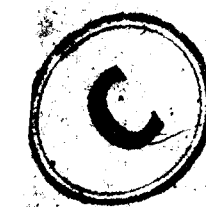


Government of Madras
Public Works Department
(Irrigation Branch)

Kistna Reservoir Project

vol-I



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Government of Madras.

PUBLIC WORKS DEPARTMENT

(IRRIGATION BRANCH).

KISTNA RESERVOIR PROJECT.

VOL. I.

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1992
செப்பன்டு தற்காது எடுதற்கு
தொள்ளப்பட்ட நாள்
1992
செப்பன்டு முடித்த நாள்

சாப்பார்க்கும்
மு.பா.எ.
கைமொப்பம்.

செப்பன்டு
1992
செப்பன்டு முடித்த நாள்

(i) General arrangements and proposals for the project and detailed designs, estimates and report on head works.	Special Superintending Engineer.
(ii) Detailed designs and estimates for extension of delta irrigation due to this project under Bezwada Anicut.	Superintending Engineer, II Circle.
(iii) Detailed designs and estimates and report on the proposed upland canal system of irrigation.	Executive Engineer, Kistna Project.
(iv) Revenue investigation and land acquisition	The Special Revenue Officer, Kistna Project.

Volume I gives the reports on the project and the financial statements and notes and recommendations of the Chief Engineer and Board of Revenue and Government.

Volume III contains detailed abstracts of estimates and classified abstracts and tabular statements of works and their cost and distribution. Also it contains hydraulic and stability calculations.

Volume I, Part I—The Special Superintending Engineer's Report—describes the general proposals constituting the whole project and gives further detailed reports on the designs and estimates for the head works and the programme of execution and the rates for construction of the whole works proposed.

Volume I, Part III—The report to the estimates for the construction of the upland canal system (by the Executive Engineer, Kistna Project).

Volume I, Part IV—The review of the above reports by the Chief Engineer for Irrigation with financial statements and recommendations.

Volume I, Part V—The Special Revenue Officer's report with the Proceedings on this of the Board of Revenue and the orders of Government in the Revenue Department.

(d) The following table of contents makes clear the arrangement of the papers and statements in Volumes II and III and no further note on the sub-divisions of these is called for.

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KISTNA RESERVOIR PROJECT.

PART I.

SPECIAL SUPERINTENDING ENGINEER'S REPORT.

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KISTNA RESERVOIR PROJECT.

PART I.

Special Superintending Engineer's Report.

SECTION I.

THE KISTNA RIVER AND SYSTEMS OF DELTA IRRIGATION.

1. *The Kistna River.*—The following description is taken from Walch's "Engineering Works of the Kistna Delta" to which book reference may be made for full descriptions of the work in the Existing Delta System of Irrigation:—

"Along the western side of the Peninsula of India from the Valley of the Tapti to Cape Comorin, a distance of nearly 1,000 miles, rises the mountain range known as the 'Western Ghats' roughly parallel to, and but a short distance from the Arabian Sea."

2. *Drainage Basin of the Kistna river.*—"This great barrier is nowhere pierced by rivers, and all the country eastward of its summit levels, even though they are within sight of the West Coast, has to send its surplus waters to the Bay of Bengal. It thus comes that the drainage from 47,827 square miles of the Bombay Presidency, from the whole of the Nizam's Dominions and of the Mysore Territory, and from almost the whole of the Madras Presidency, besides that from upwards of 54,000 square miles of the Central Provinces and Berar,—a total area in all of about 338,100 square miles,—has to find its way into the sea along the eastern coast of the Madras Presidency.

"This is effected chiefly by four great rivers—the Godavari, Kistna, Penner and Cauvery, the drainage areas of which are 115,000 square miles, 97,050 square miles, 20,000 square miles, and 26,266 square miles, respectively. This History has to treat of the Engineering works, by which the delta of the second of these rivers has been converted from a poverty-stricken sparsely cultivated tract, subject to recurring droughts, into a prosperous country covered with cereal crops rendered virtually independent of the precarious local rainfall by a network of canals and channels from the great river which formerly carried nearly all its wealth of waters uselessly to the sea."

3. *Course of the Kistna.*—"The River Kistna ('Krishna') has its sources and those of its affluents spread along the eastern slope of the Western Ghats over some six degrees of latitude, almost touching to the north the headwaters of the Godavari, and to the south overlapping those of the Penner and Cauvery. Of these sources the one which is the traditional fountain head of the Kistna issues from a spout fashioned into the image of a cow's mouth in an ancient temple of Mahadeo at the foot of a steep hill near the Bombay sanitarium of Mahabaleshwar, some 4,000 feet above sea-level. From this the Kistna runs southward in a rapid course, flowing through the British (Bombay) districts of Satara and Belgaum, the cluster of Native States which form the South Maratha Agency, and the district of Kaladgi. There it turns east to pass into the dominions of the Nizam of Hyderabad. In this portion of its course it receives many tributaries, of which the chief are the Yerala, Warna, Idganga, Ghatprabha and Malprabha. All these, like the main stream, are characteristic rivers of the plateau of the Deccan. They run in deep channels, from which it is almost impossible to lead off channels for irrigation. In the rainy season they swell into brimming torrents, but during the remaining eight months of the year they shrink to mere threads of water, straggling through a sandy waste.

"On entering the Nizam's Dominions, the Kistna drops to the 'alluvial Doabs' of Shorapur and Raichur. The fall is as much as 408 feet in about 3 miles. The first of the Doabs mentioned above is formed by the confluence of the Bhima, which brings down the drainage of Ahmadnagar, Poona and Shorapur; the second by the confluence of the Tungabhadra, which drains the north (and west) of Mysore, and the 'Ceded Districts' of Bellary and Kurnool. At the point of junction with the Tungabhadra the Kistna again strikes upon British territory, and, still flowing east, forms for a considerable distance the boundary between the Madras Presidency and the Nizam's Dominions. There it is joined by its last important tributary, the Musi, on whose banks stands the Nizam's capital of Hyderabad. On reaching the frontier chain of the Eastern Ghats the Kistna turns south.

"It then passes through a narrow gorge and enters the plains of the Coromandel coast but does not for another 35 miles or so get quite clear of outlying hills, till at Bezwada it flows between two of them, which confront one another at a distance of only $\frac{3}{4}$ mile apart. Beyond this point stretching away on both sides of the river lies the alluvial plain it has formed, which bears the name of the 'Kistna Delta'. Through this the river continues in a single channel of great width for another 40 miles, when it sends off to the left a branch known as the 'Puligadda' which forms the 'Island of Divi,' and after a course of 20 miles enters the sea at the 'Point' of that name. The main stream continues for another 15 miles and then breaks up into three mouths, the 'Narasagunta Kistna,' 'Lankevanirichi Kistna' and 'Venisagara Kistna,' separated from one another by two small islands covered for the greater part by dense mangrove jungles, and more or less submerged during spring tides and high floods, but having, nevertheless, some 2,000 inhabitants with a few hundred acres of precarious cultivation.

"These mouths of the river lie in from $15^{\circ} 45'$ to $15^{\circ} 49'$ N. latitude, and between $80^{\circ} 52'$ and 81° E. longitude, about 200 miles north of Madras and only 60 miles south of the Vasista mouth of the Gódavari.

"From its most distant source to the sea the Kistna is approximately 800 miles in length."

4. *Flood discharge of the Kistna.*—"The drainage basin of the Kistna, like that of the Gódavari, lies chiefly under the influence of the south-west monsoon rains and it is therefore from June to October that it brings down by far the greater quantity of water."

Occasional very large floods sweep past the proposed reservoir site and over Bezwada Anicut. Much the highest recorded flood is that of 7th October 1903 of which the discharge is computed at 1,060,830 cubic feet per second, a quantity more than twice as great as the flood discharge of the Nile and more than 120 times as great as the maximum flood discharge of the Thames at Staines. Generally the high flood months are July, August and September, and the 7th October must be regarded as a very late date for a flood of extraordinary magnitude. After the middle of October the flow generally decreases rapidly till sometime in the period November to January, the draw-off of the canals takes all the flow available and no water is passed over the anicut at Bezwada.

In February-April the river dwindles to a petty stream with a discharge running down to as low as 100 cusecs.

5. *Existing Kistna Delta System of Irrigation.*—In the Madras Presidency limits the Kistna in its upper reaches forms the boundary between Madras Government districts on its right side and Hyderabad State on its left. As it approaches the sea the river runs altogether within the Madras Presidency and forms the boundary between the Kistna district on its left side and the Guntur district on its right.

Both these districts derive great benefit from the Kistna Delta System of Irrigation Works of which the head works are at Bezwada.

Here an anicut has been constructed across the river raising the water level sufficiently high to command by natural flow the flat deltaic tracts of land which lie

between Bezwada and the sea and through which the river flows for some 60 miles with a southerly course before it finally discharges into the Bay of Bengal. At Bezwada the canal supplying the "Kistna district" deltaic land known as the Kistna Eastern Delta takes off.

On the opposite side of the river at Seetanagaram from just above the anicut the canal takes off which supplies the Guntur district delta lands known as the "Kistna Western Delta". The ultimate area of land to be irrigated under the existing Irrigation System in the Eastern Delta is 420,000 acres and in the Western 305,000 acres. Of this total area 725,000 acres as much as 716,000 were actually irrigated in 1909-1910.

Some description of the existing Irrigation System will be found later in Part II which deals with the proposed extension of irrigation in the Delta under the Kistna Reservoir Project.

6. *Reasons for construction of a Reservoir.*—The mean annual discharge of the Kistna at Bezwada may be stated at nearly 2 million million cubic feet of water while the lowest discharge recorded (year 1899-1900) is 879,000 million cubic feet. The latter quantity would suffice for the irrigation of some 5 million acres of rice. In spite of this the failure of sustained supply towards the end of the irrigation season, 15th October to 15th December, has on several occasions caused serious difficulties and scanty supply to the area under irrigation and the frequent small discharge of November limits extension of the irrigated area under Bezwada Anicut to 725,000, although 850,000 could be commanded and is irrigable.

Further the scanty discharge between January and May makes the cultivation in the Kistna Delta of any considerable area of second crop or irrigated late crop impracticable.

As the existing irrigation works taking their supply from the basin of the Kistna are extended and new works are constructed in Bombay, Hyderabad, Mysore and in the Ceded Districts of the Madras Presidency, the flow is likely to be diminished and more and more difficulty will be experienced in supply of the deltaic area. As years go on, the conditions of supply of the existing deltaic irrigation is likely to become more and more difficult, although water sufficient for the irrigation of millions of acres is being surplused yearly into the sea.

Such a condition of affairs is obviously capable of improvement by the construction of a reservoir capable of impounding the unwanted water of the earlier months for use in the later months of deficiency.

7. *Previous proposals for the construction of a Reservoir.*—The proposal to construct a reservoir on the Kistna for supplementing the November-December supply to the delta and to enable a second crop to be grown has been made on several occasions, but no definite scheme was put forward and investigated till that of Mr. Reid for which detailed estimates were forwarded to the Government of India with letter No. 974 I. of 14th September 1906.

8. *Mr. Reid's Kistna Reservoir Project—Daida Site.*—A preliminary report regarding this project was drawn up by Mr. Reid in 1901 and the proposals for a detailed investigation of this project was approved by the Irrigation Commission and undertaken by the same officer in 1902 and submitted in February 1905.

The project as modified by the Special Chief Engineer (Mr. Davidson) provided for a masonry dam, 228 feet high, being built across the Kistna near Daida (42 miles above the dam site of the present project). From it a high level canal was proposed 186 miles in length and irrigating one million acres of land north of the Gundlacamma river. Of this 180,000 acres was to carry a second irrigated crop each year. The reservoir was further to irrigate an additional area in the delta under Bezwada anicut of 170,000 acres first crop and to enable a second irrigated crop of extent 180,000 acres to be grown. The project did not, at the rates then allowed, fulfil the requirements of a productive project, while it was considered that the cost of carrying the Main canal through the very difficult country which had to be traversed in the first 40 miles had been greatly under-estimated and would be such as to be a bar to the prospects of the project.

9. *Search for a new site for a Reservoir.*—On the recommendations of the Inspector-General of Irrigation (Sir J. Benton), the scheme was abandoned and search for a site for a Reservoir dam lower down the Kistna was instituted which would give facilities for taking off an upland canal while avoiding the great length of difficult country which the Daida site entailed.

10. *Essential Conditions.*—The essentials which the site sought for must possess may be briefly summarised—

(a) It must give facilities for canal off-take on the right side and if possible, off-take so as to avoid the necessity of traversing the Bellamkonda ridge.

This ridge stretches from the river right margin near Pulichintala where it forms a high very narrow and steep ridge adjacent to and parallel to the river and is here called Pulichintala ridge, and runs from here in a continuous line of heights south for 20 miles to Bellamkonda Peak.

The north end of the ridge is on the right river margin, opposite the village of Wadanapalli on the left side.

Any canal taking off any distance above this must either cut or tunnel through the ridge and it has been ascertained that no saddle through this line of heights exists which would allow of cutting through with reasonable depth.

This consideration barred all sites above the narrow, knife edged, north-end of this ridge which offers facilities for tunnelling.

(b) The site must have suitable rock foundations and must be one in which the general rock surface is not very deep below the dry season water level.

This condition throws out a possible site at the narrow gorge above Chintapalli as water stands 40 to 60 ft. deep here at all seasons.

(c) There must be facilities for surplusing the huge floods of the Kistna.

From this last consideration any otherwise possible sites between Wadanapalli and Chintapalli become impossible with the exceptions noted in the next paragraph.

Chintapalli is the place from which the river emerges from bordering hills into an open plain below in which there is obviously no suitable site for a dam. It is here noted that there is below the outfall of the Paleru no site which appears a good one, even were facilities for surplusing available, and further that any such sites would entail the submergence of a large area of valuable land including the town of Jaggayapet, a place of considerable importance.

11. *Possible Sites.*—On the above considerations the possible sites for a reservoir dam are narrowed down to—

(a) Sites at or in the vicinity of Wadanapalli on the left of the Kistna and on the right in the neighbourhood of the north end of Pulichintala ridge which is itself the north end of the Bellamkonda range of hills. These are referred to as the "Pulichintala" sites.

(b) A site between Mukhtala and the confluence of the Paleru.

One of the former sites is that chosen for the proposed work and is dealt with in detail later and the latter is noted on here.

12. *Site between Mukhtala and the Outfall of the Paleru.*—The advantage of this site is that there is a practicable and favourable site for a surplus work over the ridge forming the water shed between the Kistna and the Paleru.

This ridge is of napah with a flat top running a level about + 150 for over half a mile and then rising in a length of half a mile to 180 and in another half a mile to + 200. This formation while entailing surplus works, more expensive than those of the site proposed, is distinctly favourable and has the advantage of surplusing the water into such a large existing tributary as the Paleru over a surface of napah stone.

The main objection to this site is the great length of high dam across the river which it entails.

The right flank of the main dam must rest on the chain of shale hills which at this place stand back from the existing river-bed one mile from the margin. Thus a wide marginal tract of alluvial soil intervenes between the right river margin and the flanking heights.

This entails a length of dam across the river to the flanking heights on either side of 12,000 feet as compared with 4,724 for the Pulichintala site, and a total length of dam to the right flank of the surplus of 15,800 feet as compared with 10,475 for the site selected.

The great length of main dam has been considered a bar to further consideration or investigation of this site, and no trenches or trial pits in the margins have been opened up to find rock levels, and the point of junction of the napah formation on the left with the shale on the right of the river has not been located. The site, however, has the recommendation of a napah foundation for part of the length under the main dam, especially when it is highest, and a good set of conditions for the surplus works, although these would involve greater cost than on the site proposed.

For the purpose of the proposed work, it is considered that this site cannot compete with that proposed, but should the question of building on the Kistna a diversion dam merely for raising the water-level come under investigation, it is believed that the site is worth further consideration.

From the above, it will be seen that the most favourable site for a reservoir is located to be near the north end of Pulichintala ridge and in the next part will be described the general scope and the general conditions of the works and proposals which constitute the present project.

The detailed description of the reservoir site selected and various considerations concerning it are described in Section III of this volume which describes the Head Works in detail.

SECTION II.

GENERAL DESCRIPTION OF THE PROJECT.

13. *Scope of the Kistna Reservoir Project.*—The works comprising the Project now put forward are—

- (1) The construction of a reservoir by building a dam across the Kistna at Pulichintala.
- (2) Construction of an Upland Canal system taking off direct from the reservoir for the supply in the Guntur district of irrigation to 610,000 acres now unirrigated.
- (3) Extension of the area capable of irrigation (June to December) under the Bezwada anicut, Kistna delta system by 125,000 acres of new irrigation and construction of the necessary distribution works.
- (4) Supply of water to the area under Bezwada anicut for the irrigation of a "late crop," (February to May) of an area averaging 167,000 acres.

This late crop is sub-divided into two categories—

- (a) A "second crop" raised on lands growing an irrigated first crop yearly between June and December.
- (b) A "short single crop" to be raised on lands growing no other crop and unfit owing to submergence or defective drainage from growing a crop in the "Early" (first) crop season.

14. *The various functions of the Impounded supply.*—It is, in an ordinary year, primarily on the impounded supply of water available between 1st November and 15th June that the extensions of irrigation proposed depend.

- This impounded supply is made use of to fulfil three distinct functions—
- (i) Supply of water from 15th May to 15th June yearly for the growing of seedlings for the earlier transplanted crops.
 - (ii) The supply to the "early crop" both in delta and upland in the months, October to December, any water required in excess of the direct flow of the river.
 - (iii) Supply of water in sufficient quantity to enable a considerable area of "late crop" to be cultivated wet.

The importance of these duties is in the order named.

15. *Supply of water for early seedlings in Kistna Delta.*—In the existing Kistna delta system there is practically no "late crop."

The river-flow in the months of March and April is unreliable and insufficient for supply of any considerable area, of irrigation.

The canals are generally closed from about the middle of March till 1st June and for the first 10 to 12 days of June the river-flow is frequently insufficient to give any adequate supply to canals.

There is no water from sources other than canal supply available for raising early seedlings for any considerable extent of transplantation. As a result the sowing of seedlings does not begin on a considerable scale till after 10th June, and they are not ready for transplantation till 5th to 10th July. Although the river is generally in full fresh from about 18th to 22nd June advantage cannot be taken of this to push transplantation vigorously till the second week in July and much water which might, under other conditions, have been used for earlier transplantation is yearly wasted.

In the neighbouring Godavari delta the river supply in March and April is fairly well sustained enabling a large area of late irrigated crop (160,000 acres) to be raised yearly. The canals do not close till the end of April and are only closed for one month. This affords facilities for storing water in shallow tanks, or in the sub-soil, which is largely used for raising early seedlings, of which there is ample supply available for transplantation early in June.

Although the Godavari canals reopen after the annual closure the same date as the Kistna (1st June) the early (first) crop in that system is generally nearly a month in advance of the Kistna area in transplantation. This is in some degree attributable to the better supplies generally available in the first half of June, but is chiefly due to the facilities which exist, and are taken advantage of, for raising early seedlings in the Godavari system.

The first duty of the proposed Kistna Reservoir is to furnish from its impounded supply between 15th May and 15th June, water for raising early seedlings for the Kistna delta area, and thus to advance the transplantation in the delta by nearly a month. The supply of water required for this is quite small, while the advancing of the transplantation by a month, and is of the greatest importance enabling the fresher of the river which cannot be impounded to be fully utilised on transplantation and ploughing. Supply of early seedling water ensures the date of maturing of the crop being advanced and demand for water to cease correspondingly earlier. It is not till the month of November that the river "direct flow" supply generally becomes seriously inadequate and the earlier cessation of "draw off" for the crops is thus a matter of very great moment. It is not too much to say that the whole increase in the "early crop" area of irrigation under Bezwada Anicut would be feasible by "direct-flow" supply were the water for early seedlings available, even though there were no impounded supply to draw on in November. The rules for working the reservoir therefore provide for always holding impounded water for early seedlings for the next year's crop.

16. *Supply of impounded water to the "early crop" area.*—The second rôle of the impounded water is making up any deficiency in the "direct-flow" supply to the "early crops."

The direct-flow supply is practically always sufficient to the middle of October. Thus even in bad years there is only a draw off from the impounded water for one to two months for maturing the early crop.

In the worst year on record 1899-1900, the deficiency of "direct-flow" for the full duty supply to the early crop is computed as 46,983 mills. cubic feet, and this impounded supply would have served to fully supply the whole early crop area (1,460,000 acres). This quantity of water would only suffice to irrigate 237,600 acres of "late crop" or about one-sixth of the early crop area. This example shows very clearly the high efficiency of the impounded water when it is used for the purpose of early crop supply, and will make plain why the supply of late crop area should only be undertaken after water for other purposes is first secured.

17. *Impounded water supplied to the "late crop" area.*—The late crop season only commences on 1st February, and as draw off from the reservoir ceases from 15th December to 1st February, it is possible to foretell within the close limits, a month in advance the impounded supply available yearly for late crops, and thus to limit the area of late crop grown each year, to that for which supply can be guaranteed.

Thus, while the area of late crop varies from year to year, there will be no failure in the crops actually put in, or loss of cultivation expenses. It cannot be considered a hardship to a ryot to be obliged occasionally to forego growing a late wet crop on land on which he has the same year already raised an early crop, when he suffers no loss for cultivation expenses.

Thus in a good year the impounded water which will not be required for the early crop can be profitably employed in raising late crops in the delta, while in a bad year, without occasioning hardship on the cultivator it can be used to safe-guard from loss or deficient supply the immense area of early crop.

18. *Early crop areas to be irrigated how fixed.*—The capacity of the reservoir is fixed by considerations of the deposition of silt carried by the Kistna and the rate and distribution of such deposition. The capacity taken as effective for purposes of working tables and revenue forecast is 50,000 mills. cubic feet.

The area to be irrigated under the Upland Canal System is 610,000 acres. This represents the whole irrigable area, after making suitable reservations, commanded up to the Gundlacamma river, which the canal does not cross.

The area to be newly irrigated in the delta under Bezwada Anicut 125,000 acres comprises all the suitable commanded area not allocated to the delta system already in existence. This, in addition to the whole area of the existing delta system 725,000 acres constitutes the area under "early crop" to be supplied through the proposed reservoir and amounts to a gross total of 1,460,000 acres.

19. *Double crop area how arrived at.*—The area of "late crop" irrigation is fixed on two considerations. The first is the limit of area which it is considered advisable or desirable to cultivate with two wet crops a year.

The matter is discussed and considered in detail in the Special Revenue Officer's Report, Part V, paragraphs 89 and following, and it need only here be stated that this officer considers the limit of double wet crop cultivation should be placed at 24 per cent. of the early crop area, which is the proportion of second to early irrigated crop which has been realised in the Gódavari Delta. 24 per cent. of 850,000 acres is 204,000 acres. It is desirable to restrict the second crop area to this. These considerations are connected with the agricultural aspects of double cropping, and considerations of manure supply.

20. *"Single short crop" area.*—The late crop area grown as "single short crop" on marshy or low-lying lands are not affected by these restrictions and this area is limited only by the land available, the water-supply and the engineering considerations in regard to carrying the water on to the land.

The area available for this class of crop consists of —

(i) Marshy, ill-drained or low-lying plots scattered here and there throughout the irrigated area which are not now cultivable on account of liability to excessive damage by floods or by submergence. Such areas generally speaking are scattered throughout the deltaic tracts in small plots totalling to 9,494 acres. Whether it is worth while to irrigate such plots depends on the allocation of the double cropped area, but it is certainly not advisable to carry small quantities of water to scattered isolated plots.

It is therefore decided only to specifically provide for the irrigation under head (i) of the large plot known as the "Pedalanka Block", 5,094 acres (*vide* Special Revenue Officer's report, paragraph 64).

(ii) *The Collair Lake area.*—The Collair lake is a shallow flat depression of deltaic formation into which discharges the drainage from the upland areas between the mouths of the Gódavari and Kistna. This flat depression has an outlet and discharges into the sea through the river called the "Upputeru" which forms a boundary line between Kistna and Gódavari Irrigation systems.

There is no defined margin to the lake and the area submerged varies from year to year.

After November when the rains have ceased the water in the lake recedes laying bare much fertile soil fit for irrigation in the late crop season.

By January the greater part of the area of Collair lake, normally submerged from July to October, is dry and fit to carry wet crops.

A small area of such land is now cultivated in both Kistna and Gódavari systems, the irrigation season being from January to April. The crop is harvested in May.

The water-supply required is not great, but the existing cultivation is precarious owing to the frequent inadequacy of the supply available.

Given however a fair supply the cultivation of the short crop known as "Dalwa" paddy is most profitable.

Under this project, the proposed reservoir water, without risk of failure of supply, will be available, and this Collair lake area gives a most promising field for the cultivation of single short late-crop.

The question of prospects of such cultivation has been dealt with by the Revenue Officer in his report, paragraphs 67 to 78 and 89 to 92.

The area of Collair lake allocated to "short late-crop" cultivation in the project is restricted to 20,000 acres in the estimates prepared under the Superintending Engineer, II Circle, on account of engineering difficulties in conveying water to the area. The area fit for this class of cultivation as given by the Revenue Officer is 72,000 acres.

21. *Existing Seasons for Wet Cultivation and Water-supply.*—The existing wet cultivation season in the Kistna commences nominally with the first fresh of the year, but actually about 20 days later, when the growth of seedlings raised under the river water is sufficiently forward to warrant wetting and ploughing the land for transplantation; water is required for the crop till the middle of December. From about 15th December no further irrigation water is required.

22. *Navigation Season.*—The canals, however, remain open till about the 15th March for navigation purposes, and in this period insignificant areas of dry crops, and second (wet) crops take water.

January to March is the busy season so far as navigation is concerned. The crops are harvested in December and January and there is a rush to get them out.

With a failing water-supply, the navigation in February and March is carried on under difficulties, and in March, and frequently earlier, boats have generally to be loaded very light as the depth of water available is insufficient to carry full loads.

From about the middle of March to 1st June yearly the canals are closed. During this season the annual repairs to works are carried out. The season for this is very suitable and economical, because this is just the time at which agricultural labour in the fields is in little demand.

23. *Proposed seasons for Water-supply.*—For the new conditions introduced by the Kistna Reservoir it is proposed to alter the season for closure of the canals in the Kistna Delta to suit the actual requirements of crops to be grown. The canal water which is now available only from the date of the first fresh in June for raising of seedlings will be passed down in May from the impounded supply in the reservoir which will always be issued for this purpose from 15th May. Transplantation water will be issued from 15th June and water-supply for irrigation and navigation will be maintained in the canals till the end of November.

The canals will then be closed for two months, December and January. The canals reopen 1st February for supply of water to the "late-crop" and also for navigation.

The irrigation supply to "late-crop" ceases 15th May, but the canals do not then close, but commence the next season's "seedling supply."

For navigation therefore the canals are continuously open ten months and the closure is December and January.

24. *Inconvenience caused by cold weather closure.*—It is considered that, although inconvenience to navigation will be caused by closure of canals in December and January, the full use of the canal with sufficient water for carrying full loads in February to April will more than compensate for this.

As regards the "repair" season, the inconvenience in the alteration of the date of closure will undoubtedly greatly increase cost of any earthwork, or work involving any considerable quantity of unskilled labour, as in December-January the demand for labour in the fields is very great.

The works which cannot be done when canals are open are mostly —

- (a) Repairs to locks and weirs and regulators on main and branch canals.
- (b) Clearances of silt.
- (c) Repairs in those distributaries open all year.

The (b) and (c) require cool labour, but the quantity is not very great and while difficulties will be experienced, and rates at such times must be high, the objection does not hold against the advantages of the proposed cold-weather closure.

25. *Gódávári Canal Season for Water-supply.*—The Gódávári canals would, it is considered, adopt the same system.

The "late crop" in the Gódávári delta would in such case benefit materially by getting some canal water in the first half of May.

26. *Cold-weather closure altogether in interest of the "late crop."*—The change of season for closing canals is proposed entirely in the interests of "late crop irrigation" the requirements of which are deduced from the agricultural practices of that crop in the Gódávári delta.

It would appear at first sight that the economy of water and general convenience of agriculture would best be served by issue of water for the second crop as soon as the first was harvested as is done in the Southern districts (Tanjore, Madura and Tinnevely).

In the neighbouring Gódávári system, although the system depends on "direct flow" which in the months of December and January is much more abundant than in February to April, the ryots do not transplant the second crop or late single crop until the end of January or beginning of February.

There is a good deal of difficulty in supply of water sufficient for the crop in March and April, and when canals close (viz., on 1st May) many fields still require watering which is, in some cases, supplied by baling or from a supply impounded in adjoining fields, while in many cases the crops suffer from want.

This being the case, the evidence that the crop cannot be transplanted earlier, when there is ample water to mature it, is strong.

The first crop is reaped in November, December and a plentiful supply of water runs to waste in December, January.

The reason alleged for not planting second crop in December is that the crop does not flourish if transplanted during the continuance of the cold-weather wind, and all enquiries have confirmed the accuracy of the view that these crops do not flourish if transplanted too early. The Special Revenue officer deals with the question in his report, paragraphs 90, 91, 92, and it is considered that it is fully established that the "late crop" season for transplantation should be the month of February and not materially earlier. The "late crop" supply season is therefore from 1st February to 15th May.

27. *Irrigation Season, Upland System.*—On the Upland canal system, it is only proposed to grow a single crop.

Water for seedlings will be supplied from 20th June and for transplantation from 15th July yearly, and supply of water ceases for the year and canals will close on 15th December.

So far as irrigation is concerned, this approximates to the existing delta system present cultivation dates. Further, whenever there is water to spare from the delta, which is almost always in the first half of July, such water, to any extent that can be utilised, will be passed to the upland system. This again approximates to the present system in the Kistna delta.

28. *Carrying capacities of canals.*—These are designed for both systems to be capable of carrying sufficient supply to enable transplantation to be completed over the whole system in two months in a year of average rainfall between 15th June and 15th September, and in 2½ months in a year of very deficient rainfall in this period.

29. *Late date for commencing Transplantation—Upland area.*—The Duty Tables allow for the issue of transplantation water to the Upland System only from 15th July, although surplus water is practicably always available from the 1st of July. The reason for this is, that the difficulty of raising early seedlings under sources, other than that of the Kistna, new season water, will, it is anticipated, delay transplantation

as it now does in the existing delta system. It is proposed as already explained to pass surplus water into the Upland Canals as early each year as it becomes available and this will be a material help in pushing on transplantation although not counted on in the Duty Tables.

As in the Delta, so in the Upland area, the earlier transplantation can be started and completed the better both for economy of water and outturn of produce, and it may be found possible to get the upland area transplanted earlier. It is not considered however safe to allow for this.

The area under the whole combined systems is allowed in a normal year three months for the transplantation of 1,460,000 acres, and it is doubtful if labour supply would suffice, even if seedlings and water were always available to greatly shorten this period.

30. *The Duty Tables.*—The Duty Table following is that on which the Working Tables of the reservoir are drawn and the project designed.

The detailed considerations and data on which the half monthly duties are based are fully described in Part IV, Volume II, to which reference may be made. The duties are based on those actually realised in the existing Kistna Delta system and their suitability and adequacy are considered fully established.

Months.	Duty for early crop.						Duty for late crop.								
	Upland Canal system, 610,000 acres.						Delta system, 854,000 acres.								
	Average rain.	Duty in acres per cusec.	Equivalent in inches.	Million cubic feet.	Average rain.	Duty in acres per cusec.	Equivalent in inches.	Million cubic feet.	Loss in transmission 5 per cent.	Total million cubic feet.	Total draw-off for period.				
Second half, May ..	1.74	..	..	..	1.99	..	..	2,300	115	2,415	M.C. FT. 2,415	1st February { 1st half .. 2nd	11	32.7	41.92
First " June ..	2.52	69	6.17	11,460	3.26	70	5.10	15,810	115	2,415	2,415					2nd March { 1st half .. 2nd .. ..	11	32.7	41.92
Second " " ..	2.91	69	5.17	11,460	3.04	70	5.10	15,810	791	16,601	18,501	3rd April { 1st half .. 2nd	6	60	23.87
First " September ..	2.91	69	5.17	11,460	3.04	70	5.10	15,810	791	16,601	19,201					2nd May { 1st half .. 2nd .. ..	6	60	23.87
Second " " ..	3.16	75	4.75	10,540	3.87	80	6.10	16,870	844	17,714	20,934	4th May { 1st half .. 2nd	6	60	22.87
First " October ..	3.16	96	3.75	8,830	3.88	90	6.10	16,870	791	16,601	28,061					3rd April { 1st half .. 2nd .. ..	6	60	22.87
Second " " ..	3.15	96	3.75	8,830	3.88	100	3.97	12,300	661	13,671	20,131	Total ..	52	..	198.19 m.c. ft. per 1,000 acres of late crop.
First " November ..	1.83	85	4.20	9,300	2.00	120	3.97	11,800	590	12,390	21,270					4th May { 1st half .. 2nd .. ..	6	60	22.87
Second " " ..	1.82	85	4.20	9,300	2.00	400	2.77	9,220	461	9,681	18,981	Total ..	52	..	198.19 m.c. ft. per 1,000 acres of late crop.
First " December ..	0.20	85	4.20	9,300	2.00	400	2.77	9,220	139	9,369	12,209					3rd April { 1st half .. 2nd .. ..	6	60	22.87
Total in supply period ..	23.29	..	45.83	..	31.85	..	44.03	..	..	..	..	REMARKS.—(1) Column 4 figures include 5 per cent. extra water for loss in transmission. (2) Rainfall February to 15th May averages 1.8 inches of which .7 inch is the average of first half of May.			

36. "Diversion Period" of the project is the period of time during which the problem is dealt with by maintaining the level of water at the dam site throughout the whole heavy silt-carrying season at a nearly constant level, this level being just sufficient for fully supplying the "Upland Canal System".

For this reason the level is termed the "Diversion Level" and it has been fixed at + 190.5.

The "Diversion Level" in this artificial delta takes the place of "Mean Sea Level" in a natural deltaic formation.

It is assumed, to be on the safe side, that the level of permanent regime of marginal formation in the reservoir will be the level of a river flow of 650,000 cusecs, and it is computed that the reservoir with level at the dam + 190.5 will silt, upstream of the dam site, forming such a delta as is above described, and only keeping sufficient depth and bed width open to pass a flood discharge of 650,000 cusecs, within its own self-formed margins. The capacity at "Diversion Level" then is only the capacity of the river bed with water held at + 190.5 which is calculated at 1,500 millions cubic feet. The computed time for reaching this stage by process of silt deposit is 44 years.

This stage of silt deposition, that is, the 650,000 cusec "Margin Stage," is referred to as the commencement of the "Final Stage" of silt deposition. Throughout the whole of the heavy silting period the water level at the dam is maintained at approximately "Diversion Level", and the period during which it is so maintained is termed "the Diversion Period".

It will be clear from the above that during the "Diversion Period" there is practically no effective impounded supply available in the reservoir, and during this period irrigation must be given water by "Direct Supply" from the river flow.

37. *The "Impounding Period" of Reservoir Regulation.*—In order to secure an impounded supply for issue to irrigation, the dam and works are designed to enable water at the dam to be held up when desired to a level + 224.5 or 34 feet above Diversion Level.

This level is termed the "Impounding Level" or "Full Reservoir Level", and the period when level is maintained as high as possible is termed the "Impounding Period." The "Diversion Period" will clearly be that during which the river flow is always sufficient for direct supply, and during this period a great proportion of the total annual silt is carried in suspension.

The "Impounding Period" must commence in time to get an adequate, and if possible a full supply in the reservoir, but on the other hand it is of great importance to have the reservoir at or about "Diversion Level" at the dam whenever any considerable quantity of silt is being carried, because all the silt carried in suspension in the "Impounding Period" will be deposited in the reservoir bed, and so much of this as is deposited over the margins of the submerged new deltaic river, will remain permanently in the reservoir diminishing capacity for impounding.

38. *Rules for regulating Reservoir.*—Rules for regulation of the reservoir which are believed to meet and fairly balance the antagonistic requirements of the "Impounding Period" have been drawn up and appear at the end of this section (page 17.)

39. *Remarks on Computed Quantities of Silt Deposit.*—The following statement of silt deposits and effective capacities which are extracted from Volume II, Part III, will give a good idea of the great importance of the silt problem and how greatly the cost and prospects of the project are affected by it:—

Stages of Reservoir life.	Silt deposit in reservoir. MILL. C. FT.	Water capacity. MILL. C. FT.
Gross capacity of reservoir at Impounding Level; water level + 224.5		
Gross capacity of reservoir from Diversion Level; water level + 190.5	Nil.	163,586
Effective capacity 44 years after construction at commencement of "final stage" at Impounding Level; water level + 224.5	Nil.	100,623
Effective capacity 44 years after construction at Diversion Level; water level + 190.5	113,479	50,107
Effective capacity 377 years after construction at Impounding Level; water level + 224.5	113,479	1,500
	128,372	35,000

40. *Probable error in Silt Computations.*—The writer will here record the opinion that the rate of silt deposition is probably considerably exaggerated, and that it will not be so rapid as represented by the computations. Nearly every doubtful point or assumption which was made the basis of calculation has been taken on the safe side, and probably with a considerable error on that side.

41. *Effect of Silt Deposit on Cultivated Area.*—The effect of the reservoir on the silt supply of the cultivated lands, will be, to deprive these of the greater part of the silt for some 20 to 30 years, and after that, to give silt again in gradually increasing quantities, till, at the beginning of the "Final Stage", the quantity of silt abstracted annually will be so small as to be inappreciable. The ryots generally do not greatly value Kistna silt of which to a great extent their lands are formed. The sandy and saline tracts are improved by silt deposit, but elsewhere silt deposit is not considered a valuable asset (*vide* also Revenue officer's report, paragraph 88).

42. *Assumed Stage for Working Tables.*—The working tables of the reservoir are drawn for the reservoir in the 650,000 cusec stage of marginal formation, that is, at the beginning of the "Final Stage".

Prior to this the effective capacity will be greater than at this stage (50,000 millions cubic feet); after this, the effective capacity gradually is reduced till at the end of 377 years it becomes 35,000 millions cubic feet.

For purposes of revenue computation the above is not considered, the gain in the earlier years being balanced against the loss in the later ones.

The working tables are drawn for 16 years for the flow recorded daily at Bezwada, reduced by the prospective diminution due to Up-river projects in Bombay, Hyderabad and Madras (for details of which see Volume II, Part II).

The tables are worked out by half-monthly periods, for issue of water to the gross areas proposed to be irrigated under the reservoir, at the duties shown in the duty tables, and show what would have been the results as regards areas irrigated, and supplies to these areas, for each year of the sixteen, had the works proposed, and the up-river projects, been then in existence.

43. *Summarised Results of Working Tables.*—As a result in one year only (1899-1900) is the supply available for issue to the main crop (the early crop) less than the duty requirements. In this year, the loss to the deltaic area would have been inappreciable. To the upland area appreciable loss would have been experienced, as, from 23rd November to the middle of December the supply would have been very inadequate, and the tail-end lands would have suffered severely.

In no other year is there any deficiency of supply to the early (long) crop.

The "late-crop" area in 1899-1900 is nil.

In other years, as already explained, the area varies in accordance with the impounded supply on 1st February, and it varies from a maximum of 222,550 acres, of which over 220,000 acres is realised in seven years of the sixteen, to a minimum of 62,708 acres in 1900-1901. The yearly average late crop area including 1899-1900 is 167,000 acres.

In every year there is sufficient water for early seedlings.

44. *Life of the Reservoir.*—The details of the computation of this are to be found in Vol. II, paragraph 70. The assumption made in computing "life" has been that the reservoir is efficient so long as the reservoir capacity suffices to fully and efficiently protect the "early crop" which is the main crop (1,460,000 acres) and leave enough water for early seedlings the following year. The analyses of the working tables for 16 years show (as explained in Vol. II, paragraph 109), that an effective capacity of 35,000 millions cubic feet will suffice for this duty, and the limit of the life of the reservoir in which effective capacity is not less than 35,000 millions cubic feet is computed in Vol. II, Part III, at 377 years which is the computed "Life of the Reservoir."

45. *The Dual Reservoir Scheme.*—Another method suggested for dealing with the silt difficulty is to make an impounding reservoir on one of the branches of the Kistna where the quantity of silt will be comparatively small, and to make at Pulichintala.

a dam wholly, or chiefly, for diversion purposes. The only site for such an impounding reservoir so far seriously considered is the site across the Tungabhadra proposed for the great reservoir for the Tungabhadra project which has been shelved for the present. The silt measurements of the Tungabhadra river taken in 1909 show that the proportion of silt carried in suspension by this river, although large, is materially less than that of the Kistna, while the annual discharge of the Tungabhadra is small compared with that of the Kistna at Bezwada. The mean annual discharge of water and the silt in suspension passing the Tungabhadra reservoir site near Hospet in the months June to November has been computed at 426,000 millions cubic feet of water and 491.8 millions cubic feet of silt.

The site of the dam at Hospet is on hard rock, making it safe to pass water at very high velocity through deep sluices in proximity to the river bed.

The water supplies of the Tungabhadra are such that it would be practicable to pass all flow up to the end of August, through sluices in the dam without impounding, and thus work this reservoir as the Assouan reservoir is worked.

So worked, it is computed the permanent annual silt deposit in the Tungabhadra reservoir can be kept down below 150 millions cubic feet yearly.

The proposal involves the final abandoning of any future prospect of carrying out the Tungabhadra project. The capital cost of such a project is likely to exceed that of the project for a single reservoir as in the project as now submitted by about 130 lakhs. The Tungabhadra dam would cost about 130 lakhs, but the head works at Pulichintala would cost about 50 lakhs less with full level + 208.5.

From the dual reservoirs the returns of revenue for early crop would be the same as for the single reservoir scheme, but the dual reservoirs would have capacity and water enough to enable a large area of second crop to be irrigated in the Upland Canal System, and an increase of second crop area in the Delta System. Worked out on the most favourable assumptions, the project of the dual reservoirs at Hospet and Pulichintala does not compare favourably from a revenue point of view with the single reservoir at Pulichintala. A note on the aspects of such a dual reservoir proposal, by Mr. C. T. Mullings is on record, No. 488, dated 12th July 1910, forwarded to the Chief Engineer with Special Superintending Engineer's No. 264-I., dated 29th July 1910.

The scheme suggested by this officer involved using the Pulichintala dam for diversion and also in a modified degree for impounding, and this suggestion certainly has its attractive aspects.

The proposal was to have "Diversion Level" at + 190.5 and "Impounding Level" at the height computed to be necessary for passing the maximum flood or 204.5. Suppose, however, the impounding level fixed 4 feet higher at + 208.5. The silting computations give the capacity at this level 16,000 millions cubic feet. This amount is much more than sufficient to secure water for early seedlings, but is insufficient to effectively protect the early crop area in both Delta and Uplands.

