u>Head works.</u>	50.80	269.63	320.43	
2. <u>Main canal and Branches.</u>				
A-Preliminary.	6.62	10.48	17.10	
B-Land.	1.66	15.85	17.51	
D-Regulators.	7.70	14.54	22.24	
E-Falls.	0.21	1.59	1.80	
F-Cross Drainage works	0.86	17.14	18.00	
G-Bridges.	0.10	0.69	0.79	
H-Escapes.	0.19	0.19	0.98	
K-Buildings.	12.17	44.89	57.36	
L-Earthwork.	36.24	91.37	127.61	
L 1 -Service and boundary roads.	6.91	7.18	14.09	
L 2-Lining of canal.	-	14.36	14.36	
M- Plantation.	-	1.01	1.01	
O- Miscellaneous.	2.35	26.61	28.96	
O-1 Pumps and pipe lines.	-	-	-	
O 3-Outlet heads.	1.21	-	1.21	
Total.	76.82	246.20	323.02	
P-Maintenance at 1% of items 'A' to 'O3' excluding cost of B-Land.	0.75	2.30	3.05	
Total 2. Main canal and Branches.	77.57	248.50	326.07	
3. Distributaries. & Minors.	187.25	186.10	373.35	
4. Drainage and Protective works.	71.57	62.55	134.12	
5. Water courses.	91.93	60.03	151.96	
6. Special Tools and Plant.	2.54	13.18	16.02	
Less-Depreciation charged to works.	(-) 2.29	(-)12.13	(-)14.42	
Net amount of special Tools and Plant.	0.25	1.35	1.60	
7. Losses on stock.	0.50	0.50	1.00	
Unforeseen.	2.00	2.00	4.00	

Abstract of Cost No. II (Contd)

Sub-head	Existing canal system	New Canal system.	Total amount in lac. of Rupees.	RE. - RRS.
Total I-Works.	481.87	830.66	1312.53	
II-Establishment.	6.43	36.85	43.28	
III-Tools and Plant at 1% of I-Works.	4.82	8.31	13.13	
IV-Suspense.	-	-	-	
V-Receipts on capital Accounts.				
(a) Resale value of special T&P on completion of work.	(-) 0.25	(-) 1.35	(-) 1.60	
(b) Other Misc. Revenue.	(-) 0.12	(-) 0.10	(-) 0.22	
(c) Recovery of cost of water courses.	(-) 91.93	(-) 60.03	(-) 151.96	
Total R & R on capital account.	(-) 92.30	(-) 61.48	(-) 153.78	
Total Direct charges.	400.82	814.34	1215.16	
VI. Indirect charges.				
(i) Capitalisation of abatement of land Revenue at 5% cost of B-Land.	4.46	5.12	9.58	
(ii) Audit charges at 1% of I-Works.	<u>2.41</u>	<u>4.15</u>	<u>6.56</u>	
Total Indirect charges.	6.87	9.27	16.14	
Total Direct and Indirect charges.	407.69	823.61	1231.30	
cost per acre of C.C.A.	Rs. 75/-	Rs. 183/-	Rs. 124/-	

APPENDIX XIV

Abstract of cost No. III.

Mszundar Committee's proposals for alternative arrangements for irrigation and flood disposal.

Sub-head	Existing canal system.	New Canal system.	Total amount in lakhs of Rupees.	RE-MAR-KS
1. Head works.	50.80	342.29	393.09	
2. <u>Main canal and Branches.</u>				
A-Preliminary	6.62	6.73	13.35	
B-Land.	1.66	3.57	5.23	
D-Regulators.	7.70	182.54	190.24	
E-Falls.	0.21	-	0.21	
F-Cross Drainage works.	0.86	-	0.86	
G-Bridges.	0.10	-	0.10	
H-Escapes.	0.49	-	0.49	
K-Buildings.	12.47	40.79	53.26	
L-Earth work.	36.24	13.20	49.44	
L 1-Service and boundary roads.	6.91	7.18	14.09	
L 2-Lining of canal.	-	11.26	11.26	
M-Plantation.	-	2.12	2.12	
O-Miscellaneous.	2.35	9.59	11.94	
O 1-Pumps and pipe lines.	-	-	-	
O 3-Outlet heads.	1.21	-	1.21	
Total	76.82	276.98	353.80	
P-Maintenance at 1% of cost of items 'A' to 'O3' excluding cost of B-Land.	0.75	2.73	3.48	
Total 2. Main canal and branches.	77.57	279.71	357.28	
3. Distributaries and Minors.	187.25	186.00	373.25	
4. Drainage and Protective works.	71.57	943.34	1014.91	
5. Water-courses.	91.93	60.04	151.97	
6. Special Tools and Plant.	2.54	17.12	19.66	
Less Depreciation charged to works.	(-) 2.29	(-) 15.41	(-) 17.70	
Net amount of special Tools and Plant.	0.25	1.71	1.96	
7. Losses on stock.	0.50	0.50	1.00	

Abstract of cost No. III(Contd).

Sub-head	Existing canal system	New Canal system.	Total amount in lakhs of Rupees.	REMARKS.
Unforeseen	2.00	2.00	4.00	
Total I-Works.	481.87	1815.59	2297.46	
II Establishment.	6.43	36.85	43.28	
III Tools and Plant at 1% of I-works.	4.82	18.16	22.98	
IV Suspense.	-	-	-	
V-receipts on capital Account .				
(a) Resale Value of Spl.T & P	(-) 0.25	(-) 1.71	(-) 1.96	
(b) Other miscellaneous receipts.	(-) 0.12	(-) 0.10	(-) 0.22	
(c) Recovery of cost of water courses.	(-)91.93	(-)60.04	(-) 151.97	
Total R & R on capital Account.	(-)92.30	(-)61.85	(-) 154.15	
Total Direct charges.	400.82	1808.75	2209.57	
<u>VI-Indirect Charges.</u>				
(i) Capitalization of abatement of Land revenue at 5% cost of B-Land.	4.46	4.90	9.36	
(ii) Audit charges at 1/2% I-Works.	2.41	9.08	11.49	
Total Indirect charges.	6.87	13.98	20.85	
Total Direct and Indirect charges.	407.69	1822.73	2230.42	
Cost per acre of C.C.A.	Rs.75/-	Rs.404/-	Rs.225/- .	