There are, however, so many uncertainties in the assumptions and calculations of silt deposit, that it is by no means unlikely that the deposit of silt will leave a much greater permanent effective capacity than computations show, while the rate of silt deposit will also very likely be slower before the beginning of the "Final Stage" than computations allow.

It is by no means improbable that at the beginning of the Final Stage, it will be found that effective capacity is as much as 50 per cent. more than that computed, while the time of attaining such a stage may be as much as 66 years, or more, in place of the 44 years allowed.

Should such a difference between the computations and actuals be realised, it would be possible to dispense altogether with the second reservoir, and to work the (early) crop tolerably secure, although without the absolute security provided for in the project now submitted.

In any case the large capacity of the Pulichintala reservoir in the first 30 to 50 years of its life would enable the construction of a second reservoir to be postponed until the actually observed facts of silt deposit enabled close estimates of ultimate necessities to be computed.

The dual reservoir scheme as proposed by Mr. Mullings therefore involves using the Pulichintala reservoir for both diversion and impounding and construction of a second reservoir for impounding only, if, and when, silt deposit in the first reservoir makes this course necessary.

46. *Risk of making too large a Reservoir.*—Although this scheme has not been adopted, there is room for careful consideration of the principles involved.

The uncertainties of the silt problem results, and the probability that a too pessimistic view of it has been taken, point to a policy of restricting the capacity between diversion and impounding level to what will serve, certainly for 50 to 60 years, but which will serve possibly for centuries. The adoption of such a policy would avoid the danger, a very real one under the proposals now made, of making the reservoir unnecessarily large.

The whole problem is one involving so many uncertainties, that while recognising the logical and possible alternatives, it is considered better to adhere to the more expensive programme, which is the logical deduction from the pessimistic assumptions made the basis of computations in the solution of the silt problem.

47. *Recapitulation and Remarks on the Proposed Project Works.*—The proposals, it will be seen, are for the construction of a reservoir of gross capacity 163,586 millions cubic feet and height of water above mean river bed level of 144 feet by means of a masonry dam. It is computed that by silt deposition the effective capacity of the reservoir will be reduced after about 44 years to 50,000 millions cubic feet and at the end of 377 years to 35,000 millions cubic feet. The dam proposed will so raise water as to enable an area of 610,000 acres under the projected Upland Canal System to be irrigated.

In addition the whole ultimate area of irrigation under the existing Kistna Delta System (725,000 acres) will be protected from scarcity of supply in bad seasons, and a further area of 125,000 acres in the delta will be irrigated. The project provides for the necessary alterations and extensions of the existing Head Works at Bezwada and canal system to enable this extra area to be irrigated.

Further from the impounded water a "late crop" will be cultivated varying in extent from a maximum of 222,550 acres downwards and averaging 167,000 acres yearly.

Rules for Working Kistna Reservoir.

I. On or after 10th September commence to impound if the river-flow does not exceed 100,000 cusecs and no flow of over 100,000 cusecs is indicated by up-river wires.

On or after 15th September impound as soon as the river-flow does not exceed 150,000 cusecs and no flow of over 150,000 cusecs is indicated by up-river wires.

II. On wires from up-river indicating a flow amounting to 150,000 cusecs, surplus the reservoir down to "Diversion-level" and keep it at this level till the surplus impounded water.

up-river wires indicate a flow below 150,000 cusecs and when the actual inflow is reduced to this amount impounding must be at once recommenced.

Never surplus the reservoir between 31st October and end of May following.

III. From or after 1st June yearly the reservoir should be surplus down to a level not higher than + 194.5 from the first date in which a fresh of 30,000 cusecs is advised or after 4 consecutive days of flow exceeding 10,000 cusecs and surplus down to impounding level (+ 190.5) on approach of a flood exceeding 50,000 cusecs or after 6 consecutive days' flow of 10,000 cusecs.

Computing area of late crop to be cultivated yearly.

$$\text{on formula } \frac{Q-6000}{198.5} = A;$$

A = late crop area in thousands acres.

Q = impounded quantity in millions cubic feet.

V. When water in excess of duty figures is available, it should be passed into

Using water in excess of duty allowances.

and only surplused over Bezwada anicut when it cannot be usefully employed in the irrigable area.

IV. The area of late crop to be cultivated to be computed on balance available in the reservoir at the end of January.

TABLE of gross capacities of reservoir at Pulichintala and quantity of silt deposits in various stages.

Contour Levels G.T.S. Datum.	Areas, million square feet.			Total area, million square feet.	Mean area.	Gross capacity, million cubic feet.	Total gross capacity, million cubic feet.	Remarks.
	In and over bed of existing river.	Right side.	Left side.					
1	2	3	4	5	6	7	8	9
132	301.20			301.20				
142	336.05			336.05				
152	361.84	78.44	131.71	546.20				
162	379.26	207.22	257.65	826.71	423.7	4,237	9,805.2	
172	398.08	361.00	413.43	1,153.74	686.46	6,864.6	14,042.0	
182	416.20	514.77	569.31	1,482.16	990.22	9,902.2	20,906.6	
192	435.02	668.55	725.14	1,809.89	1,317.55	13,175.5	30,808.8	
202	453.49	850.13	905.95	2,191.10	1,646.02	16,460.2	43,988.3	
212	468.47	1,081.71	1,086.76	2,571.95	2,000.50	20,005.0	60,448.5	
224.5	486.59	1,213.29	1,267.55	2,949.31	2,381.52	23,815.2	80,453.5	
		1,538.14	1,653.21	3,892.94	2,760.63	27,606.3	104,268.7	
					3,171.12	31,711.2	131,875.0	
							163,586.2	

These capacities differ from the previous capacities, G.O., No. 458-I., dated 9th December 1908, by the area of the river bed being materially greater. The areas are now taken from 2nd Revenue Survey map specially lent for the purpose by Revenue Survey; also the capacity in the river bed is computed for the full affected length of river bed and not as previously for only 42 miles.

TABLE of ultimate capacities showing capacities and waterspread area, Kistna Reservoir, in the beginning of the "Final Stage" of silt deposit.

Water level in reservoir.	Capacity, million c. ft.	Area, million sq. ft.	Water level in reservoir.	Capacity, million c. ft.	Area, million sq. ft.
190.5	1,500	232	214.2		
191.8	2,000	296	214.7	26,000	1,922
194.4	3,000	424	215.2	27,000	1,959
196.5	3,823	526	215.7	28,000	1,995
198.8	4,000	545	216.3	29,000	2,032
199.2	5,000	654	216.5	30,000	2,069
201.1	6,000	763	216.7	30,466	2,087
201.5	7,000	873	217.1	31,000	2,096
202.2	7,246	900	217.5	32,000	2,113
203.1	8,000	957	217.9	33,000	2,131
204.0	10,000	1,038	218.3	34,000	2,148
204.9	11,000	1,108	218.7	35,000	2,166
205.8	12,000	1,184	219.2	36,000	2,183
206.5	12,828	1,260	219.6	37,000	2,201
206.6	13,000	1,320	220.0	38,000	2,218
207.2	14,000	1,381	220.4	39,000	2,236
207.8	15,000	1,433	220.8	40,000	2,253
208.5	16,000	1,485	221.2	41,000	2,271
209.1	17,000	1,537	221.6	42,000	2,288
209.7	18,000	1,589	222.0	43,000	2,306
210.3	19,000	1,641	222.4	44,000	2,323
211.0	20,000	1,693	222.8	45,000	2,340
211.5	20,855	1,735	223.2	46,000	2,357
211.6	21,000	1,740	223.6	47,000	2,374
212.1	22,000	1,776	224.1	48,000	2,391
212.6	23,000	1,813	224.5	49,000	2,408
213.1	24,000	1,849		50,000	2,425
213.7	25,000	1,886		50,107	2,437

SECTION III.

KISTNA RESERVOIR AND HEAD WORKS.

A.—General Report.

48. *The Reservoir waterspread.*—The position and extent of the reservoir waterspread is shown on the index map in the pocket of this volume and on a larger scale in the map in the pocket of Vol. II.

The full level of reservoir fixed at 224.5 involves a waterspread area of 123 square miles of which 17.5 square miles is existing river-bed and 53.8 square miles on the left side is Hyderabad State territory and 51.7 square miles on the right side is British.

The boundary line between British and Hyderabad territory is in the river bed.

49. *Area submergible outside the waterspread.*—In the case of the Kistna Dam the area affected and liable to submergence will not be confined, as is the case in general, to the area included within the contour of waterspread, but will include an area above level +224.5.

The reasons for this are fully explained in Part III, Vol. II, which deals with the "Kistna Silt Problem."

Briefly it is due to the alteration in the level of flow of the Kistna from above the dam for some 50 odd miles upstream which will be caused by the raising of water levels at the dam. A new river bed and new river margins will be formed by silt deposition in the "Diversion Period" and these margins will be much above the existing margins, for a considerable distance above the points of intersection of the waterspread contour with the latter.

The longitudinal section of the river (in pocket of Vol. II) shows the forecasted levels of the new river-bed and margins and shows that the waterspread contour intersects the new river margins at only 23 miles above the dam site but that new margins will be formed and flood levels of the Kistna raised for about 62 miles above the dam site.

For purposes of estimating the area outside the waterspread contour which will be affected by submergence and silt deposition owing to the construction of the Kistna Dam lines rising at $\frac{1}{4,000}$ has been traced at approximately the forecasted level of the ultimate 650,000 cusec flood, from the limits of the waterspread on either side of the river until these lines cut the existing river margins.

50. *Total area submergible.*—These lines or the waterspread contour, whichever is the outermost, give the affected or submergible area due to the construction of the dam.

These lines are shown on the map in the pocket of Vol. II and the following statement shows the affected areas—

- In the waterspread of the reservoir.
- Outside the waterspread area.

It is to be noted that the latter areas will only be submerged gradually as silt deposit in the reservoir area affects the surface slope and conditions of flow of the new river.

After a period of submergence, new marginal alluvial areas will gradually form and the areas outside the waterspread will eventually become very fertile alluvial tracts which can be again re-occupied and cultivated. The period involved is computed at 44 years, but it would be probably a good deal longer, and acquisition of the whole affected tracts is provided for.

Area submerged excluding existing river bed.

Area submerged.	British territory.		Hyderabad territory.		Total square miles.
	Acres.	Square miles.	Acres.	Square miles.	
Waterspread area level 224.6...	33,125	51.75	34,458	53.84	105.59
Above waterspread level ..	7,100	11.09	13,320	20.81	31.90
Total ..	40,225	62.84	47,778	74.65	137.49

51. *Remarks regarding conditions of the Dam Site.*—Generally speaking, the rocks on which the foundations of all the Head Works rest are of two kinds—
(i) Shale having the general characteristics of slate.
(ii) Limestone.

The Main Dam in all its deepest parts and throughout the greater part of its length is founded on the former.

The surplus works are founded and discharge their water over the latter.

On first consideration of the Pulichintala sites the first point to be settled was recognised to be the suitability or otherwise of the shale as a foundation for a great dam.

It was recognised that the shale was by no means an ideal foundation, and it was settled that a report on the sites by an experienced Geologist was desirable before spending money in further investigations. With the kind permission of the Mysore Government, the services of Dr. W. F. Smeeth, State Geologist, Mysore, were made available and this officer has written a full and clear report on the various sites which were at that time under consideration.

52. *Geological report.*—This report is reprinted as Appendix II of this volume and refers to various sites since eliminated from consideration, but it specially has reference to the several sites in the immediate vicinity of the Pulichintala ridge. The site which originally appeared the best (No. 2 of Dr. Smeeth's report shown in dotted red line on the site plan opposite page 24) has been abandoned owing to the very soft condition of the shale in the ridge (A, B in Dr. Smeeth's geological map Appendix II) proposed as the position for the main surplus works which was discovered on digging trial pits.

The site selected is No. 1 of Dr. Smeeth's report. It may here be mentioned that the objection taken to this site by Dr. Smeeth of interstratification of shale and quartzite has not, so far as the borings show, proved serious. The veins of quartzite have been very thin, generally less than one inch thick, and disappear altogether within from 10 to 20 feet of the rock surface.

The report of Dr. Smeeth on the shale (slate) available for foundations has been decidedly favourable and on this report it was decided to proceed.

The geological report, Appendix II, should be referred to for fuller particulars, but the most important paragraphs having reference to this matter are quoted below, the remainder of this paragraph being from Dr. Smeeth's report:—

"Slaty shales . . . overlie the lime-stones and form the bed of the river from a little south of Mukhtala up nearly to Vellatur. The slaty shales are on the whole much more of the character of slates than of shales, and hereafter I shall call them Slates. They were originally mud-stones containing a large, though variable, proportion of fine sand, subsequent pressure has consolidated them, and recrystallized the argillaceous components to a very large extent, with the production of chlorite, mica, and allied minerals."

"In some layers small amounts of carbonate of lime have been formed and in places a little pyrites, a few of the beds approach argillaceous limestones in character, and some containing coarse sand grains might be described as "grits."

"Although the beds are dipping at low angles, they have evidently been subjected to considerable pressure resulting not only in the crystallisation above referred to, but also in the development of an imperfect slaty cleavage, which is frequently distinctly oblique to the original planes of bedding of the rocks. This pressure has been a favourable and important factor from the point of view of the suitability of the rocks to serve as the foundations of a large dam. Not only has the original material been strongly compacted, but much of it which once existed as fine sediment, has been converted into a crystalline material forming a cement for the larger sand grains, thereby rendering the rock as a whole little pervious to water."

"*Resistance to deformation.*—The slates are on the whole fairly soft rocks, that is to say, they have not much power of resisting abrasion. This fortunately is a factor which does not affect the problem of the proposed dam very much. In dealing with the very large volume of surplus water which comes down the Kistna, it will of course be necessary to construct the waste weir of solid masonry with a well-built apron and to guard against any lateral scour along the toe of the dam, if the site finally chosen tends to produce such scour, but there is, I should say, no difficulty in providing for this by suitable construction."

"As to resistance to crushing due to forces acting on the masonry of the dam, it may be admitted that the average crushing strength of these slates is not very high as rocks go, that is to say, the rock would not give very high results if crushed in a testing machine. Good slate will give a crushing strain of 10,000 lb. per square inch and upwards, but I should doubt if the rock in the Kistna river would stand more than about one-third of that amount. This is only a rough guess, and as none of the rocks which are exposed in the river are really sound and unweathered, no useful tests have been possible. Sound rock will be met with in excavating for foundations and I should be glad to have some tests made subsequently."

"Supposing, however, the rock can stand only a strain of 3,000 lbs. per square inch, this will still amount to about 190 tons per square foot, and as the strain on the foundations is not to exceed 10 tons per square foot, there appears to be an ample margin of safety even if my estimate was found to be somewhat too high."

"Further, it must be remembered that the crushing of a block in a testing machine by no means represents the sort of work which the rock is called upon to perform in practice. In the foundation the rock is confined and supported on all sides and cannot yield unless it is compressible or unless the pressure is sufficient to set up a flow, and there can be no question that the compressibility of the rock will be negligible—probably not exceeding that of the masonry of the dam itself—and that the pressure which could produce flow will never be approached. In my opinion, therefore, there is no question as to the rock being amply strong enough to bear any weight which may be placed upon it without sensible deformation."

"*The quartzites.*—These are interbedded with the slates. A thick bed of quartzite forms the crest of the Pulichintala ridge and lies on the eastern slope of the same. In the bed of the river there are a few comparatively thin beds of quartzite and three or four beds of quartzite form the chief out-crops on the ridges south of Wadanapalli which sweep away westwards and return and cross the river near Pulichintala. South of Pulichintala I did not see any out-crops of quartzite though the beds no doubt extend under the capping of alluvium and soil."

"From the point of view of foundations we have to consider a number of thin beds of quartzite intercalated with the slates. These quartzites are composed essentially of sandgrains from fine to coarse in texture and cemented together by a little altered argillaceous material. In several cases the quartzite beds have been penetrated by veins of quartz and the original sandy grains have been largely connected by infiltrations of silica rendering the material rather vitreous in character and making it very compact and impervious. This appears to have been largely the case with the big bed forming the crest of the Pulichintala ridge and with portions of the beds intercalated with the slates in the river bed."

"Taken as a whole, these quartzite beds will have a considerably higher resistance to crushing than the enclosing slates. On the other hand, although the material of the quartzite beds will be *per se* more impervious than the slates, the amount of jointing and fissuring which they have suffered renders them more permeable in their superficial parts. I am of opinion that this jointing and fissuring will not be found to extend to any considerable depth below the bed of the river and that whatever percolation may occur at first, will not prove deleterious to the strength and stability of the rock material and will probably be reduced to a comparatively insignificant amount by the filling up of the cracks with fine sediment."

53. *Position of the main dam.*—The site selected for the Kistna dam is referred to as the "Pulichintala site" (site No. 1 on site plan of Head Works, opposite page 24). The right end of the dam rests on Pulichintala ridge which is close to the river margin and also close to the north end of the ridge, while the Upland Main Canal is designed to be led round the north slope of the ridge in steep sidelong ground in preference to tunnelling through the ridge (which would involve a length of about 2,000 feet of tunnel) which was the original proposal.

The reason for the alteration is that rough estimates showed the former alternative to be much more economical.

From the Pulichintala ridge the dam is carried across the Kistna river bed in a direction about west by north to a small hill standing close to the left margin of the river on the northern slopes of which stands the small village of Wadanapalli. The hill is hereafter alluded to as "Wadanapalli Hill" (or Ridge). The distance across from Pulichintala ridge to the top of Wadanapalli Hill (point B) measured at level of full reservoir is 4,724 feet. The top of the hill is much below full reservoir level being about + 180. Here the line of dam is diverted in a northerly direction and crosses a minor depression to the extreme left flank of the solid dam which stands on the crest of a minor spur, the point "K" on the site plan.

The level of the spur at this point is + 156 so that the water at full reservoir level stands at 68 feet in depth over this point.

The left flank of the "Main Dam" and the right flank of the surplus works which are a prolongation of the dam meet at K.

The length B. K. is 5,910 feet making a total length of Main Dam including Head Regulator of 10,634 feet.

54. *Description of Dam Head Works.*—The following is a general brief description of the Dam and Head Works.

On the extreme right flank of the works the Upland Main Canal takes off being supplied by a head regulator forming the extreme right flank of the dam.

The regulator has six vents of 16 × 16 feet with cill at + 174.5. Over the Regulator and Dam and Surplus-works is a roadway of 14 feet wide running from end to end of the work at a level + 231 over the Dam and 233½ over the Surplus sluices.

The Upland Main Canal is aligned round the north end of the Pulichintala ridge in steep sidelong ground. The road leading to the top of the dam from the right side is cut along the right of the main canal in the hill side above it. The main dam is designed as a solid gravity dam on a straight alignment. It is pierced by 4 deep sluice culverts each of section 7 feet wide and 30 feet high with cills at + 144.5 and separated by piers 28 feet thick. These sluices are on the extreme right of the deep river bed and are so placed to serve as scouring sluices to keep the approach to the Head Regulators of the Upland Canal free from obstruction by silt deposit.

For the length of dam in which these sluices are placed a special form of profile is provided to secure stability, and this profile has a projecting floor provided on the downstream side at sluice cill level, to carry the water from sluices clear of the downstream face of the dam so that it will fall direct into the water cushion without impinging on the face of the dam.

With this exception, the profile of the main dam is the same throughout, to where it connects (at K) with the right of the surplus sluices, and follows the ordinary recognised type. It is designed generally for a limiting pressure of 8 tons per square foot.

Further detail regarding the design and pressures is given in the technical paragraphs (120 to 122).

From the right flank to the top of Wadanapalli Hill the dam is to be built of small random rubble in surki lime mortar, and on the left of this it is to be built of limestone (napah stone) slabs laid in parallel courses inclined at 1 in 4 to the horizontal. This applies also to the surplus works.

Statement of lengths and levels of the Kistna Dam proposed.

	FEET.
Length of Main Dam	10,475
Length of Surplus Works and flank extension excluding earthen bank	6,998
Length of Head Regulator	159
Total length of work from end to end	17,632
Level of top of dam	+ 230
Level of top of parapet	+ 235
Full reservoir level during impounding season	+ 224.5
Level during discharge maximum flood	+ 204.5
Levels of crest of cushion dam	+ 110 and 116
Mean level of river bed	+ 80
Computed area of water-spread at full level at beginning of Final Stage of Silting	sq. Mls. 67.65
Area submerged at full level under existing conditions	121.71
Total masonry in Main Dam and Head Works	CUB. FT. 5,89,15,000

55. *Surplus sluices.*—From the angle K the sluices stand on the napa-stone ridge along the alignment K.D. and occupy the whole of this length with sluices of various dimensions as noted below working from right to left.

Right surplus sluices	95 vents of 16 feet wide by 14 feet high, cill at + 172.5.
Central surplus sluices	54 vents of 20 feet wide, 16 feet high, cill + 178.5.
Left surplus sluices (set B).	27 vents 30 feet wide, 12 feet high, cill + 191.
Left surplus sluices (set A).	15 vents 30 feet wide, 12 feet high, cill + 191.

The left surplus sluices (set A) are placed across the head of the Mukhtala valley to the left of the angle D.

The surplus sluices all consist of masonry piers 7 to 7½ feet thick, spanned by masonry arches carrying a road, and carrying on the upstream side of the road the platforms from which the sluice shutters are operated.

To the left of sluices the piers and arches carrying the road are continued, the space between piers below full reservoir level being closed by horizontal masonry arches of limestone sprung from the piers.

A similar method of closing the spaces above the top of the shutters of the surplus sluices is adopted.

On the extreme left flank an earthen bank is used where the ground level is above + 220. The road is carried over the top of this bank and connects with the metalled road to be carried from here to join the existing Jaggayapet-Mukhtala road.

56. *Power for operating Surplus Sluices.*—The great number of sluices call for a rapid and efficient means of operating in flood time and it is proposed that the surplus sluices shall be operated by power derived from two electric motors mounted on trollies and running on rails on the sluice platform, which can be connected in turn with each sluice shutter. Four lifting gear trollies with hand-gear for operating the shutters should be provided for use in case of break-down of the electric plant. Two turbine tubes and turbines will be installed on the main-dam in the vicinity of K for supply of power for this and for Workshops which must be permanently maintained at the site of these works.

The details of design of the turbines, turbine-tubes and power-house have not been worked out, but ample lump-sum provision for these is made in the estimates for the Works.

57. *Cushion-Dam*.—Across the Kistna river below the Main-Dam, a subsidiary low dam (on line XI, X and XII) forms part of the Head Works.

The function of the work is the protection of the river-bed below the Main-Dam from the effects of surplusing over the partially finished work during construction. Such a system of surplusing forms a waterfall of huge volume and of considerable height and the shock and action on the river-bed below the work, if unprotected, would be very great. It is, therefore, proposed to pool the water below to a depth of not less than 30 feet by means of a cushion-dam.

From the hillock (F) on the right margin a spur of quartzite rock runs out into the river-bed and stands up above its general level forming a natural groyne of hard rock projecting into the river-bed and running in a diagonal direction about one-third the whole distance across.

The cushion-dam site is aligned along this quartzite following the alignments of this feature using the hard rock of this feature as a safe foundation and as an apron to take the impact of water falling over the work on to it.

From where the hard rock terminates the cushion-dam is aligned following the shortest line to the projecting slopes of Wadanapalli hill into which its left flank is tied. Detailed description of the Cushion-Dam will be found under "Technical" paragraph 141.

58. *Remarks on Site of Head-Works*.—The site plan of the Head Works shows the position of the out-crops of limestone on the site of the works. The limestone of this formation (locally termed "Nawah-stone") is a hard crystalline marble, generally slate coloured, but found also in various shades from almost pure white, and also in purple colours.

The limestone outcrop intersects the overlying shale on the left of the river in a line of direction about north-east. The limestone is solid and bedded to great depth, and is considered a suitable and safe surface on to which to discharge the surplus flow of the Kistna.

The shale while suitable for a foundation being homogeneous, and capable of bearing any load which will be placed on it, is unsuitable for withstanding the attrition caused by a rush of water moving over it with high velocity, or the impact of falling water in great masses.

For this reason the surplus works are all located on "nawah stone" and with a run off over this formation. The line *DK* showing the general line of the Surplus Works nearly coincides with the top of the spur forming the water-shed between the minor valley running past Wadanapalli village and referred to as "Wadanapalli Vagu" (or valley) and the minor drainage joining the Kistna just above Mukhtiala which is called "Mukhtiala Vagu." The latter drainage is bounded and confined on both sides by a "nawah stone" formation and outfalls into the Kistna $2\frac{1}{2}$ miles below the dam-site. The Wadanapalli Vagu runs mostly through a shale and alluvial formation and joins the Kistna less than a mile below the dam-site.

The "nawah-stone" outcrops along the line *KI* are split up by bands of shale intruding between them. The question of installing surplus sluices along this line has been considered and is judged to be undesirable. The fall from such surplus would be such that the water would run off with such great and destructive velocity as to endanger serious displacement even of a solid and continuous "nawah stone" formation, and this formation is not continuous "nawah stone".

It has been decided therefore to carry the Main Dam across the Wadanapalli Vagu and to pass all the surplus into "Mukhtiala Vagu".

This decision affects and decides the alignment of the dam between B and K. The point K is fixed as high up the ridge KD as will permit:—

(a) Discharge by the surplus works of about 475 cusecs with a water-level in the reservoir not above + 190.5.

(b) Carrying capacity in the "Muktiala Vagu" of the water discharged by the surplus sluices up to a maximum of about one million cusecs.

(c) Discharge through surplus sluices with eills limited to a depth not below + 172.5.

It is not considered desirable to place very deep sluices in the length CK with the effect of discharging water with great velocity on to the "napah stone" slope, although by so doing it would be possible to shift the point *K* higher up the ridge.

It will thus be seen that the left end of the alignment of a dam of which the right flank rests on the north end of Pulichintala ridge at (II) is fixed at *K* by consideration of surplus requirements. The alignment fixed for the Main Dam between *B* and *K* has been drawn with a view to damming between these points in the most economical manner without throttling unduly the waterway giving access to the surplus sluices. The alignment from *B* to *K* is taken along lower ground than would otherwise be necessary in view of the last consideration. The alignment across the main river from the right flank to Wadanapalli Hill is the shortest.

59. *The rift in the river-bed.*—Over a great part of the river-bed the shale formation is exposed with occasional thin intrusions of quartzite. On the margins similar formation is exhibited. In part of the crossing sand overlies the rock.

In the preliminary investigations the depth of rock below the sand was judged by probing with sharp pointed iron rods until a hard surface was struck and it was believed from these that the rock was nowhere more than 10 feet below the sand surface, that is, nowhere below level + 70.

The borings which were undertaken as part of the detailed investigations has revealed a much less favourable state of affairs. It is found that under the sand nearly in the centre of the river-bed there is a deep gulley, or rift, in the rock bottom and this is filled with shingle up to a level of from + 70 to + 73, which shingle had been taken to be rock surface from the preliminary probings.

The gulley has a width at the top, at level + 70, of 425 feet, while it goes down at an intermediate point in this width to + 20 before shale is struck. The top 6 to 8 feet of this shale is soft and to be quite safe, it is assumed that the deepest foundation in the bottom of the rift will be at a level + 7 for a length of 160 feet.

It will be evident that the existence of this rift introduces an unexpected source of difficulty and expense into the construction.

It will at once suggest itself that it is possible such a formidable depression may be avoided by taking another alignment across the river. In this connection it may be noted that it is unlikely that such a depression as has been located occurs in the form of an isolated pot-hole, and the probability is that it is a continuous gulley extending probably for some miles and the fact of its being filled with rolled shingle supports this view. It is, however, by no means unlikely that at some other point of crossing, the gulley while existing is of less formidable dimensions.

The borings taken at the site of the Cushion Dam (alignment XI, X, XII) locate a similar gulley on the left centre of the river-bed and of depth of 40 feet. The series of borings on this site are too few to give all the information required.

60. *Borings.*—The boring apparatus procured for the investigations consisted of a calyx drill (Ingersoll Rand Company of New York). This is a rotary rock-drill cutting a core which can be lifted from the bore, the cutting being done by chilled steel-shot. As a rock-drill, the apparatus has proved thoroughly efficient and rapid, and had the beds of shingle between the sand and rock not been met with, sufficient borings might have been taken in the river bed in five months.

The penetration of the shingle proved a very tedious and slow operation, occasionally as little as one foot a day being got through, and as a result, at the end of the second dry season's work, the borings in the river-bed have been insufficient to locate fully the depth and width of the gulley on the Cushion Dam selected alignment, and has not permitted trial borings on any other alignment to be taken.

For this reason boring operations are being continued in the river-bed during the current dry season (1911) and are now in progress.

Trial borings are now being taken along the alignment III, X, XII which line may also, for other reasons than those connected with the size of the river-bed rift, be preferred for location of the Main Dam. The other reasons are discussed in paragraph 68.

61. *Reason for completing designs and estimates for the upper alignment.*—The boring in shingle being so slow a process, there is no possibility of sufficient result of the work in progress being available within the next month, and it has been decided to make designs for the Head Works on the supposition that the alignment on which borings are available is the best and to re-design the plans of the Head Works, should this appear desirable, on the further borings now being undertaken becoming available. The only alternative to this procedure appears to be to delay design of the Head Works till the further borings are available which will probably not be till the beginning of June 1911 and may possibly even then be insufficient for a final settlement of the best alignment.

The alternative would involve either keeping on the investigating and designing staff at great expense, awaiting the results of borings, or of dispersing this staff to other duties, leaving an altogether incomplete project. It is considered therefore better to complete the project for a site of dam which it is admitted may prove not to be the best.

It is to be realised that a better site will probably connote lower cost of Head Works, and that if the present estimate errs in the matter of site, the cost will not be increased by a change.

62. *Alternative alignment of Dam to the left of Wadanapalli Hill.*—The alignment (KI) of dam to the left of Wadanapalli Hill is fixed by the requirements of surplus works on the ridge line *KD*. If any considerable proportion of the surplus can be passed elsewhere, this alignment can be modified and the cost materially reduced.

The surplus works originally proposed by the writer provided for 40 (36 additional) deep sluices in the Main Dam of $7' \times 30'$ with cills at $+144.5$, and capable of discharging 6,428 cusecs per sluice, or a total 231,228 cusecs for the 36 sluices with water in the reservoir at Diversion Level ($+190.5$) or standing 46 feet over cill level. (The coefficient used in this computation is .70 the actual of Assouan Dam sluices, flowing full, being .72).

The effect of such an arrangement would be to render it unnecessary to carry the right end of the surplus escape so far down the ridge as *K* and it would be located in the vicinity of *C* and the alignment of dam would be along *IC* while the reduction in capacity required of surplus works along *KD* would be equivalent to the discharge of 66 of the Right Sluices, that is, equivalent to a length of 1,518 feet length of such surplus sluices.

A great saving in cost would be realized on construction of the left section of the dam and surplus works by adopting this arrangement, but this would be nearly counterbalanced by the extra cost of the 36 additional sluices in the dam, and of building the dam of the extra cross sectional dimensions for the "Vented Section" throughout the length in which such sluices are installed.

A rough alternative estimate has shown that the difference in cost between the two arrangements is inconsiderable, and the one provided for should be that considered best independently of cost.

63. *Arrangement of sluices selected by the Inspector-General of Irrigation.*—The matter has been carefully considered and discussed with the Inspector-General of Irrigation (Sir J. Benton) when that officer visited Madras, and it is in deference to the strongly expressed opinion, and specific desire, of that officer that the arrangement of design in this respect is made. Only four deep scouring sluices are provided in the Main Dam to keep the approaches to the Head Regulator of the Upland Canal clear of accumulations of silt.

64. *Alternative arrangement of surplus sluices advocated by the Special Superintending Engineer.*—While thus deferring to Sir J. Benton's opinion and

wishes, the writer wishes to record his opinion that the original proposal to have a set of 40 powerful surplus sluices (of the Assouan Dam Type) in the Main Dam is a preferable arrangement and the various aspects of the question are briefly noted on.

65. *Reasons for and against each alternative.*—The main objection taken to surplus sluices in the Main-Dam is, that the river-bed consists of shale, a rock not calculated to stand severe action either by shock or rush of great masses of water, and the protection of the river-bed between the dam and the cushion by heavy flooring would be a very costly work. On the other side of the question it is urged that it is proposed to build a Cushion Dam with crest, 30 feet above river-bed, and thus form a pool from 30 to 50 feet deep into which the falling water will drop. Such a work is imperatively called for to protect the river-bed from damage by the falling of surplus water passed over the top of the dam during construction.

The cill proposed for the deep sluices is $+144.5$ and the fall will thus not be excessive, while increasing the height of the cushion by six feet is a simple and inexpensive work and the cushion is designed with a view to this possibility. The sluices in the left flank of the dam would always be opened sufficiently to cause the river to back up 15 to 20 feet deep below the cushion dam before surplus through sluices in the dam; thus, this work would be amply protected and not itself require a further Cushion Dam.

Further the only method of surplus the whole river during construction with floods up to at least 500,000 cusecs, and a possible million cusecs, is over the Main Dam, up to a level of dam crest of $+150$. To protect the bed below the dam during construction a Cushion Dam is a necessity. If it is safe to surplus floods up to say 500,000 cusecs and for one or two seasons to pass all river flow from June to October continuously over the dam with such a fall, it will certainly be safe to surplus 250,000 cusecs for three or four days a year with a similar fall into a similar cushion, after the dam is completed.

The writer has some slight misgivings regarding the safety of the surplus during construction, but none as regards the surplus through deep sluices after the dam is completed.

Further it is pointed out that a few scouring deep sluices in the main dam are necessary to keep open access to the Head Regulator and it appears almost equally dangerous to work four such sluices as 40, so far as the effect on the part of the river-bed immediately below the sluices is concerned.

66. Again it is shewn by the Inspector-General in his notes and remarks on the Kistna Project, that if the Main Dam can be suitably located some distance below the main draw-off to the surplus works, such as on an alignment between E and F, a great accumulation of silt will be thrown down immediately upstream of the dam filling the whole old river bed with silt up to a level probably $+175$ or more.

If in spite of all precautions, the forecast as regards silt deposit prove erroneous and the reservoir capacity becomes insufficient, then the full reservoir level (impounding level) can be raised by building an earthen bund, say along the line of the dam now proposed (A-II) founded on the impervious silt.

This would give a further life to the reservoir at comparatively small cost.

This expedient would be inapplicable, in combination with surplus sluices in the Main Dam and this may be regarded as an objection to such sluices. The other side of this matter as it presents itself to the writer is, that the probability of the silt computations erring greatly in allowing too long a life to the reservoir is remote. Further it is considered that in the event of impervious silt deposits lying against the dam and for some distance upstream to a level of, say $+130$ (15 feet below cill of surplus sluices in the dam), it would be a better and safer alternative to raise the masonry of the dam and water level by 3 or 4 feet (equivalent to added life of several hundred years) than to resort to the earthen-dam proposed. The lesser pressure against the dam of the impervious silt as compared with water which the silt replaces, would make such raising absolutely safe.

67. *Advantages and disadvantages of surplus sluices in Main Dam.*—The advantages claimed for the forty surplus sluices in the main dam are :—

(1) They will keep open the main river-bed and approach to the Head Regulator, keeping the bed of the river here down to about sill level of the deep sluices, or at any rate, to so far below sill of the regulator as to keep all heavy sand out of the canal.

(2) They will relieve the very heavy work thrown on the run-off channel (Muktiala Vagu) in carrying the whole discharge of such a river as the Kistna. If 40 sluices of 7×30 feet were as proposed installed in the Main Dam, the discharge through Muktiala Vagu would only exceed 400,000 cusecs, about three days in two years.

(3) They will materially facilitate surplusing during construction.

The disadvantages are :—

(1) Possible damage to the river-bed below the dam.

(2) They are a bar to raising impounding level by construction of an earthen dam on the silt deposit above the dam.

68. *Alternative lower site of Main Dam across deep river-bed.*—The site plan shows that certain advantages would result, were the Main Dam constructed between the north end of Wadanapalli Hill and hill *F* on the right side of the river.

By such a construction the reservoir waterspread would out-flank the north end of Pulichintala ridge and a very expensive length of canal round the north of this ridge (about $1\frac{1}{2}$ miles) would be saved. This alternative alignment would necessitate several small stop dams on lines (V, VI), east of (VII, VIII) and along (H, M).

These works, however, present no difficulties and would not be costly.

The Upland Canal Head-Regulator would be at M.

Before the higher alignment (II, A) with the right flank resting on the main ridge was selected, the lower one was considered. The reasons for preferring the upper one were —

(a) The length of high dam is somewhat less across the upper site.

(b) The lower site for the Main Dam interferes with the site selected as the best for the Cushion Dam approximately on alignment XI, X, XII and an alternative but less convenient alignment (XI, XIII, XIV) must be adopted for this if the main dam is on the lower site.

(c) The rocks on the lower alignment are more mixed and especially on the right side of the river the intrusions of quartzite are much more formidable than on the upper site.

The Geological report especially draws attention to the disadvantages of this.

(d) It will be more difficult with the lower position of Main-Dam to keep the approaches to the Head-Regulator of the upland canal free from obstruction by silt.

It has been noticed already that with a dam on the lower site it is probable that great quantities of silt will be deposited in the main river-bed between line A-II and the dam and incidentally over all the space between the hill *F* and Pulichintala ridge. In the event of a main dam without deep surplus sluices in it being built, the whole draw-off to the undersluices along the line *KD* will be through the openings in the marginal hills south of *A*, and it is almost certain that, in spite of the draw-off for irrigation through a regulator at *M*, and the draw-off from a few powerful deep sluices in the main dam (near III), huge masses of silt up to level between + 175 to 185 will fill the whole area north of line A-II and in the basin between *H G F* and the Pulichintala ridge.

The advantage to be derived from this is the possibility of erecting on this mass of silt an earthen reservoir bund along an alignment about II-A for raising full reservoir level, should, owing to excessive silt deposition, capacity be found anticipated in keeping open the channel to the canal off-take. On the whole the writer is of opinion that, given similar difficulties as regards the deep rift in the river-bed at both sites, the upper site is to be preferred.

Further if the borings show the lower site preferable, he considers the 40 deep surplus sluices in the main dam still more desirable than in the case of the dam at the upper site on account of the help these will give in keeping the approaches to the head regulator at *M* open.

69. *Borings on the lower site in progress.*—The discovery of this rift has, however, rendered the necessity for further investigation by borings along the lower one apparent and this work is now being carried out.

As already explained (paragraph 61) for the purpose of this estimate the upper site is the one selected in the absence of the borings necessary for making a full comparison of the two sites.

70. *Dealing with river discharge during construction.*—There are two distinct seasons of river flow and the arrangements for construction must depend on these.

The "Dry Season" having small discharge lasts from about 16th November to 15th June, but for purposes of a construction programme 1st December to 31st May (six months) is assumed generally to be the period of low or "dry season" discharge.

Throughout this season discharge is generally less than 10,000 cusecs.

The "Flow season" lasts from 16th June to 15th October and in this season discharge on any day may be as much as 100,000 cusecs, while ordinary floods may be expected yearly up to 400,000 to 500,000 cusecs, and extraordinary floods once in very few years go up to about 650,000 cusecs. The maximum recorded in sixty years is one million cusecs, but this is much in excess of the next highest record.

In describing the methods of water disposal during construction, the "Dry Season" and "Flow season" methods are taken separately.

71. *Disposal of surplus water in the "Dry Season".*—The only time when this presents any difficulty, is when the foundations of the dam in the main river-bed are below river-bed level and are being put in and the arrangements proposed for this period of construction are described in the following paragraphs.

72. *Dimensions of rift in river-bed.*—The rift in the river-bed consists of a wedge-shaped gully in the shale filled up to level + 76 with shingle and above this with sand to about level + 83.

Soft shale to a depth of about 6 feet overlies the hard shale at the bottom of the gully. The deepest level of hard shale is + 14.

The widths between hard shale across the gully from side to side are as below :—

Level.	Width in feet.
+ 14	160
+ 20	240
+ 40	300
+ 60	375
+ 74 top of shale on right side	425

73. *Arrangements for shutting off water from the rift.*—The top of the shale on the left side of the gully is + 79 to + 80. The whole of the filling of shingle and sand lying in the rift will be full of water and before putting in foundations here, it will be necessary to un-water the foundation trench. The nature of the filling will allow so free a passage of water and the cross sectional area of the rift is so great that it is plain that the construction of a stop-wall which will prevent any considerable percolation at each end of the space to be cleared of water is a necessity. It was originally proposed to construct 2 coffer dams across the rift, 200 feet upstream and downstream of the centre of the dam.

Each of these was to be composed of 2 rows of interlocking steel piles driven on the circumference of a segment of a circle concave to the dam.

The shingle between the rows of piles was to be dredged out and filled in with Portland cement concrete. This would have resulted in constructing 2 arched concrete dams with springings on the shale sides of the rift. It was proposed to then pump out water and remove the shingle between these coffer dams.

This method of construction would be very costly and there would be difficulties in forming secure skew backs in the shale sides for springings of the arches.

74. *Curtain of interlocking steel piles.*—This proposal has been modified in favour of substituting for each of the coffer dams proposed a single row of interlocking steel piles driven through the sand and shingle several feet into the soft shale forming the bottom of the rift and with top levels + 186.

In order that the water pressure may tend to close the joints in this water-tight barrier, it is proposed that the piles should be driven on a segmental alignment with radius 450 feet. It is proposed that this thin water-tight bulkhead shall be backed by sufficient shingle and sand on the dam side of it and that stability be obtained from the weight of shingle now lying *in situ* in the rift instead of from the originally suggested concrete and steel arched dam. The modification entails leaving a quantity of shingle undisturbed in the space between the bulkheads, and the proposed distance between the springings of the arches is 600 feet in place of 400 feet originally proposed. This leaves space for over 150 feet of shingle backing to each curtain of piles. The actual location of each curtain or bulkhead must be fixed by borings giving details of the cross sections of the rift some 300 to 400 feet above and below the centre line of dam. In the absence of such borings, for the purposes of the estimates, the cross section of the rift on the dam line is taken as the dimensions of the ends to be blocked.

It is proposed that the piles shall be driven from barges and thus work can be done at any time when the depth of water over the site does not exceed, say, 10 or 12 feet.

For work in the dry season, sufficient depth to float the barges can easily be obtained by dredging.

The operations proposed are neither very difficult nor very costly and they are believed to be quite safe. There will be no doubt some percolation under and between the piles, but this will not be great and can easily be removed by powerful pumps. After the completion of the dam up to + 80, the piles will be drawn and used again for the curtain wall upstream of the water cushion dam where it is founded on wells.

75. *Diversion walls across the river.*—From the ends of the curtains of steel piles, it is proposed to build masonry walls 5 feet thick across the river and with crest at + 83. The walls will be built of random rubble and will be bedded on the shale in the river bed, at levels about + 75 on the right of the rift under the sand, to and about + 80 or higher on the left of the rift.

A space of width 450 feet will be left unclosed to the left side of the rift and in this space it is proposed to pass all the river water during the years of construction of foundations. On each side of this 450 feet, space walls 4 feet thick will be built parallel to the river axis and with top level + 86. These walls will, in the flood season, offer no material obstruction to water-way, and between them all river water in the dry season will be passed. The ends of the diversion walls built across the river with crest level + 83 will be connected to these boundary walls and to the ends of the coffer dams.

In the diversion walls will be built iron anchor bolts at about 12 feet interval to which trestles will be bolted yearly as soon as the dry season begins.

These trestles will carry beams and a footway and will support corrugated iron needles with top at + 190 blocking all water-way, which (the needles) can be placed in position or removed from the footway and will divert the water in the dry season.

76. *Advisability of permanent diversion works.*—It is considered that the expenditure to be incurred in putting in these solid diversion works in the first 2 dry seasons devoted to preliminary operations will be more than repaid by the time saved in yearly forming temporary stop banks and diversion works which would be a constant source of anxiety throughout each dry season and would yearly have to be constructed afresh.

In the following diagram are sketch sections of the coffer dam and interlocking steel piles and also of the diversion wall with trestles, needles and footway.

Diagram illustrating the cross-section of a weir structure. The structure is built on a foundation of rubble masonry, which is flanked by shingle and shale. The water level is indicated as +181. The weir structure includes a fixed anchorage and a removable trestle. The top of the weir is labeled +182.5, and the maximum water level in the dry season is +186. The diagram also shows corrugated sheet piling and a shingle layer.

Labels and dimensions in the diagram:

- MAXIMUM WATER LEVEL DRY SEASON +186
- +186.5
- +187
- +182.5
- +181
- +176
- SAND
- SHINGLE
- SHALE
- RUBBLE MASONRY
- SHINGLE
- CORRUGATED SHEET PILING
- REMOVABLE TRELLIS
- FIXED ANCHORAGE
- 1 IN 2
- 5'

Diagram illustrating a cross-section of a concrete structure, likely a dam or bridge pier, showing a curved profile. The structure is divided into sections with dimensions: a vertical section of 20 FT, a horizontal section of 8 FT, and a sloped section of 20 FT. The sloped section is labeled "BATTER 3/4". The top surface is labeled "DOTTED TOP WORK IS PORTLAND CEMENT CONCRETE".

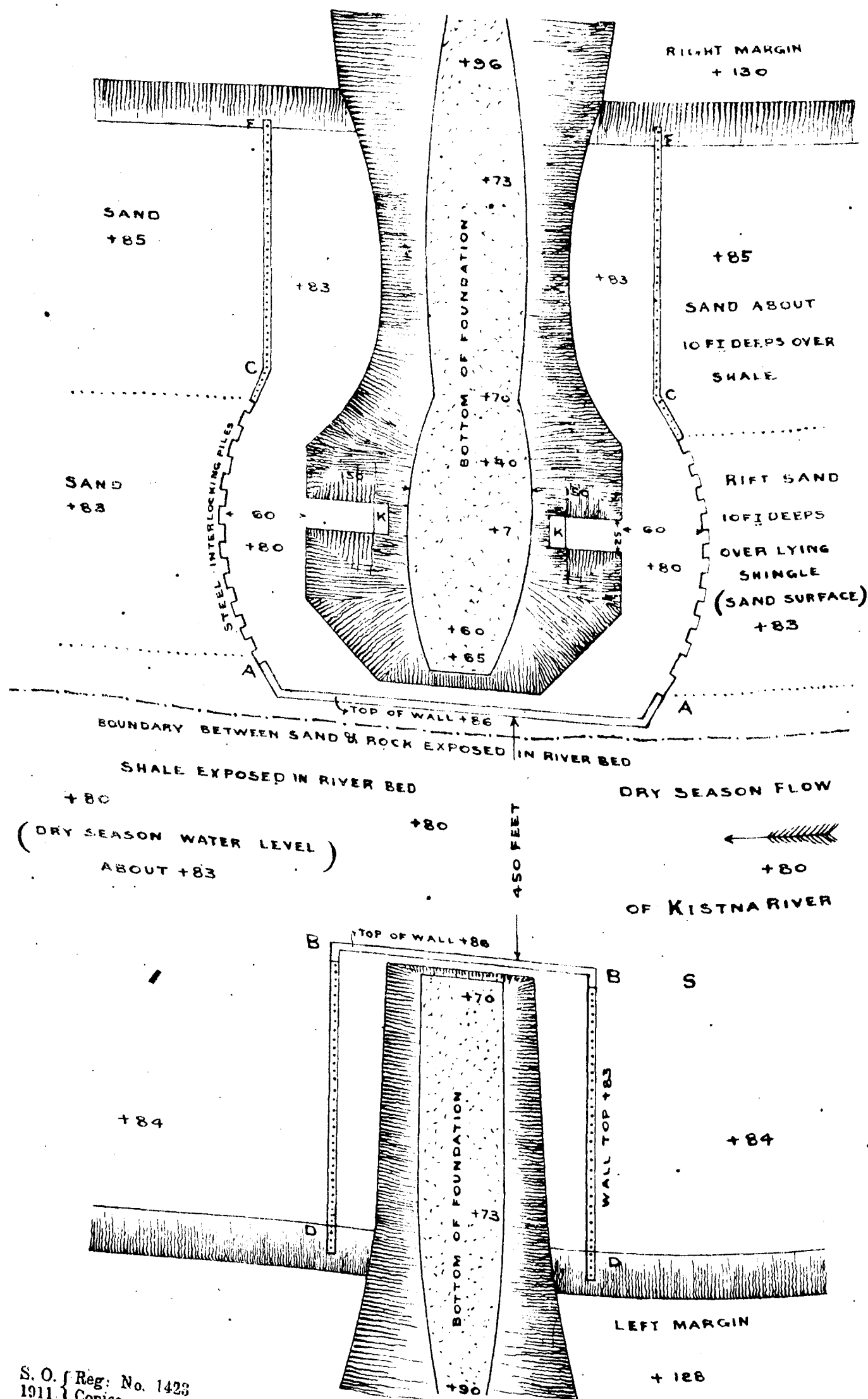


CHANNELS 15" X 4" OF 41.94 LBS
 ZEDS 5" X 3" X 3" OF 14.17 LBS

STANDARD PILING
 49 LBS PER SQR. FT.

SKETCH PLAN SHEWING DIVERSION OF WATER DURING WORKS ON FOUNDATIONS

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77. *Description of sketch plan.*—In the sketch plan the steel pile curtain walls are shown at *a.c.*

The diversion walls *fe* and *bd* while the surplus channel runs between the longitudinal walls (*aa* and *bb*) with tops at level + 86.

This space between the walls, *a a* and *b b* through which the dry-season river flow is to be passed, is considered the soundest and easiest part of the whole foundation and it is proposed to lay all the foundation to the left of *b b* before taking out the rock and laying the foundation in the space *a, a, b, b*.

The greater part of the foundation to the right of *a a* will also be laid before the foundation in this 450-ft. space is excavated and masonry put in.

While this operation is in progress, water will be temporarily diverted to the left of *b b* and when this foundation is built to + 80, will be again diverted between (*a*) and (*b*).

The points *k* in the sketch plan are shafts 20 feet $\times$ 4 feet sunk to below deepest foundation level.

The shafts will be constructed with interlocking steel piles cross-braced internally as required and with openings at the bottom and here and there along the sides which will admit water.

Over these shafts powerful electric pumps will be installed to de-water the space *f c a a c f*.

78. *Surplus in the "Dry Season" after foundations stage.*—The main wall across the river will be raised to + 86 before any closure of the opening *a b* is made.

After this the whole dam will be raised steadily during the dry season, leaving till a late stage a notch 450 feet wide in the space *a b* varying from 4 to 6 feet in depth. The ordinary dry season river flow will be taken through the "construction sluices", but abnormal freshes will occasionally surplus in part through the notch *a b* (vide plan showing progress of construction year by year, portfolio No. 1).

79. *Construction sluices.*—The construction sluices are six in number, 12 feet high and 7 feet wide, with cill at + 83 and are to be placed in the space between *b b* and *c c*. These will serve the dual purposes of surplusing the "dry season" flow and passing water to delta irrigation in the first years of extension of its irrigated area. As soon as the scouring sluices in the right of the main dam are sufficiently advanced to take up the latter duty, the construction sluices will be permanently closed and the culverts built up solid in masonry.

80. *Discharge and duration of the "Dry Season."*—The dry season extends from about the 15th November to the 15th June, but for purposes of work, it may be considered that 1st December to 31st May or six months can be counted on. The following statement shows for the last fifteen years the greatest flow yearly recorded between 16th November and 15th June. It will be seen that in the first half of December there have been three floods of over 30,000 cusecs in this time.

Between 16th December and 31st May, it may be considered safe to count that the maximum flow will be below 30,000 cusecs. Two days' warning of the approach of the 1st June fresh can be always got by wire and it is safe to count on a six months' "dry season" for work.

Between 16th January and 15th April it is safe to count that flow will not exceed 10,000 cusecs and generally the maximum of the period is below 2,000 cusecs.

81. *Discharges of surplusing notch and construction sluices.*—It will be clear from the statement following of the discharging capacity of a 450-ft. notch and of the six construction sluices that after the main dam is above the river-bed level throughout, there will be no difficulty in dealing with the "dry season" flow.

Statement of maximum flow in cusecs.

Year.	November, 2nd half.	December, 1st half.	16th December to 16th January.	16th January to 16th February.	16th February to 16th March.	16th March to 16th April.	16th April to 16th May.	May, 2nd half.	June, 1st half.
1894-1895	27,702	13,649	9,168	3,490	1,713	1,016	560	990	4,855
1895-1896	28,906	10,010	8,388	4,222	4,075	2,565	977	465	54,425
1896-1897	65,906	41,065	4,499	2,033	1,267	47	2,191	2,353	3,238
1897-1898	37,969	16,549	4,820	2,227	1,759	610	9,432	6,464	42,659
1898-1899	73,688	13,750	8,736	2,553	1,684	3,628	15,498	18,546	(12th June) 13,168
1899-1900	4,267	1,722	1,235	912	680	592	1,118	1,064	9,795
1900-1901	8,412	3,425	3,011	2,229	13,061	2,287	39,512	28,819	32,670
1901-1902	10,304	6,893	2,814	1,711	1,857	656	276	962	16,707
1902-1903	35,581	117,403	103,659	7,137	2,203	1,112	725	701	9,584
1903-1904	46,788	33,922	(16th Dec.) 16,868	3,809	1,681	1,011	393	2,265	13,670
1904-1905	9,801	4,818	3,293	1,749	416	202	121	4,213	7,171
1905-1906	5,622	3,090	3,006	3,506	2,402	700	130	52	Nil.
1906-1907	10,960	5,187	25,935	4,463	1,822	2,060	19,467	4,480	7,028
1907-1908	8,040	7,314	(in January) 5,978	3,668	1,636	855	719	976	1,110
1908-1909	9,042	4,054	3,046	2,364	1,624	1,084	1,329	8,733	147,726
Maximum	73,688	117,403	103,659	7,137	13,061	3,628	39,512	28,819	(9th June) 147,726

Discharge of a notch, 450 feet long.—Discharge of a notch 450 feet in length—

1 foot deep	CUSECS.
2 feet "	1,395
3 " "	3,915
4 " "	7,245
5 " "	11,160
6 " "	17,280
	20,475

Discharge of construction sluices with varying levels of water above the dam.—
Discharge of six construction sluices, 7 feet wide, 12 feet high, sill +83.

Just submerged (12 feet deep) water	+ 95	CUSECS.
7 x 6 x 120 about with water level		5,418
With water level	+ 100	With outfall face.
Cushion dam	+ 110	5,964
complete and	+ 120	7,860
dam sluices	+ 130	9,754
fully open.	+ 140	11,700
	+ 150	13,633
	+ 160	15,600
		17,570

82. *Surplusing river during construction in the "Flow Season."*—The quantity of water to be disposed of during the flow-season is very great and it is proposed to pass this water over that part of the Main Dam standing over the existing river-bed. In the early stages of construction until the Main Dam has been built to a height of about 6 feet above the general river deep bed level to about +88, no special arrangements are necessary. The water will pass over all the works in the river bed without damage.

As the Main Dam rises, the Cushion Dam below must be built to a suitable height to cushion water passing over the Main Dam.

As the dam increases in height, it is proposed to continue to pass all water in the "Flow Season" over the section of the works directly over the river bed, until the dam is sufficiently high to divert part or all of the flow to the west of Wadanapalli hill, that is, until the Main Dam over the river bed is up to about +165. The length over the river bed is about 1,852 feet. On either side of this surplusing length the dam will be built up to a considerably higher level, thus making over the river bed a notch 1,852 feet, a length through which river will discharge with a clear overfall.

83. *Depth of flow over Main-Dam.*—The depth for various discharges with notch 1,852 feet long without velocity of approach is noted below:—

	CUSECS.
5 feet ...	71,040
10 " ...	181,115
15 " ...	333,360
20 " ...	512,820
25 " ...	716,875
30 " ...	942,100

The ordinary yearly high flood will flow 20 feet deep over the dam.

A depth of 25 feet might be experienced for a day or two during the whole period of construction, while a depth of 30 feet, although possible, is very unlikely.

84. *Effect of Cushion-Dam in protecting river bed.*—In considering the effect of such a flow over the dam, the depth of water in rear is of the greatest importance and this is altogether controlled by the arrangement of the Cushion Dam.

It will be clear that if the arrangement of the Cushion Dam as a protection the river bed during surplusing are satisfactory, when the height of the Main-Dam the greatest height at which a large flood will pass over it, the conditions before the Main-Dam is at this height, need not be separately considered.

85. *River water levels for various discharges.*—The approximate levels of water above the Cushion-Dam due to discharges as noted are given below, the sluice in the Cushion-Dam being closed:—

Discharge.	Level above cushion.	Level below cushion.	Depth of water in cushion.
100	+ 110	+ 81	30
19,500	+ 113	+ 91	33
55,400	+ 116	+ 96	36
76,000	+ 117	+ 98	37
143,900	+ 120	+ 102	40
267,500	+ 124	+ 111	44
481,500	+ 129	+ 121	49
650,000	+ 134	+ 128	54
875,000	+ 141	+ 135	61

This shows that the depth of the pool below the Main-Dam into which the water pouring over the top of it will be precipitated, varies from 37 feet with a depth of 5 feet over the Main-Dam to 49 feet with a depth of 20 feet; the maximum height of the Main-Dam is +150. The depth from the surface of the water above the dam to that below with a considerable flood 481,500 cusecs passing, would be 41 feet and the depth of the cushion 49 feet and with a flood of 650,000 cusecs, the corresponding figures are 41 and 54 feet.

86. *Diversion of floods west of Wadanapalli Hill.*—As soon as the length of dam over the river bed is up to +150, a portion of the surplus water will in floods be diverted into Mukhtala vagu. This is in the eleventh year of construction.

In the thirteenth year according to the construction programme, the whole of the surplus water not passed through sluices in the Main-Dam would be so diverted.

The programme of construction provides for keeping the Main-Dam surplusing section over the river not above +150 until all is ready to divert the full floods of the Flow-Season west of Wadanapalli Hill. In the dry season previous to this, the Main-Dam over the river bed will be raised to +190 finally affecting diversion of the flood waters away from the main river immediately below the dam site.

87. *The effect of surplusing over the crest on the downstream face of the dam.*—In his note on the Cauvery Project, the Inspector-General of Irrigation made special mention of the destructive effect of water falling over the crest of a dam and impinging on the masonry on the downstream face as shown in the case of the Dhukwan reservoir.

The proposals above made involve passing 20 to 25 feet of water over the dam and it is of importance that this great mass should not impinge on the downstream face of the masonry of the dam, but glide over that face without obstruction or shock.

The shape of the crest of the dam and of the downstream face should therefore be such that water passing over it will adhere to the masonry and further the face of the masonry should be built as smooth and even as possible and the cement pointing should carefully flush up the joints and leave a clear smooth surface for water to glide over.

In the case of the Austin dam on the Colorado river, the whole river with a discharge over 200,000 cusecs passed over the dam and caused no injury to the masonry of the downstream face.

A similar arrangement on a small scale obtains in the Vyrnwy dam.

The Austin dam had a downstream face batter of 3 in 8 and the masonry from the top of the dam was connected with the downstream face by a circular curve of radius 20 feet. In the case of the Kistna dam it is proposed, as the flow season approaches, to push on the downstream 30 feet width of dam to a greater level than the masonry in front, and curve it off to join the downstream-face slope with a shape approximating to a curve of 20 feet radius. Over the rough masonry, concrete in cement will then be laid smoothing off the curve and leaving a smooth clean slope to which the water will adhere.

A similar proposal has been made for the Cauvery Project (Vol. I, paragraph 119), but there the importance of this matter has not been emphasised. The arrangement is shown in the sketch section (page 31).

88. *Disposal of the surplus flow of Kistna after completion of works.*—The conditions of surplus flood waters from the Kistna Reservoir are peculiar and the exact accuracy of the level of water required to surplus the maximum flood is not, in the case of this reservoir, of the importance it has in an ordinary case.

The calculations of maximum flood discharge are made for the disposal of one million cusecs which is the maximum recorded discharge and is very much greater than the next highest record. As has been already detailed, the rules for water regulation provide for surplusing the reservoir down to "Diversion Level" on warning being received of the approach of a flood of 150,000 cusecs or upwards. Further, the reservoir is yearly kept at "Diversion Level" till the greater part of the flood season is over.

The conditions under which a large flood has to be disposed of, will therefore be with water level in the reservoir below full reservoir level (+ 224.5) by upwards of 20 feet. It is calculated that the full flood discharge of one million cusecs can be surplused through the surplus works with the level of water above the dam of + 204.5. Should the previous records be eclipsed by a flood materially greater than one million cusecs, it is clear that the reservoir works can discharge such a flood without any danger or even inconvenience so far as concerns the Head-Works stability or discharge capacity.

As a fact, the capacity of the surplus works have been fixed to enable a flood up to about 450,000 cusecs to be surplused without allowing water level at the dam to rise above diversion level (190.5).

The figure 450,000 cusecs is selected as being roughly about the magnitude of the greatest flood of a year of normal discharge and is purely an arbitrary figure. There is therefore no need for anxiety or special precautions in making calculation assumptions so as to be sure that the result, if erroneous, will err on the safe side.

If, for instance, it is found in practice that the approaches to the sluices cause such a loss of head that the maximum discharge from a water level on the dam of 190.5 is only 425,000 cusecs, the practical difference would not be material. This matter is further considered under technical in paragraphs 152 to 154.

89. Table of discharging capacity of surplus sluices.—

Level of water at dam.	Discharge capacity Surplus-Sluices on left of Main-Dam				Discharge capacity scouring sluices, main dam.	Total surplus capacity.
	Left sluices.	Central sluices.	Right sluices.	Total, col. 2 to 4.		
1	2	3	4	5	6	7
190.5	..	123,500	322,500	446,000	25,500	471,500
192.5	5,100	160,000	360,000	525,100	26,300	551,400
194.5	20,400	200,000	393,000	613,400	27,200	640,600
196.5	42,000	242,000	423,500	707,500	28,600	736,100
198.5	72,000	279,000	452,000	803,000	28,800	831,800
200.5	105,500	308,000	477,500	892,000	29,500	921,500
202.5	145,000	335,000	501,000	981,000	30,300	1,011,300
204.5	186,500	358,500	524,000	1,067,000	31,000	1,098,000

90. *Magnitude of the greatest recorded flood.*—The maximum flood on record, 7th October 1903, was largely contributed to from the local rivers in Hyderabad which were all in heavy flood.

The drainage area of the Kistna at Bezvada is 97,050 square miles and at the Dam site is 90,371 square miles. The maximum recorded discharge at Bezvada is computed at 1,060,830 cusecs. Under these circumstances, 1,000,000 cusecs is taken as the maximum discharge for which calculations are made for the surplus works and flood levels in the Muktiala Vagu.

91. *General methods of construction.*—It is proposed to use machinery and mechanical power freely in carrying out the works.

With the exception of the locomotives and launches, all power machines will be actuated by electricity generated by steam from a central power station. From this central station overhead power lines will be carried to the various points when power is required.

The following operations will be carried out wholly by machines actuated by electric motors:—

Pumping.	Mortar-mixing.
Pile-driving.	Workshop machine work.
Grinding and screening surki.	

The following works will be partly done by machinery electrically driven and partly by hand:—

Breaking concrete stone.	Stone-dressing.
Drilling for quarry work.	Hoisting by cranes.

Where mechanical power is employed for transport, the steam engine either in locomotive or launch will be used.

92. *Works preparatory to building masonry of the dam.*—It is proposed, should the works be sanctioned, to spend the greater part of the first two years of construction in preparatory works and installing machinery and plant required. The preparatory works to be constructed in these two years other than those forming necessary part of the construction of the main dam are—

- (1) Construction of a complete system of light railways for communication from the nearest railway station (Bonakalu) to the Dam Site and for all transport work of building materials to the workshop.
- (2) Construction of roads and footways as required.
- (3) Construction of quarters for the staff to be engaged on the work.

(4) Construction of workmen's huts estimated at 3,000 of a semi-permanent and 2,000 of a temporary type.

(5) Construction of power-house, workshops, stores, engine sheds and railway buildings.

(6) Installing a piped and filtered water-supply throughout the lines.

(7) Building hospital, police-station, treasury and offices, etc.

(8) Collecting stocks of stone and material for starting works.

In addition, the following works in the river-bed will be undertaken during the "preparatory" works period, when the river flow is such as to permit such work to be done:—

(1) Driving curtains of interlocking steel piles in the rift.

(2) Building diversion works.

(3) Excavating foundations of Main-Dam.

93. *Preliminary operations.*—Prior to beginning construction-work, one year will be employed by a special staff consisting of the Engineer-in-Chief and three officers with a staff of subordinates and draftsmen in elaborating working-plans, drawings, ordinary plant and stores and making all arrangements to begin work.

This time is not included in the programme as a year of "Construction".

94. *General programme of masonry on Main-Dam.*—From the third year, it is proposed that work on the Main-Dam masonry shall be pushed rapidly and take precedence to all other works and the programme of construction (section VI) is based on the supposition that 500 masons are available and actually at work on the Head-Works masonry all working days.

95. *Quartzite and "Napah" stone masonry used in different lengths of the dam.*—The stone proposed to be used for the dam and surplus works is quartzite on the right of Wadanapalli Hill and "Napah" stone to the left of this.

It is recognised that for a gravity dam quartzite random rubble is a more suitable material than the "Napah" stone, which latter must be built in courses with parallel bedding.

There is no quartzite available in any considerable quantity on the left of the Kistna, while "Napah" stone exists exposed in unlimited quantities all round.

The difficulties of keeping up a supply of stone which has to be taken across the Kistna during the flood season, has led to the substitution for the shallower section of the dam on the left of Wadanapalli Hill of "Napah" stone.

96. *Transport of building materials.*—The amount of materials required to be transported daily is very great being nearly 2,000 tons a day.

It is proposed to transport the building materials from quarries to the dam site or to crushers or mortar mills by light railway of 30-inch gauge, a complete system of railway tracks (18 lb. rails) being laid down and maintained for this purpose.

A line (22 miles long) of this light railway will also be laid from Bonakalu, the nearest railway station, to the Head-Works and this line will carry all coal, cement, provisions and imported and manufactured materials required for the works. The transport of coal will constitute the heaviest traffic to be carried on this line.

97. *Haulage of materials on the works.*—Where the "lead" is more than about one mile, it is proposed to haul by light steam locomotives capable of hauling 6 trucks loaded (30 tons) up a gradient of 1/100.

For shorter leads the haulage will be coolies, who will also load and unload their trucks.

It is considered desirable to instal steam in place of electric haulage, as the former enables changes in arrangement of tracks and sidings to be made more freely, and the transfer of plant to works on the canal system also becomes practicable.

98. *Rolling-stock and Railway Material provided for works.*—Provision is made in the estimates for—

80 miles of 30 inches track with sleepers, points, turn-tables, curves, etc.

Rails of 18 lbs. per yard.

300 trucks of 60 c. ft. capacity (4 tons).

100 trucks of 27 c. ft. capacity (2 tons).

16 light locomotives.

A few miscellaneous carriages.

99. *System of delivery of stone to masons on the Dam.*—It is proposed that several tracks of 30 inches light rails shall be laid along the top of the masonry of the dam at intervals of not less than 20 feet.

The carrying capacity of the trucks is 60 cubic feet (4 tons) of stone and the suggested arrangement is that the trucks shall be hoisted completely loaded by 5-ton cranes installed at each end of the section of dam under supply and lowered on to rails on the top of the dam. The trucks will be run by hand over this line by coolies under the direction of special staff who will supervise and direct the places and arrangement for unloading. The leading truck on each track will unload at the place farthest from the hoisting place where stone is required. The trucks will be unloaded by the pushing coolies assisted by the men attendant on the masons whose stone supply is being replenished.

At the end of the section remote from the starting point, the empty trucks will be transferred by cranes to return line-sidings clear of the dam on which sidings empty trucks will be re-made into trains or groups and hauled back to the quarries for refilling.

It is where work is most concentrated, that the greatest difficulties will occur in supply of material and this will be on the surplus section of the dam during the dry season in the year when the whole masons' labour is concentrated on this length and the width is smallest. Under these circumstances there is room for 2 tracks on the top of the dam, but not for three.

The amount of stone to be carried daily is 1,340 tons, say, 340 truck-loads. Each track would have to carry 170 truck loads of stone a day.

In addition truck-loads of mortar at 40 per cent. of the above will be required making a total per track of 238 truck-loads daily or say 24 trucks an hour or one truck every 2½ minutes. This, with proper control and organisation, presents no great difficulty.

100. *Delivery of mortar on the Works.*—It is proposed to instal the mortar mills west of D near the left end of the Dam.

In the case of the part of the Main-Dam to be built of quartzite rubble, the stone comes from the right side of the river and the mortar from the left.

It is considered essential that trucks should only move in one direction along each track laid on the top of the dam. When the dam top is so wide as to give ample room for a special track to be set apart for loaded mortar trucks, as will generally be the case during the first 7 years of construction, this course may be adopted.

Where width is too restricted for this, the mortar must be hoisted on to the dam from the same end as the stone. This would necessitate in certain cases taking the full mortar trucks to the end of the work furthest from the mills before hoisting on to the dam and would thus entail some extra cost for haulage. This, however, would be the exception rather than the rule.

The maximum requirement of mortar on the work daily is 8,000 cubic feet or 133 truck-loads of 60 cubic feet capacity.

Forty trucks are allowed for as "mortar trucks" in the estimate allowing about 4 round trips daily for each truck.

101. *Central Power Station.*—It is proposed that all power-driven machines employed on the works except locomotives and launches shall be driven from electric motors supplied with power from generators installed at a Central Power-Station.

The source of power will be steam engines with boilers fired with Singareni coal.

The estimate provides for engines and generators for power of 400 Kilowatts in separate sets of 50 to 100 Kilowatts capacity.

102. *Sites for motors and disintegrators.*—It is proposed to instal the lime kilns along the west of the "Napah" stone spur D K, burning for lime the "Napah" stone excavated for the approach and foundations of the surplus works.

Bricks for surki burned in the waterspread area would be landed from barges at a convenient point near this site, from which point rails will be laid to the disintegrators in which these bricks will be pulverised into surki.

103. *Quartzite quarries.*—The quartzite quarries are proposed to be along the crest of Pulichintala ridge. The stone will be blasted from the exposed faces of solid quartzite on the east side of the ridge crest and will be precipitated down the east slopes, and the main quarry lines and sidings must be parallel to the steep slopes but in sites clear of injury from falling stones.

Here the quarry trains will be made up for haulage by locomotives. From these main sidings single lines will be run out to the vicinities of the various stone slides at the foot of the slopes. Injury to these tracks by falling stones will not be infrequent and the tracks will be rough and over them the trucks will be hauled by coolies. Lengths of quarry face along the ridge will have to be worked in turn, as collection of the rolled stone at the foot of the slopes can only be made when blasting and stone rolling from the top is not in progress. Power lines will be carried across the river and over the Pulichintala ridge above the quarry faces for actuating the compressors and drills which will be employed in drilling blast holes in the quartzite.

It is proposed to supplement machine drilling, by hand labour which is cheaper, to such extent as labour conditions allow.

104. *"Napah" stone quarries.*—The "Napah" stone quarries can conveniently be to the south of D, in a safe position for blasting, close to the source of power and at a level from which there will be a gentle down grade for haulage of stone to the points of delivery along the surplus sluices and dam line west of Wadanapalli Hill.

105. *Healthiness of the site.*—There is no reason to apprehend that the vicinity of the site of the Head-Works will prove feverish or otherwise unhealthy.

There has been work going on in this vicinity now for 2½ years and although there is some fever in the cold weather resulting it is believed from chill, on the whole the site is normally healthy.

The heat, however, is very great especially from April to June. The encircling hills, the great sheets of exposed rock and sand contribute to this, while it is known the normal temperatures of the uplands in Kistna and Guntur districts in the hot weather, are among the highest in the Presidency.

106. *Water-works.*—The estimates provide 1½ lakhs for installing a complete system of piped filtered-water supply to all lines, camps and residences. No details of this supply has been worked out. It is considered that it will probably be found best to instal pumps drawing direct from the river on the side of Pulichintala ridge about a mile above the Dam Site. Settling tanks in which silt can be precipitated will be required and from this water can be piped to the filters and service reservoir which will probably be on the top of the Hill F. It is considered that Jewell Filters will in such a site prove most suitable. In the early stages of construction it will pay to instal a separate service for water supply for masonry on the Main Dam, thus avoiding the cost of unnecessary lift which taking from the general water-supply system would involve; when the masonry work is above + 150, it will probably be advisable to take water for masonry as well as for sanitary, domestic and general use from one water-supply system.

107. *Sanitary and special staffs.*—The estimate provides for the services of a Medical Officer with two Hospital-Assistants to take Medical and Sanitary charge of the hospitals, camps and works.

A Stationary Sub-Magistrate to be resident on the works with a staff of Police (1 Inspector and 30 Constables) is also provided for. It will be necessary to pay great regard to sanitation and enforce rigid compliance with the rules and orders issued to ensure the health and cleanliness of the works and workmen's lines and the whole vicinity.

108. *Housing of workmen.*—The estimate makes provision for 3,000 huts for workmen's houses of a semi-permanent nature suitable for continuous occupation for, say, 15 years and for 2,000 huts of a temporary character giving shelter for 2 to 4 years.

These huts will be laid out in regular lines and it is considered that not more than 500 huts should be allowed in one group.

It is computed that, with proper spacing of lines, 500 huts will cover 10 acres. The proposed positions of the more permanent workmen's lines are shown on the site plan (blocks in red). Opposite page 24.

There is some difficulty in locating these, as they must be at a level not liable to submergence till a late stage of construction, while they should not be far from the works and must not be on the sheet limestone on account of the heat.

109. *Location of Residences, Offices, Workshops, etc.*—The residences and offices for the officers, upper subordinates, office staff and the hospital, etc. will be on the flat open top of the Hill G and in this vicinity. The soil here is soft shale covered with a thin crest of earth. The residences of the Mechanical and Electric Engineers and staff and artificers attached to the Workshops must be on the other side of the river near the Power-House, Workshops and Stores.

The Power-House, Workshops and Stores will be located to the north of the left escape and above water-level.

The buildings **WW** are shown in red on the site plan.

This spur consists of nodular kunkur overlaid with a thin coating of soil which is an intrusion in the surrounding sheet limestone and is the only suitable site for habitable buildings and offices in this vicinity. For this reason the residences of the staff and the Workshops must be grouped more closely together than would otherwise be proposed.

110. *Communication with the outside world.*—The main line of communication with the outside world will be by a light 30"-gauge railway to be laid, which, starting from near the site of the Workshops, will run in a general northerly direction along the left side of Muktiala Vagu and, passing near the town of Jaggayapet, will meet the broad-gauge railway at Bonakalu railway-station. The country to be traversed is an ordinary undulating country which presents no special difficulty.

The distance is 22 miles.

The drainages to be crossed with 2 exceptions are insignificant.

The two exceptions are the rivers Muniyeru and Paleru which are big streams which in times of flood become great rivers.

It is proposed to take the light line over this on girder bridges carried on iron trestles. Rock foundations are available into which the trestles can be anchored. The estimate allows Rs. 10,000 per mile exclusive of track and sleepers for construction of this line with necessary buildings and Rs. 80,000 is allowed for bridging the above two rivers.

From Bonakalu railway-station the following is the railway mileage to various centres:—

	MILES.
To Bezwada	45
To Singareni (coal fields)	42
To Madras	313
To Bombay	669

In addition, the Kistna is navigable for steamers and barges from Bezwada to 40 miles above the Dam-Site between 15th June and 15th November. A metalled road now connects Bonakalu with Muktiala, and this road will be continued to the Dam-Site.

The light railway from Bonakalu will be linked up with the system of light railways which will connect various parts of the Head-Works and quarry sites. The railway will be carried over the Kistna (a double track) on the top of the Cushion Dam. It will be submerged when discharge exceeds 55,000 cusecs. This allows rail carriage across the Kistna for 263 days yearly on an average.

At other times carriage across must be by steam launches, barges and boats.

111. *List of preparatory works.*—The following list of provision made for "Preparatory Works" exclusive of maintenance and of works on the Head-Works proper, gives a good idea of their variety and magnitude.

	Rs.	Rs.
<i>O. Miscellaneous.</i>		
Water supply—		
Installation of piped and filtered water	...	1,50,000
Communications—		
Roads, foot-ways, etc.	45,000	
Rail roads (exclusive of rails, sleepers and rolling stock).	3,40,000	
		<u>3,85,000</u>
		5,35,000
<i>K. Buildings.</i>		
Public Works Department Offices, Workshops, Stores, Power-House, Cement sheds	1,03,000	
Law and Police—		
Court, Police-station, Treasury, Quarters for Police and Magistrate	22,000	
Medical services—		
Hospital and quarters for medical officers and staff.	37,000	
Quarters for Public Works Department staff—		
Officers and Upper and Lower subordinates and office staff	1,91,000	
Housing workmen	4,20,000	
		<u>7,73,000</u>
Total, K. Buildings ...		7,73,000
Grand Total ...		13,08,000

112. *Annual Upkeep and Repairs and Miscellaneous works.*—The following annual allowances, operation, maintenance, repairs or renewals of miscellaneous works are made in the estimates :—

	Rs.
Water-works	6,000
Communications	17,800
Non-residential buildings	4,540
Sanitary works	12,000
Residential buildings of staff	3,800
Housing work people	10,980
Total ...	55,070

These are included in the item for "Maintenance during construction."

113. *List of special tools and plant.*—The following is a list of the "special plant" for which provision is made in the estimates for the Head-Works :—

	Rs.
Central Station Power Plant (400 K.W) with steam-engines, boilers, generators, switches, motors, lighting-plant and 30 miles of overhead-line	2,29,000
Workshops machines with motors	50,000
Pumping plant	57,500
Turbines and Generators for sluice operating gear	15,000
Quarry and stone dressing plant	49,800
Stone crushers and concrete mixing plant	30,000
Burki and mortar grinding plant	1,99,500

	Rs.
Hoisting plant	1,30,500
File drivers	15,000
<i>Light Railway Plant—</i>	
	Rs.
Light locomotives	1,00,800
Rolling stock	1,69,200
30" track 18 lb. rails and steel sleepers	5,25,000
	<u>7,95,000</u>
<i>Floating plant—</i>	
One Grab Dredger, 20 steel barges and 2 steam launches ...	1,94,000
	<u>17,65,300</u>
	1,34,700
Unforeseen	<u>19,00,000</u>

114. *Forecast of expenditure year by year.*—The table shows the forecast of expenditure on the Head Works during the 18 years of construction.

The programme of execution of the whole system is dealt with in Section VI and the programme for the Head Works representing the tabulated incidence of expenditure is described in paragraphs 216 to 227.

KISTNA PROJECT.

HEAD-WORKS.—Forecast of expenditure year by year in thousands of rupees and nearest thousand.

Main Head and sub-divisions.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	Total.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Works carried out at site .. Shutters and structure of I. Works { Land	805	899	1,787	2,158	1,885	1,887	1,773	1,608	1,437	1,236	1,456	1,092	1,628	1,378	1,014	972	913	414	24,941
Total, I. Works ..	941	1,009	1,787	2,203	1,900	2,049	1,833	2,118	1,877	1,684	2,237	2,333	1,805	2,228	1,434	1,387	1,185	568	30,238
Public Works II. Establishment .. { Department .. Special ..	149	218	411	406	441	437	414	370	344	284	392	307	374	373	260	249	217	95	6,831
Total, II. Establishment ..	182	263	445	530	476	461	442	398	367	310	419	332	399	399	285	274	242	120	6,332
III. Tools and Plant. { Special .. General ..	449	630	215	120	90	80	61	24	35	24	50	24	35	24	24	24	16	7	1,900
Total, III. Tools and Plant ..	451	645	242	152	119	109	88	48	59	43	80	49	59	56	43	42	15	7	2,306
IV. Surplus	30	70	50	50	20	20	10	..	..	..	..	..	..	..	..	..	..	..	..
V. Receipts on capital account ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total, Direct charges ..	1,604	1,963	2,509	2,916	2,555	2,620	2,364	2,545	1,984	1,968	2,717	2,675	2,204	2,613	1,693	1,634	1,267	445	38,256
Indirect charges	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Grand Total	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	40,960

* Includes "preliminary expenses" 200.

† To be paid XIX to XXIII year at 154 yearly.

B.—Technical.

115. *Surveys and Levels of Head Works.*—The datum of all levels for the Head Works and the Project generally is that of the Great Trigonometrical Survey.

A list of Bench marks and Survey marks is printed in part I, volume III. The surveys of the Head Works site and immediate vicinity has been based on triangulation made with a theodolite.

In the waterspread and submerged area existing village and taluk maps have been utilised in producing the water-spread map, and the transverse lines of levels have been run with compass and chain.

The contours in the submerged area have been interpolated from the lines of levels and cross sections which are to be found plotted in positions on the plans of the submerged area.

Above Daida the contours have been taken from the surveys made in connection with Mr. Reid's project for a reservoir with head works near Daida.

116. *Plans of Head-Works.*—The following is a list of the plans of the Head-Works which accompany the Project estimates:—

LIST OF PLANS: HEAD-WORKS.

Plan numbers.

Mounted on roller.

Contour map submerged and waterspread area, scale 4" to 1 mile, 3 sheets	H 1 (a), (b), (c).
Contour plan of country in vicinity of Head Works, scale 8" to 1 mile	H 2
Contour plan both sides of Kistna below Dam site, scale 4" to 1 mile	H 3
Contour plan of site of surplus works (scale 1/2500)	H 4

In Portfolio No. 1.

Site plan of Head Works, scale 8" to 1 mile	H 5
Plan showing positions and result of borings	H 6
Plan showing positions and results of trial-pits sunk	H 7
Longitudinal section of Main Dam and Head Regulator	H 8
Longitudinal section of surplus sluices	H 9
Profile of Main Dam	H 10
Profile through scouring sluices showing vented section of dam	H 11
Main Dam, construction sluices	H 12
Head Regulator, upland canal	H 13 and 14
Head Works, right surplus sluices	H 15
Head Works, right surplus sluices, plan showing cushioning	H 16
Head Works, central surplus sluices	H 17
Head Works, left surplus sluices	H 18
Head Works, extension beyond left surplus sluices	H 19
Site plan, Cushion Dam	H 20
Cushion Dam, longitudinal and cross sections	H 21
Left bank connection of Cushion Dam	H 22
Longitudinal section showing programme of construction year by year	H 23
Longitudinal and cross sections, Muktiala Vagu	H 24 to 29
Plan showing proposed line of Railway from Bonakalu to Head Works.	H 30

117. *Data for design of dam profile.*—The dam proposed is a solid gravity dam of rubble masonry of specific gravity, 2.25.

The full reservoir level is + 224.5.

The general rock level in the river-bed is + 80 and the general foundation level + 70, the latter being $154\frac{1}{2}$ feet below the reservoir full level.

118. *Unprecedented character of the proposed dam.*—As in the case of the proposed Cauvery Reservoir, there is proposed here a great length of gravity dam of height over 150 feet, and it is to be realised no such work has, heretofore, been constructed. While many dams are in existence of much greater height, in every case such dams stand in a V-shaped gorge, and these certainly derive some support and possibly much support from the sides of this gorge.

The matter is discussed at some length in the paper on "Mass Dams and Dams with arches" by Mr. R. A. Ryves, A.M.I.C.E., which has been published with the Chief Engineer for Irrigation Circular No. 753 of 14th June 1910.

In this case the Kistna Dam runs for a length of 1,450 feet with water-level standing at over 150 feet above foundation level without possibility of deriving any support whatever from the sides of the gorge. On account of the unprecedented nature of the work; it has been considered necessary to exercise very great caution in designing this mass of masonry. Did the general theory on which gravity-dams are designed give an accurate and fully-accepted representation of the stresses developed, there would be no reason to exercise greater caution with a long dam designed as a gravity-dam than a short one. There is, however, much doubt regarding the distribution of stresses in a gravity-dam especially in the lower part in the vicinity of the foundation, and as one cannot rely on the precedent of existing works for guidance and example, it is necessary to compute the stresses by the most severe and rigid methods.

119. *Some remarks on methods of computing maximum compressive stresses in Masonry Dams.*—The most severe method of computing maximum compressive stress of a masonry-dam is that of Dr. Unwin. This gives the maximum stress on the downstream face of a gravity-dam in terms of the vertical pressure multiplied by a function of the angle of inclination of the downstream face and appears to be undoubtedly sound. The method, however, fails in application unless this vertical pressure (p) is known.

The accepted method of computing this is to make the assumption that this pressure varies uniformly from upstream to downstream face on any horizontal section. This assumption is known to be inaccurate, and that it represents intensity of vertical pressures on the downstream face as being greater than they really are. It has been usual, however, in the past, to design dams on this assumption and either to assume the vertical pressure (p) the maximum to which the masonry is subjected, or to take the probably more accurate, and certainly safer, assumption recommended by M. Bouvier that the maximum pressure is $p \sec^2 A$, where A = angle which the line of resultant pressure makes with the vertical. Under Dr. Unwin's theory the maximum pressure would be represented by $p \sec^2 \phi$ where ϕ is the angle that the downstream face makes with the vertical.

Under this theory the maximum stress in proportion to p becomes rapidly greater, as ϕ increases and with a downstream slope of 45° the pressure becomes $2 p$.

There are the strongest reasons for believing that the distribution of pressure on the assumption of uniform variation becomes more and more erroneous as ϕ increases, and if this assumption is retained, the pressure denoted by the expression $p \sec^2 \phi$ must become proportionately more and more in excess of the actual as ϕ becomes greater.

120. *Method of computing maximum stress and limits of compressive stress, Kistna Dam.*—Similarly to the case of the Cauvery Dam design, it has been designed for the Kistna Dam to compute the maximum stresses on Bouvier's theorem, viz., maximum pressure = $p \sec^2 A$ and the limiting pressure for design selected has 8 tons per square foot.

Unwin's proposition has so far been regarded that it has been the guiding principle that the pressure $p \sec^2 \phi$ must not exceed 12 tons.

123. *Filling in of foundation trenches.*—It is proposed that the foundation trench or excavation on the upstream side of the dam shall be filled in in the "rift" with impervious Kistna silt up to ordinary river bed level and provision for this is made in the estimate.

On the downstream side of the rift, shingle filling is proposed up to the level of the shingle below (about +75).

In every case, however, it is proposed to fill with concrete the space between the side of the rock trench in which the dam is founded and the dam up to a level of 10 feet above foundation level or to rock surface whichever is least.

124. *Profile of vented portion of the dam.*—For the portion of the dam in which the 4 scouring sluices are provided a special profile has been designed.

The sluices provided are 4 in number 7 feet wide by 30 feet high with cills at +145.5. The piers between the culverts are 28 ft. thick. The special profile extends for a length of 148 feet, that is, for 18 feet beyond each side of the flank culverts.

In considering the stability and limiting pressures on the piers of the culverts, all masonry of the dam upstream of the downstream sides of the grooves on which the sluice roller paths are bedded, is neglected.

This leaves a considerable margin on the side of safety.

In continuation of the floor of the culverts a horizontal bench is carried out on the downstream side of the profile to a point vertically above the lowest level of tail water in the water-cushion.

This ensures that the discharge from the sluices shall never fall on the downstream face of the masonry of the dam, but shall always fall directly into a water-cushion. The above features of design necessitate increased widths being given to the "vented profile" to keep the stresses within the limits laid down.

The character of the vented profile is similar to that of the rest of the dam, the batters are the same on both up and downstream faces, and the part of the downstream face having a batter of 7 in 8 of the vented section is designed in the same plane as the unvented section, so that below level of the bench springing (+110), the vented and solid profiles are in one plane on the downstream side.

125. *Alternative arrangement to above.*—An alternative to the bench for carrying the sluice discharge clear of the downstream face of the dam would be to drop the culvert floor downstream of the sluice shutter and run it into the downstream face of the dam with such a curve that the discharge from the sluice under all conditions would adhere to the face of the masonry in a similar fashion as is proposed for surplusage over the dam during construction. No design for this arrangement has been worked out.

126. *Curvature of dams in plan.*—In the Cauvery Project, a curvature in plan was proposed for to the main sections of the dam of radius 4,000 feet. The extra cost involved was about 1 per cent. The advantage claimed for the curved form was that the deflections due to loading would tend rather to close than open joints. With a straight dam, deflection tends to open joints on the downstream side.

The Inspector-General of Irrigation in his note on the Cauvery project, dated 26th November 1910, pointed out that with so long a radius the effect for any reasonable deflection in closing joints was so small that he considered it inappreciable and not worth the extra expenditure involved. The Kistna Site does not allow of any shorter radius being used, while the extra cost is nearly 3 per cent. for the length of dam over the river which it was at one time proposed to build curved. Under the circumstances, a straight alignment has been proposed.

127. *Temperature cracks in dams.*—The very large and continuous masses of masonry are, it is recognised, certain to develop cracks due to expansion and contraction under changes of temperature.

The distribution and the direction of such cracks are uncertain and while they may be expected generally to be in a more or less vertical direction, as being caused by shrinkage along the length of the dam, there are dangers of the development of

horizontal or inclined cracks which tend to further develop by the action of uplift, due to pressure of water, in such a crack and by such action the stability of the dam is diminished. If each section of the dam is considered safe and stable from its own weight, the presence of open vertical "through joints" in the dam would in no way affect stability and it may be laid down with certainty that an open crack or joint in a vertical direction is less injurious than in any other direction.

It will be clear therefore that, as it is certain that there will be a tendency for joints (or cracks) to open owing to variations in temperature, it is desirable to ensure as far as possible that such cracks, if they actually occur, shall be vertical. This can be done by introducing through joints at suitable intervals along the length of the dam, which joints offer less resistance to tensional stress caused by shrinkage than other parts of the structure.

128. *Temperatures of masonry during building.*—In building a solid masonry dam in hot countries, it generally occurs that the greatest part of the masonry is built into the structure when the material is exposed to air and sun temperatures much above the normal.

The masonry is, when first placed and until covered up by succeeding layers, exposed to the direct rays of the sun to which it will never again, so far as the hearting of the work is concerned, be exposed.

Further considerable, although unknown, rise in temperature occurs by chemical action in the setting of the mortar. Combining these two effects, it is certain that for the first few weeks after building into position the temperature of the bulk of masonry in large masses is higher in a tropical country than it will ever be again.

129. *Stress required to resist expansion.*—The tendency of a solid is to expand with a rise of temperature and to contract with a reduction. The generally accepted coefficient of expansion for granite is .0000045 per degree F.

The coefficient of granite rubble masonry is unknown, but the measurements made on the Assouan dam in Egypt (paragraph 131) is worked out to a coefficient of .00000137. This is probably too small and for purposes of computation, the former figures will be taken.

The modulus of elasticity of masonry will be taken as 3 million lbs. The tendency of a mass of masonry to expand or contract with temperature may be taken up, and change of bulk prevented, by stress of tension or compression in the mass.

The stress required to resist expansion or contraction per degree

$$\begin{aligned} F &= .0000045 \times 30,000,000 \\ &= 13\frac{1}{2} \text{ lb. per square inch.} \\ &= 1,944 \text{ lb. per square foot.} \\ &= .87 \text{ ton per square foot.} \end{aligned}$$

While masonry can only take up safely tensional stresses of from 2 to 2½ tons per square foot, it can with safety take stresses up to 18 tons or 20 tons in compression.

From this, it appears clear that if, instead of being at its highest temperature, the masonry was when it was first built at its lowest, it could safely stand without crushing a much greater range of rise of temperature, than it can a fall of temperature without cracking.

Taking 18 tons as a safe compression, the range of rise of temperature which masonry not free to expand can safely take, would be

$$= \frac{18}{.87} = 20.7 \text{ degree F.}$$

130. *Through joints in the dam.*—It is proposed for the Kistna Dam to introduce joints into the work, these joints being open ones right through the masonry in a direction at right angles to the length of the dam.

The joints to be spaced at distances from 250 to 400 feet apart, the exact spacing being decided by local considerations.

At the time of the building, these joints will be left as openings right through the dam, but they will be filled up with solid masonry after the high temperatures due to initial setting of the mortar has cooled down, and at a time of year (January

or February) when the mean temperature is low. As the masonry in the through joints will be merely filling and having no longitudinal bond, the joints will form planes of weakness and in case of shrinkage of bulk, the dam would crack vertically at these joints more easily than at any other places.

131. *Movements in cracks and temperature movements of Assouan dam.*—Careful observations of the movements and changes of temperature of the Assouan dam in 1907 have been recorded by the Egyptian Public Works Department and communicated to the Government of Madras (letter No. 68-R/50, dated 27th January 1911). The results communicated are summarised below:—

In the Dam there are 12 "well defined cracks" and 69 "faintly defined cracks." The length of the dam is 6,201 feet and the extreme range of mean weekly temperature in 1907 was 36° F., the mean being taken for each week as average of the 9 out of the 12 well defined cracks have been made weekly, by observing the positions of keys set in the string course projection on the downstream face of the dam.

The "well defined" cracks can be traced from the top of the dam to the low water level.

The "faintly defined" cracks vary in the depth to which they can be traced, but usually they are undiscernible below about 16 to 20 feet from the top of the dam. The dam is built on a straight line running nearly east and west, and the prevailing wind, which has a cooling effect, blows from the north, that is on to the downstream face. The measurements of the nine well defined cracks given for the range of temperature recorded give an average variation of two millimetres each.

Diagrams have been drawn showing the weekly spacings of the keys and the mean temperatures.

These diagrams show a close connection between the mean temperature and variations in the measurements of the cracks, that is, of variations between spacings of the keys.

From the above measurements the following estimate of the coefficient of expansion of the dam has been computed for the range of temperature 36° F:—

		MILLIMETRES.
Expansion of nine measured "well defined" cracks at two millimetres each	...	18
Three unmeasured "well defined" cracks at the same estimated allowance	...	6
Sixty-nine "faintly defined" cracks at the estimated variation one millimetre each	...	69
Total	...	93 = 3.6 inches.

The length of the dam is 6,201 feet and the coefficient of expansion works out to .00000137 per degree F.

132. *Spacing of cracks in the Assouan dam.*—The spacings of the "well defined" cracks in the Assouan dam are as below:—

From east extremity to No.	No.	1 crack	Spacing in feet between successive cracks.
" No. 1	to " 2	"	328
" " 2	to " 3	"	705
" " 3	to " 4	"	351
" " 4	to " 5	"	970
" " 5	to " 6	"	1,342
" " 6	to " 7	"	413
" " 7	to " 8	"	646
" " 8	to " 9	"	203
" " 9	to " 10	"	440
" " 10	to " 11	"	131
" " 11	to " 12	"	171
" " 12	to west end	"	151
			361

The averaging spacing is ... 477 feet.

The "faintly defined" cracks in the Assouan dam are 69 in number and the spacing of all visible cracks throughout the length of the top part of the structure is about 75 feet.

133. *Remarks on the low coefficient of expansion deduced for Assouan dam observations.*—The difference between the expansion of the Assouan dam and that due to the free expansion of granite, is possibly due in part to the expansion and contraction being checked and taken up in internal stresses, but more so by the "lag" of the change of temperature of the internal masonry of the dam, behind the weekly change of air temperatures recorded. This "lag" would have the effect of reducing materially the range of temperature change in the heart of the dam especially in the lower and thicker portions. The effect of the cool north wind on the exposed downstream (north) face of the dam must be very considerable, especially if any dampness lies on that face, and as there is "sweating" through most large dams, this is probably the case.

134. *Range of temperature at Kistna Dam site.*—The range of temperature at Assouan is much greater than that in Southern India.

The mean weekly temperatures recorded in 1907 running between extremes of 56.6 and 93.7, a range of 36° F.

The following table prepared from the mean of the maximum and minimum daily temperatures for 20 years, in monthly periods extracted from Sir John Elliott's Climatological Atlas of India shows the mean monthly temperatures in the vicinity of the Kistna Dam site and gives an extreme range on mean-temperatures of 20.5 degrees:—

Month.	Mean monthly temperatures F average of 20 years.
January ...	72.5
February ...	77.5
March ...	84.5
April ...	90.0
May ...	93.0
June ...	87.5
July ...	82.5
August ...	82.5
September ...	81.0
October ...	75.0
November ...	72.5
December ...	72.5

135. *Spacing of temperature joints.*—In his note on the Cauvery Reservoir Project, dated 26th November 1910 (paragraph 47), the Inspector-General of Irrigation suggests it might be possible to calculate the proper spacing between temperature joints, taken for the Cauvery Project as about 400 feet.

The writer has failed in his attempt to get any guidance from calculation. It appears however from the spacing of the "well defined" cracks on the Assouan dam in which the mean spacing is 477 feet, that a suitable spacing should be from 300 to 400 feet.

It also is clear that (as would be expected) the tendency to crack is greater at the top of the dam than elsewhere. The top of the dam is less massive and therefore more exposed to temperature changes and the motion due to variations of water load will also be greater at the top.

In the Cauvery Project Report it was suggested (paragraph 99) that above water level the temperature joints be either left open, or filled only with some plastic material. It is now suggested for the Kistna Dam that above "Diversion Level", the through joints should not be filled with masonry, but with bitumen or other suitable plastic material. It would also be desirable to double the number of joints in this top portion of the dam.

This would prevent undue pressures due to expansion and deflection under loading being developed in the top 40 feet of the dam, which it is to be remembered will, generally during the greater part of the hottest season, not have water standing against it.

136. *Further advantages of through joints.*—The arrangements for dam construction necessitate leaving a notch in the section over the river bed to take the river flow and the top of this notch is some 25 to 30 feet lower than the adjacent masonry on the dam. Such a construction is likely to produce unequal settlement and attendant stresses on the masonry. A "through joint" at each end of the notch which would only be filled after the work was brought up to a uniform height, would absolutely prevent this, and such joints even if only left open until the mortar had set hard, would much lessen the risk of undue stresses occurring.

Again to the left of Wadanapalli Hill the dam foundation is alternately standing on shale and napah, which materials are likely to settle unequally under loading. "Through joints" located at the ends of sections standing on different foundations would minimise risk due to this. Thus the actual location of temperature joints should, it is considered, be arranged with reference to foundation, and other local conditions, and the spacing may be varied to suit between 250 and 400 feet, averaging about 300 feet.

137. *Time for filling in temperature joints.*—Generally it appears desirable to fill in temperature joints permanently in the cold season after the masonry on either side has been laid, if six months has passed since the masonry of the length so "keyed up" was built. Where unequal settlement is to be feared, it will be desirable to have joints open longer, but it is not considered desirable to leave a joint unfilled of a greater vertical depth than about 30 feet.

138. *Nature of the ordinary temperature joints proposed.*—Generally it is proposed that the joints shall be 4 inches in width, and the masonry faces forming each side should be left very rough with projections and hollows in each face forming a good key for the filling.

The filling may be small stone ($\frac{3}{4}$ inch) Portland cement concrete, 1 cement, 2 sand, 4 stone, put in rather wet and well probed with pointed iron rods and worked into every crevice of the opening. Before filling in, the sides of the opening should be cleaned with a water jet working under high pressure.

139. *Special temperature joint.*—When the joint is in a length of dam over which surplus water has to be passed, and into which in consequence silty water will have access, leaving possibly a dirty or slimy deposit on the stones, it is considered the joint should be 3 feet wide. The upstream side of the joint should be faced across with a thickness of 3 to 4 feet of masonry. The top of the joint before the "flow season" will be covered over by beam stones or trough plates with Portland cement concrete 1 foot thick as a top surface and this will exclude the surplus water from flowing through the joint.

The covering will be removed after the "flow season." Before building up this 3 feet wide joint, the sides will be cleaned thoroughly where required with sand blast, or chisel, giving a perfectly clean face of stone.

In closing this joint a rubble wall 2' 8" thick will be built centered on the centre of the 3 feet space and 2" spaces on either side will be filled quite solid with Portland cement concrete as already described for the 4" joint.

140. *Estimated spacing and cost of temperature joints.*—The estimate provides for filling in temperature joints at six annas per square foot of joint, and a mean spacing of 300 feet is allowed between joints.

141. *Description and details of Cushion Dam.*—For its height, this dam is made very wide, 20 feet at the top, for two reasons—
First, the great rush of water over it from the fall above, renders massive construction desirable.

Second, it is proposed to maintain traffic over the work both by rail and road and a one-rail track will be laid close to each edge of the wall, while road traffic will take the centre.

The dam is therefore designed 20 feet wide on top of quartzite rubble (or if found more convenient, of surki concrete faced with napah stone), it has front and rear face vertical to a level + 86, and below this, the downstream face has a batter of 3 in 5.

For a length of 1,215 feet from the right end the dam, is founded on a reef of hard quartzite running in a direction oblique to the river axis and the dam follows this and is conveniently flanked on the right by a quartzite spur from hill F.

The line of cushion proposed is XI, X, XII, on the site plan. The exposed quartzite is all along the line XI, X.

The left half of the river bed is surfaced with shingle overlying shale, as in the rift on the main dam site.

Full borings over this are not available, but those that demonstrate that in the centre of the river to the left of X, the shingle is of depth 20 to 40 feet.

The design here provides for the dam to rest on a concrete slab 2 feet thick + 72, with spacing 9 inches between wells.

In order to shut off percolation under foundations and thus prevent either movement or uplift under the wells, it is proposed to drive an impervious curtain of interlocking steel piles, 10 feet upstream of the Dam. These piles will be withdrawn from the curtains driven to block the rift for Main Dam construction, and again used in this site where they will be permanently located.

The piles will be driven several feet into the shale and an impervious apron of concrete will connect the tops of the piles with the Cushion Dam.

On the downstream side for 50 feet an apron of very large dry packed stones will be put.

This heavy apron will prevent any motion of the underlying shingle, while allowing free escape to any water leaking through under the foundations of the work.

The work is in two sections with different crest levels.

The right length 1,215 feet founded on quartzite has a crest at + 110 (about 30 feet above river bed level), while the left section has a crest level + 116 and a length 1,000 feet. The whole work is designed to be stable if raised to + 116 and holding up water to that level with water in rear at + 181. Into the masonry of the lower (right) section, standards at 12 feet interval will carry a roadway of trough plates at level + 116 over this section. This leaves waterway capable of discharging 55,000 cusecs below road level and the roadway over the cushion dam is thus fit for rail and road traffic during construction, whenever the discharge is below this amount.

A second cushion wall with crest at + 92 built on the quartzite 75 feet on the downstream side of the main cushion wall, relieves the rock of the shock of the water falling on to it. Water will not surplus over the left part of the cushion until the level above is + 116 and discharge 55,000 cusecs.

This connotes a rise of river level below to + 96 and thus this portion of the dam is cushioned naturally before any discharge goes over it.

The table, paragraph 85, shows the computed water levels above and below the Cushion Dam and discharges for each level.

142. *Sluices in the Cushion Dam.*—In the Cushion Dam with cill at + 81, six sluice vents are provided of dimensions each 7' x 12' with cills at + 81 similar to the construction sluices in general details.

These sluices are chiefly of use during the period of construction prior to closing of construction sluices in the Main Dam, especially in the seventh to ninth years of construction.

In the later stages of construction, one or two vents would suffice and it may be found desirable to close the others.

143. *Remarks regarding the nature of masonry provided for various parts of the Head Works.*—The masonry of the dam to the right of Wadanapalli Hill and also of the Head Regulator is provided in quartzite random rubble. For a mass dam, random rubble is generally recognised as the most suitable kind of masonry.

To the left of Wadanapalli Hill the Dam and all works are to be built of coursed napah stone. For the dam this class of masonry is considered not so suitable as random rubble, but stone for this class of work can only be got from the right side of the river and the difficulty of conveying large quantities of quartzite across the river in floods has led to the provision of napah stone for the shallower portion of the dam which lies west of the Wadanapalli Hill. Napah stone is unsuitable for uncoursed work.

It quarries like slate with parallel beds and can only be built in courses.

For the surplus sluices, napah stone is a much more suitable material than quartzite and is indeed eminently suitable for such work.

All the napah stone work taking a water thrust as a gravity dam or pier, is proposed to be built with coursing sloping down towards the water with a slope of 1 in 6 up to Diversion Level (+ 190.5). This construction will present no great difficulty, while increasing the stability and crushing resistance of the work.

The napah stone is a hard, heavy sound crystalline limestone and is considered a suitable lining for surplus sluices, vents or floors and no special granite lining is provided for these. Indeed such lining, while very expensive, would be objectionable, owing to unequal settlement likely to occur and the difficulty of bonding a granite lining into masonry of the character proposed.

The napah stone being generally in slabs of 2 to 6 inches thick will be used for all archwork both horizontal and vertical throughout the whole of the Head Works. It forms an ideal rough arch stone and is certainly safe for a pressure of several times 6 tons per square foot, which is the maximum pressure to which it is worked in zontal arches.

In the case of the deep scouring sluices of the Main Dam, these walls are to be built in cement, but elsewhere in surki mortar.

The floors and sides of the scouring sluices in the Main Dam and of the Head Regulator are to be lined with granite ashlar, the stones on the sides being alternate headers and stretchers.

In the case of the Construction Sluices, which will only be worked for six years, the sides will be quartzite rubble facing and the floor of granite ashlar.

The corbelling out of the top of the dam and sluices will be done with coursed napah stone, but for the copings of the parapets and the facings of cut waters will be of granite ashlar.

144. *Finish to front and rear faces of the dam.*—No specification is made for the pointing or other finish to the joints of masonry in upstream and downstream faces of the dam, but ample rates are allowed for such work in the estimates.

The downstream pointing should flush up joints and irregularities and make the face as smooth as possible.

The upstream pointing should aim at being water tight. Both must be carried up with the masonry work year by year and must not be left to the last.

145. *Filling foundation trenches.*—It is proposed to fill between the masonry of the dam and the sides of foundation trenches cut in rock with surki concrete to the top of rock level or to 10 feet above foundation level whichever is least.

In the deep river bed above this level on the upstream side the remainder of the trench is filled up to level + 80 with impervious soil (Kistna alluvial deposit). The upstream side of the rift will thus be filled up to + 80 with impervious filling in place of the shingle removed.

On the downstream side, the shingle will be filled in again.

146. *Statement of sluices in the Head Works—*

Names of sluices.	Number of vents.	Cill level of vents.	Dimensions of vents.	Nature of sluice gates and how operated.
Left surplus sluices	42	+ 191.0	30' × 12'	Alternative electric or hand power from trollies travelling along sluice platform counter-balanced and raising on free rollers of usual type behind front face wall.
Central " "	54	+ 178.5	20' × 16'	
Right " "	95	+ 172.5	16' × 14'	
Scouring sluices	4	+ 144.5	7' × 30'	Hand power from fixed winches raising on free rollers into well.
Head Regulator	6	+ 174.5	16' × 16'	Hand power from fixed winches counter-weighted raising on free rollers behind front face wall.
Construction (temporary) Sluices.	6	+ 83.0	7' × 12'	Hand power from fixed winches running on face of the dam on free rollers in endless chain which lift with the sluice shutters.
Cushion Dam sluices	6	+ 81.0	7' × 12'	Hand power operated by single rising screw, shutters running on face of the dam as for Construction Sluices.

147. *Remarks on design of Surplus Sluices and Head Regulator.*—The surplus sluices throughout are designed so that the whole stability is given by the weight of the piers and arch and roadway above, and the same applies to the Head Regulator.

In calculating stability, all masonry of the upstream or downstream side of the grooves on which roller paths are fixed is, neglected.

The upstream face walls between the piers will be built of napah stone on edge (vertical bedding) so as to act as arches against both horizontal and vertical thrust, which they would not do so effectually, if laid with horizontal bedding.

Downstream of the cill wall, a clear and uncushioned overfall up to a maximum of 4 feet is allowed on to the solid napah rock. Where the overfall exceeds 4 feet, a cushion wall is provided and in the case of the right end of the right surplus sluices, a second cushion wall.

148. *Sluice shutter and actuating gear.*—All sluice shutters are to be built up of steel and to move on free rollers. The Surplus Sluices and Head Regulator shutters are all counterbalanced. The rates provided are taken from quotations for similar shutters furnished by Messrs. Ransomes and Rapier in connection with the Cauvery Reservoir Project.

The Head Regulator Sluices and the Scouring Sluices will be worked by hand gearing fixed over each sluice shutter. The Surplus Sluices will be worked alternatively by hand, or electric power, the actuating machines moving on trollies on a rail track laid all along the sluice platform.

There should be four hand-power and two electric-power trollies.

The power will be supplied from two turbines installed in tubes passed through the dam at the angle between the dam and right flank of the surplus-works.

Vertical spindles from the turbines to the Generating House to be built on the angle of the dam above, will drive the electric generators keyed direct on to the spindles.

Lump sum provision for the Turbines and Generators is made.

For the trollies and motors, the provision for sluice shutters and gear, covers the requirements of motors, trollies and other lifting apparatus.

149. *Construction sluices.*—For the Construction Sluices, a special type of shutter running on the face of the dam (which is a design made by Messrs. Ransomes and Rapier on the suggestion of the writer) is provided.

For the construction sluices, the adoption of this type saves the building of sluice wells and much masonry in connection with them on the upstream face of the dam, which masonry becomes useless as soon as the Construction Sluices are closed.

The Construction Sluices are six in number of dimensions 7×12 feet with cills at + 83. The Construction Sluice culverts will be built up with masonry, as soon as supply to be passed during construction to the Delta can be passed through the scouring sluices; this would be, according to construction programme, from the thirteenth year of construction:

150. *Passage of drift.*—It is fortunate that the Kistna, unlike the neighbouring Gódávāri river, does not normally carry much drift in floods.

The arrangement made for passing drift is to pass this during the diversion period through the central sluices, the tops of openings of which are 4 feet above Diversion Level.

Whichever of these sluices are kept open, should generally be lifted to the full height so as to leave free passage for drift.

The top of the right sluices are specially designed to be 4 feet below Diversion Level to minimise surface draw towards these.

The design of these sluices provides for gratings fixed in front of the sluice openings to catch any drift drawn down towards these orifices.

151. *Sluice-shutter, Emergency arrangements.*—All the surplus sluices, except the right sluices which are fitted with gratings in front and also the Head Regulator, have grooves between the out-waters and the front face of the work.

In case it is desired to withdraw any shutter which is jammed and unworkable, it is proposed to lower into these grooves from a travelling crane on the sluice platform, either spare shutters or steel beams of the necessary section which will span the openings, leaving open spaces between them. Vertical needles can then readily be lowered in front of the beams and the opening closed sufficiently to enable the faulty shutter to be removed.

For the Right sluices, the projections for the first gratings in front do not permit of this arrangement. In this case, grooves across the piers downstream of the sluice shutter are allowed here to enable head when desired to be taken off any shutter in a similar way to the other sluices, this would permit removal of any jammed or defective shutter.

For the deep Scouring Sluices in the Main Dam, an iron rolling curtain lowered by a crane in front of the sluice opening is provided for. This arrangement is similar to that adopted on the Assouan Dam.

To provide for ordinary repairs, painting, etc., of the shutters in the Right and Central surplus sluices, spare shutters are provided, three for the Central and six for the Right sluices. Ordinary repairs and painting will be carried out continuously throughout the year, the spare shutters taking the place of those under repair.

152. *Conditions of approach to Surplus Sluices.*—Reference to the contour map of the site plan of the Head Works will show that a free and open access for river discharge with water level at + 190.5 or above it, exists up to a section roughly along the line *I. D.*

Between this line and the sluices, the cross sections of flow which the water to the sluice openings must traverse, are restricted to such an extent as to require a considerable addition to the normal flow velocity of the river on approaching the surplus work.

Further the immediate site on which the surplus sluices to the left of "C" stand, has to be cut down (the red lined area in site plan) to the depth of the sluice cills to afford a clear approach and run off.

Over this area, with the reservoir at or about diversion level, the depth of water running to the sluices when fully open, is small and the velocity of approach is consequently great.

These conditions of approach are considered in the discharge calculations of the surplus sluices, for water levels above the contracted approach section (south of *I. D.*) varying from 190.5 to 204.5.

153. *Loss of head in approach to sluices.*—The conditions of approach and the loss of head due to this for the Right, Central and Left surplus sluices have been considered separately and the results are recorded in general terms in the following statement:—

Sluices.	Water level south of line <i>I. D.</i> on site plan.	Water level just above sluice when fully open.	Velocity of approach at sluice.	Head due to velocity of approach.
Right surplus sluices, cill + 172.5, 95 vents of 16×14 ..	190.5	187.69	9.7	1.47
	196.5	194.27	8.87	1.23
	200.5	198.69	8.34	1.09
	204.5	202.96	7.88	0.97
	204.5	188.14	8.68	1.17
Central surplus sluices, cills + 178.5, 54 vents of 20×16 .	190.5	193.61	10.78	1.82
	196.5	197.87	10.70	1.78
	200.5	202.28	10.10	1.69
	204.5	..	..	..
	190.5	195.14	6.42	0.65
Left surplus sluices, cill + 191, 42 vents of 30×12 ..	196.5	198.74	8.71	1.18
	200.5	202.22	10.66	1.74
	204.5	..	..	..

154. *Calculations and coefficients of discharge.*—From the levels of water immediately above the sluices, the discharges of the sluices are calculated.

In this calculation the run-off downstream of the sluices is taken as a "free outfall." The slope downstream of the sluices which has to be cut away, is estimated to have—

Downstream of Right sluices ..	...	...	...	...	...	$\frac{1}{250}$
" Central "	...	...	...	...	...	$\frac{1}{250}$
" Left "	...	...	...	...	...	$\frac{1}{250}$

A reference to the discharge levels and sections of the Mukhtala Vagu (Portfolio No. 1), into which the sluices discharge, shows that the water levels of this never submerge the sluice cills.

Calculations of discharge show that the differences of level between water immediately in rear of sluices, and simultaneous water level in the Mukhtala Vagu, give a surface slope to the run-off, which in every case will carry the water down the tail slope at greater velocity, than the mean velocity of discharge through the sluice vent.

This is the justification for treating the discharge as having a free outfall. The co-efficient taken is 0.625. As a test of this, calculations have been made on the assumption that with sluices fully open, the depth of water in rear of the sluices is that due to a surface slope of departure of $\frac{1}{250}$ for the Central sluices, and $\frac{1}{200}$ for the Right sluices.

Discharge calculations due to water in rear of depth as above, have been made, and show no material difference in result from the calculations of discharge with the outfall considered as free. In these last calculations the co-efficients taken have been—

Unsubmerged portion of orifice	...	...	...	...	...	= 0.625
Submerged "	...	...	...	...	...	= 8

On the above considerations, it has been decided that the calculation of discharge with a free outfall is a correct assumption and the discharges shown in the table paragraph 89 show the results of such computations.

The discharge co-efficient of the scouring sluices in the Main Dam taken is 0.70. Messrs. Ransomes and Rapier informed the writer that the actual co-efficient realised for the deep sluices of the Assouan Dam when fully open, is 0.72.

It is admitted that opinions will vary as regards the assumptions made for surplus sluice discharge calculations, but it will be realised that even if actual levels of discharge varied as much as one or two feet from the results of calculations, no serious inconvenience would be felt in the reservoir working under the peculiar conditions under which the regulation has to be carried out.

155. *Role of Left surplus sluices.*—The Left surplus sluices have little discharging capacity when water in the reservoir is standing at the levels from which any considerable floods will be surplused. The principal object and duty of these high level sluices is to surplus down the reservoir from Impounding to Diversion-Level on the approach of a flood being notified.

The discharging capacity of the sluices with reservoir at full level (+ 224.6) is 380,000 cusecs, the level of water over oill being $33\frac{1}{2}$ feet.

The left surplus sluices will also pass all river flow during the Impounding period, both surplus flow and irrigation-flow required for the delta.

156. *High road level over surplus sluices.*—It will be noticed that the designs show the level of the roadway over the surplus sluices is $2\frac{1}{2}$ feet above that over the Main-Dam. This extra level has been given as convenient in giving a greater free board, while the extra height does not entail any additional expense as the disposition of weight of masonry in the greater height of the roadway assists stability.

In the event of its being desirable at any future time to raise the Impounding Level, the levels of surplus works enable this to be done without any alteration.

157. *Discharge of Upland Canal Head Regulator.*—The Head Regulator is designed to discharge the full supply into the Upland Main Canal from Diversion level (190.5) with a head of one foot. The co-efficient for calculating this discharge has been assumed at .75.

158. *"The Thrust Buttress dam," a suitable alternative.*—In considering the the Kistna Dam, it is desirable to have in view the type of arched dam designed by Mr. R. A. Ryves, A.M.I.C.E., when making studies in connection with this project and which he called the "Thrust Buttress Type". The dam is of masonry throughout and consists of a series of piers with horizontal arches sprung between to take the water thrust and transfer it to the piers or buttresses.

In this, the dam is similar to Captain Garrett's type. It differs however in making the arches inclined to the vertical at an angle of 45° and the buttress downstream face at right angles to this.

All the load is taken by the buttresses in direct compression and there are no material cross strains, indeterminate distribution of stress due to loading or considerable temperature effects.

The full description will be found in Mr. Ryves' papers published with Madras Public Works Department, Irrigation Branch Circular No. 753 of 14th June 1910, and 1088, dated 11th August 1910.

The design appears to the writer thoroughly practical and suitable for such a dam as the Kistna and its adoption would greatly facilitate surplusage during construction. Further, one might search far before finding a material so eminently suited for such a form of construction as napah stone, for both buttresses and for arches, it is an ideal material.

The works proposed are so enormous that the writer does not propose such a departure to be adopted without trial on a smaller but yet considerable scale elsewhere, but he sees no theoretical or practical objection to the type of construction and believes it to be quite suitable for the Kistna site.

It is proposed to build the Bugga Vagu dam in the 6th mile of main canal of this type, as there also napah stone is available close to the site.

There is reason for thinking that it may be years before the Kistna Dam is started. Should this be so, in reconsidering proposals it would be well to reconsider the thrust buttress type of dam, which is likely to have assumed tangible reality in construction before many years are over.

SECTION IV.

CANAL SYSTEM.

159. *Detailed descriptions of canal systems in Parts II and III.*—The detailed descriptions of reports on the designs and estimates for the construction of the systems of canals and channels by which water from the Head Works will be conveyed and distributed over the areas to be irrigated are contained in Parts II and III of this volume.

These are written by the officers who have been employed on the survey and investigation of the areas and who have actually had the immediate charge of the drawing up of the designs and estimates.

For this reason, only a few remarks on the canal systems will here be made while the reader is referred to Parts II and III for the general and detailed descriptions of the canal systems.

160. *Extension of Delta Canal system under Bezwada Anicut.*—The ultimate area which can be irrigated by direct flow under Bezwada anicut is 725,000 acres (*vide* G.O., No. 39 I., dated 3rd February 1911) being an "Early single crop" raised between July and December. The area which can be commanded and which is fit for irrigation after making suitable reservations is 850,000 acres.

Thus the additional area of early crop which can be irrigated under Bezwada anicut through this project is 125,000 acres.

161. *Works required for extension of "early crop area" in the Delta.*—The distribution works required to effect such extension consist of—

(a) Works necessary to enable existing canals to carry the water required for the increased total areas coming under them.

(b) Extension of the distributary system to convey water to the lands to be newly irrigated.

162. *Works to increase carrying capacity of existing canals.*—The works under (a) comprise installing falling shutters on the Kistna Anicut of 7 feet in height to supersede the existing 3 feet shutters.

These will enable water to be carried at greater depths in the main canals with consequent added carrying capacity.

Works of a minor nature in widening and improving the grading of the canals are here and there necessary and are provided for. It may here be noted that in designing the alterations in carrying capacity of existing delta canals, the matter of critical velocity, which was not considered in the original designs, has not been lost sight of, and the works proposed are likely to improve the existing conditions of flow and silt deposit in delta canals, as well as to afford increased carrying capacity.

163. *Extensions of distribution system in Delta.*—The works under (b) consist generally of construction of minor distributaries for carrying water to plots of land scattered all over the deltaic area. The only block of considerable area coming under new canals is the East Bank Canal (Eastern Delta). The area of extension is 125,266 acres (73,266 in Eastern and 52,000 in Western).

This extension is one which has been in view for many years and has not been carried out, solely because it was found that the available water could be supplied more cheaply to lands elsewhere requiring it more.

164. "Late crop" irrigation in Delta.—In addition to the extension of the existing irrigated crop area (the early single crop), it is proposed to extend irrigation by cultivating in the delta "late crop" from February to May.

This late crop consists of—

- (i) Second crop grown on areas raising an early crop the same year.

For the supply of water to such areas, no further distribution works are required. The maximum area proposed for second crop is 197,456 acres.

- (ii) A single late crop raised, February to May yearly, on marshy or water-logged areas unsuitable for raising an early irrigated crop.

For these areas new distributaries are required.

This area consists of only two blocks, one of which (Pedalanka block 5,094 acres) calls for no remark.

The other the Kollair lake block (20,000 acres) is a stretch of land in the bed and along the submergible margins of the Kollair lake which is always dry in the "late crop" season.

There is 72,000 acres of land fit for "late crop" cultivation in the Kollair lake area and it is the difficulties of carrying water which restricts the area proposed for irrigation.

165. Upland Canal System.—This system is an entirely new system taking off directly from the Reservoir through head sluices forming the right flank of the Main Dam.

The area to be irrigated is 610,000 acres and it is proposed that only a single "early irrigated crop" (July to December) should be grown in this area. The canal system is a large one and the estimated cost of construction is high.

The country is broken up in a succession of minor spurs and valleys generally from $1\frac{1}{2}$ to 4 miles apart. The top of the spurs have a fall generally of from 20 to 30 feet a mile, while their sides are much more steep, falling from 30 to 50 feet.

166. The Upland Main Canal.—The Main Canal is a contour canal 147 miles in length, having a carrying capacity diminishing from 8,878 cusecs at the head to 515 cusecs at mile 147. Following the contour of the country the course of the canal is tortuous and generally while the country in which it runs, with the exception of the first 7 miles, presents no special difficulties, it is such as to entail a high cost in construction. The first seven miles of canal is carried through a very broken rough country, full of minor steep undulations, and small hills, and entailing a series of numerous successive cuttings and banks, and many cross-drainage works. This length of canal is all in shale and provision is made for carrying the canal with high velocity and with a depth of 15 feet (4 feet deeper than normal) through this length. This arrangement is made on the score of both convenience and economy.

167. Level of offtake, Upland Main Canal.—The level of off-take Upland Main Canal is a matter which has been the subject of very careful consideration.

The conditions of the reservoir are such that the effective capacity depends to a great extent not, as is usual, on the height of the dam, but on the difference between Impounding and Diversion Levels.

The lower the Diversion Level therefore, the lower might be the Impounding level and therefore the Main Dam for the same ultimate effective capacity. This gives a strong reason for desiring to keep "Diversion Level", and therefore main canal full supply level, low. On the other hand however there are very serious objections to lowering the Diversion Level. First the natural advantages and facilities of the dam site for surplusage on the left flank become smaller as the Diversion Level gets lower.

The best Diversion Level for purposes of surplus is probably about + 194 or higher, and the cost and difficulties of surplus arrangements increase as Diversion Level becomes lowered.

Again as canal full level is lowered, the irrigable area commanded becomes reduced, that is, revenue is reduced, while the actual cost of canal construction per acre is increased by the necessity of making deeper the deep cuttings where diversions cannot be made (there are 4 of these on the canal line) and by the greater length of canal when carried at the lower level.

Reconciling these conflicting considerations, the Diversion Level proposed has been lowered from the original level proposed of + 192 to + 190.5 and this has been accepted as suitable by the Inspector-General of Irrigation (paragraph 15 of note, dated 30th November 1910—vide Appendix I.)

168. Depth and grading of the Upland Main Canal.—The capacity required of the canal is great, while the alignment is tortuous and the cross fall of the country is in places considerable. These considerations make it desirable to keep down the bed-widths and therefore to have a rather deep canal.

It is considered prudent to grade the canal for a critical velocity of V_c .

The delta canals have a velocity generally about $.9 V_c$ and have not suffered badly from silting.

The critical velocity for Kistna silt (black soil) appears from observations taken to be about $0.8 V_c$. That for the coarse river bed sand is probably from $1.15 V_c$ to $1.1 V_c$.

It is considered that it would be rash to design the new canal for so low a critical velocity as $.9 V_c$, although the delta canals have successfully operated under these conditions. On the other hand, it would be very costly and almost impracticable to align for such a high critical velocity as $1.1 V_c$. It is considered that V_c is a safe compromise and has accordingly been adopted. It is probable that the soil of the margins of the Upland Canal would not withstand without serious erosion a canal mean velocity exceeding 4 feet per second, and this fixes a limit to the depth of the canal at 11 feet (V_c for a depth of 11 feet is 3.9). The canal has therefore been designed for its upper reaches 11 feet deep, except in the shale country in the first six miles in which marginal scour need not be feared; in this a depth of 15 feet is given.

There is some doubt whether the margins will be safe with so high a velocity and as a precaution an extra width of berm equal to half the depth of the cutting is allowed wherever the velocity of the canal exceeds 3.2 feet per second as a precaution against marginal erosion.

169. Branch canals (Uplands).—Branch canals have been designed and estimated in full detail and their names, acreage commanded and lengths are detailed below:—

Name.	R.D. of off-take on Main Canal.	Length in feet.	Total area irrigated.	Remarks.
1. Tadikonda	29/9075	71,680	55,078	Takes off at 0/3100 from head of Guntur branch and irrigates 46,928 acres of the 122,200.
2. Guntur	32/7700	76,400	122,200	
3. Ankireddipalem	"	34,250		
4. Elur	47/7500	68,500	33,280	Takes off at 0/900 from head of Annavaram branch and irrigates 23,111 acres of the total area.
5. Annavaram	56/8700	20,200	60,066	
6. Anantavaram	"	6,600		
7. Daggupad	65/7000	16,170	27,585	
8. Kanuparti	77/6500	15,840	28,600	

Off-takes from the Main Canal of capacity exceeding 300 cusecs are classed as "Branch canals". Channels of less capacity than 300 cusecs are termed "Distributary channels". Branch canals and distributaries are generally aligned along the crest of ridges and there is no cross drainage, while "Falls" (drops) are introduced to adjust the difference between the fall of the channel and the fall of the ridge. For short lengths, exceptions to this have to be made and the branch or distributary is aligned as a contour channel with cross-drainage works.

170. "*Distributaries, Upland System.*"—The "distributary channels" include all channels to be constructed at Government cost having a carrying capacity of less than 300 cusecs.

In order to estimate the cost of the Distributary System, four blocks have been selected being typical of the whole country to be irrigated, and of irrigated extent a little over 10 per cent. of the area to be irrigated.

For these four blocks, distributary systems have been designed and estimated in full detail, and from the figures so ascertained the estimate for the cost of the "Distributaries" for the whole Upland System has been deduced.

In making the estimates for cost of "distributaries," a further classification has been made, viz.—

Major distributaries—

Channels of capacity 300 down to 25 cusecs.

Minor distributaries—

Channels of capacity 25 cusecs and under.

171. *Limits to size of channels to be constructed by Government.*—Provision is made for constructing channels at Government cost so as to deliver water at a commanding point within the limits of each village to be irrigated, leaving to the ryots the construction, under direction, as regards alignment, of irrigation Officers, of "water courses" for the distribution of water from this point to individual fields.

Further limits to the above are laid down, in that Government will not construct any channel for a less area than 100 acres, while ryots are not called on to construct any channel of greater capacity than 5 cusecs. These limits are those which are usual in practice and have been also adopted for the Cauvery Reservoir Project.

172. *System of estimating the cost of distributaries.*—In estimating from the cost of the "typical blocks" the cost of "distributaries" for the whole Upland System two different methods have been adopted—

For the "major distributaries", the basis of the estimate is the cost of channels per "cusec mile".

For the "minor distributaries", the cost is based on the cost "per acre irrigated".

In the Cauvery Project, "acreage rate" system was adopted for both Major and Minor distributaries. The Inspector-General of Irrigation had advised in his note, dated 30th November 1910, on the Kistna Project, paragraph 15, that the "cusec mile rate" is to be preferred and it is admitted that this system is likely to give greater accuracy. It has been found however that the labour of laying out the detailed system of distributaries down to the smallest channel for the whole area (610,000 acres) entailed so much time as to be likely to materially delay the submission of estimates. Orders were therefore given by the writer to compute the cost of Minor distributaries on the "acreage system", while using the "cusec mile" system for the Major distributaries.

173. *Allowance for run-off of cross-drainage.*—The capacity of the cross-drainage works has been calculated for discharging with a velocity of about 10 feet per second a run-off from the intercepted area calculated from Ryves formula ($D = CM^{\frac{2}{3}}$) with a co-efficient (C) of 1,000. This is a very high co-efficient in view of the recorded rainfall (*vide* Volume II, pages 224 to 239). The reason for adopting it is that the ascertained co-efficient for the run-off of the Gundlacamma river reaches this figure. It is to be recognised that the Gundlacamma is a considerable river, having a considerable area of hill catchment in the Kurnool district, while the drainages crossing the Upland Main Canal have only local catchments.

On the other hand, it is known that flood surplusing across the Commamur Canal in Kistna Western Delta have been of extraordinary magnitude and it has been considered prudent to adopt the high co-efficient computed from the Gundlacamma floods for all the cross drainage-works.

174. *Data for types of works, Upland Canal System.*—While the detailed designs for the whole Upland System have been made by the Executive Engineer, the types of the canal and channel sections, cross-drainage works, and bridges, and the general data for designs have been drawn up by the writer, and have been approved by the Chief Engineer for Irrigation before final adoption as a basis of design.

In accordance with the desire of the Inspector-General of Irrigation, the types of falls have been designed to follow the general lines of the plans found successful in North India and referred to in paragraphs 16 and 17 of his note on the Kistna Project of 30th November 1910 (*vide* Appendix I) and paragraphs 65 to 68 of note on the Cauvery Project, dated 26th November 1910.

For the Minor Distributaries only, the "syphon well" type of fall has been retained. Most of the falls on the Minor Distributaries involve considerable drops (8 feet and upwards), and for such this type secures both economy and efficiency, and has been found successful both in the trial well erected at Red Hills Tank near Madras and in Northern India as per paragraph 66 of Inspector-General of Irrigation's note.

175. *Concluding Remarks.*—Although only these few remarks regarding the canal system are here offered, the following sections of this report regarding materials available, rates for work, and programme of execution, refer to the whole project works and not only to the Head Works. Had the description of the canal systems formed part of this report it is here such description would have been placed. It is recommended that Parts II and III describing these systems be read before the remaining sections of this report.

SECTION V.

BUILDING MATERIALS AND RATES.

Materials.

HEAD WORKS.

176. *Building stones*.—The building stones available at the site are of two kinds—Quartzite and Limestone.

(a) *Quartzite*.—This stone is found overlying the shale formation on the summits of the steeper hills and in detached pieces on the slopes where they have rolled down from above.

The crown of the Pulichintala ridge consists altogether of quartzite and it is from here that the stone for building the random rubble in the Main Dam and Head Works is to be procured.

The stone is very hard and durable and the boring of holes for blasting will be expensive.

The formation of the stone as it stands with steep and nearly vertical faces along the whole length of the ridge, is such as to give a large outturn of stone from blasting and the rate allowed for quarrying (Rs. 5 per 100 c. ft.) is considered liberal.

It is a higher rate by 10 per cent. than allowed for quarrying for the Cauvery Project on account of the greater cost of boring holes.

The stone quarries in irregular shaped pieces very suitable for random rubble and it crushes or breaks into pieces of suitable shape for high class concrete.

Its irregular shape makes it unsuitable for coursed masonry. It is proposed to use it for all concrete or random rubble masonry in the Main Dam east of Wadanapalli Hill.

The stone has been subjected to crushing test in the College of Engineering, Madras, on 6" cubes with the undernoted results :—

Nature of Specimen.	Weight per c. ft. in lbs.	Load at 1st crack tons per sq. inch.	Maximum load tons per sq. inch.
Quartzite from river bed (Cushion Dam site) two specimens	160	4.97	5.11
Quartzite from near north and Pulichintala ridge, one specimen	165	10.78	10.87
Do.	166.8	* 1.43	4.99
Do.	165	did not crush with 100 tons.	

* Corner crack.

A truck load of stones were crushed in a Blake and Marsden's stone crusher and broke into pieces well shaped for concrete work.

Specimens both of the boulder stones found on the hill sides, and of the quarried stone from the crest of Pulichintala ridge did not exhibit any difference in difficulty of crushing or in the resulting broken stones. Thus it is considered that the hill side stones can be collected and broken for concrete and in consequence the rate for "quarrying" stone for crushing for concrete is lower than the rate for "quarrying" for random rubble.

177. *Limestone*.—This stone is a compact crystalline laminated limestone having a distinctive clear ringing sound when struck and locally termed "Napah" stone.

It quarries in flat slabs of thicknesses varying from $1\frac{1}{2}$ to 12 inches and generally the thickness of quarried stone would be about $2\frac{1}{4}$ to $3\frac{1}{4}$ inches. The sides are absolutely parallel and flat and so smooth as to be frequently suitable for flooring without dressing. For the purposes of the present investigation the limestone has not been tested, but tests of similar stone lying however in masses of thicker stratification were made for the previous Kistna Project (Daida Dam site) and gave a minimum crushing load of 4.5 tons per square inch on cubes of 3" side, while the average crushing load was about 50 per cent. higher.

This limestone is very suitable for coursed masonry and for the construction of arches of small rise. It is proposed to use this stone for the arches of the sluice wells, for the arches over the Scouring Sluices for the Main Dam as well as for the coursed masonry in the Main Dam west of Wadanapalli Hill and in the surplus Sluices throughout. It is proposed that in this work the courses shall not be horizontal, but shall incline with a slope of 1 in 6 towards the upstream side of the work. The stone occurs in great beds on the left of the Kistna and the left flank of the dam and the whole of the surplus sluices are bedded on it.

The "napah" stone outcrop crosses the river above Mukhtala and appears at Madapad on the right side.

178. *Lime*.—The limestone (napah stone) above described is to be used for the manufacture of lime for building the Dam and Head Works. Samples of the stone taken from the left of the Kistna on the ridge on which the escape sluices are to stand, have been burned and a very extensive series of tests carried out with this lime mixed with various proportions of surki.

The surki was made from bricks made from the soil taken from the margins of the canal at Bezwada, which is Kistna river alluvial deposit of similar nature to the alluvial marginal deposit near Pulichintala site from which the surki for mortar manufacture of the dam will be made.

The original tests were made in a tensile machine by Mr. F. C. Clift, Assistant Engineer, and were made from a very great number and variety of briquettes. Tests were made with lime burnt from "napah" stone with three separate fuels.

- (a) Singareni coal.
- (b) Wood (Tumma).
- (c) Charcoal.

There is not a very marked difference in the resulting mortar strengths, but the lime burned with coal gave results not inferior to that with wood or charcoal. The charcoal burnt lime did not show better results than any other. As the Dam-site is not far from the Singareni Coal fields, it is proposed to burn all lime with Singareni coal.

Of the various proportions of mortars tested, the undernoted proportions gave the highest strengths.

The briquettes were, after making, kept damp for 24 hours after which they were immersed in water and kept submerged till the time of tensile test.

Time after making briquettes.	Proportion of material in mortar lime: surki, sand by measure, lime burnt with coal.		
	1: $\frac{1}{2}$: $1\frac{1}{2}$	1: 1: $1\frac{1}{2}$	1: $\frac{1}{2}$: 2
	LB. PER SQ. INCH.	LB. PER SQ. INCH.	LB. PER SQ. INCH.
Four weeks	183	125	137
Six "	200	156	179
Eight "	221	195	165
Nine "	238	177	182

The table (page 66) gives further details of tests.

The mortar proportion giving the greatest strength is 1'lime, $\frac{1}{2}$ surki, $1\frac{1}{2}$ sand, and this proportion is that selected for estimating the cost of works.

Crushing tests of the broken briquettes were made between five and six months after making them. The briquettes were too thin (1 inch) to cut into cubes for crushing and the specimens crushed were one inch in thickness and of area about 2 square inches.

On this account the actual crushing loads per square inch of area have been reduced by 17 per cent. to give equivalent loads on a cubical specimen. The results give an average of 2,100 lb. per square inch=135 tons per square foot for ten briquettes of mortar 1 : $\frac{3}{4}$: $1\frac{1}{2}$ from lime burnt with coal.

The tests show the mortar to be of extraordinary high quality.

179. *Surki*.—This will be made from the alluvial soils taken from either margin of the Kistna. In the earlier stages of construction earth for surki can be dug and burned in the waterspread area above Pulichintala village. In the later stages of construction, it will be taken from the lands between Wadanapalli and Mukhtiala.

The bricks for surki will be burned with wood taken from the waterspread area, and it will be desirable to burn these on the river margins in various places on either side of the river and to carry them after burning by water to the surki mills near the Dam-site.

This arrangement will minimise lead for firewood and carriage of material.

In later stages of construction when the alluvial margins above the Dam are submerged, surki earth will be taken from below the Dam site and it will probably be desirable to burn it with coal.

180. *Sand*.—The sand in the bed of the Kistna is abundant in quantity and of the best quality, being clean, sharp, granitic sand.

There is plenty of sand for works in the river-bed within two miles of the Dam site which is exposed and easily obtainable in every dry season.

In the bed of the Paléru also, an unlimited supply of the best kind of building sand is obtainable.

The sand can either be excavated during the dry weather and placed on unsubmerged margins either upstream or downstream of the site and conveyed to site as it may be conveyed by water. The former arrangement is probably the best.

A rate of Rs. 1-12-0 per 100 cubic feet for sand has been allowed for the cost of sand delivered at the mortar mills.

181. *Firewood*.—It is proposed to use coal from the Singareni Coal fields for the work of burning lime and possibly also for surki in the later stages of construction. Coal will also be used for production of power.

For making bricks for surki and for sundry and domestic use, firewood from the submerged area will be used. In view of the price at which coal is obtainable, estimate remunerative to use firewood for manufacturing operations which costs more than Rs. 7 per ton delivered at site, and consequently it will probably not pay to convey wood from the more remote portions of the area to be eventually submerged.

182. *Firewood available in the submerged area*.—The basis of estimation of the quantity of firewood is the report of the Special Revenue Officer on this area (part VIII of his report). The area on which he reported was not so large as the area which subsequent investigations of the silt problem show would be submerged, but it includes the greater and the most important parts of this area.

The firewood in the extra area may be taken in the same proportion per acre submerged as in the area reported on by the Revenue Officer.

The Revenue Officer has not given credit to the Forest Department for forest lands submerged, but he quotes the valuation and estimate of outturn of firewood per acre of forest submerged at Re. 1 per ton with an outturn of 4 tons per acre (paragraph 125). The area of Government forest and waste submerged is 16,091 acres. A good deal of this is rocky barren soil with sparse stunted tree-growth and it will be safe to reduce the estimated outturn on this whole area to 2 tons per acre, or say 32,000 tons.

On the Nizam's side forest growth is estimated at Rs. 94,447 (Revenue Officer's Statement VII-B) and at the valuation of Rs. 1-8-0 per ton, 62,000 tons firewood. Tree valuation in patta lands is Rs. 75,047 (VII-A statement, column 8). This will probably be at a higher rate than firewood value. On the whole, it is safe to take 100,000 tons of firewood in the area dealt with by Mr Turing.

183. *Coal*.—The Singareni Coal fields are distant by broad-gauge rail 42 miles from Bonakalu.

The cost of coal in single truck loads delivered at Bonakalu is about Rs. 10-8-0 per ton. For transshipment to light-railway, haulage to site, unloading and wastage, a further allowance of Rs. 3-8-0 per ton is made which will amply cover all cost, and coal at site is estimated at Rs. 14 per ton.

184. *Carriage of building materials*.—An extensive system of narrow-gauge (30") railway will be installed all over the vicinity of the Head Works and quarries as well as to the nearest railway station of Bonakalu for the conveyance of building materials. For any leads of over one mile light locomotives (fired with coal) will be used. The system of conveying material to the workmen on the Main Dam is described elsewhere.

TABLE of tensile breaking tests of mortars of "napah" stone mortar in pounds per square inch made in proportions specified.
[The mortar was ground in a steam mortar mill and made into briquettes same day. The briquettes were kept in the shade and damp for 24 hours and then kept in water till the date of tests.]

Briquettes made weeks before test.	Lime burnt with coal.										Lime burnt with wood.										Lime burnt with charcoal.									
	Proportion of mortar lime : surki : sand.										Proportion of mortar lime : surki : sand.										Proportion of mortar lime : surki : sand.									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Two weeks	66	64	79	106	116	97	164	168	168	63	60	108	106	134	119	124	107	109	133	66	52	115	77	103	70	87	88	106	69	76
Three weeks	108	113	106	126	137	97	174	183	183	59	66	121	131	143	144	130	114	106	167	78	66	121	121	136	136	113	127	102	102	140
Four weeks	123	123	123	123	123	117	117	117	117	92	90	124	116	124	117	124	113	111	161	83	70	133	123	121	101	116	131	140	140	140
Five weeks	114	93	80	123	126	75	99	123	86	61	74	131	143	116	116	116	117	117	147	83	64	93	81	141	61	87	93	66	66	66
Six weeks	121	128	137	153	153	127	173	200	87	73	132	124	167	136	151	141	145	166	84	69	144	151	163	110	132	130	112	112	112	112
Seven weeks	135	155	175	179	179	128	200	200	91	93	131	161	162	164	146	144	139	180	89	90	146	160	181	142	130	140	103	103	103	103
Eight weeks	147	157	182	162	162	117	191	206	86	86	148	164	167	167	167	171	152	176	112	84	140	175	191	130	142	143	116	116	116	116
Nine weeks	174	165	177	165	165	140	198	221	92	95	157	157	202	139	179	147	158	190	106	92	140	164	181	160	143	149	120	120	120	120
Ten weeks	180	206	189	174	174	138	226	291	107	105	191	191	226	136	204	161	172	151	119	97	94	201	201	164	150	150	150	150	150	150
	125	145	121	150	150	93	163	188	81	81	167	177	177	137	161	122	150	200	96	94	130	171	175	153	153	153	153	153	153	153
	182	177	187	182	182	119	197	238	87	93	171	171	177	167	176	163	149	178	93	92	108	199	206	206	206	206	206	206	206	206
	173	189	195	195	195	195	195	195	195	195	195	195	195	195	195	195	195	195	195	195	195	195	195	195	195	195	195	195	195	195

Note.—The sign "..." over a result denotes that the briquette was kept damp in air in the shade till tested.
The sign "..." dry in air.
Each result recorded in this table is the average from the breaking of ten briquettes.

IRRIGATED AREA.

185. *Building stone—Quartzite.*—In the vicinity of the Head Works and for the first 10 miles of Upland Main canal, quartzite bedded in nests of boulders or strewn on the sides of steep hills, will be found on the larger hills. This stone is well suitable for revetment and pitching as well as for random rubble concrete.

Limestone (Napah).—This is found on the right side of the Kistna at Madapad (opposite Mukhtala) and again on the right side of the Kistna near Chintapalli.

The stone is very suitable for all coursed masonry or for arches of large radius as well as for pitching or revetment.

Granitoid gneiss.—This is the ordinary stone to be found in the irrigated tract and most of the works are designed to be built of it. The gneiss generally can be quarried by burning and comes out in flat stones of thickness from 4 to 12 inches and is very suitable without dressing for coursed rubble or rough archwork.

It also works well under the chisel, and ashlar of the best quality can be made from it.

Murchisonite gneiss.—This stone composes the group of steep isolated hills in the vicinity of Bezvada and Mangalagiri and it is generally known locally as "Bezvada stone". It is a free stone working easily and cheaply under the chisel, and while sufficiently durable for all ordinary purposes, is much softer and cheaper to work and to quarry than the granitoid gneiss. This stone is almost exclusively used for works in the Kistna Delta.

Sandstone.—A soft red sandstone is found near Chebrole. It is easily worked and when protected from the air is a good building stone. It weathers badly under the action of sea air.

Laterite.—This is found near the tail-end of the Upland Main canal system in Ongole taluk.

186. *Sand.*—Good sand for building is found in the beds of all streams of any considerable size. Sand in the smaller drainages frequently is dirty and not in sufficient quantities for masonry works and carting of sand for considerable distances to works in the Upland Canal system has frequently to be provided for.

187. *Brick earth for surki.*—This is not generally widely distributed and is only obtainable in tracts formed by alluvial deposit along the margins of the Kistna-Gundlacamma and one of the two of the larger drainages.

In the black soil tracts or in the deltaic tracts at a distance from the river, it is unusual to find any brick earth or soil suitable for making surki.

On this account the use of surki in the works on the Upland Canal system is restricted to wet foundations and works when mortar of a specially high quality is required, such as concrete arches.

188. *Limestone.*—The only crystalline limestone obtainable is the "Napah" stone already mentioned which is only obtainable near the Head Works and near Chintapalli. Generally, deposits of nodular kunkur of good quality are to be found here and there widely distributed throughout the Upland tract to be irrigated. This makes a good hydraulic mortar mixed with sand in proportion 1 to 2.

Its hydraulic properties are much improved by the addition of surki and a mortar of 1 lime, 1 surki, two sand is about half as strong again as one of 1 lime, 2 sand.

For works in the delta, lime from near Mangalagiri is burned at Vaddeshwaram at the side Kistna Western Main-canal, whence it is transported by barges all over the deltaic tract.

189. *Fuel for canal works.*—This is required for quarrying and for burning surki. In the Upland tracts south of Krosur, it is dear and scarce and there will be probably considerable difficulty in getting wood for burning the granite and lime required. It will be always possible as an alternative to blast the stone, but this would not produce the flat-sided stones which are got by burning.

An extra rate is allowed for quarrying gneiss south of Krosur of Re. 1 per unit on account of the extra cost of firewood. In the delta, considerable quantities of fuel trees are grown on the canal and drain margins.

Coal from Singareni will be used for lime burning in the deltaic tracts, as is indeed the existing practice, and it may possibly also be found necessary to use it for burning bricks for surki.

190. *Carriage of Materials for Canal System.*—On the Upland tracts for the carriage of building materials such as stone, lime and sand, it will be necessary to depend principally on bullock carts, although light tramways and trucks will no doubt also frequently be made use of in suitable localities. There will be great difficulties in arranging for sufficient bullocks and carts to supply materials. In the black-soil tracts, it is impossible to cart when the ground is wet except over metalled roads.

In the delta the stone and lime supplies all come from places near the margins of navigable canals and conveyance for all the long leads is done in barges. This form of carriage is far cheaper than carting and the cost of masonry works in the deltaic black-soil tracts would be frequently more than doubled, were it not for the water carriage available. From the nearest practicable point on navigable canals to the actual work site, materials must be carted in the deltaic as in the Upland tracts. The local supply of carts however is likely to be adequate and no great difficulties should be experienced in carriage of materials in the delta.

Rates.

HEAD WORKS.

191. *Rates for Head Works.*—These are worked out for completed work and include lead and all incidental expenses, except capital cost and depreciation of machinery and plant, which is covered by the provision made under "tools and plant" and Sanitation, Hutting of workmen and Supervision which are separately provided for.

The principal items of the work are random rubble masonry of quartzite, and coursed rubble of laminated limestone (Napah stone), and for these detailed data are worked out.

For quartzite, concrete in lime and surki mortar, detailed data are also given.

For other rates, liberal allowances are made having in view existing and local conditions of labour and carriage.

192. *Random rubble.*—Detailed data for small random rubble of quartzite in surki mortar.

<i>Heating.</i>						RS. A. P.
Material stone quarried and stacked (add one-tenth wastage) at	Rs. 5 per 100 c. ft.	...	...	...	...	5 8 0
Mortar 44 c. ft. at Rs. 15-6-0	...	...	...	...	...	6 12 0
						<u>12 4 0</u>
<i>Conveyance—</i>						
Stone from quarry to masons on Dam 2½ miles...	...	...	...	...	...	4 0 0
Conveyance of mortar	...	...	...	...	...	1 0 0
						<u>5 0 0</u>
<i>Labour—</i>						
2½ masons at Re. 1	...	...	...	...	...	2 8 0
2½ men at As. 6	...	...	...	...	...	0 15 0
2½ women at As. 4	...	...	...	...	...	0 10 0
						<u>4 1 0</u>
<i>Sundries—</i>						
Platforms for stone, etc., scaffolding	...	...	...	...	...	2 0 0
Contingencies	...	...	...	...	...	0 11 0
						<u>2 11 0</u>
Total for heating	...					<u>24 0 0</u>

For "Face work" two extra masons will be required with two women as attendants on these masons.

Rate for facing	...	...	...	...	...	RS. A. P. 26 8 0
193. <i>Napah stone coursed rubble—</i>						RS. A. P.
<i>Material—</i>						
Stone quarried and stacked Rs. 4-8-0 including one-ninth wastage.	...	...	...	...	...	5 0 0
Mortar 36 c. ft.	...	...	...	...	...	5 8 6
						<u>10 8 6</u>
<i>Conveyance—</i>						
Stone from quarry to masons on dam	...	...	...	...	...	3 0 0
Conveyance of mortar	...	...	...	...	...	1 0 0
						<u>4 0 0</u>
<i>Labour—</i>						
4½ masons at Re. 1	...	...	...	...	...	4 8 0
2½ men at As. 6	...	...	...	...	...	0 15 0
4½ women at As. 4	...	...	...	...	...	1 2 0
						<u>6 9 0</u>
<i>Sundries—</i>						
Scaffolding, platforms for stone and mortar, etc.	...	...	...	...	...	2 0 0
Contingencies	...	...	...	...	...	0 14 6
						<u>2 14 6</u>
Total	...					<u>24 0 0</u>
194. <i>Lime manufacture.</i> —Burning Lime with Coal (100 cubic feet Limestone).						RS. A. P.
¾ ton coal at Rs. 14	...	...	...	...	...	12 4 0
Firewood for lighting 2 cwt. at	...	...	...	...	...	0 8 0
100 cubic feet Napah stone broken	...	...	...	...	...	5 8 0
<i>Operations—</i>						
Loading, unloading, slaking and screening	...	...	...	...	...	4 0 0
Maintenance of kilns	...	...	...	...	...	1 0 0
Contingencies	...	...	...	...	...	0 12 0
						<u>24 0 0</u>
Outturn 200 cubic feet of slaked lime. Rate say Rs. 12 per hundred cubic foot.						
						4 0 0
						1 0 0
<i>Limestone—</i>						
Quarrying and breaking	...	...	...	...	...	5 0 0
Conveyance to site within half mile	...	...	...	...	...	per c. ft.
						<u>5 0 0</u>
<i>Surki—</i>						
2,000 country bricks at Rs. 5	...	...	...	...	...	10 0 0
Breaking	...	...	...	...	...	0 8 0
Conveyance to site	...	...	...	...	...	1 8 0
Pulverising and screening	...	...	...	...	...	3 8 0
Handling, shedding and contingencies	...	...	...	...	...	1 0 0
						<u>16 8 0</u>
Per 100 c. ft.	...					<u>18</u>

195. Mortar manufacture—

Proportion by measure—Napah lime 1: Surki $\frac{3}{4}$: Sand $1\frac{1}{4}$.
 Outturn of mortar— $2\frac{1}{2}$ c. ft.

Estimate for manufacture—	RS.	A.	P.
100 cubic feet slaked lime	12	0	0
75 cubic feet surki	12	6	0
150 cubic feet sand at 1-12-0	2	10	0
	27	0	0

Conveyance of material—

From shed to mortar mills and attendance on mills	1	8	0
Grinding mortar	6	0	0
	7	8	0

Total ... 34 8 0

Outturn 225 cuso. ft. ...

Rate per 100 cubic feet of mortar ..	15	6	0
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196. Concrete quartzite in surki mortar—

Material—

Quarrying stone for crushing Rs. 4	4	0	0
Breaking and crushing stone	4	8	0
Mortar 50 cubic feet at 15/6	7	11	0
	16	3	0

Total ... 16 3 0

Conveyance—

Conveyance of stone to crushers and from crushers to mixers	2	4	0
Conveyance of mortar to mixers	0	8	0
Conveyance to site on work	1	8	0
	4	4	0

Total ... 4 4 0

Mixing concrete

Spreading and ramming and watering (2 men and 2 women)	1	8	0
	1	4	0
	2	12	0

Contingencies	0	13	0
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Total ... 24 0 0

UPLAND CANAL SYSTEM.

197. Rates for works—Upland canal system.—The rates for works in the Upland Canal System are computed from "initial rates" which include the cost of getting or making the necessary material and the cost of building or excavating. The cost of carriage of building material from the nearest suitable place to the site of each work is computed separately and is not included in the initial rate. The rates throughout have been fixed materially higher than the local rates and are fixed with a view to what rates would probably have to be paid in the early stages of the work, were actual work commenced within the next year or two.

198. Rates for materials (exclusive of lead)—

(i) Broken stone for concrete—	RS.	A.	P.
Granitoid gneiss per 100 cubic feet	4	8	0
Quartzite	4	8	0
Bezawada stone	3	8	0
Chebrole sandstone	3	8	0

RS. A. P.

(ii) Roughstone suitable for random rubble or pitching—	7	0	0
Granitoid gneiss (blasted)	6	0	0
Quartzite	3	6	0
Bezawada stone	3	4	0
Laterite (for revetment)			
(iii) Stone suitable for coursed rubble—	8	0	0
Burnt stone granitoid gneiss (above Krosur)	9	0	0
Burnt stone south of Krosur	5	6	0
Bezawada stone	5	8	0
Squared laterite			
(iv) Cutstone—	1	4	0 to 2
Granitoid gneiss per cubic feet	0	12	0
Bezawada stone or Chebrole sandstone	16	0	0
(v) Slaked lime 100 cubic feet	16	0	0
(vi) Surki (screened) 100 cubic feet			

199. Rates for labour—

Masonry—

Concrete laying and ramming per unit	2	12	0
Do. in archwork	3	12	0
Building random rubble	5	4	0
Do. coursed	6	12	0
Do. dry stone aprons	1	8	0
Do. dry revetments	1	2	0 to 2
Plastering one coat	1	8	0
Do. two coats	2	8	0
Flush pointing	1	8	0
Grinding mortar per cubic feet	0	0	6

200. Earthwork and excavation, Upland system.—"Initial rate" includes two yards' lift and 20 yards' lead and sectioning and trimming slopes.

	RS.	A.	P.
(a) Sand initial rate per 1,000 cubic feet	2	8	0
(b) Black or red soils per 1,000 "	3	14	0
(c) Gravel and kunkur gravel 1,000 cubic feet	8	8	0
Soft rocks—	16	0	0
(d) Decayed gneiss per 1,000 cubic feet	10	0	0 to 25
(e) Yellow shale per 1,000 cubic feet according to hardness	25	0	0 to 35
Blue shale per 1,000 cubic feet	35	0	0
(f) Laterite do.	40	0	0
(g) Micaceous schist do.	40	0	0
Hard rocks—	70	0	0
(h) Napah stone	70	0	0
(i) Granitic gneiss	0	4	6
(j) Quartzite	0	4	6
Extra lead by head load for 10 yards or part of 10 yards per 1,000 cubic feet	0	4	6
Extra lift for one yard of part or one yard per 1,000 cubic feet. For rocks extra lead and lift 25 per cent. extra.			

201. Conveyance of materials.—Conveyance of material by cart over made-roads or hard smooth ground:—

	Brokenstone, roughstone or laterite per 100 cubic feet.	Gravel, sand, cement surki per 100 cubic feet.	Lime per 100 cubic feet or 1,000 bricks.
	RS. A. P.	RS. A. P.	RS. A. P.
Up to half mile	0	12	0
Half to one mile	1	4	0
One to one and a half miles	1	12	0
One and a half to two miles	2	4	0
Add for every additional half mile or part thereof	0	8	0

For carting over rough or soft ground 25 per cent. added to above rates.
In several places in the Main Canal there are deep cuttings in close proximity to large banks and it is proposed to convey the spoil from the cutting by portable tram line and tipping trucks to form the banks.
As a rule, the lead in such cases will not exceed 2 furlongs.
The rate for such work is made out as below :—

It is assumed that each truck with 25 cubic feet of spoil will be pushed six miles loaded and six empty daily with a limit of 24 trips daily as a maximum two men could work a truck on a level, but six will be required to push it up a slope of 1/50.

On an average, four men per truck are allowed at As. 5-6 per man = Rs. 2-4-0 per unit.

For longer leads than 2 furlongs flatter slopes can be arranged and for extra to 2 furlongs three men only are allowed or an extra rate of As. 13-6 per furlong.

For cross lifting and sectioning, the tipped spoil Re. 1 per unit is allowed.
For shifting tram-rails and repairs, As. 4 per unit.

The total cost for leading spoil under 2 furlongs with slopes (loaded) not exceeding 1/50 is per unit of 1,000 cubic feet, Rs. 3-8-0.

For each added furlong above 2, add As. 13-6 of 1,000 cubic feet.

DELTA SYSTEM.

202. *Rates for extension works.*—The estimates for the Extension Works in the Kistna Delta under Bezwada Anicut were prepared under the supervision of the Superintending Engineer, II Circle, as the existing Delta System forms part of this circle.

The rates forming the basis of the estimates for extension in the Eastern and Western Deltas respectively are those now in force in the respective areas and a statement of these follow.

203. *Earthwork rates in delta.*—Earthwork rates in both Eastern and Western Deltas are the same for alluvial, black and ordinary soils, viz.—

	RS.	A.	P.
Initial rate including 20 yards' lead, 2 yards' lift per 1,000 and including sectioning and trimming slopes of banks and cutting	2	14	3
Extra for each 10 yards or part of 10 yards lead	0	3	1
Extra for each one yard or part of one yard lift	0	3	1

204. Table of rates.—Kistna Delta—

Item.	Kistna Eastern Delta.			Kistna Western Delta.		
	RS.	A.	P.	RS.	A.	P.
<i>Masonry works.</i>						
1. Concrete ordinary mortar	10	11	0	12	16	0
2. Concrete surki mortar	11	13	0	13	12	0
3. Random rubble ordinary mortar	11	3	0	13	12	0
4. Random rubble surki mortar	12	2	0	55	7	0
5. Cutstone in surki mortar	48	14	0	5	13	0
6. Revetment or apron of roughstone	5	0	0	3	7	0
7. Quarry rubbish backing	2	1	0	22	6	0
7-a. Screened quarry rubbish laid as backing to revetments	18	8	0	2	8	0
8. Brickwork in surki mortar	1	10	0	3	14	0
9. Pointing with surki mortar	3	3	0	5	3	0
10. Plastering with ordinary mortar	3	12	0	3	4	0
10-a. Plastering with surki mortar	3	12	0			
11. Plastering with Portland cement cement 8 sand $\frac{1}{4}$ " thick						
12. Broken stone for metalling						

205. Rates for conveying materials per mile.—

Nature of materials.	Kistna Eastern Delta.			Kistna Western Delta.			Remarks.			
	By canal boat.	By cart.		By canal boat.	By cart.					
	RS.	A.	P.	RS.	A.	P.	RS.	A.	P.	
Broken stone or quarry rubbish, 100 c.ft.	0	1	6	1	0	0	0	1	6	The rates for conveyance by boat are exclusive of cost of loading and unloading.
Rough rubble stone, 100 c.ft.	0	1	6	1	0	0	0	1	6	
Cutstone, 100 c.ft.	0	1	6	1	8	0	0	1	6	
Sand, 100 c.ft.	0	1	6	0	13	4	0	1	1	
Lime (slaked) per 100 c.ft.	0	0	9	0	9	0	0	0	8	
Surki	0	0	9	0	9	0	0	1	1	
Bricks for 100 c.ft. brickwork	0	1	7	0	14	0	0	1	6	0

206. *Centage addition made to delta rates.*—These rates, as well as those in the list following, only suffice for carrying out the ordinary petty works of Maintenance and Repairs and Minor Extensions which are carried out yearly in the Delta, but it is considered that they are undoubtedly insufficient to provide for rapid and steady execution of Project Works of considerable aggregate magnitude and 15 per cent. has therefore been added in the classified abstracts to the totals of all the estimates for the Delta Extension Works to provide sufficiently high rates to enable the works to be rapidly pushed, should they be sanctioned within the next two years.

This 15 per cent. is not added to items for Preliminary Expenses or Land.

207. *Head works rates compared with those on similar works.*—The following statement shows the rates allowed for the masonry in the Head Works estimates and those allowed in the Cauvery Project estimates and the actuals for work on the Periyár Dam, the Marikanave Dam and the Darna Dam.

The conditions of the Periyár were peculiar, the climate was wet, cold and unhealthy, the place remote, the work was discontinued for several months each year and the lime had to be brought from the plains.

The conditions of Marikanave do not differ materially from those of the proposed work, except that no sand was obtainable for mortar making of the former work and all mortar was made with lime and surki without sand.

	Random rubble in surki mortar.	Coursed Naph stone surki mortar.	Concrete in surki mortar.	Remarks.
	RS. A. P.	RS. A. P.	RS. A. P.	
Periyár dam actual	30 4 0	..	32 0 0	
Marikanave actual	18 6 0	..	17 8 0	
Darna dam actual	17 8 0	..	24 8 0	
Metur dam, Cauvery Project estimated	24 8 0	..		
Kistna dam Polichintala estimates ..	*24 0 0	24 0 0	24 0 0	The mortar for Cauvery Dam is more expensive than for Kistna. * For Random rubble masonry an extra Rs. 2-8-0 per unit.

208. Comparative statement showing the rates allowed in the Project Upland Canal and the schedule rates of Guntur, Kistna Eastern and Kistna Western Divisions, exclusive of Carriage of Materials.—

Nature of work.	Upland area.		Existing rates.		Remarks.
	Project rates, upland canal.	Guntur division existing rates.	Kistna Eastern delta.	Kistna Western delta.	
1	2	3	4	5	6
	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	
1. Concrete in ordinary mortar.	12 4 0	8 4 0	10 11 0	..	
2. Concrete in surki ordinary mortar.	12 12 0	8 12 0	11 13 0	12 15 0	(c) For concrete arch work Rs. 1 extra is allowed.
3. Random rubble ordinary mortar.	(a) 14 0 0	9 2 0	11 3 0	..	
4. Random rubble surki ordinary mortar.	14 8 0	9 6 0	12 2 0	13 12 0	
5. Coursed rubble ordinary mortar.	16 1 0	9 4 0	..	..	
6. Coursed rubble surki ordinary mortar.	17 2 0	10 0 0	..	..	
7. Revetment of rough stone ..	17 8 0	10 0 0	..	..	(b) For roughstone arch-work Rs. 2 extra is allowed.
8. Apron of rough stone ..	18 9 0	10 4 0	5 0 0	5 13 0	(c) Rs. 5-12-0 for laterite. (d) Rs. 5-4-0 for laterite.
9. Brickwork in surki mortar ..	19 11 0	17 4 0	..	..	
10. (a) Excavation in ordinary soil including 2 yards' lift, and 20 yards' lead and sectioning slopes.	(b) 21 2 0	18 4 0	18 8 0	22 6 0	
(b) Extra lift 1 yard or part of a yard.	22 3 0	21 12 0	2 14 3	2 14 3	
(c) Extra lead 10 yards or part of 10 yards.	(c) 8 10 0	3 12 0	0 3 1	0 3 1	
	12 0 0	4 0 0	0 3 1	0 3 1	
	8 2 0	3 10 0	0 3 1	0 3 1	
	(d) 11 8 0	3 14 0	..	..	
	..	15 12 0	..	..	
	..	21 0 0	..	..	
	3 14 0	2 5 0	..	..	
	0 4 6	0 3 1	..	..	
	0 4 6	0 3 1	..	..	

209. General remarks on rates.—The rates on which the estimates are drawn, are those, it is considered, for which the works could be carried out if the works were started without delay and making no allowance for the yearly upward tend of prices of labour and of land.

Even if the works were started at once, many years must elapse before they are complete and it is a certainty that as years go by, the prices of labour will become higher and higher.

210. Provisions for Unforeseen Works.—It is considered necessary to make such allowance under the heading of "Unforeseen" which will cover such rises of rates for labour as well as the cost of works of which the necessity is not now foreseen.

The rates allowed for the Head Works have fewer possibilities of large percentage excesses than for the canal system and a smaller percentage addition for unforeseen will, it is considered, suffice to make this estimate a safe one. An allowance as below has been added for "unforeseen" to the totals of all sub-heads of estimates as below.

Head Works.—10 per cent. to all items under the "Head Works" except Preliminary Expenses and manufactured structural steel.

Canal system, Upland and Delta extension.—20 per cent. to all items included under "works" except Preliminary Expenses.

211. Provision for Establishment Charges.—The estimate allows the regulation 23 per cent. for "establishment" charges, this percentage being calculated on the total cost of "Works", excluding the items "Preliminary Expenses" and "Land" and allowing only 10 per cent. on the cost of sluice shutters and structural steel and gear to be imported from the manufacturers in England. These charges are allowed for in accordance with regulations, but are greatly in excess of any possible actual expenditure on engineering establishments. The special establishments from other departments are provided for separately.

212. Indirect charges.—These include provision for—

(a) Abatement of Land Revenue capitalised at 25 years' purchase.

(b) Leave and pension allowances of the engineering staff at 14 per cent. on the sum allowed for salaries as above and of the special establishments furnished by other departments.

213. Tools and plant.—In addition to the special tools and plant allowed for, the usual $1\frac{1}{2}$ per cent. on cost of "Works" excluding "Preliminary Expenses" and "Land" is allowed for ordinary tools and plant.

214. Suspense.—Under this head, provision is made for maintaining a stock of building materials, machinery fittings and small stores. During the early years of construction the value of such stocks must be considerable. As the work approaches completion, stocks will be reduced by issue to works, sales, etc., and provision is made for losses and "stock" maintained after completion of works amounting to rupees 50,000 for Head Works and 40,000 for the Canal System.

215. Receipts credited to Capital.—The chief realisation under this head will be revenue earned in conveyance of passengers and private goods on the light line between Bonakalu and the Head Works. Food-stuffs must be carried in large quantities and much miscellaneous private goods. A receipt of Rs. 10,000 early on this account has been taken credit for.

Further credit for bungalow and land rents at Rs. 9,000 a year is allowed.

During the last few years of construction, sale of plant and machinery will be undertaken and realisations credited to Capital. The total realisation to Capital during the 18 years of construction is estimated at Rs. 6,70,000 for Head Works and Rs. 64,682 for Upland canal system.

SECTION VI.

PROGRAMME OF CONSTRUCTION.

Head Works.

216. *Programme of construction: Head Works.*—As already explained, the works in section III, construction of the Head Works, will be preceded by one year's preliminary work consisting of surveying, estimating and plan-making, ordering plant, etc., which period is not included among the years of "Construction."

The first two years of construction will be devoted to "preparatory works" as described in paragraphs 92 and 93. The actual masonry on the Main Dam does not begin till the third year of construction.

217. *Working Seasons.*—In making the programme of masons' work, the years are assumed to run from 1st December to 30th November to accord with the seasonal discharges and it is assumed that masonry work on the Main Dam foundations begins in the third year "dry season".

The "dry season" is taken from 1st December to 31st May.

The "flow season" from 1st June to 30th November.

218. *Basis of calculation of rate of progress.*—The rate of construction depends on the rate of outturn of masonry work.

The programme of construction forecasts a rate of working which is reasonable in view of the time taken elsewhere to build large masonry dams. The basis taken for calculation for rate of outturn of masonry on the Head Works is on the number of masons which can, on an average, be counted on for work and the mean daily outturn of work by each man.

It has been assumed that 600 masons can be counted on, of whom 500 will be daily employed on the bulk of the rubble masonry, while 100 men will be required for cutstone work, for pointing up the faces as work proceeds, and for works in which extra labour is entailed, such as sluice floors, archwork, wells, and miscellaneous works throughout the area.

Thus of the 600 masons, only 500 are available daily for building the mass work on the dam.

219. *Daily and yearly outturn of work by masons.*—The outturn of work for each mason daily assumed is—

Quartzite Random Rubble Hearting 40 cubic feet.

" " " Facing 22 "

Allowing facing at 5 per cent., the above combined works out to 38.75 cubic feet of quartzite rubble per man per day.

Napah stone coursed rubble, each man will outturn 22 cubic feet daily.

It is counted men will work on an average 24 days monthly and in addition in the rainy season work will be interrupted 12 days yearly.

The total working days is therefore 274 yearly.

220. *Minimum spacing of masons on works.*—When it is necessary to crowd masons on some part of the work, it is counted that they will work in pairs separated by 15 feet intervals parallel to length of the dam and 20 feet intervals in a direction at right angles to the length.

It is only in the beginning of the work (third and fourth dry seasons) that there is any restriction to progress on this account.

221. *Monthly distribution of masons and outturn of work.*—The monthly distribution of masons on the work and the rate of progress has been worked out in detail up to the time when the Upland Canal has been opened (13th year) and the dam is throughout up to + 205, at which level the maximum flood can be surplused into Mukhtiala Vagu (14th year).

Once the Upland Canal is opened, the development of revenue is not dependent on rapid completion of the Dam, but is limited by the rate of extension of new irrigation.

The number of masons on the Dam can then be reduced if required to reinforce those employed for the masonry works of the Canal System, which from the fourteenth year assumes a position of commanding importance.

A longitudinal section of the dam showing each dry and flow seasons outturn of masonry work and progress of work till the dam is up to level + 205 is among the plans furnished (Portfolio No. 1).

222. *Years for beginning irrigation.*—The programme gives sufficient storage for beginning to extend early crop irrigation in the delta from the eighth year of construction.

Water to the Upland Canal can only be given from the thirteenth year and impounding capacity for second crop in the delta also only becomes sufficient from this year.

223. *Programme of land acquisition: Reservoir and Head Works.*—The estimate provides for land acquisition of the land in the reservoir submerged area which exceeds the area reported on by the Special Revenue Officer at the same proportionate rates per acre under all compensation sub-heads as was allowed by this officer.

The complicated question of acquisition, or submergence without acquisition, of land in the Hyderabad State is not settled, and is not dealt with further in this report.

The programme of acquisition of land for the Head Works and Reservoir allows:—

(a) Acquisition in the first year of "construction" of land for Head Works, camps, roads, railed-roads, quarries, etc., in short, all lands required in connection with the Head Works.

(b) In area of submergence up to thirteenth year of "construction," area to be acquired yearly which is under any risk of submergence the following year.

(c) After the thirteenth year land to be acquired to be yearly one-tenth of the area submerged will be acquired yearly and the whole area will thus be acquired by the twenty-third year of construction. The exact years of submergence of this land cannot be told as it depends on the incidence of silt deposit.

The table below gives details of land areas to be acquired yearly on the above programme.

224. Table showing area of land to be acquired for reservoir and head works.—

Year of acquisition.	Level at which land submerged.	British.				Hyderabad State.			
		Area acquired.		Total area to be acquired.		Area acquired.		Total area to be acquired.	
		MILL. SQ. FT.	ACS.	MILL. SQ. FT.	ACS.	MILL. SQ. FT.	ACS.	MILL. SQ. FT.	ACS.
I ..	..	23	528	23	528	15	314	15	344
IV ..	130	15	344	38	874	30	689	45	1,033
VI ..	140	60	1,377	98	2,249	80	1,837	125	2,870
VIII ..	160	258	5,923	356	8,172	268	6,106	391	8,976
X ..	173	200	4,591	556	12,763	209	4,798	600	13,774
XI ..	180	107	2,456	664	15,219	110	2,525	710	16,299
XII ..	200	360	8,035	1,013	23,264	355	8,150	1,065	24,449
XIII ..	205	95	2,181	1,108	25,435	88	2,020	1,153	26,469

From the thirteenth year, the balance of land required will be taken up in ten years by equal quantities each year up to twenty-third year of construction.

The areas are—

In waterspread area contour + 22'45"	7,690	..	33,125	..	7,989	..	34,458
Above waterspread level in upper reaches of river	7,100	..	40,225	..	13,320	..	47,778

225. *No seigniorage on stone, etc., allowed.*—It may here be mentioned that it is assumed in these estimates that no seigniorage or compensation will be paid for digging or quarrying earth, sand, stone, lime either in the dominions of the His Highness the Nizam's or British Territory.

These materials lie close to the site of the Head Works in enormous quantities and have apart from these works neither present nor prospective value.

226. *Irrigating capacity of the Reservoir during construction.*—For the purposes of Delta Extension, it is the effective capacity of the Reservoir during the "dry season" that determines when extension of irrigation can be begun and to what extent practised.

The first consideration is the supply of early seedling water.

With this available water, the "early crop" extension of area may be undertaken and developed to its ultimate extent as fast as possible. The requirement for this is from 4,000 to 6,000 millions cubic feet.

For the "late crop" in the delta any capacity of water available in excess of the above only can be utilised.

It is, on these considerations, that the year of starting extension of "early" and also for starting "late crop" cultivation is fixed.

The supply of Upland Canal area is a matter of command, and the irrigation under this is commenced from the year when water is held up high enough to pass into the Upland Canal.

The question of capacity available is complicated by consideration of silt deposit.

In the early stages of construction until the dam is above river-bed, no silt will be deposited. When the dam rises above the river-bed, but does not cause a great submergence of existing margins during the ordinary "flow season" discharges, but little silt will be deposited.

As the dam rises higher and higher, and the waterspread extends more and more, silt will be thrown down and when a considerable area of almost motionless water stands above the dam nearly, all the silt carried in suspension (about 4,000 millions cubic feet) will deposit in the river-bed yearly.

On these considerations, assumptions regarding the silt deposited yearly during the earlier years of construction are made and the gross and effective capacities available yearly are computed as shown in the following table.

It is from this table that the year of beginning of the new cultivation in the Delta and Upland is arrived at.

Extension of "early crop" delta begins 8th year of construction.

"Late crop" cultivation delta begins 13th year of construction.

Upland wet cultivation begins 13th year of construction.

227. Table showing level and capacities available in Reservoirs in February-March, each year according to Construction Programme:—

Year of construction.	Level of water in Reservoir.	Gross capacity at level column 2.	Annual and total silt deposit.	Effective capacity.	Details of new irrigation proposed.
1	2	3	4	5	6
		M. C. FT.	M. C. FT.	M. C. FT.	
VI	91	1,000	Nil.	1,000	
VII	104	2,500	200	1,800	
VIII	123	5,250	1,300	3,750	From this year delta canals open early for supply early seedlings. ACS. 15,000
IX	130	9,000	1,500	5,500	Early crop extension on Delta .. 30,000
X	138	12,200	2,000	5,950	Early crop extension Delta.. 45,000
XI	143	14,750	2,750	6,250	Do. .. 60,000
XII	150	19,750	3,500	6,000	Do. .. 75,000
XIII	170	41,000	4,000	23,250	Early crop extension Delta .. 90,000 Late crop Delta—second crop .. 13,600 Single .. 6,250
XIV	185	66,500	17,750	44,750	Early crop Uplands .. 36,000 Early crop Delta .. 105,000 Late crop—second crop .. 27,200 Single .. 12,500
XV	200	99,000	21,750	74,250	Early crop Uplands .. 72,000 Early crop Delta .. 120,000 Late crop—second crop .. 40,800 Single .. 18,750
			25,750		Early crop Uplands .. 108,000
After 14th year of construction the capacity till completion of works is always more than ample.					Correspondingly increased areas each year till full development is attained.

Delta Canal System.

228. *Programme of construction of Distribution System for Delta Extension.*—As water for extending the delta will be available from the 8th year, it is desirable that the Distributary System should be ready before June of that year in order that the scattered areas may develop as fast as possible, that is, that the distribution works in the Delta for the early crop extension should be far advanced by the 7th year and completed by the end of the 8th year.

For the "late short crop" the works should be carried out in the 12th and 13th years as the irrigation of this crop begins in the 13th year.

The programme of works in Kistna Delta therefore should provide for work—on extensions for early crop 6th to 8th years (three years), and for the short late crop in 12th and 13th years (two years).

Upland Canal System.

229. *Programme of development of Distribution System*:—The canal opens in the 13th year of construction and the Revenue forecast allows of development of wet cultivation at the rate of 36,000 acres yearly.

The total area 610,000 acres will therefore be realised in the 29th year.

In order to push and encourage to the utmost the rapid development of wet cultivation, it is proposed as a programme that the Main Canals, Branches and Major Distributaries shall be complete yearly for double the whole area which the forecast shows will be irrigated under the Upland System the next year.

Thus in the 21st year the forecast shows 324,000 acres under wet cultivation and the whole Main Canals and Branches and Major Distributaries should be capable by the end of the 20th year of carrying water throughout their lengths. It is considered undesirable to make the Minor Distributaries so much in advance of irrigation, as a Minor channel which is made five or six years before it is brought into use, will have to be half re-made before it is efficient.

It is proposed therefore that the Minor distributaries shall only keep pace with the Majors, till the area served is 144,000 acres in excess of the area expected to be irrigated the next year.

The following table shows the approximate areas for which the Canal System should be ready to feed to this programme.

This provides for the completion of the Canal System in the 24th year of construction.

230. Table showing proposed programme of construction, Upland Canal system and areas irrigated year by year :—

Year of construction programme.					Area for which main canal, branch canal major distribu- tary will be complete.	Area for which minor distribu- taries will be complete.	Area irrigated according to forecast.
Twelfth	year	..	..	..	ACS.	ACS.	ACS.
Thirteenth	"	..	..	..	72,000	72,000	....
Fourteenth	"	..	..	..	144,000	144,000	36,000
Fifteenth	"	..	..	..	216,000	216,000	72,000
Sixteenth	"	..	..	..	288,000	288,000	108,000
Seventeenth	"	..	..	..	360,000	324,000	144,000
Eighteenth	"	..	..	..	432,000	360,000	180,000
Nineteenth	"	..	..	..	504,000	396,000	216,000
Twentieth	"	..	..	..	576,000	432,000	252,000
Twenty-first	"	..	..	..	610,000	468,000	288,000
Twenty-second	"	..	..	..	....	504,000	324,000
Twenty-third	"	..	..	..	....	540,000	360,000
Twenty-fourth	"	..	..	..	....	576,000	396,000
Twenty-fifth	"	..	..	..	....	610,000	432,000
Twenty-sixth	"	..	..	..	....	....	468,000
Twenty-seventh year		..	..	..	....	....	504,000
Twenty-eighth	"	..	..	..	....	....	540,000
Twenty-ninth	"	..	..	..	....	....	576,000
		..	..	..	....	....	610,000

231. *Programme entails early start at construction of Canal System.*—This end of the 12th year and involves beginning vigorous construction works on it in the 5th year, and entails very heavy expenditure on the Main Canal for many years before any Revenue return from it can be obtained.

The table of forecasted expenditure year by year on the Upland Canal system given in the report by the Executive Engineer (Part III of this volume) shows this in detail.

In the Delta the area of land to be acquired will be acquired two-thirds in the 5th year and the balance in the 6th year of construction.

For the Upland area the whole of the lands required for the system (excluding minor distributaries) will be acquired 4th to 7th years of construction.

For the Upland System minor distributaries the land will be acquired as soon as the distributary has been finally exactly located, which however will probably be only one to two years before construction.

It is considered a fair forecast to allow for all land acquisition for the Upland Canal system except for minor distributaries to be equally divided into the 4th, 5th, 6th and 7th years and to allow the cost of the land for "Minors" being taken up as these distributaries are made.

233. *Occupiers of land not to be permanently disturbed.*—It is proposed in the case of land acquired before occupation is called for, to allow the occupiers to continue as yearly tenants and thus loss of revenue and undue disturbance of the people will be avoided.

ORGANISATION OF CONSTRUCTIONAL STAFF.

234. *Control vested in an Engineer-in-Chief.*—It is proposed that the whole of the works, except those for extension of irrigation in the Delta, shall be placed under the control of an Engineer-in-Chief (with head-quarters at Guntúr) who will be an administrative officer with the powers of a Chief Engineer.

This officer will be given a Personal Assistant who will be an Assistant Engineer. The Engineer-in-Chief will guide and control the whole plan of operations and progress of works, distribution of labour and selection and ordering of special machinery, plant and stock.

Working-plans of the more important works, and types to be followed for the smaller ones, will be prepared in his office which will have a large staff of draftsmen.

The Engineer-in-Chief will control the construction of Head Works through the Superintendent of Works, and of the works on the Upland Canal system through the Executive Engineers in charge of Construction Divisions who will work directly under his orders.

235. *Superintendent of works for executive charge of Head Works.*—The whole of the works comprising the Head Works including the first two miles of Upland Main Canal will be under a Superintendent of Works who will be an Executive officer with powers of a Superintending Engineer and with Executive Engineers working under him. This officer will have an Assistant Engineer as Personal Assistant. This office will be the accounts office of the whole Head Works, and accounting correspondence will be as far as practicable centralised in this office, and the offices and indoor work of the Executive Engineers and their subordinates will be reduced to the smallest compatible with punctual settlements of accounts and continuous record of rates and expenditure on various operations.

Under the Superintendent of Works, the executive direction of operations will be sub-divided as shown in the diagram which is self-explanatory.

236. Table showing organisation and composition of the Head Works Executive Engineering staff.—

Superintendent of Works with Personal Assistant (one Assistant Engineer).				
MATERIALS AND TRANSPORT.	—	CONSTRUCTION.	WORKSHOPS AND MACHINERY.	STORES AND OBSERVATIONS.
One Executive Engineer.	One Executive Engineer.	One Executive Engineer.	One General Superintendent.	One Executive Engineer.
One Assistant Engineer—Quarries, quartzite and limestone supply.	One Assistant Engineer—Lime and surki and mortar manufacture and supply.	One Assistant Engineer—Lime and surki and mortar manufacture and supply.	One Assistant Engineer—Outdoor machines and plant.	One Upper Subordinate.
One Assistant Engineer—Surki burning, firewood, sand, floating plant.	Three Assistant Engineers—On Dam and Works.	Three Assistant Engineers—On Dam and Works.	One Assistant Engineer—Workshops and transmission lines.	
One Assistant Engineer—Roads and railed roads and land. Transport generally.	Six Upper Subordinates.	Six Upper Subordinates.	Three Foremen.	
Eight Upper Subordinates.				

Upland Canal System.

237. *Organisation of Executive Divisions.*—The Upland Canal Construction staff will be organised in the undermentioned Executive Divisions:—

"A" division—

One Executive Engineer.
Three Assistant Engineers.
Seven Upper Subordinates.
Head-quarters near Chintapalli.
(Spur on left Bugga vagu near Dam Site.)

Limits of charge.—Main Canal and all Distributaries and off-takes up to 19 miles and also Bugga Vagu Dam. The first $1\frac{1}{2}$ miles of Main Canal would however be carried out by the "Head Works staff" (up to M on site plan).

To be started in fifth year of construction and get water through and hand over unfinished work to Sattenapalli division at end of twelfth year.

*Head-quarters—Guntur.**"Sattenapalle" division—*

One Executive Engineer.
Two Assistant Engineers.
One Upper Subordinate Sub-divisional Officer.
Seven Upper Subordinates.

Limits of charge.—Charge from 19 miles (near Krosur) to 57 miles to off-take Tadikonda branch and including all works on the left of Tadikonda Vagu.

To be started in fifth year of construction.

*Head-quarters—Guntur.**"Guntur" division—*

One Executive Engineer.
Two Assistant Engineers.
Two Sub-Divisional Officers—Upper Subordinates.
Eight Upper Subordinates.

Limits of charge.—From limit Sattenapalle division to Nadendla vagu, 85 miles, with all irrigation commanded by Main canal in these limits.

Project construction from tenth year.

"B" division—

Establishment transferred from "A" division at end of twelfth year.

Charge.—From south limit of Guntur division to tail-end of Main-canal and all offtakes and distributaries from this section of canal.

Project construction from 13th to 22nd year.

At end of 22nd year, the Guntur Division will transfer to Sattenapalle Division the Main-canal up to the offtake of Guntur branch with all canals and channels and irrigated area under that branch and will take over all charge of "B" division works.

238. *Explanatory remarks on organisation proposed.*—It is proposed that the existing Guntur Division shall take up the Project Work of the Project Guntur Division, and that the Provincial Works of Irrigation, and Roads and Buildings, in the non-deltaic portions of Guntur district shall, during and after construction, be carried out by the Executive Engineers holding the territorial project charges in which the works lie.

Palnad taluk works will be taken by Sattenapalle Division and Narasaraopet and Vinukonda and Ongole by the Guntur Division; on completion of all works charge of the Upland Canal Irrigation and all ordinary works in the non-deltaic parts of the district will be vested in two divisions.

The Sattenapalle Division taking the Head Works and Main Canal and Branches down to and including Guntur branch. The Guntur division will take the rest of the district. The Head Works will be a Special Sub-Division of Sattenapalle Division

under a "General Superintendent" who will be a skilled Mechanical and Electrical Engineer who will take charge of all works on the Head Works and the Main Canal up to and including Bugga Vagu dam.

239. *Remarks on programme of Works and Organisation.*—In carrying out works especially on the cuttings in the Main canal, no attempt should be made to open to full width at once.

The object to be aimed at should be to get the water through in quantities sufficient for current needs.

Thus although by the end of twenty years the water should be through to the tail-end of each major distributary, the works will be by no means finished, and it may be counted that the works will not be fully completed till 24th year.

This is the reason for keeping on "B" division to the end of the 22nd year, and of the continued capital expenditure in the Sattenapalle and Guntur divisions for years after water is throughout the areas comprising the charges of these divisions.

It may be counted that water can be so pushed through for 80 per cent. of the estimated total cost for "works," and the balance 20 per cent. of works in any length or channel can be done after the canals are opened for supply throughout such length, and the programme of expenditure is drawn out having this in view.

240. *Total Executive staff, Upland Canal system.*—For construction of the Upland Canal System there will be required, when the works are in full swing (from 10th to 20th year),—

Three Executive Engineers.

Seven Assistant Engineers.

Three Upper Subordinates for sub-division charges.

Twenty-two Upper Subordinates for section charges.

241. *Delta extension works controlled by the Superintending Engineer, II Circle, with separate staff.*—These works will, it is proposed, be carried out in the existing delta divisions and under the control of the Superintending Engineer, II Circle.

The staffs must be strengthened for this purpose, but large extra staff will be unnecessary and the matter is not dealt with in this report.

242. *Special staff for Land Acquisition.*—In addition to the Engineering staff, the following staff of the Revenue Department is required for land acquisition for Head Works Upland and Delta canals.

The bulk of the land will be acquired between the fourth to seventh years, but land acquisition must go on till the project is almost complete.

	RS.
One Deputy Collector and office from the year prior to construction beginning to 22nd year of construction, 23 years at Rs. 400 monthly	1,10,400
One Sub-Collector from fourth to seventh year of construction at Rs. 1,000 (four years)	48,000
One staff and office of Sub-Collector, fourth to eighth year, viz., one Deputy Collector, two Tahsildars and subordinates at Rs. 1,400 (four years)	67,200
	2,25,600

The salary of these officers would be covered many times over without excess if debited against the allowances made for "Establishment" at 23 per cent. on estimated cost of works, but in accordance with custom, their salaries, direct and indirect, are included as separate items in the estimate. The same remark applies to other establishment other than the Public Works Department.

243. *Medical, Police and Forest staffs.*—The provision for other special establishments made are—

	RS.	RS.
<i>Medical and Sanitary—</i>		
Medical and Sanitary officer, 18 years, at Rs. 1,000	2,16,000	
Two Assistants at Rs. 200 and Rs. 100, 18 years	64,800	2,80,800
<i>Law and Police—</i>		
One Sub-Magistrate, 18 years, at Rs. 150	32,400	
One Police Inspector, 18 years, at Rs. 120	25,920	
Thirty Constables for 18 years at Rs. 12 each monthly.	77,720	1,36,040
<i>Forests—</i>		
One Assistant Conservator, 4 years on Rs. 500	24,000	24,000
		4,40,840

SECTION VII.

ACKNOWLEDGMENT OF ASSISTANCE AND SERVICES.

244. *Period of investigation.*—The investigation of this project has been in progress for nearly three years and a Special Executive Engineer and staff have been employed on it for $2\frac{1}{2}$ years. The work of design and estimating would have been completed about December, had the preparation of this estimate not clashed with that of the Cauvery Reservoir Project. It was found impossible to collect a suitable staff of draftsmen and estimators to make rapid progress with both estimates and it was therefore decided to give preference to the Cauvery Project.

Thus until that project was completed in November last, the drawing office of the Executive Engineer, Kistna Project, was very insufficiently staffed, and it is only from then that rapid progress could be made with detailed designs and estimating.

245. *Services of the Executive staff.*—The whole of the field-work of investigation since November 1908 has been carried out directly under the Executive Engineer, Kistna Reservoir Project, Mr. C. T. Mullings, who has made all arrangements for the surveys, borings and trial-pits and field-work generally. The calculations of daily discharges of Kistna river at Bezvada, the results of which appear in Volume II were carried out under this officer. Mr. Mullings has prepared all the detailed designs and estimates for work of construction of the Upland Canal system, entailing an immense quantity of drawing, estimating and detail and the detailed report on this system. (Part III of this Volume) is written by this officer. The reports, designs and estimates submitted testify to his services in these respects.

The following Assistant Engineers have worked under the Executive Engineer, being employed exclusively on work in the field :—

Mr. H. L. Nicholson.
Mr. W. J. Davis.

Mr. A. B. Adams.

Mr. Nicholson was originally employed from April 1908 on reconnaissance of the river in search for possible sites for a dam and the selected site, as well as the other sites mentioned in this report, were recognised and reported on by this officer at a very early stage of investigation. Mr. Nicholson was in charge of all the preliminary work in the field, which included the survey of the water-spread area, up to the time before the appointment of an Executive Engineer to the charge of the investigation in November 1908.

He then continued to serve under this officer till invalided in March 1909.

He was succeeded by Mr. Davis who took charge of the survey operations at the Head Works and in the northern part of the area to be irrigated and had also charge of the digging of trial-pits and boring operations, and silt measuring observations at the site for the Dam.

This officer is working in charge of the boring operations still in progress in the river bed at Pulichintala.

Mr. A. B. Adams was employed in charge of the survey of the southern part of the area to be irrigated and was employed for about a year. The work of the Executive Engineer and Assistant Engineers has been strenuous and efficient, while the nature of the work has been such as entails much exposure, and considerable hardship.

The subordinates employed on surveying and other work under these officers have worked loyally and well.

The field-work has mostly been surveying, a duty which, especially in the hot weather, entails very strenuous physical effort.

246. *Services in the Drawing office.*—The writer would acknowledge the efficient services rendered in supervision of the drawing-branch of his own office by Mr. P. A. Venkatarama Aiyar, B.C.E., Sub-Engineer, Public Works Department.

In making stability and hydraulic calculations in connection with the Project, Mr. T. R. Narasimhachari, B.A., B.C.E., Overseer, Public Works Department, has proved himself most efficient. This Overseer has also done good work in charge of the survey of lower portion of the waterspread area in the absence of Mr. Nicholson in June and July 1908.

247. *Officers working on the Delta Extension.*—The designs and estimates for the works for extension of irrigation in the Kistna Delta have been drawn up under the general direction of the Superintending Engineer, II Circle, by Mr. A. V. Ramalinga Aiyar, B.A., B.C.E., Executive Engineer, Public Works Department, for the Western delta and Mr. M. O'Brien, Assistant Engineer for the Eastern delta. The former carried out the work in addition to his normal duties as Executive Engineer in charge of the Kistna Western division. The reports in Part II of this volume are by the above officers.

248. *Officers of other services.*—In addition to services of the above members of the Public Works Department, acknowledgment is made of the cordial co-operation, with the Public Works Department staff, of Mr. J. M. Turing, I.C.S., the Special Revenue Officer, whose report on the revenue aspects of this project is printed in Part V.

The services and assistance of Dr. W. F. Smeeth, M.A., D.Sc., State Geologist, Mysore, in making the geological examination and report on sites (Appendix II), which examination was made in the hottest season of the year, are here cordially acknowledged.

W. M. ELLIS, Lieut.-Col., R.E.,
Superintending Engineer on Special Duty.

12th April 1911.

PART II.

REPORT ON EXTENSIONS OF THE IRRIGATED AREA
IN THE KISTNA DELTA.

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REPORT ON EXTENSIONS OF THE IRRIGATED AREA IN THE KISTNA DELTA.

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PART II.

Report on Extensions of the Irrigated Area in the Kistna Delta.

Preliminary Remarks by the Special Superintending Engineer.—The extensions under Bezvada anicut being closely connected with, and scattered through, the existing irrigated area under that work, it was arranged that the estimates for extensions of irrigation in that area due to the reservoir project should be prepared under the directions of the Superintending Engineer in whose circle these works lie and that only the estimate for alterations required to the anicut and headworks should be prepared by the Special Superintending Engineer.

This course has accordingly been pursued.

The estimates for extensions of irrigation in the Eastern and Western sections of the Kistna delta have been further prepared by two separate officers.

In the Eastern delta the area of extensions are greater and entail alterations to increase the carrying capacities and grading of main and branch canals and for this work an Assistant Engineer was specially posted and this officer (Mr. O'Brien) has written the report which follows describing the extensions proposed in the Eastern delta and estimates drawn up by him under the direction of the Superintending Engineer, II Circle.

In the Western delta the main canal and branches have sufficient carrying capacity without being altered other than in depth and no works are required in them.

The extensions are confined to distributaries. These estimates have been prepared by the Executive Engineer, Kistna Western division (Mr. Ramalinga Aiyar), in addition to his other works and the report on the extensions in the Kistna western delta which follow is by that officer.

Since preparing the estimates, revised orders regarding the limit of area to be irrigated under the existing anicut scheme have been approved and the area raised from 7,00,000 to 7,25,000 acres. This has the effect of transferring from the reservoir project to the existing delta system of 25,000 acres of the ultimate irrigable area, of which some 16,000 acres were for the first time irrigated in 1908-09. This has thrown out from the reservoir scheme 20,000 acres Eastern delta and 5,000 acres Western delta.

The necessary revision of the report and estimates of the Executive Engineer, Kistna Western division, to conform to the above have been made by the writer, while Mr. O'Brien himself has revised his reports on the Eastern delta extension. These remarks will serve to explain how certain differences which will be noticed in the types of some of the works in the Upland, and both delta systems, have found place in the estimates for these works which is being submitted as one project, although prepared under the control of more than one officer.

The estimates for works in both Eastern and Western deltas have been drawn up from the current rates in force. These rates are known to be low and it is only with difficulty that the scattered miscellaneous works and repairs can be now carried out at these rates.

For carrying out the proposed works with reasonable promptitude, the rates would not suffice. The writer has, therefore, in the classified abstracts added 15 per cent. to the total of all sub-heads of the estimates except "Preliminary expenses" and "Land."

These enhanced totals do not appear in the detailed estimates and are not the amounts referred to in the reports of Messrs. O'Brien and Ramalinga Aiyar.

REPORT ON THE ALTERATIONS TO THE HEADWORKS AT BEZWADA BY THE SPECIAL SUPERINTENDING ENGINEER.

2. *Description of Bezwada anicut.*—The Bezwada anicut, as at present standing, is a solid masonry weir consisting of a body wall with a 6 feet wide crest at level + 47.05. The mean width of the body wall is 8 feet and it stands on a foundation of masonry wells sunk to a level + 21.8. In front (upstream) of the body wall about $1\frac{1}{4}$ feet below its level, a stone paved (hand packed) roadway, 20 feet wide, serves to pass traffic across the river during the dry months of April and May.

On the downstream side, the body wall is backed by a talus of roughstone which has been deposited in great quantities forming an apron sloping at about 1 in 12.

The surface of this apron for some 30 feet from the crest wall is built of rubble in mortar or of lime concrete.

Further from the crest the surface is large roughstones packed close together and the interstices grouted with surki lime concrete.

At each end of the solid weir are sloping ramps, rising at about 1 in 23 to join the river margins.

Under these slopes are constructed 15 culverts of 6 feet width on each flank with sills about level + 37.3 and of varying heights forming scouring sluices, the vents of which are closed with double shutters, lifted or lowered by a screw-gear rod carried on a trolley running on rails on the sloping platform.

In floods, the platforms are wholly or partly submerged and the shutters under the submerged portions cannot be worked till the water subsides.

On the Bezwada (left) side the sloping end stops abruptly at a vertical river wall at level + 59.3 from whence a flight of stone steps gives access to the roadway above.

On the Seetanagram (right) side the slope is carried right up to the cart road above and it is over this sloping platform that the cart traffic crossing the river in the dry months passes.

A longitudinal and cross section of the anicut is enclosed with the plans (Portfolio No. 2).

3. *Existing falling shutters, Bezwada Anicut.*—The level crest of the anicut for a length of 3,076 feet is fitted with 307 falling shutters of length 10 feet and height 3 feet.

The shutters stand at a level $\frac{1}{4}$ foot below and behind the solid crest of the anicut and thus effective height of the shutters is $2\frac{3}{4}$ feet. The shutters are overturned automatically by the water pressure when the level above the weir is from $2\frac{3}{4}$ to $3\frac{3}{4}$ feet above the solid crest level.

A travelling crane worked by hand, running on rails bedded in concrete downstream of the shutters, is used to raise them, and they can be raised with 2 to 3 feet of water passing over the anicut crest.

4. *Canal off-takes.*—On each flank of the anicut a main canal takes off for irrigation of the deltaic areas on either side of the river below the anicut.

The Eastern delta is on the left or Bezwada side and the Western delta on the right side of the river.

5. *Height required for anicut shutters.*—The existing anicut shutters are barely of sufficient height to supply the area to be irrigated under the existing irrigation system (725,000 acres) and the extensions of area to be irrigated owing to the construction of the proposed reservoir necessitates installing higher shutters on the anicut.

The proposals for extension involve a height of water in rear of the head sluices—Western delta of + 52.8 and in the Eastern delta of + 51.45. Access of flow to each head sluice is by a leading channel between the margin of the river and stone groyne which run out upstream from the anicut between the scouring sluices and the weir.

Head is lost in traversing this channel and the level of water just in front of the head sluices will be $\frac{1}{2}$ of a foot lower than on the river side of the groynes.

It is desirable to have $\frac{1}{2}$ a foot to spare between the top of shutters and the maximum level at which water must stand to give full supply to the canals.

Further a loss of head in the two regulators at the head of the Kistna Western delta main canal of .3 feet may be counted on.

For these reasons, it is considered desirable to make the new shutters 7 feet high with an effective height of $6\frac{3}{4}$ feet. This gives a water level upstream of the shutters 6 inches below top of shutter of + 53.3, while the full supply level of Western delta main canal is + 52.8.

6. *Type of new shutters proposed.*—The type of shutters proposed for Bezwada anicut is the Zifta weir type.

These shutters are Messrs. Ransomes and Rapier's patent and a set has been installed on the Zifta weir on the Nile, and the reports on their working received from the Egyptian Government Engineers show they have worked well and given no trouble. The shutters installed at Zifta weir were 108 in number, each shutter being 9' 10 $\frac{1}{2}$ " wide and 5' 8 $\frac{1}{2}$ " high. They were arranged in groups of 9, each group being worked by a master shutter.

For the Kistna the shutters are proposed to be 10 feet long by 7 feet high and arranged in 37 groups of 10 shutters. Instead of the master shutter being in the centre of the group as at Zifta, it will be on one flank and in addition to the hydraulic working, the master shutter will be fitted with an arrangement for working by hand. Messrs. Ransomes and Rapier have stated that these proposals made by the Chief Engineer for Irrigation (Mr. C. A. Smith) can be introduced into their designs without difficulty.

7. *Shutter lifting machine.*—A special lifting machine capable of raising these shutters with 6 feet of water passing over the weir.

The machine runs under its own steam power on rails fixed for it along the length of the anicut and travels with a speed of 100 feet per minute, picking up each shutter as it passes.

A drawing of the machine which is supplied by Messrs. Ransomes and Rapier and is patented by that firm will be found in Portfolio No. 2.

The machine runs on two rails fixed, one rail upstream and one downstream of the shutter bed.

On these legs at a height well above the top of the shutters when raised, a platform carrying the propelling machinery and staff is installed.

A spiral path is fixed to the traveller, the lower end travelling just above the masonry of the anicut and just clear of the edge of the shutters lying prone on the masonry. To the centre of the top edge of each shutter is attached a smaller roller projecting beyond the edge and having a clearance of 2 or 3 inches over the floor where the shutter is lying flat.

As the travelling machine straddling the shutters travels along the line, the lower end of the spiral path runs under this projecting roller and the forward motion of the machine raises the shutter, the roller travelling up the spiral path and only leaving it when the shutter is standing erect.

The spiral is shaped and fixed to suit the position of the shutter edge when being raised for every height of the edge.

The action is similar to that of a plough turning up the earth from a furrow. As it is propelled along, a shield on the upstream legs of the traveller helps to divert the water from the shutter being raised and throw the stream of water forward and clear of this shutter.

8. *Method of dropping the shutters.*—The operating agency for dropping each master shutter is a small hydraulic ram from which a small pipe built into the concrete of the weir runs to the operating shed on shore.

The ram is actuated by a force pump installed in this shed.

For the Kistna there will thus be 37 pipes, one to each master shutter.

The falling of the master shutter actuates the next shutter to it and each shutter as it falls, starts the falling of the next. The arrangements make it possible to collapse any group of shutters from the shore, even if access to them is impossible, but it is proposed generally to let shutters fall before they are topped.

The shutters are supported by struts hinged at fixed points on the shutter and on a shafting fixed in the masonry and also hinged in the centre of the strut.

The action of the hydraulic ram is to force the lower limb of the strut (which is fixed to shafting actuated by the ram) out of line with the upper limb. The water pressure on the shutter then at once causes the shutter to collapse.

9. *Alternative type of shutter.*—An alternative type of shutter suitable for Kistna anicut is the "Ashford patent weir shutter". The objection to this shutter is that its length is very small (about 3 feet) as it is supported by a single strut only and this entails much loss by leakage. If a satisfactory installation of shutters of 10 feet length can be designed which does not appear impossible, it is considered that these shutters would be on the whole more suitable than the Zifta type, while there is no doubt that suitable modifications in the lifting machine could adapt it to this type of shutters.

This matter requires further study before a final decision is come to.

The Zifta shutters would be more expensive than the "Ashford" and thus the estimate will be adequate whichever kind is erected.

10. *Leading groynes to be raised.*—The stone groynes separating the leading channels to the head and scouring sluices from the main river, will require to be raised 3 feet when the high shutters are put in and provision is made for this in the estimate for installing the shutters.

REPORT TO ACCOMPANY THE ESTIMATE FOR KISTNA EASTERN DELTA EXTENSION UNDER KISTNA RESERVOIR PROJECT (BY MR. M. O'BRIEN, ASSISTANT ENGINEER).

11. *Irrigable areas in Kistna Eastern Delta.*—The Kistna Eastern Delta contains 1,160 square miles (742,400 acres) of which about 416,000 acres are now irrigated. The irrigation is carried out by a system of canals with numerous distributaries branching from them. The water-supply takes off from the Kistna river at Bezwada from above the anicut. The principal canals are the Main, Ellore, Ryves', Masulipatam or Bandar, Polraz, Bantumalli and Pulleru.

12. *The Main Canal.*—The Main canal takes off from the eastern flank of the anicut at Bezwada by a headsluice of six vents each 20' wide and 10' in height. It is only a little over 5 furlongs in length and for the whole of this length it skirts on its left side Bezwada town, whilst on its right side it is separated from the river by a very narrow strip of bank. This bank is faced with a river wall. The canal is re-vetted on the right side and for nearly the whole length on its left, there is a wharf through which boats can load and discharge. It is connected to the river by a lock very confined and it would be exceedingly difficult to widen it if such widening were desired. At its end it trifurcates into the Ellore, Ryves' and Bandar canals, each having an open head.

13. *Ellore Canal.*—The first canal to take off is Ellore which after leaving the Main canal, turns to the east and with a fall of only from 1 to 2 inches per mile, runs in an unbroken reach of 40 miles to Ellore town, where it is connected to the Gódávari canals by a lock. It thus forms a portion of the through canal route from Madras to Cocanada. The canal lies above the delta proper and irrigates only on its right side. It runs right across the watershed of the upland country and the drainage of 1,174 square miles has to be passed across it. Of this extent, 540 square miles are drained by the Budameru. The latter river is passed across the canal by means of various works between 7th mile and 13th mile, of which the more

important are the Budameru and Kesarapalli aqueducts. Between 12 miles 6 furlongs and 37 miles 4 furlongs only small drains are passed. At 37 miles 4 furlongs the Tammileru draining about 367 square miles is met. Before it reaches the canal, this drain divides into two branches known as the West and East Tammileru. The west branch crosses the canal at 37 miles 4 furlongs by means of a level crossing with vents down to the canal bed level, fitted with shutters which are lifted at flood times to let the water pass across the canal, the flood water being prevented from running up and down the canal by means of stop gates. The other branch is passed across the canal in a similar manner just above Ellore lock at the 40th mile.

14. *Ryves' Canal.*—This takes off between the heads of Ellore and Bandar canals. Till 1891 there was a regulator at its head, but in that year it was removed and a new regulator built one mile farther down. This regulator was destroyed by floods in 1903, but it was immediately re-built and a lock constructed beside it rendering the canal navigable down to Komatigunta weir at 12 miles. In recent years a new lock was built at this latter weir and the canal is now navigable from its head to a few miles below the weir. The volume of navigation is however small. It is the largest of the three canals, as it has to carry in addition to its own supply, most of the supply for the Pulleru. It meets the Pulleru at its 23rd mile and though Ryves' is much the bigger canal of the two, the united stream from this is called the Pulleru canal. The reason of this is that Ryves' canal was dug much later than the other in order to send additional water down the Pulleru for the large area under it and the Polraz and Bantumalli canals, the supply which the Pulleru was receiving from Bandar canal being insufficient.

15. *The Bandar or Masulipatam Canal.*—The Bandar or Masulipatam canal is the last of the three canals branching off from the Main canal. It runs south-east for 50 miles to where it joins the sea at Masulipatam. It is divided into five reaches by first class locks and lock-weirs at 12 miles 5 furlongs, 24 miles 4 furlongs, 37 miles, 43 miles, and 49 miles 2 furlongs. It irrigates mostly on its right side and the land under it is probably the best in the delta. At 12 miles 5 furlongs, just above Kankipad lock are two headsluices supplying the Pulleru canal.

16. *The Pulleru.*—The Pulleru was originally a large natural drainage course used for irrigation before the anicut was constructed. It takes off from Bandar canal at 12 miles 5 furlongs. It is very winding and has a considerable bed fall. It seems to have been originally incorporated into the canal system without special changes being effected to it. It ends at 36 miles 5 furlongs, where it bifurcates into the Polraz and Bantumalli canals. It receives the Ryves' canal at 23 miles of the latter and draws most of its supply from that canal.

17. *The Polraz Canal.*—The Polraz canal from the end of the Pulleru runs north-east for 26 miles where it joins the Upputeru a short distance below its exit from the Colair lake. It is navigable throughout and has three locks, the last leading to the Upputeru along which boats can pass to the Gódávari canals. It irrigates on both sides and much of the land supplied by it is very low and swampy.

18. *The Bantumalli Canal.*—The Bantumalli canal is very similar to the Polraz. It is 26 miles long and ends in Upputeru which it joins by a tidal lock. The lower part runs through salt plains and swamps on which good rice crops are grown.

19. *Area available for irrigation in the Eastern Delta.*—According to the Special Revenue Officer's report, the total irrigable area in the Eastern Delta is 493,266 acres. Of this extent, 420,000 have been allocated to the existing system, leaving 73,266 acres for extension of cultivation which will be due to the construction of the proposed Kistna reservoir. On the statement, paragraph 15, is shown the distribution of this acreage among the canals. To supply this extra extent the capacity of the canals has to be increased. In the succeeding paragraphs of this report the method proposed for effecting this is explained at length for each canal. It will be seen therein that no change is required for the Main canal beyond increasing the depth. The Ellore and Bandar canals require slight widening. Ryves' canal requires merely slight silt clearing and protection to its banks. Pulleru, Polraz and Bantumalli canals require no alteration.

20. *Discharge capacity of canals.*—In working out the discharges required, the minimum duty has been taken as 70 acres per cusec in accordance with the orders of the Chief Engineer for Irrigation in his letter No. 31, dated 12th January 1910.

MAIN CANAL.

21. *Works required for Main Canal.*—The ayacut to be supplied is 493,260 acres requiring at 70 duty 7,047 cusecs. The length of the Main canal is 5 furlongs to the head of Ellore canal and $5\frac{1}{2}$ to head of Bandar canal. There is no fall allowed in its bed, the level throughout as originally designed being the same as the headsluice sill, namely + 49.55. It is now somewhat silted up at its end, and at the head of the Bandar canal, it was about $1\frac{1}{2}$ higher than this, when levels were last taken. It is cleared every year at this place to a depth of 1 foot above level of headsluice sill. It is revetted throughout on the right side to 1 : 1 slope and on the left side there is a vertical or nearly vertical wharf wall. The widths vary from 184 feet at the head to over 200 feet at the end. A site plan (Portfolio No. 2) accompanies with sections showing these widths. According to the gaugings taken in 1908, a gauge reading of 10.9 or surface level of + 51.45 will give the above discharge. The velocity developed under these conditions is $.9 V_0$ (V_0 being Kennedy's critical velocity for Punjab sand). It was found that it was impossible to get a higher velocity than this, without losing command of the land in I Reach of Bandar canal and without having to raise the bed at head to an impracticable height. It is therefore proposed to leave the bed as originally designed, namely level with the headsluice sill, and neglecting any silt deposit, the end of the Main canal will have a depth of 10.55 or a level of + 51.10. Enclosed with the estimate are calculations for discharge through the headsluices. It will be seen from this that, with a head of 0.6 foot, the existing vents of headsluice can discharge a little more than the required discharge. The co-efficient used is 0.882 which was arrived at during the gaugings in 1908. To provide this head of 0.6 foot, the top of the shutters must be 5 feet above the crest of the anicut or say $5\frac{1}{2}$ feet to allow a little margin.

BANDAR CANAL.

22. *Bandar (or Masulipatam) Canal, 1st reach.*—This canal, to which either of the above titles is indifferently applied may be said to be a continuation of the Main canal. Its head is at $5\frac{1}{2}$ furlongs from the headsluice of the Main canal and its mileage begins at the Main canal headsluice. It has an open head. The bed level at the head is supposed to be that of the headsluice sill, but it is silted up somewhat, the silting varying from 1 foot to about $1\frac{1}{2}$ feet in depth throughout the season. It is revetted on the right side to the 2nd mile and on the left side to about 1 mile 6 furlongs. The first reach ends at 12 miles 5 furlongs at Kankipad lock, where there is a weir discharging into the second reach and two headsluices above the weir discharging into the Pulleru canal. At 4/4 the East Bank takes off.

This first reach of Bandar canal is in very good order and may be said to be in permanent regime, neither silting nor scouring.

23. *Conditions of discharge, Bandar Canal, 1st reach.*—The ayacut at head which includes the East Bank canal area is 133,883 acres requiring at 70 duty 1,913 cusecs. In addition to this, as is explained in the report on Ryves' canal, it has to carry 1,200 cusecs for Pulleru making the total 3,113 cusecs. Below 4/4 allowing the same duty, it will have to carry 2,373 cusecs.

Now the surface level at the head is to be + 51.10. The bed at head will be at the headsluice sill level or + 49.55 and thus a depth of 10.55 is obtained. The present F.S.L. at Kankipad at 12 miles 5 furlongs is + 44.44 or a gauge reading of 6.5. This is just sufficient to command the first reach ayacut of 23,188 acres which is mostly supplied by channels taking off fairly close to the Kankipad lock. Starting from this F.S.L. and working upwards, it was found that with the depth of 10.55 at the head and with the falls available, a velocity equal to $.9 V_0$ will be obtained to the end. The surface fall will be 0.58 foot per mile down to 4/4 and 0.55 foot per mile below this.

The original design of the existing canal allows a bed fall down to 4/4 of 0.34 foot per mile. If this fall be retained, the depth at 4/4 becomes too great and the velocity

with the surface fall available becomes less than $.9 V_0$. To get $.9 V_0$ at 4/4, the depth required is only 8.6 and consequently the bed fall has to be reduced. A bed fall of 0.08 per mile is therefore allowed in this portion, but it may be noticed that the bed level attained thereby will closely coincide with the existing silted bed below 4/4. The surface level will be sufficient for the levels proposed in the East Bank canal. The bed fall down to 12/5 will be 0.27 foot per mile, which is more than allowed in the existing canal as designed.

24. *Proposed works, 1st reach, Bandar Canal.*—The proposed cross sections have been calculated using these bed and surface falls and Kutter's formula, taking N as 0.02. The bed widths vary from 78 feet at head, 110 feet and 80 feet at 4/4, to 137 feet at 12/5. The change from 110 feet to 86 feet will of course have to be made gradually. At the head, the present width is about 5 feet too much, but it is not proposed to make any change. From 3/0 to 4/4 some widening has to be done. From 4/4 to 5/0 it is slightly too wide. The widening will be done as far as possible on the left side to avoid interfering with the tow-path and the trees close to it. Just above Kankipad, it will have to be done on the right side, as there is a metalled road on the left bank. There is plenty of land available for these widths and the only expenditure will be on earthwork. The location of the spoil earth has not been shown on the sections, as it can be thrown beyond the present banks and there is enough of room for it. There are no paved ramps to be interfered with. No alterations will be required to any of the headsluices of the irrigation channels, as the surface levels have not been altered and they are far back enough from the proposed widened edge of the canal. The Pulleru sluices require no alterations, as they will not have to take any bigger discharge than they are now taking. The lock weir can also be left as it is. Calculations of the discharge likely to be obtained through it are enclosed. The co-efficient used, namely, 0.625, is less than the co-efficient of 0.659 got by gauging, but it has been used as there was some doubt about the latter. It would be an advantage to have a higher F.S.L. at 12/5, as that proposed, namely, + 44.44 gives very little to spare and if it were higher, more land could be commanded, but as the desired critical velocity could not be attained otherwise than as proposed, the F.S.L. has to be left as it is.

25. *Bandar Canal, 2nd reach, from 12/5 to 24/4.*—This reach is 11 miles 7 furlongs long and ends at Veeranki lock. The ayacut at the head, that is, the total of II, III, IV, & V Reaches is 59,259 acres, requiring at 70 duty 846 cusecs. The irrigated area in 1907-1908 was 47,165 acres. The irrigation begins at 22/0 where the Medur channel with an ayacut of 15,491 acres, takes off. The next big off-take is the Bheemanadi channel which is just above Veeranki lock, the only other off-take in the reach being a small pipe sluice near 16th mile. There is a surplus weir or escape at 22/0 and this is an important work, as it is the only escape on the Bandar canal, except for a small outlet near the end at mile 49.

26. *Conditions of discharge, Bandar Canal, 2nd reach.*—If a line from Kankipad lock lower sill to Veeranki lock upper sill is taken as the originally designed bed, it can be seen from the sections that the present bed is about 1.5 feet higher than this. This silted bed however remains at pretty much the same level year after year and no silt is ever removed. The depth of water at F. S. Ls. now maintained is about 6 feet above the silted bed and in 1908 it was found that the velocity as gauged with this depth was about $.75 V_0$. The present bed widths vary from about 35 feet to 40 feet. The bed and surface falls are about 0.33 foot per mile.

27. *Works required, Bandar Canal, 2nd reach.*—Now if the bed is left as it is and a depth of 6 feet with bed and surface falls of 0.33 foot per mile be allowed, a bed width of 72 feet will be necessary for the required discharge. The velocity would be 1.84 feet per second or $.7 V_0$. There is enough of land available to provide for this width except at one or two places. Navigation would not be interfered with, as the canal would be practically as it is now. There are no bridges and only three paved ramps in the reach. As however the velocity of $.7 V_0$ is not thought sufficient, the present estimate provides for re-modelling the canal to run at a velocity of $.9 V_0$. In working this out, the level required at 22/0 has been first taken into consideration. The F.S.L. required in Medur channel there, is + 32.00. The level in this channel

may have to be raised somewhat to give enough discharge for its ultimate ayacut. Even if it is raised + 33.20 in the canal ought to be enough. A depth of 5.45 has been allowed there and a surface fall of 0.58 foot per mile back to 12/5 and a bed fall of 0.52 foot per mile. This gives at 12/5 a depth of 6 feet and the bed widths vary from 54 feet at 12/5 to 64 feet at 22/0. The bed at 12/5 will be 2.16 feet higher than the lower sill of the Kankipad lock, but as it is now 1.50 feet higher, this involves a further raising of only about 0.66 foot. At 22/0 the bed will be about 1 foot below the existing bed. From 22/0 to 24/4 the same bed fall is allowed and a surface fall of 0.63 foot per mile. This gives at Veeranki a depth of 5.15 feet at F.S.L. and the bed will be at the same level as the upper sill of the lock. This F.S.L. is sufficient for Bheemanadi channel, but the lock weir will have to be enlarged either by the addition of another tambogi vent or by cutting down the crest of the now useless weir. Calculations of the extra vent required are enclosed with the estimate. The extra width of the canal can be easily arranged for. The three crossings will have to be lengthened on one side at least. Bheemanadi head-sluiice will have to be enlarged to allow of passing water for the proposed extension of area. The cost of this is covered by the allowance made for distributaries.

28. *Navigation, Bandar Canal, 2nd reach.*—There may be some trouble with navigation under these proposals. If, with the maximum depth now possible at Veeranki, still water be held up in the reach, the surface level will, at 12 miles be raised by 2.16 feet higher than the sill, there will thus be only 3.35 feet depth of water there. However, Veeranki lock gates may be made 1 foot higher and this would give 4.35 feet at 12/5 or say 5 feet allowing for some flow of water. This would be enough for boats except for the fact that the leading channel below the lock will silt badly as it now does. It may, however, be dredged out towards the close of the flood season and as the water will be clear then, there ought to be no further silting.

29. *Bandar Canal, 3rd reach, 24/4 to 37 miles.*—Below 24/4 there is no additional area proposed to be supplied by the Reservoir Project and therefore no proposals are made for improving this portion of the canal.

EAST BANK CANAL.

30. *General.*—The excavation of this canal for irrigating 60,000 acres was originally sanctioned in February 1888. In November 1888, the estimate was revised to irrigate 44,000 acres of which 33,000 acres were to be on Divi Island. For some reason, probably on account of the expense of an aqueduct to Divi, the proposal was never carried out. Nothing was done till February 1902, when it was ordered that the canal be made only to the 13th mile and channels be dug for irrigating 11,000 acres. Even this order was but partly carried out. The canal was made to mile 11, and the present irrigation is only about 2,500 acres. This is mostly under direct spouts.

31. *Existing East Bank Canal.*—The canal takes off at 4/4 Bandar canal, i.e., 3 miles 7 furlongs from its head. There is a II class lock at its head and a weir. Both works are in good order except that the weir shutters have mostly rotted to pieces. The weir is not now used and is banded off, all water for irrigation being sent down through the lock culverts. The canal is navigable and is used to a certain extent by boats. It runs immediately along the inner toe of the river flood bank following the line of borrow pits dug to form the bank. It is in deep cutting at its head, but very quickly is at ground level. It is in bad order. There is a small surplus escape in the bund at mile 11, through which there is much waste in the irrigation season.

32. *Ayacut.*—The present proposals leave Divi Island altogether out of account hitherto thought. Below the road leading from Masulipatam to Divi, there is a very big tract of rich low-lying land. This land is to a certain extent subject to floods from the river and from the big drains draining the land between the Bandar canal and the river. Submergence is limited to a few days at a time and is not likely to damage cultivation except in its very early stages. On the maps is shown the commanded area and a list is enclosed with the estimates showing the total area of

irrigable and unirrigable land in each village. Practically every bit of land is commanded, but the Revenue officer has made reservation for various purposes. In the low tract above mentioned, he has made some special reservations for grazing and for other purposes. He has given at length in his report all reservations. The land is nearly all zamindari.

The total commandable area is 72,409 acres, out of which about 20,909 acres have been excluded, thereby reducing the total to about 51,500 acres or 49,000 acres over and above the area irrigated in 1907-1908. The block may be divided into two portions, (1) triangular block between the river, the Kanikalamadugu drain and the Bandar-Divi road, (2) the block below the road, extending as far as high tide level towards the sea and to within a few miles of Masulipatam. They are shown in the key map (portfolio No. 2). The land in No. 1 block is very fertile and the ryots are very anxious to convert it into wet. Most of No. 2 is also very fertile, but is thinly populated and in its lower portion sandy. It should all come under cultivation as quickly as water can be supplied.

33. *Description of proposed East Bank canal.*—This estimate provides for digging a canal for irrigating 51,435 acres. It will be 35 miles long stopping just short of the road from Bandar to Divi. It will be navigable throughout and as the tract is very badly supplied with roads, it ought to be most useful in this respect. If a wharf is built at its end, it is likely that a good deal of the produce of Divi will be also carried on it. The canal will be divided into three reaches from 0/0 to 12/0, from 12/0 to 23/4 and from 23/4 to 35. There will be locks and regulators at 12/0 and 23/4. Below 35/0, there are about 14,500 acres to be supplied and these will be commanded by a channel which will follow the flood bank down to near Vadapalem and which will be, as it were, a continuation of the navigable canal. It will have to be taken around Mopidevi village at the beginning, as this village abuts on the flood bank and there is no room between. It will be about 14 miles long.

34. *Land.*—Enough Public Works Department land is available down to mile 19. From there to mile 31, extra small strips will have to be acquired and from mile 31 to the end, the total extent required has to be acquired. Land has also to be acquired at the flood bank diversions at miles 21/6, 25/6, 30/0 and 31/0 to enable the canal to be taken round them in proper curves. The total extent is only about 35.5 acres for which a high rate of Rs. 450 per acre has been allowed. This is the rate given by the Revenue authorities in Divi Tahsildar's letter No. 216, dated 13th February 1910, and, considering the valuable nature of the land, does not seem too high.

35. *Earthwork.*—The canal will follow the line of flood bank borrow pits and it will be noticed from the sections that these are in many cases already too deep and too wide. In most cases where they are too wide, the banks have been thrown back, and it is expected that silt berms will gradually form and reduce the canal to the proper width. It is expected that the bed will also silt up to proper level. The presence of these pits reduced the excavation considerably, and in many cases there is not enough to form banks. Where this is the case, the necessary earth will be taken from the bed and from outside borrow pits for which temporary occupation rates will be paid. In some places, on the other hand, there will be too much earth especially at the head and portion of it can be thrown on the river side of the flood bank or used to widen it. If the proposal to widen the flood bank to carry a road, which has been approved, is carried out, all the surplus earth can be disposed of in this way.

The left bank will be of a minimum width top of 6 feet throughout. Below mile 12½, the line of canal is now covered with tamma trees and bushes. No provision has been made for removing this growth, as the sale of it ought to more than cover the cost of removing it. The soil is black throughout with a larger proportion of sand than usual in the lower portion.

36. *Hydraulic particulars.*—From the hydraulic statement and sections, it can be seen that it is proposed to run the first two reaches at 9 V. and the third at 84 V. or very nearly the same velocity. The level at the head will be 85 foot less than that

in Bandar canal. With this head, no change is required in the weir beyond removing the semi-circular panels over the vents. A plan of the weir is enclosed showing what alterations are to be made. Its sill will have to be raised by 1 foot to bring it to a level with the bed of Bandar canal. If this reach were run at a less surface fall, the command over the land would be much better than it will be under this proposal. However the area under reach I is only 2,700 acres and as the fall away from the canal is rapid, only a narrow strip along the side of the canal is likely to be affected. In the other reaches the command is sufficient.

37. *Masonry works.*—There will be but few masonry works along the canal. There will be the locks and regulators at 12/0 and 23/4, head sluices at heads of distributary channels, a surplus escape at 17/1, girder bridges at 12 21/2, 19/2, 24/0 and 29/4, where there are now important river-crossings and metalled ramps at the other crossings which are generally at each village. There will be also ferry ballacuts at these latter places. There are no drainage works and none are required. The escape at 17/1 is just close to the head of Kanikalamadugu drain and there is now a leading drain from the canal to the main drain which will require only slight improvements. The escape is designed so as to take practically the whole discharge. There is no other suitable place for an escape and it is considered that this one will be enough. A detailed plan and estimate is submitted for it. It follows the design of the surplus weir at 22/0 of Bandar canal.

No plans are submitted for the locks and regulators. The regulators will be exactly like the regulator at 10 of Ryves' canal except for having fewer vents. The quantities were taken from the estimate for the latter and the rates are the current rates in the Kistna Eastern division. Similarly the quantities for the locks have been taken from the estimate for exactly similar locks in Ryves' canal. The girder bridges agree very closely as regards size and other requirements with that recently designed for the bridge at 18/6 of Bandar canal and hence the quantities for them also have been taken from that estimate.

The bridge at 29/4 will replace the existing masonry bridge at Nadakuduru which is badly cracked and does not give enough head room for navigation. Provision is also made in the estimate for 29 second class ballacuts (ferry boats) for taking villagers across the canal. The ramps will be ordinary metalled ones. The bed of the canal will not be metalled, nor will any ramps be made on the flood bank, unless they are done by the River Conservancy. These ramps will not be much required except in the dry season for carts and cattle crossing the river. No detailed estimates have been made for the channel head sluices, as their cost is included in the acreage rate for irrigation.

ELLORE CANAL.

38. *General.*—This canal takes off at the 5th furlong of the main canal and its mileage begins at Bezwada head sluice. Its ultimate ayacut is 76,049 acres, requiring at 70 duty 1,086 cusecs discharge. It has an open head and there are no regulators throughout its length of 40 miles. There is a road bridge just at its head. It is navigable throughout and is a portion of the through route from Madras to Cocanada.

39. *Existing Ellore Canal.*—The canal has a very slight bed fall. Taking its bed at head as on the same level as the head sluice sill, as it is supposed to be, the bed falls work out as follows:—(1) From head to Budameru aqueduct at 7 miles 3 furlongs, 0.22 foot per mile, (2) from Budameru to Kesarapalli aqueduct at 10 miles 7 furlongs, it is level, (3) from Kesarapalli aqueduct to West Tammileru escape at 37 miles 4 furlongs, about 0.07 foot per mile. However, its bed at head was, at the time levels were taken, about 2 1/2 feet higher than the originally designed bed. At mile 2/0 it was only .9 foot higher and at mile 4/0, it corresponded with the originally designed level. Every year silt has to be removed from the first two miles. The canal has to pass a lot of cross drainages as it cuts right across the drainage of the country. There are numerous under-tunnels and escapes and long flush inlets and outlets. The biggest works are the Budameru and Kesarapalli aqueducts, Vatlor and Pedapad under-tunnels, the West Tammileru escape and the East Tammileru escape,

near Ellore lock. All these works are so designed that they will surplus if the present F.S.L. is exceeded. For this reason, it is not possible to raise F.S.L. higher than what is now maintained. Owing to the fact of the canal having an open head, it often happens that when a high register is maintained in the main canal, surplusing has to be done. There is a surplus sluice at 4/4 into Ryves' canal and most of the surplusing is done there. Occasionally the canal has to be surplused into the Budameru drain also. The present F.S.Ls. give an average surface fall between 10.7 and 37/4 of only 0.17 foot per mile. It varies however from sluice to sluice, the greatest fall between any two being 0.325 foot per mile. The small falls available leave no choice in the matter of velocity.

40. *Description of proposed alterations, Ellore Canal.*—Now the discharge required at the head is 1,086 cusecs. The F.S.L. in the main canal at 0/5 is 51.10. With the present bed widths and surface fall available, this level would give too much discharge down the canal and it would be difficult to get rid of it. A regulator seems therefore required as close to the head as possible. This will necessitate building a lock also. As things are at present, there is no convenient site for a regulator until 2/1 or 1 1/2 miles from the head is reached. It is proposed, however, to raise the bridge at the head, to improve the railway level crossing. If this is done, there is no reason why the bridge should not be combined with a regulator and a lock built alongside it, the bridge being continued over the lock. As this new bridge has to be built by the Madras and Southern Mahratta Railway, under the orders of the Superintending Engineer, II Circle, no provision is made in this estimate for the lock and regulator.

Note by Special Superintending Engineer.

Lamp sun provision for regulator and lock has been added to the estimates.

However, an estimate, which was prepared for both at 2/1 before these orders were received, is available and it may be useful to provide for the probable cost.

It has been assumed then that there will be a regulator at the head. This being so, the bed level at the head has been taken to be the same as the main canal bed. It is found that with this and with the present bed-width and a surface fall of 0.24 foot per mile down to 10/7, the depth of water required is only 9.15 which gives a head of 1.4 feet for the regulator which is more than is necessary. The widths have been worked out by Kutter's formula taking N as 0.0225. It will be seen from the cross sections that, down to mile 4, no earthwork is required save clearing down to proposed bed level and from there down to 10/7, there will be slight widening. The velocity runs from 1.76 to 1.59 or an average of .53 V. The first few miles may silt badly every year as they do now, but this cannot be helped. From 10/7 to 37/4, the maximum surface fall available has been allowed and the F.S.L. is that kept at present. The depth decreases from 8.25 to 5.5 and the velocity from 1.51 feet to 1.04 feet. Widening has to be done all through, but the bed remains mostly as it is. The disposition of the spoil has not been shown on the cross-sections, and it will be thrown on the right or left bank as circumstances dictate.

The F.S.L. is slightly higher than the crest level of some of the inlets and outlets, but this can be easily arranged for by small bunds on the crests. All the masonry aqueducts and under-tunnels are wide enough and require no alteration. There are only two bridges below 10/7, namely, Telaprole girder bridge at 21/2 and Perikeed masonry bridge at 27/1. The latter has a span of 50' and is quite big enough and the former, being of 35' span, can discharge the required quantity of water with an afflux of .1 foot. The velocity through the bridge will be 2.66' per second as against the normal velocity of 1.33 in the canal in this portion. The bridge is only 35' wide, while the bed above is 66' wide. It is next to impossible to widen it or provide a side vent without tunnelling through the masonry of the abutments.

From 31/4 to Ellore lock at 40/3, nothing is required save silt clearance, which is an annual maintenance charge. The bed-widths are sufficient and so are the spans of the bridges in Ellore town. As the upper sill of the Ellore lock is about 5' lower than the bed at 37/4, any velocity can be obtained by giving enough of

surface fall, but a high register must be kept at the lock to command the lands near it. Even so, a surface fall of .5' per mile or even more is easily attained and with the increased discharge, it ought to be possible to prevent this portion from silting very much.

RYVES' CANAL.

41. *General.*—This canal branches off from the main canal at 5 $\frac{1}{2}$ furlongs from its head. Unlike the other canals, its mileage begins from its head only and not from the main canal head. At mile 1/0 it is controlled by a regulator of 16 vents, each 6' wide and 7' high, its sill being 19.85. At 13/5 there is a vented weir, called Komatigunta weir, with five vents, each 7' 6" wide and 6' high. The canal is navigable and there are second-class locks at 1/0 and 13/5. It ends at 23/0 where it joins the Pulleru canal. From this although the united streams are called the Pulleru canal, the mileage is carried on from Ryves' canal head.

42. *Irrigation.*—Except for 1,200 cusecs which it is proposed *vide* paragraph 23—to supply *via* the Pulleru which branches off from Bandar canal at 12/5 of the latter, the total ayacut of Ryves' Pulleru, Polraz and Bantumalli canals, namely 283,335 acres, is to be supplied from Ryves'. One thousand two hundred cusecs have been fixed for Pulleru, because that is what it now carries at full supply and if it were to carry any more, Bandar canal will have to be inconveniently enlarged. A 70 duty, this ayacut of 283,335 acres requires 4,048 cusecs. Deducting the above mentioned 1,200 cusecs, there is left 2,848 cusecs to be carried *via* Ryves'. Of the total ultimate area of 283,335 acres, 263,857 is credited to the existing Delta system leaving 14,477 acres to be supplied from the Kistna reservoir.

There is very little irrigation till close to 13/4, where several big channels off-take with an ultimate ayacut of 59,000 odd acres. At 12/2 the new Vempad channel will take off. The F.S.L. now maintained at 13/5 commands the ayacut of these channels and it is not proposed to change it. Between 13/5 and 23/0 there are off-takes for only 2,398 acres. At 23/0 there is Gudivada channel with its ayacut of over 35,900 acres.

43. *Hydraulic details.*—This estimate deals with the canal only to 13/5. After that, down to its bifurcation at Cowtaram at 36/5, no alterations are required. As will be seen from the hydraulic statement accompanying the estimate, it is proposed to run the canal at .9 V₀ throughout. As originally designed, the bed fall from its head at 1/0 was .7 foot per mile. If this bed fall be allowed, the canal would have to be narrowed from its present width of about 100 feet to 64 feet. It is proposed to adhere to the present width and to reduce the fall to .55 foot per mile. It may be noted that the proposed bed will agree more or less with the present silted bed. The surface fall will be the same as the bed fall. This obviates the necessity of any expenditure in this portion.

The bed above the regulator at 1/0 will be 2 feet higher than the regulator sill. Calculations of the discharge of the regulator are enclosed in a separate sheet. The co-efficient of .8 used was that arrived at by gaugings taken in 1908. The discharge proposed to be sent down, namely, 2,848 cusecs, is not much in excess of the maximum that has been carried in recent years. As the canal now receives surplus from Ellore canal through a sluice at 4/2 of the latter, and as no gaugings have been taken below this point, it is not possible to say what this maximum really is. The maximum above mile 1/0 in 1908 was 2,434 cusecs.

44. *Alterations and discharges, Ryves' canal.*—From the sections, it will be seen that the width from 1/0 to 13/5 is more than the calculated required width. This is due to the fact that the canal now scours its sides and silts up its bed. The material in the banks is poor and easily eroded. This estimate provides for reducing the bed to proper widths by the formation of silt berms. This formation is to be brought about by means of groynes of brushwood and bamboo stakes at right angles to the current, the top of the groynes being on a level with the F.S.L. The groynes are to be 6 feet width and 165 feet apart. If these groynes are not approved, the depth of water may be reduced by raising the bed and adhering to the present widths and F.S.Ls. at 1/0 and 13/5. The surface level proposed at the latter place must be especially retained to command

the land there. Any spoil earth from the bed which is only a small quantity will be thrown on the outer side of the banks which are sufficiently high above the F.S.L. and therefore its location is not specially noted on the sections.

The F.S.L. allowed above Komatigunta weir at 13/5 is sufficient to command the ayacut there and is practically what is now maintained. The sill of the weir is 34.29 which is about 2 feet higher than the existing bed in front of it. It was possibly made like that to reduce the bed fall, but if so, it has not produced that effect. The bed level now proposed above it, will be 3,220 which is still 2.09 feet below the weir sill. The co-efficient used for the discharge of the weir, namely, .65 was that arrived at by gauging in 1908.

The discharge required below it is 2,004 cusecs. The gaugings taken in 1908 by Mr. A. Vipin show that this discharge is realised with a level of water below the weir of 34.83, that is, a depth of 5.3 feet against the depth of 4.8 feet now maintained. In 1908, gaugings showed that at times, practically the full supply for the ultimate area was sent down, while at the same time, the Pulleru was conveying full supply and thus the existing discharge capacity is sufficient. Where the Pulleru will meet Ryves, at 23/0, it will have lost about 261 cusecs in supplying the ayacut above that point, so that its contribution will have dwindled down to 939 cusecs.

The sections and hydraulic statements will further explain the proposals.

45. *Allocation of areas to be irrigated.*—In the irrigation accounts of the Board of Revenue for 1909-1910 just published, the area irrigated in the Eastern delta is given as 416,548. On this basis 420,000 have been assigned by Government to the present delta system, that is, 416,548 for the present irrigation and a lump allowance of 3,452 acres for scattered areas from which it would be difficult to keep water. An endeavour was made to allocate the total of 420,000 acres amongst the canals by taking the total extent as irrigated in 1909-1910 by each canal given in the Board of Revenue's accounts. It is now found however that the present irrigated area of 416,548 acres must have been incorrectly distributed amongst the canals and some areas must have been ascribed to wrong sources. For example, if the area given as irrigated by Ryves' canal be deducted from the total area given as irrigable by the Special Revenue officer, there is left a balance of only 2,435 acres. Now, one of the blocks investigated by the Revenue officer and included in his total irrigable area was the Vempad block of 6,000 acres. This block comes under Ryves' canal and is so situated that none of it could have come under cultivation since the above officer's investigation. Instead therefore of there being a balance of only 2,435 acres irrigable under this canal, there should be at least 6,000 acres. For this and other reasons the total of 420,000 acres is now reallocated amongst the canals and in the following statement the new allocation will be found. (On the statement is also given the further extents irrigable under each canal and these are the areas to be credited to the Reservoir Project.

Name of Branch canal.	Ultimate area allocated to the existing Delta system.	Area allocated to Kistna Reservoir Project.	Nos. of the blocks in column 3.	Total ultimate area irrigable.
1	2	3	4	5
	ACRES.	ACRES.		ACRES.
Ellore canal	70,301	5,748	8 N, 9 N, 11 N, 12 N, 13 N, 14 N and 26 N.	76,049
Ryves'	56,092	6,000	32 N	62,092
Polraz	27,454	3,057	7 O	30,511
Bantumalli	35,285	3,280	24 C	38,565
Pulleru	1,50,026	2,140	26 S	1,52,166
Bandar	77,842	4,606	36 S	82,448
East Bank	3,000	48,435	36 S	51,435
			1 S	
Total	4,20,000	73,266		4,93,266

46. As explained in paragraph 45 above, the total extent of new cultivation to be assigned to the Kistna Reservoir is 73,266 acres. Of this extent 48,435 acres will come under the East bank canal and 24,831 acres under the other canals. The maps accompanying the estimate (portfolio No. 2) show all these blocks and a statement with the estimates gives the area of each and indicate how they may be supplied. The positions of all the blocks are also shown on the index map. The areas are compiled from the village registers prepared by the Special Revenue officer which are now recorded in the Guntur Collector's office and will therefore be available when required. The blocks with their areas are as follows:—

STATEMENT of blocks and areas to be irrigated.									
Block number.									Area in acres.
25 S	...	...	...	...	...	...	...	...	1,831
26 S	...	...	...	...	...	...	...	...	309
35 S	...	...	...	...	...	...	...	...	2,020
36 S	...	...	...	...	...	...	...	...	1,210
37 S	...	...	...	...	...	...	...	...	1,376
7 C	...	...	...	...	...	...	...	...	3,057
14 C	...	...	...	...	...	...	...	...	1,123
24 C	...	...	...	...	...	...	...	...	2,157
32 N or Vempad block	...	...	...	...	...	...	...	...	6,000
8 N	...	...	...	...	...	...	...	...	4,115
9 N	...	...	...	...	...	...	...	...	
11 N	...	...	...	...	...	...	...	...	
12 N	...	...	...	...	...	...	...	...	
13 N	...	...	...	...	...	...	...	...	1,633
14 N and 15 N	...	...	...	...	...	...	...	...	
26 N	...	...	...	...	...	...	...	...	
Total									24,831

From the above it can be seen that the blocks are all fairly large varying from 1,100 to 6,000 acres.

DISTRIBUTARIES.

47. *Typical distributaries system.*—To arrive at the approximate cost of irrigating these blocks, the Vempad block was selected as a typical one and detailed estimates prepared for its complete irrigation. These estimates and the accompanying plans will be found in portfolio No. 2. The channel will be of the ordinary type with pipe sluices, trapezoidal notches and one or two small cross drainage works and as the blocks to be supplied require channels of a similar type, the cost arrived at ought to be a reliable indication of what it will cost to irrigate the total extent.

The Vempad block contains 7,300 acres of which 6,000 are new irrigation. Taking only the new irrigation into account, the cost worked out to Rs. 10-0-0 per acre of land supplied, that is, Rs. 5 for works and Rs. 5-0-0 for land. The land to be acquired is valuable dry land, and compensation at varying rates has been allowed the average being Rs. 350 per acre. It includes 15 per cent. for compulsory acquisition.

For most of the other blocks the land to be acquired will also be dry lands and as the rate of Rs. 350 quoted above is applicable the same rates of Rs. 5 for works and Rs. 5-0-0 for land is allowed in their case also. For four blocks (namely 25 S, 26 S, 7 C and 26 N) where wet lands may have to be acquired, a rate of Rs. 6 is allowed for land acquisition, which is based on the rates per acre for wet lands given by the above officer. To provide for the extra cost of conveyance which will be necessary in these cases the rate for works has been increased to Rs. 7-8-0 per acre. Thus the total rate for these blocks is Rs. 13-8-0 per acre as against Rs. 10-0-0 in the case of the others.

48. *East bank Canal distributaries.*—As mentioned in paragraph 46, the extent of new irrigation to be supplied by this canal is 48,435 acres. It is proposed to supply this extent by means of 12 distributaries. These have not been aligned on the ground, but the approximate positions of their head sluices have been indicated on the block map (portfolio No. 2). On looking at this map (or the key map) it will be seen that down to about mile 29, the tract to be supplied is fairly narrow with a

regular rapid fall towards the Kanikalamadugu drain which bounds the tract. On this account the distributaries down to these will be short and their alignment is an easy matter. There will be no difficulty with drainage disposal.

It was intended to work out the cost of one distributary, but when final orders were received as to the supply levels in the canal, there was no time left to do so. The positions proposed for the head sluices of the distributaries and the acreage to be supplied by each is as follows:—

Number of off-takes.	Mileage.		Acreage.	Remarks.
	Miles.	Furlongs.		
1	5	6	700	3,000 acres irrigated under existing system.
2	8	2	600	
3	9	..	1,335	
4	14	4	800	
5	18	2	2,500	
6	20	5	4,750	
7	24	6	3,500	
8	27	4	6,500	
9	28	7	3,500	
10	29	6	3,750	
11	32	2	10,000	
12	35	..	14,500	

From the above it will be seen that with the exception of the last two, the distributaries will be of moderate size. The last two will not only supply large areas, but will be pretty long, the 12th being about 14 miles in length.

In arriving at an acreage rate for these distributaries, the Vempad block has been again taken as the standard. As has been explained already, the rates per acre to be irrigated arrived at for that block were Rs. 5 for "works" and Rs. 5-0-0 for "land." For the first 23,935 acres of new cultivation, this rate has accordingly been allowed as the conditions are similar.

The last two distributaries supplying 24,500 acres require different treatment. They will be much bigger than the Vempad channel and there will probably be several distributaries taking off from each. For this reason it is considered advisable to increase the rate per acre for works arrived at in the Vempad block by 50 per cent., the rate for works then being Rs. 7-8-0 instead of Rs. 5. As these distributaries are a long way from the head of the canal, if stone for the masonry works is brought from Bezwada, as is usually for all delta works, the cost of conveyance will be rather heavy, as it will probably be much cheaper to use bricks instead and good bricks can either be burnt or bought locally. No allowance is therefore made on this account.

With regard to the rate for land, both distributaries will, for the first few miles of their course, pass through fairly good land worth about Rs. 150 per acre. After that, the land will gradually decrease in value and towards the end, it will be worth very little, perhaps Rs. 40 to Rs. 60 per acre. For these reasons, a rate of Rs. 100 per acre is assumed as a fair average for the cost of the land to be acquired. This will reduce the acreage rate for land from Rs. 5-0-0 to about Rs. 2-8-0. With Rs. 7-8-0 per acre for works and Rs. 2-8-0 for land, the total rate becomes Rs. 10 and for these 24,500 acres this rate has accordingly been allowed.

49. *Short late crop.*—The total area suitable for this crop according to the Special Revenue officer is 81,494 acres, including 72,000 acres in Colair lake bed and margins. Apart from the lake area the only other suitable concentrated area or block is that in Pelalanka swamp, 5,034 acres in extent. The balance of 4,400 acres consists of small scattered portions at the tail ends of existing distributary channels. As these will not require any special outlay and as in any case it is doubtful if it is desirable to irrigate them, no provision for doing so is made in this estimate. In addition to these extents, there is about 3,000 acres in the southern portion of the Bank canal block which was excluded from the ordinary crop area as being liable to incurable submersion. This could be cultivated with a short late crop. Under orders, however, of the Superintending Engineer, II Circle, it was excluded from consideration on the grounds of its being an isolated tract at a long distance from the head of the canal.

50. *The Pedalanka block.*—Thus there remain only two blocks to be dealt with, the Colair lake block, and the Pedalanka block. To irrigate the latter, all that will be required is to excavate new minor distributaries from Chorampudi channel and to continue and improve the existing tail distributaries of the Pedalanka channel. The rates for carrying out of the necessary works may be rather high, as the tract is very remote and labour scarce and hard to provide and there are difficulties about drinking water as the sub-soil water in dry season is brackish. Improvements to the drains may also be necessary. There will be no land compensation to pay as the land is Government waste. All that has to be provided for is the cost of works. For these a rate of Rs. 7-8-0 per acre which is 50 per cent. in excess of that arrived at in working out the Vempad project, is allowed. This rate ought to be sufficient.

51. *The Colair lake area.*—At first it was proposed to supply the whole 72,000 acres from the Ellore canal. On investigation, however, it was found that it would be impossible to do so. The supply for the lake would have to be taken off from the tail end of the canal and this would mean that the canal should be big enough at its end to carry water for 72,000 acres. It would be possible to provide for this, but at a very great cost owing to the large number of big cross-drainage works to be dealt with. In paragraph 39, it is explained that it is not possible to increase the present F.S.Ls. and bed falls in the Ellore canal and for this reason as the depth of water decreases down along the canal, it would have to be widened progressively from head to tail. Now this would upset altogether the conditions under which the ordinary first crop is supplied. The ultimate area below 37 miles, 4 furlongs, that is below about 2 miles, 4 furlongs from the end of the canal, is only 14,000 odd acres. If the canal were wide enough here to carry water for 72,000 acres, the ordinary season supply for the 14,000 acres would be only a mere trickle and it would be impossible to command the land. For this reason the conclusion was arrived at that no more supply could be counted on at the end of Ellore canal than would be available in the ordinary season. This supply is 200 cusecs which at a duty of 100 would irrigate 20,000 acres. A duty of 100 may seem rather high to assume, but it is, thought that the special circumstances of the Colair area warrant it. In the ordinary delta the greatest demand for water is at the time of transplantation. Now in the Colair lake it is unlikely that this will be the case. The land will have been under water for months beforehand, it will be transplanted as the water falls, the cultivation advancing with the fall of the lake level. The circumstances will be altogether different from those ruling in the delta with its land all parched and is likely that even a higher duty than 100 may be worked to. The only other time in which water will be much required, is when the crop will be ripened early in May and then again supply at 100 duty ought to suffice. At present when the crops are ripening in the delta, the canals work at a higher duty than this.

Assuming then that without altering the Ellore canal in any way, it is possible to irrigate 20,000 acres of the Colair lake area from it, the next point is how the supply is to be led from the canal to the lake. From the contoured map of the lake (Portfolio No. 2) it will be seen that two drains called West Tammileru and East Tammileru cross the Ellore canal, the former at 37/4 and the latter just above the Ellore lock at the 40th mile.

These drains cross the canal by level crossings with flood regulators with vents at canal bed level. Both drains lead to the lake. It is proposed then to drop the canal water through the above vents and to pass it down along the drains. Just short of the lake margin, the drains will be banded either by small bunds of earth and stakes which can be put up newly every year at the beginning of the short late crop season, or by rough weirs fitted with falling shutters or posts and removable lanks. On the contoured map the area it is proposed to supply by this means, is indicated by being coloured a deeper blue than the rest of the lake. It will be noticed that the portions of the bed it is proposed to supply, are comparatively high and easily drained and channels can be easily formed around their margins. The total area of the portion shown is more than 20,000 acres. The lowest portions may be reserved for drainage and only the most suitable irrigated. No work need be done on the drains themselves, as they are big enough to carry more water than is proposed to be sent down. As there will be hardly any rain in the short late crop season, the

drains will not be required to act as drains and there is no objection to use them in the manner proposed. If special channels were dug from the canal, they would be very expensive as they would pass through valuable wet land, and owing to the big fall over 6 feet per mile, there would be many masonry works required.

As regards the cost of these proposals, there need be no expenditure save that of providing the distributary system on the lake itself. This should be fairly expensive, as the channels will have to be banked to a great extent and the banks will have to be very wide with flat slopes to withstand the yearly flooding of the lake. Labour also will probably have to be more highly paid there than elsewhere, as it must be all imported. There will, however, be no land compensation to pay. For the above reasons, as was assumed for the Pedalanka block, a rate of Rs. 7-8-0 per acre is taken as a fair average rate for the cost of works of the distributary system. This rate is 50 per cent. in excess of that arrived at for works in working out the Vempad project.

52. Many other suggestions were made for supplying further portions of the lake, but were rejected on various grounds. One, however, seems fairly feasible. The Budameru drain draining 540 square miles crosses the Ellore canal near the 13th mile. It was at one time connected with the canal by a lock, but this lock is now closed up. The proposal is to drop water from the canal into the drain as in the case of Tammileru, carry it down to a point above where the drain flows into the lake and from there, take it round the lake margin by a channel. There is fall enough for the channel and the drain can take much more than the required quantity of water, and the only objection is that the channel would have to cross four or five pretty large drains between where it took off from the Budameru and where it met the West Tammileru drain. It would be very likely to be washed away every year in the rainy season where each drain crosses it. If this were not thought an insuperable difficulty, the 20,000 acres now proposed to be supplied through the Tammileru might come under the Budameru and the water available at the end of Ellore canal passed into the Gódáviri-Ellore canal and a channel taken from the latter to the upper end of the lake which is the highest end and the easiest to irrigate.

53. *Area provided for as "short late crop."*—The above alternatives have not been provided for and the estimates only provide for irrigation of an extent of short late crop as below:—

Block.	Area. ACS.	Provision for cost of distributaries rate per acre.	
		RS.	A. P.
Colair lake	20,000	7	8 0
Pedalanka block	5,094	7	8 0

REPORT TO ACCOMPANY THE ESTIMATE FOR WESTERN DELTA EXTENSION UNDER KISTNA RESERVOIR PROJECT (BY MR. A. V. RAMALINGA AIYAR, EXECUTIVE ENGINEER).

54. *Existing irrigation, Kistna Western—Sheet No. A.*—The Kistna Western Delta comprises an area of 950 square miles (608,000 acres), of which nearly 300,000 acres are now irrigated. The Western Main canal, which branches from the Kistna just above the Kistna anicut at the Seetanagaram (right) end is 13 miles long, and 230 feet wide (since reduced to 200 feet by the construction of silt fences in 1908) at its head. It branches into three main arteries called, the Bank, the Commamur and the Nizampatam canals; with the exception of the latter, which is a purely navigation canal, the others are combined irrigation and navigation systems. The irrigation on both sides of the Nizampatam canal is done by two long side channels called the "Nizampatam canal, East and West Side Channels," branching directly from the Main canal at the head the Nizampatam canal. Owing to insufficiency of water in the Kistna river under existing conditions, large blocks of land, though commanded, are either lying waste or left unirrigated, raising uncertain dry crops, for want of an adequate supply. These blocks are coloured yellow in the accompanying sketch map of the delta (Portfolio No. 3). In recent years, owing probably to the

unfavourable seasons and to the high price paddy fetches, the ryots are freely lowering their lands and converting the same into wet with and without permission from the department.

55. *Scope of present investigation.*—The present estimate provides for all possible extensions in the Kistna Western delta, on the assumption that an adequate water-supply is available at the Kistna anicut, throughout the season, by the construction of a Reservoir higher up.

A careful estimate of the area commanded brings it to 357,000 acres. Of this extent, 305,000 acres has just been fixed as the ultimate area under Kistna anicut system, Western delta, leaving a balance of 52,000 acres for irrigation under the Kistna Reservoir project. A statement showing the positions of the proposed extension is submitted.

56. *Allocation of areas to be irrigated.*—The Special Revenue officer, Mr. Turing, estimates the extent of new lands to be brought under wet cultivation by the Reservoir project at 42,000 acres (in his No. 298 of 1909, dated 29th September 1909). There is therefore a discrepancy of 10,000 acres. This is due to the fact that, while giving the probable area to be brought under the Kistna Reservoir project to the said Revenue officer, the ultimate area under the existing Kistna delta system, Western section was taken at 315,000 acres, as suggested in Kistna Western division letter No. 46-S. of 14th April 1908, instead of the since authorised 305,000 acres and as this suggestion was not accepted, the balance 10,000 acres has been included in the Kistna Reservoir project delta extension.

The following statement shows the distribution of areas suitable for irrigation in the Kistna Western delta under the Bezwada anicut and the portions of these areas allocated to the Kistna Reservoir project:—

Name of canal.	Ultimate area allocated to the existing Delta system.	Area allocated to Kistna Reservoir project.	Numbers of blocks in area column 3.	Total ultimate area irrigable.
1	2	3	4	5
Main canal including East and West side channels.	88,500	9,824	No. 1, 2, 3, 6 and 7.	98,324
Bank canal	100,000	21,750	Nos. 26, 28 and 29.	121,750
Commander canal	116,500	20,426	Nos. 15 to 21, 22 and 24.	136,926
Total ..	305,000	52,000	..	357,000

57. *Nature of the country proposed to be irrigated.*—The proposed extension comprises three different soils, viz., the rich black soil at the head of the delta, and the poor sandy soil forming the Repalli-Bapatla Sand Ridge and saline soils near the coast. More than half the extent of the extension is in the two latter classes. Excepting the former, the lands are not very retentive of moisture. In the sandy and saline tracts, the sub-soil water is close at hand, ranging from 7 to 10 feet below the surface of ground. The same cannot, however, be said of the black soil. This latter soil is, however, the only one in the area considered on which dry crops are systematically cultivated. Ragi is occasionally sown on the sandy soils here and there, under well supply. With this exception, the sandy and saline soils are now almost useless. Hence irrigation would be a boon in these parts.

The chief dry crops raised in the black soil are cholam and red gram. Alongside the canals and distributaries, there are some irrigated dry crops, such as saffron and chillies, but their extent is very trifling; excepting the irrigated crops, the income from the dry crops is about Rs. 34-8-0 per acre. The income from wet crops (paddy) is about Rs. 60-8-0 per acre. The prospect of doubling one's income is a fair inducement for cultivating rice crops, which is the staple food in the delta tracts. The ryots are conversant with the benefits of irrigation. There is therefore a clamour for irrigation even in the black soil tracts.

58. *Rainfall and its distribution.*—There are 21 rain-recording stations in the delta, of which four are civil stations and the others Public Works Department canal stations. The average rainfall for the last 15 years is 32.60 inches per annum, while the minimum and maximum are 18.22 and 57.73 inches, respectively. The irrigation season commences in the middle of June and ends with the middle of December during which season the maximum, minimum and average rainfall are 53.43, 14.02, 28.48 inches, respectively. The highest recorded rainfall in 24 hours is 6.80 inches. The delta receives the benefits of both the south-west and the north-east monsoons.

59. *Duty of water.*—In the existing Kistna Delta works, an average duty of 90 to 100 acres a cusec is being realised for the whole irrigation season. The existing canal capacity enables water to be passed at as low a duty as 60 acres per cusec and for short periods in the transplantation season, water is now carried at this duty. The canals are then strained to their utmost carrying capacity. The maximum carrying capacity of the canals are fixed at 70 acres a cusec for the purpose of irrigating the ultimate area under the Reservoir project and this is the accepted duty in the existing delta canals, although running them at much lower duty for short periods is not unusual. For further detail on the subject of the duty of water, see Kistna Western Division Report No. 676 S., dated 5th March 1910.

60. *Head works.*—The Kistna anicut has a solid body wall 7 feet high above the sill of the Seetanagaram headsluice fitted up with a self-falling shutter 3 feet deep over it. In Kistna Western division No. 508 S., dated 7th December 1909, it has been pointed out that the raising of the shutters is a very desirable work even independantly of the Kistna Reservoir project, in order to give a better fall to the Main canal and to supplement the deficiency of supply at certain periods. The regrading of the main canals to carry the extra supply required for the extension is designed on the assumption that the fitting of falling shutters with an effective height not less than 6 feet is an accomplished fact.

61. *Main Canal—Kistna Western.*—The Main canal and their masonry works are capable of conveying all the additional supply required for the extension with a slight extra depth, and consequently with little interference with the existing works. Condensed sections of these canals are given in Plans No. K. W. 2, Portfolio No. 3.

62. *Data for hydraulic calculations.*—Ganguilett and Kutter's formula is adopted in designing channel sections. In the calculations, the average values of the coefficient of discharge C and the coefficient of rugosity N obtained by the gauging operation of the last three years are adopted for existing works, in preference to the general values of $N=0.0225$ and 0.025 and $C=0.625$. There seems to be no meaning in adopting for existing works, a standard value, which (as is known) varies widely with different soil positions, etc., and which does not therefore suit any particular local conditions.

63. *Distributaries.*—The isolated nature of the blocks has necessitated the alignment of a number of new distributaries to irrigate them. Generally speaking, all blocks of more than 1,000 acres in extent have been investigated in detail, while average rates are provided for the distributaries for blocks of smaller areas. The arrangements of these distributary channels have been fixed from contoured maps submitted herewith. As a rule, the new channel lines are taken along ridges. Where existing channels require remodelling, they are, as far as practicable, also taken along ridges. The only exception to this rule is the Peddapalli branch of the East side channel which crosses two valleys. This has been done intentionally, as the long distance of the channel by the alternative ridge route, has the disadvantage of not commanding half the extent of the land now proposed to be irrigated. In a few cases especially in the black-soil tracts, the alignment is influenced by the great cost of wet lands, which will otherwise have to be acquired. The details of the design are all in accordance with the Chief Engineer's Memorandum No. 1323, dated 4th April 1907 on the subject. The F.S.L. of distributary channels is placed generally about a foot and half above the level of the irrigated land, the minimum being fixed at one foot. The low water supply is fixed at half supply level, except in the case of the Bank canal side channels. Lands commanded at this low water level only are proposed to be brought under irrigation.

64. *Drainage and Protective works.*—The existing main drains in the delta are quite sufficient. Excepting local complaints of defective drainage here and there, there are no drainage problems on a large scale to be tackled. The improvement of the Bhattiprolu drain is already taken up in the regular division. Four minor drains are estimated in this project. Three of the drains are in the Anna, Nandur and Pundla block and the fourth is in the East side channel extension. The flood discharge from drainage basins in these flat delta tracts is calculated by Ryves' formula $Q = 92 M^{\frac{2}{3}}$ in accordance with II Circle Superintending Engineer's No. 40-G.L., dated 16th April 1908. This allows for a six days' submersion of paddy crop which is not at all injurious to them. The drains are designed for carrying the discharge calculated by the above formula, but the actual excavation is provided for only a third of the discharge thus arrived at. The spacing of spoil banks leaves room for future full excavation if required, and the masonry works are designed to carry full discharge. The above procedure is in consonance with the existing practice in the delta which has worked quite satisfactorily.

65. *Critical and mean velocities.*—Agreeably to Mr. Kennedy's silt theory, non-silting channel sections are provided in the design wherever possible. There are however, few exceptional cases in which owing to the flatness of the country or the very high level of the lands to be irrigated, the necessary surface fall could not be had. According to the suggestions made by him (Mr. Kennedy), a few observations were made in the Western Delta in 1908-1909, to compare the non-silting mean velocities of this delta and Mr. Kennedy's standard (*vide* Kistna Western division No. 25-S., dated 8th April 1910). The main canal is always silting very heavily. Its present bed is now about 2.5 feet above the original bed level. Hitherto silt clearance was being done on a large scale which during the last three years is considerably reduced, by leaving the bottom of 2.5 feet of silt wedge undisturbed, and increasing the surface fall of the canal to meet the demand for water. Two observations under the above conditions made three furlongs below the head of the delta, gave a critical velocity ratio of 0.87 V, compared to Mr. Kennedy's standard. This ratio is not to be understood as final, since the main canal has not here attained a permanent regime. All the other canals and branches excepting the Commamur canal (*viz.*, the Bank Canal and the East and West side channels) run with a higher critical velocity of about 0.95 V, at their head, while the Commamur canal runs with 0.80 V, only at the head. Practically speaking, all these latter canals can be said to have attained a permanent regime. There is no record of any disturbance of equilibrium having been made within the last 10 years. The lesser value found in Commamur canal is attributed to the fact of its having the sill of the head sluice one foot above the bed of the main canal, while the others have their sills at or about the normal bed level and consequently carry off the heavier silt. The result of half a dozen distributaries of Bank canal in permanent regime, gave a ratio of from 0.92 V, to 0.70 V, depending on their distance from the head of the delta, *viz.*, from 20 to 42 miles. Since the Commamur canal itself runs with a lesser critical velocity, there will be no harm in running its distributaries at a slightly lesser velocity ratio than the distributaries of Bank canal situated at a similar distance from the head of the delta. Although there is no authoritative pronouncement on the subject, a knowledge of these experimental results has considerably influenced the selection of channel sections for the distributaries.

66. *Land Compensation.*—The value of the land proposed for acquisition was taken from Mr. Turing's report generally, except in cases, where local Divisional Officers have given different rates. This preference is due to the fact that these local officers were furnished with the exact alignment of the channel and consequently their valuation refers to that particular case. Mr. Turing has given average rates for the whole of the black soil found in the delta. This soil is extensive. It is more costly at the head of the delta and less so at the tail end (*vide* also Sub-Registrar's office figures attached to Mr. Turing's report). Where Mr. Turing's average figures are considered low, the Sub-Registrar's office figures are adopted. In recent years, the value of land in the delta is increasing by leaps and bounds, and the figures provided in the estimate are therefore on the safer side.

67. *Gauge outlets.*—A feature in the design is the introduction of Mr. Kennedy's gauge outlet manufactured by Messrs. Burn & Co. in the place of the pipe sluices.

This has been done with the approval of the Superintending Engineer, II Circle, conveyed in his No. 371-K.W., dated 19th December 1909. These gauge outlets have considerable advantages over the pipe sluices. They indicate the actual rate of flow through them at any moment and are unaffected by variations in the levels of the water surface of the field channel, except when the working head is very low, say less than 3". They are portable, easily readjusted for varying discharges and conditions unlike the pipe sluice, and can rateably distribute the available supply in times of scarcity. There are no moving parts likely to be clogged or got out of order and above all, are considerably cheaper than the pipe sluices. A trial made in the Kistna Western division with these "outlets" has given very satisfactory results. The outlet is a miniature "Venturi meter" without the recording apparatus. It is designed on the principle of what is known as the "Bernoulli theorem". The available market sizes, 15 in number, limit the use of it. Full advantage has, however, been taken of all favourable sites for the same.

68. *Reinforced concrete.*—This new building material is utilised in nearly all the masonry works in some form or other, as it lends itself to a good many purposes. Thus the usual concrete arch necessitating high and unsightly approaches is discarded in favour of the ferro-concrete slab. Ferro-concrete troughs for aqueducts and pipes for syphons are provided. Simple slabs are used for bridges and culverts up to 10 feet span, while the T or ribbed slab is adopted for spans of 10 feet and over, which save a considerable amount of material. Whatever use is made of this new building material, they have been designed with $\frac{1}{2}$ per cent. mild steel single reinforcement, with a maximum fibre stress of 450 lb. per square inch for concrete and 14,400 lb. per square inch for steel and 15 as the ratio of moduli in accordance with the Chief Engineer's Memorandum No. 4230-C., dated 22nd August 1907. The system adopted is that of "Hennibique" with 1:2:4 proportion for cement concrete. The use of the expanded metal suggested by the Chief Engineer is not adhered to, because a quotation obtained from Messrs. Oakes & Co. was found to be nearly ten times as costly as the ordinary mild steel bars, weight for weight. Such an extravagance was considered unwarranted, especially as a number of small works have successfully been carried out in this delta with the ordinary bars. The experience thus gained has led to the provision of more ambitious works of this nature in the present estimate. The necessary calculations are given on the plans themselves.

69. *Other masonry works.*—As a more or less continuous supply is the eventual goal of water regulation, trapezoidal notches, which automatically and rateably distribute the supply, are generally introduced. The 4" diameter pipes are taken as a minimum for outlets and these are fixed in earth, while pipes of bigger diameter than 4" are proposed to be built in masonry with regulating arrangements. Grade walls are introduced at every reach to indicate the correct bed level.

BANK CANAL.

70. *Kollipara Side Channel, Block No. 26.*—The block of dry land along Bank canal between the 18th and 23rd mile is proposed to be irrigated by a new parallel channel with distributaries, branching from 9 miles 7 furlongs 530 feet, right bank of Bank canal. It is the third large distributary from the Bank canal and has an ayacut of 6,160 acres, of which 300 acres are already under the irrigation of the existing Kollipara channel. The balance of the proposed ayacut, *viz.*, 5,860 acres, is composed entirely of the rich black soil. The side channel is $5\frac{1}{2}$ miles long, running parallel to and adjoining the Bank canal. It crosses the existing Kollipara channel by an aqueduct (three spans of 13' — 8") 5 feet wide at 3 miles 1 furlong.

This is the only important masonry work in the block. The trough of the aqueduct is proposed to be of the box type built of ferro-concrete calculated as a continuous beam over four supports. The top member of the box can be used as an occasional foot-path. No railings, etc., are provided, as it is not intended to be a thoroughfare owing to its proximity (say 100') to the Kollipara channel head sluice which serves the purpose. The work is proposed to be moulded *in situ*. The fall of the country along the Bank canal is so very small that it will not admit of this side channel being designed with a non-silting section. Against the

possibility of silting is to be counted the advantage of the sill of the head sluice being nearly 3 feet above the bed level of the Bank canal, which will prevent the heavier silt or heavy rolling sand getting into the channel. The nearest possible approach to such a section with the available fall is, however, adopted, viz., 0.69 V_0 at the head. Observations made in 1908-1909 at the head of the adjoining Kollipara channel having its sill at or about the bed level of Bank canal go to show that the critical velocity ratio at that site is 0.92 V_0 of Kennedy's standard. The side channel may silt a little. It will, however, be limited to the first mile of its length, since the first two distributaries take off at bed level and designed with a higher critical velocity ratio, viz., 0.83 V_0 .

There are five minor distributaries taking off from the side channel, the last of which has two sub-minors in its turn. All these minors are aligned on ridges. As the fall of the country away from the canal is greater than along the canal, it has been found possible to design them with a higher critical velocity ratio, viz., 0.80 V_0 , which, it is considered, will give a non-silting section at the site. Sufficient number of bridges are estimated to provide for easy access to the Bank canal.

71. *Isukapalli block*.—One of the big distributaries of Bank canal is the Isukapalli channel. It has a large extent of sandy and saline soils, yet to be brought under cultivation. The ayacut proposed is 24,000 acres, of which 15,000 acres is the existing wet ayacut. The proposals consist of excavating four minor distributaries, namely—

- (1) Proposed channel from third mile on right side,
- (2) Guddikayalanka branch,
- (3) Guddikayalanka minor distributary,
- (4) Pallapattu high level channel,

also the straightening of the crooked Bhattiprole drain passing through this block. The first distributary and the improvements of the Bhattiprole drain are already estimated and work partly carried out as part of the existing delta system. The other three distributaries are now investigated in detail as well as the alterations to the main Isukapalli channel for carrying the increased supply. The Aravapalli branch ayacut is increased by 1,000 acres and improvements to the same has been estimated for. The present Ullipolem, Allaparru and Kuchinapudy branches are capable of carrying the extra supply. Only minor improvements will be needed to these channels. These have been estimated in Kistna Western Division office No. 482-S., dated 24th November 1909. The existing bridges need no alteration. They are capable of carrying the augmented supply with an afflux of less than 0.10'. The critical velocity of the Isukapalli channel at its head is fixed at 0.6 V_0 , which is a trifle less than the actually observed ratio in the same channel. The reduction is done purposely, as the channel is found to scour a little.

There are only two important masonry works in this block. The one is the existing combined bridge and aqueduct over the Bhattiprole drain (10 vents 8 feet span) fully capable of carrying all the flood water of the drain (*vide* calculation on plan submitted with Kistna Western division No. 141-S., dated 29th May 1909). Its capacity and strength to carry the Isukapalli channel as now remodelled is enquired into, stresses computed and necessary improvements estimated for. The other is the proposed trapezoidal notch of 3 vents just below the off-take of the Pallapattu high level channel for which plan and estimates are submitted.

72. *Potumeraka west branch, Block No. 29*.—This is one of the minor distributaries of Potumeraka channel, a branch of Bank canal. The existing channel is proposed to be improved and extended for the irrigation of 2,080 acres, of which 1,200 acres are new cultivation. The soil is entirely of parrah or saline soil. The channel crosses a minor drainage, having a catchment of 8 sq. miles. The existing syphon is insufficient to carry either the augmented canal supply or the flood discharge, and a new ferro-concrete syphon is therefore provided in lieu. The pipe will be made of 1 : 2 : 4 cement concrete, 3½ feet inside diameter and 3 inches shell thickness, reinforced longitudinally by ¾" diameter rods 4" apart and hooped by a spiral wire ¼" diameter at 4" pitch. The work can be easily moulded *in situ*. The critical velocity provided is 0.8 V_0 , which is slightly in excess of the observed ratio on the adjoining distributaries.

73. *Kolliparra, Blocks Nos. 27/1 and 27*.—These blocks consisting almost wholly of rich black soil are already completely investigated in the regular division, but had to be kept in abeyance owing to insufficiency of water under the existing Kistna delta system. A portion of the work thus estimated for has, however, been carried out piece-meal, so far as existing water-supply would permit of extension of irrigation. Lump sum provisions are therefore made in the estimates now submitted for whatever remains to be done in these blocks to carry water to the whole irrigable area.

The total area under Kolliparra is 6,160 acres, of which 4,200 acres is the extensions due to Kistna reservoir.

74. *Fifth reach, Bank Canal*.—About 1,880 acres of parrah or saline soil is proposed to be brought under irrigation in this reach of the Bank canal and of this 1,480 is the area allocated to the Kistna reservoir project. They are commanded not by one channel, but come under the ayacut of almost every field channel and distributary branching in that reach of the Bank canal. It is on this account not specially investigated, lump sum provision being considered sufficient. The masonry sluices (sanctioned in G.O., No. 30 I., dated 26th January 1909) for all these channels are capable of giving the extra discharge and no alteration is therefore necessary in the ventway of the sluices.

MAIN CANAL.

75. *Bank Canal Side Channel (Block No. 3)*.—This is a long side channel about 9 miles in length with a distributary of 3 miles in addition. It branches directly from the Western Main canal just below the Bank canal head sluice, the F.S.L. of the latter being insufficient to command these lands. It irrigates a strip of land averaging a mile in width adjoining the right bank of Bank canal from its head down to the first distributary channel on the same (viz., Munnangi channel). The lands in the upper reaches of this side channel are very high and could not be commanded at the low water-level of the Main canal. Consequently, a large plot of these lands has been excluded from wet irrigation. A peculiarity, however, in this part of the delta is that these high level lands will either be cultivated with saffron crops, for which water will be baled from the water courses, or lowered in level so as to be fit for direct irrigation as soon as the side channel is dug. Authorised or unauthorised, such a contingency is sure to happen and not to provide for this is nothing but short-sightedness. It is therefore proposed to supply these lands with water for irrigated dry crops, such as saffron, chillies, etc., by baling at a duty of 200 acres a cusec. It contemplates the irrigation of 5,411 acres of wet land and 1,417 acres of irrigated dry land, of which 1,811 acres wet are already irrigated by existing sources. It is regrettable that a non-silting section was found impossible in this case owing to the flatness of the country and the very small difference of head available. The nearest approach to such a section is adopted. The sill of the head sluice also is at a higher level than the bed of the Main canal, thus minimising the entry of heavy rolling silt, but still, it is feared, that the channel will silt and clearance must be faced. The low water-level in this channel is fixed at three-fourths of the supply considering all circumstances, while other distributaries are designed with half supply. Lands commanded at this low level only are included for wet irrigation. Enough bridges are provided for the side channel to admit of easy approach to the Bank canal.

76. *East Side Channel Extension, Block No. 7*.—The large block of sandy land near Nizampatam, comprising an extent of 11,000 acres, is irrigable by extending the East side channel. Of this 11,000 acres, nearly 7,000 acres are already irrigated by the existing channels, which are ill-aligned and are in very bad order. The present proposal is to re-align and re-model the existing distributaries so as to command as much land as possible.

The East side channel by itself is not capable of carrying the increased supply below Kuchipudi calingulah. Condensed sections of this portion are given showing the widening, etc., necessary and improvements estimated for. The critical velocity of the channel is as it should be.

The chief new distributary is Peddapalli channel, the existing channel of that name being abandoned, as is also the existing Thollavagu channel.

The new channel is aligned for the first half mile along the existing Peddapalli channel and below that along the Thollavagu channel.

From this channel four new minor distributaries off-take.

In addition extension of irrigation is carried out from existing Ramarajoo and Komaravole channels.

In the irrigated area, it is proposed to excavate a drain called the Pandikodu drain for which provision is made.

COMMAMUR CANAL.

77. *Aremanda block*.—This block is irrigable by the Aremanda branch of the Tungabhadra side channel, which last is the first major distributary taking off from Commamur canal. The Aremanda branch forms the old course of the irrigation channel from the Guntur Nalla drain, which, since the introduction of the Kistna delta system, is converted into a branch of the Tungabhadra side channel. As is usually the case with such channels, it runs at a low level, scarcely commanding the lands on both sides of it, excepting the low-lying valleys. At about the 9th mile, it encounters a sandy ridge about a mile and a half in width, which it encircles by a circuitous course of about seven miles. The present proposals are to remodel the channel so as to command the adjacent lands and to cut through the said sandy ridge, so as to give a better command to the lands at the tail end. The bed of the existing channel should gradually be silted up to raise the water level. It is proposed to bring in 1,500 acres of new land under cultivation, partly by the new Singupolem branch and partly by direct irrigation. The critical velocity of the newly designed section is $0.69 V_0$, which coincides with the observed results.

78. *Anna Channel, Block No. 18*.—This is a distributary branching off in 21st mile of Commamur canal right bank running parallel to the Pandarapad drain. It has three minor distributaries. Excepting 500 acres at the tail end of Upparapolem branch, all the rest are existing wet cultivation. The Garikipad side channel, which had hitherto a separate head sluice from the Commamur canal, is now to be made a branch of the Anna channel. The critical velocities of this ($0.60 V_0$) as well as all other branches of Commamur canal, are lower than those of other branches similarly situated in Bank canal. This is no disadvantage, as the Commamur canal itself has less silt-carrying capacity than the Bank canal. A new drain called the Vallabharowpalem drain is proposed to be excavated right along a valley line. This cuts off a portion of the existing wet ayacut under Anna channel and its distributaries, which is added on to the new Pundla channel system.

79. *Pundla and Nandur blocks, Block No. 12*.—One of the worst blocks in the delta is the Pundla-Nandur blocks consisting practically all of black soil and bounded by the Pandrapad, Tungabhadra and Nallamada drains. At present this block is irrigated by the Anna, Nandur, Pundla and Steels channels branching from Commamur canal. All these channels are practically in their old primitive state. Improvements have been delayed for one reason or the other, the most urgent ones being attended to piecemeal. The three latter channels are not on ridges and consequently give rise to drainage complaints. Further, almost all the existing distributaries have dual functions, viz., irrigation and drainage. It need not be said that such a system is productive of a lot of trouble. To remedy this it is proposed to abandon all these channels and excavate one new channel called the "New Pundla channel" on the intervening ridge and provide for a complete system of well-velocity at the head is fixed at $0.6 V_0$, which is considered quite sufficient. There are only three masonry works of any importance, the head sluice of, and the two bridges over, the new Pundla channel. Two new culverts under the existing railway line will be necessary. A lump sum of Rs. 4,000 for each is provided in the estimates which includes cost of diversion, etc., during construction. As already stated, the Vallabharowpalem drain will divide the ayacut between the Anna and the new Pundla channels serving the northern portion. The existing Ogeti channel is

proposed to be converted into a drain and the improvements of the Appicatla drain are estimated for. These two will serve the central and southern portions of the block respectively and remove drainage complaints.

80. *Perali, Ganapavaram block*.—The sandy tract near Bapatla, south of the coast road, is at present irrigated by the Perali and Karlapolem channels, branches of Bapatla channel taking its source at 29 1/4 miles of Commamur canal. There is at present only a very limited amount of wet cultivation in the low-lying valleys. The present proposals are to improve the existing Perali channel and excavate eight distributaries from the same on ridges. The existing courses will practically answer as drains. It is proposed to bring about 9,000 acres of new land under wet cultivation. The main Bapatla, Mulapolem and the Karlapolem channels are incapable of carrying the additional discharge, so that widening the said channels and other improvements to masonry works are estimated for.

81. *Bápalla swamp*.—About 4,000 acres of the swamp area is fit to be brought under irrigation. These have been investigated in the regular division and therefore lump sums based on these estimates are provided.

Of the total area, 52,000 acres are proposed for assignment as irrigable on account of the construction of the Kistna reservoir.

82. *Sanitation and water-supply*.—In the sandy tracts of the delta drinking-water is brackish, and special arrangements will have to be made to supply this precious liquid, especially during the summer. A lump sum provision is therefore made in the estimate for water-supply and other sanitary arrangements, which are inevitable when large gangs of labour are concentrated.

83. *Communications and Markets*.—The district is one of the surplus producing districts of the Presidency. Export of paddy is going on on a large scale. The Madras and Southern Mahratta Railway's North-East Line which passes along the western part of the delta, conveys the food stuff to distant parts of the Presidency such as Madras, Madura, Bellary, etc. The Buckingham canal also performs this function to some extent. To facilitate the export trade, roads from the centre of the rice-producing tracts to the railway stations are necessary. The navigable canals of the delta perform this function at present, making a connection with the railway at Tenali where numerous rice mills have recently been started. This town is rising in importance by leaps and bounds and ere long, it would become congested to the utmost. Early steps should therefore be taken to relieve this by opening up other feeders. The delta taluks are badly in need of roads. The District Board of Guntur is now taking up this question. The projected Guntur-Repalli railway line, *via* Tenali, will pass through the richer delta tracts and relieve the pressure to a considerable extent. These works should therefore be taken up simultaneously.

KISTNA DELTA EXTENSIONS.
ABSTRACT of cost by sub-heads.

Name of work.	A Preliminary expenses.	B Land.	C Works.	D Regula- tors.	E Falls and weirs.	G Bridges.	H Escapes.	I Navigation works.	K Buildings.	L Earthwork.	O Miscellane- ous.	P. Mainten- ance.	Total.
<i>Head Works.</i>	RS.	RS.	RS.	RS.	RS.	RS.	RS.	RS.	RS.	RS.	RS.	RS.	RS.
Bowwada ariet	..	..	2,43,000	..	..	..	..	..	..	..	..	..	2,43,000
Add 20 per cent. on Rs. 61,000 for works to be done in India ..	..	..	12,200	..	..	..	..	..	..	..	..	..	12,200
Total	..	..	2,55,200	..	..	..	..	..	..	..	..	..	2,55,200
<i>2. Main Canals and Branches.</i>													
Eastern Delta canals	11,000	25,000	..	32,200	14,835	92,230	5,235	1,94,235	8,595	3,62,940	3,450	2,300	7,52,120
Add 20 per cent. for unforeseen contingencies	..	5,000	..	6,440	2,967	18,446	1,047	38,847	1,739	72,688	690	460	1,18,224
Total	11,000	30,000	..	38,640	17,802	1,10,676	6,282	2,33,082	10,434	4,35,628	4,140	2,760	9,00,344
<i>3. Distributaries.</i>													
(a) Eastern Delta— (1) Ordinary early crop	5,500	3,11,400	2,42,814	..	..	..	..	..	..	1,65,038	1,02,063	..	8,27,805
(2) Short life crop	..	..	1,02,807	..	..	..	..	..	..	70,341	42,287	..	2,16,435
(b) Western Delta— Ordinary crop	4,500	2,09,263	2,62,799	..	..	..	..	..	..	2,45,836	16,992	6,900	7,76,200
Total	10,000	5,20,663	6,08,420	..	..	..	..	..	..	4,82,215	1,92,342	6,900	16,20,530
Add 20 per cent. for unforeseen contingencies	..	1,04,141	1,21,680	..	..	..	..	..	..	96,443	38,402	1,380	3,52,046
Total	10,000	6,24,804	7,30,100	..	..	..	..	..	..	5,78,658	2,30,734	8,280	21,82,576
<i>4. Drainage and Protective work</i>													
Western Delta	..	14,530	..	..	..	..	..	..	..	4,740	404	..	19,734
Add 20 per cent. for unforeseen con- tingencies	..	2,905	..	..	..	..	..	..	..	948	93	..	3,946
Total	..	17,435	..	..	..	..	..	..	..	5,688	497	..	23,680
Grand Total	21,000	6,72,239	9,85,300	38,640	17,802	1,10,676	6,282	2,33,082	10,434	10,19,874	2,35,431	11,010	33,51,800

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Year of construction.		6	7	8	12	13	Total.
<i>I. Works—</i>							
Land	..	10,21	19,00	4,29	1,74	66	26,300
.. .. .	..	4,48	2,74	..	..	..	6,72
Total	..	14,69	12,24	4,29	1,74	66	33,62
<i>II. Establishment—</i>							
Ordinary	..	2,30	2,30	98	40	16	6,14
Special	..	5	..	..	..	..	5
Total	..	2,35	2,30	98	40	16	6,19
<i>III. Tools and plant</i>							
.. .. .	..	13	13	6	2	..	34
Grand Total	..	17,17	14,67	5,33	2,16	82	40,16

DELTA EXTENSION.

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PART III.

REPORT ON UPLAND CANAL SYSTEM.



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PART III.

REPORT ON UPLAND CANAL SYSTEM.

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PART III.

Report on Upland Canal System.

SECTION I.

MAIN CANAL AND BRANCHES.

A.—General.

1. *General description of area commanded.*—The main canal is $147\frac{1}{2}$ miles long and commands 810,000 acres wholly situated in the Guntūr district, out of which area about 610,000 acres are irrigable.

The commanded area is bounded on the north by the Kistna river, on the south by the Gundlacumma river, on the east by the Kistna delta system of canals, and on the west by this new, Upland, canal. It consists of an undulating tract of black clay soil very suitable for irrigation. The sub-soil is usually kunkur, gravel, decomposed limestone, or decomposed granite and the underlying rock is granitic gneiss which is found at depths of 5 to 35 feet along the whole canal, except the first 8 miles which run in shale. Near the Kistna western delta granitic gneiss disappears, and at the north-east corner the hills are of murchisonite gneiss (Bezwa stone), replaced further south near Chebrole with sandstone, and further south still is lithomarge, and in the south-east corner near Ammanabrole, laterite rock is exposed. The high cost of rock excavation combined with the proximity of rock to the surface necessitates an unavoidably tortuous alignment for the main canal.

The general slope of the country is north-east or east with a fall of from 50 feet a mile near some parts of the canal to $1\frac{1}{2}$ feet a mile near the Kistna river and Kistna delta. This ensures good drainage. Sub-soil water is found on an average at about 22 feet below ground level.

The whole area is occupied on ryotwari tenure and grows excellent crops of cotton, chillies, tobacco, cereals and pulses in years when the rains are both timely and sufficient. Owing to the vicinity of the rich delta, cultivators in the uplands are well acquainted with wet cultivation which they are eager to adopt in place of their present dry crops that depend solely on a capricious rainfall and are always less profitable than wet crops.

The area is well supplied with railways of both metre and standard gauges, and the Guntūr District Board will shortly construct a line connecting Guntūr direct with the delta. There are several good roads in the area, but they will require extension by the District Board before the project is completed.

Exports from this area are (i) cotton of which 11,500 tons valued at 65 lakhs leaves Guntūr district annually for Europe, (ii) chillies of which 10,000 tons worth about 25 lakhs are exported in a year of good rainfall to Calcutta and Madras, (iii) tobacco of which some 3,500 tons go to Cocanada, (iv) about 2,500 tons of pulses which are exported to Bangalore and Belgaum. Item (i) refers to the whole district and the others only to railway stations in the upland area.

2. *System of reduced distances and mileage adopted.*—The system of "reduced distances" adopted for main canals and for branch canals is the measurement in feet from the head regulator of the main or branch canal concerned.

In order to obviate the inconvenience of dealing with very large numbers, an independent unit of 10,000 feet termed a "Hecto-chain" (being 100 chains of 100 feet each) is generally used as a notation in the fractional form thus R.D. 7/0860 instead of 70,860 feet.

The survey plans furnished are to a scale based on "inches to a statute mile." All Madras Presidency irrigation works and roads are sub-divided into statute miles and fractions of this.

For these reasons after careful consideration, it has not been considered desirable to introduce a 5,000 feet mile, an alternative which has, on other grounds, much to recommend it; the system of "Hecto-chains" which has been adopted attains the same advantages without the drawbacks inherent from the use, under the term "mile," of a length differing from the "statute mile."

All "reduced distances" (R.D.) in main canals and branches are noted either in "hecto-chains" and chains (of 100 feet) to two places of decimals, thus 7/08.60, or in "hecto-chains and feet, thus 7/0860.

On longitudinal sections statute miles, half and quarter miles are also noted for convenience in cross reference with the connected survey plans.

3. *Present revenue system.*—The land and water revenue is not fixed permanently, but is resettled about every thirty years.

The present settlement expires in Guntur district in 1934 except in Ongole taluk, where the settlement expires in 1936.

A uniform water-rate was charged in the Kistna delta up to last settlement, when the system was superseded in Government lands by a differential water-rate varying with the soil and facilities for irrigation. Zamindari and whole inam lands continue to pay the uniform rate of Rs. 5 an acre. The net effect of this new policy has not been to alter the average water-rate appreciably.

For the option of taking water or not as he pleased on lands registered as "dry", an extra one rupee was charged the ryot and so nearly all cultivators were induced to have their lands transferred to "permanent wet." The present charge for water, excluding this extra rupee, varies from Rs. 6-8-0 downwards on clay soils and Rs. 8 downwards on loamy soils. These rates were based on the prices of nine years ago, and in calculating them, famine years, by the generosity of Government, were excluded from consideration, while deductions for possible vicissitudes of the seasons were included.

4. *Probable value of water.*—Since last settlement, the rise in prices makes the present assessments in the delta extraordinarily lenient; cultivators readily admit a net profit of over Rs. 20 an acre on paddy, the gross value of which crop varies from Rs. 60 to Rs. 140 an acre. Local officials concur in the opinion that upland irrigation will be chiefly confined to paddy which is almost the only crop watered in the Kistna delta, and consequently future conditions in the uplands can be accurately deduced from present conditions in the delta, where it is notorious that the rates charged for water do not nearly approach its actual value.

Owing to the impossibility of getting accurate figures of agricultural expenses the value of water cannot be found directly, but may be obtained indirectly by comparing the market prices of similar dry and wet lands.

The Collector of Guntur suggested the following rule for obtaining this value:—

"Taking the increased value of wet land over similar dry land to represent the capitalized amount of the excess wet produce (25 years' purchase), then $\frac{1}{25}$ th of the increase in value of land + (the charge for water now levied) = approximately the real annual value of water to the ryot."

On this rule, by comparing similar ordinary delta lands worth Rs. 150 an acre as dry land and Rs. 500 an acre as wet land, we obtain Rs. 20 as the value of water per acre.

5. *Method of settling canal alignment.*—When the dam-site was first settled on and the maximum possible height of offtake fixed, a falling contour was run from this level (on a slope sufficient to produce a 3-feet velocity in any canal) until the Gundlacumma river was met near Addanki, 180 miles south.

The first 7 miles passed through unsurveyed forest reserve and a special theodolite survey was made of this area, and the rest of the alignment passes entirely through Government villages possessing fairly accurate survey plans showing each field. On these village maps the alignment was marked and the plans handed over to the Special Revenue Officer and were the basis of his report.

When the gross areas were known and when the whole circumstances had been fully investigated, it was found necessary to lower slightly the offtake level and to steepen the canal slope, and these two changes materially alter the figures which appear in the Special Revenue Officer's report printed in part V of this volume and account for all the variations in figures between this report and his.

The commanded and irrigable areas are in all cases less than those originally given by the Revenue Officer.

6. *Canal alignment.*—Inspection of the irrigation map shows a high ridge running north-east to Amravati on the Kistna river from R.D. 29/64.35 where the canal passes through Bandarupalli cutting. It will be observed that this is a fixed point on any practicable canal and the lower the head of the canal, the more expensive will be this cutting. Conversely the higher the canal offtakes from the dam, the more must diversion level be raised and the life of the reservoir shortened, while the increased area of irrigation is only 2,300 acres per foot of raising.

The compromise adopted necessitates two expensive cuttings besides that at Bandarupalli, viz., Velpur cutting in granitic gneiss with a maximum depth of 23.40 feet at R.D. 10/45.40 and Hussenagaram cutting in micaceous schist and gneiss with a maximum depth of 32.28 feet at R.D. 18/84.30. The maximum depth of cutting anywhere is 91.74 feet in the Mondibodu cutting at R.D. 3/45.30. The maximum height of bank is that which permits of the bed being 7 feet above ground at the margin of a river, that is, if the canal is 11 feet deep, the height of bank would be 21 feet.

7. *Head regulator.*—The main canal takes off from the right flank of the reservoir dam and the regulator is at right angles to the head of the canal and therefore is not quite in line with the dam. It is designed to be capable of passing full supply, 8,878 cusecs, with a difference in water level in front and rear of not more than 1 foot. The regulator has six vents of 16 feet square provided with Stoney's shutters manipulated from the top of the dam.

8. *Canal from R.D. 0 to R.D. 0/9110.*—The canal has to run in steep sidelong ground near the foot of Pulichintala ridge and to pass round a curve of 1,000 feet radius at the end of the ridge, and for economical reasons it was found best to have a canal 15 feet deep at head. The level of canal bed is +174.5, full supply 189.5, bed width 118 feet. Side walling on the left of the canal is necessary for the first 5,022 feet and this wall is founded on hard shale at an average depth of 6 feet below ground surface; the excavation from the canal bed thrown in rear of the side wall resists the water pressure, the wall being calculated only strong enough to hold up the bank when canal is empty.

Access to the top of the dam is obtained by means of a roadway cut out of the hill side on the right of the canal. The gradient of this road from the top of the dam to the point where it reaches canal level, is 1 in 50. At R.D. 0/1,725 this road is taken over the canal by a bridge of four spans of 31 feet each and the road continues down a 1 in 50 slope down the back of the left canal bank to join the present forest cart-track which will have been converted into a metalled road in the first year of construction.

To avoid the sharp 150° bend on the canal with a radius of 1,000 feet (which is less than nine times the bed width) and to avoid side-walling the canal, an alternative alignment involving a tunnel through Pulichintala ridge was investigated. The shortest tunnel would have been 2,000 feet long and a cutting 800 feet long would have joined up with the existing alignment at R.D. 0/6,600 feet. A trial heading was driven into the hill side and the estimated cost of excavation arrived at was As. 6 per cubic foot of tunnel, and this alone would be more than the cost of the longer open canal, whereas the east end of the tunnel for an unknown distance would have required heavy lining. Besides actual increase of cost, the loss of head in the tunnel alignment would have been about 2 feet instead of 1 foot as it now is, to the same point on the canal, and for the same level of offtake, the cuttings at several fixed points on the canal become more expensive, while the irrigable area is reduced. The tunnel scheme was therefore abandoned.

The drainage of Pulichintala ridge which cannot be kept out of the canal amounts to an area of 126 acres and the maximum discharge of this area would be 339 cusecs to an area of 126 acres and the maximum discharge of this area would be 339 cusecs which raises the canal level above F.S.L. by 0.5 foot. In order to provide for this extra capacity, the canal banks are carried an extra 6 inches of height, that is, with a free board of 3' 6" up to the first outlet near R.D. 3/0000.

The forest cart-track parallel to the canal having been made into a road, and since the traffic in any case after construction will be nearly nil, no road is necessary on the top of the canal bank and so the banks are made only 15' top width each side up to R.D. 3/82.80, where the left bank alters to 23' top width.

In Mr. Reid's project exception was taken to the number of subsidiary reservoirs along the line of canal which were proposed as the simplest way of crossing drainages, and only one such reservoir is allowed on this canal alignment, but at R.D. 0/5,800 to 0/7,400 is a 95° curve of 1,000' radius which could be avoided by a dam across the stream joining the left bank of the canal at R.D. 0/3,920 with the hill further east as shown in the plan accompanying the alternative estimate. The dam would be 1,430' long, of a maximum height of 47½' and would cost at head works rates Rs. 2,31,920. The length of canal replaced is 5,190', and including the two small drainage crossings at R.D. 0/69-66 and R.D. 0/91-80 the cost of the longer canal is Rs. 2,71,280. The advantage by using a single dam for crossing these two drainages is a saving of Rs. 39,360. The length of canal by the dam route is 4,120' and the saving in head of water is 0.16' which would cheapen all fixed point cuttings on the canal. The alternative route is cheaper and shorter, but the more expensive alignment is allowed for in the canal estimate.

Round the west side of Pulichintala ridge the excavation is partly in hard blue shale for which a rate of Rs. 35 for excavation is allowed. The surface, however, is soft shale which would cost about Rs. 18 and so an intermediate rate has been adopted. When the east side of the ridge is reached and for the remainder of the alignment in shale, that is to R.D. 3/5,000, no hard blue shale is met with and so a lower rate is taken.

9. R.D. 0/9110 to R.D. 3/8280.—The whole of the shale area at and near the head works has at some time or another been mined for diamonds and is one of several places laying claim to the birth of the great Koh-i-noor diamond. At R.D. 2/4100 a stream bed is crossed by the canal at the site of an old diamond working.

At R.D. 1/3000 the first fixed point on the canal is crossed at a saddle in a ridge which involves a cutting 33½ feet deep. This is in moderately hard shale.

Up to the end of this section the canal lies entirely in forest reserve land and some 260 acres will be occupied. The forest consists of yepi trees which have been lopped by graziers and so spoilt for firewood, and the little revenue obtained by the Forest Department is due to the sale of grazing. Even if good firewood could be grown, its distance from a market would prevent its sale. There will be no difficulty therefore in transfer of the required land to the Public Works Department.

Head works drawing No. H-3 shows by the contours the very rough country in this part of the canal which is further exemplified in the longitudinal sections. Since the soil is nearly pure shale, the banks will be very porous, unless the shale weathers on exposure. To meet this difficulty the banks are set back at least 20 feet in hope of silt settling to form an impermeable berm in front which can further be encouraged by brushwood groynes; but in case this is found ineffective, solid masonry revetment is allowed, whenever the canal is less than 8 feet in cutting.

There are seventeen cross drainage works on this short length of canal as the intervening ridges are too steep to connect them into groups. Only the two drainage basins crossed at 1/1970 and 2/4090 are of larger area than half a square mile. The larger of these two takes the Taduvayi stream at R.D. 1/1970. Its basin is just over 4 square miles and the cost of a syphon aqueduct Rs. 37,800. As moderately hard shale occurs in the bed of all these streams, and as some of them are now liable to a velocity of run-off of over 10 feet a second, it follows that the shale is a sufficiently hard floor and nothing is needed to protect the natural bed of the stream, but to prevent all possible action, concrete is allowed under small vents and the abutments and piers are carried an extra 2 feet deep in the large vents. At most of these works the drain in rear is cut out to form a wide channel for run-off, which, by lowering flood level in rear, will prevent blowing up by water pressure from below when the canal is empty. Earth connections give a hydraulic slope of 1 in 5 at drainage crossings.

In the whole of this section the banks at all stream crossings will be made by tramping earth from the nearest cutting, and it is found that shale can be tramped by hand labour up to "leads" of 5,000 feet cheaper than by excavating for material for a bank at site.

Near R.D. 3/9000 the Buga (vagu) stream is crossed which drains an area of 10 square miles of hilly country covered with scrub jungle and prickly-pear. Owing to the very steep ground slopes along the valley of this stream, a contour canal crossing was found impracticable. Further the Mondibodu ridge at R.D. 3/4500 is such a narrow knife-edged ridge that it was impossible to carry the canal round it on a contour and it was taken through a saddle near the north end at a place lower than any other along this ridge.

No practicable radius for the canal in the cutting through the Mondibodu ridge permits of a contour crossing of the Buga vagu, and a dam had to be provided.

The Buga vagu dam site is the best procurable and cheapest possible site. Foundations are on whitish shale of a very tough nature and only a maximum amount of excavation of 17 feet is necessary. The stream is dry for seven to eight months a year. The type of dam proposed is a mass dam of the ordinary type.

The Mondibodu ridge is of shale with a quartzite cap. Into this cap at the saddle crossing a trial pit, some 30 feet deep, was excavated and the quartzite found was observed to be probably unsuitable for building as it is in a rather comminuted condition.

Further examination of the ridge may show good quartzite elsewhere within easy reach of the dam; but, as granite is found 3 miles east of the dam near Chintapalli village by the Kistna, provision for this material is made. The arches will be built of the masonry which is found at the foot of the ridge within a mile of the dam and also on the margin of the Kistna 3 miles distant. Sand and surki will be brought from the nearest point of the river and water must be pumped 3 miles to the site both for masonry and labourers. The total length of dam is 1,800 feet, maximum height 81 feet, height above ground 68 feet. Plans Nos. V-66 and V-67.

The possibility of the Buga vagu drainage suddenly raising the canal level and tending to breach the banks, has led to the inclusion of an automatic surplus sluice of six vents, 14 feet long × 6 feet high, capable of discharging 5,000 cusecs on a suitable ridge on the left (west) of the dam. This will be probably sensitive enough to open and close the vents within a total range of 3 inches. The type of sluice is similar to that adopted for the recently-finished Darna dam in Bombay, and the automatic movement is due simply to the shutter counterweights becoming submerged when water, rising above F.T.L., falls into the counterweight chamber; the counterweights then cease to balance the shutters and the shutters fall, opening the vents. Conversely, when water sinks below F.T.L., the counterweight chamber has no inflow of water and its outlet sluice soon drains the chamber, then the counterweights regain their weight and raise and close the shutters. Plans Nos. V-68 and V-69.

The canal F.S.L. is considered to fall through the reservoir at the same slope as in the canal above it, but this will only be the case if the reservoir has quite silted up. The F.T.L. of this reservoir is considered as +185 at the dam and surplus sluice, its capacity is 52 million cubic feet, area 475 acres, and full supply in the canal could fill it in under two hours. The area submerged is scrub jungle capable of producing 1 tons of firewood per acre every ten years. The jungle submerged will be used as firewood for burning lime and surki, but no provision is made for the area submerged, since it is all Crown land.

The canal after passing through the reservoir leaves it in cutting beginning at 3/2700, and at 3/3990 crosses a cart-track connecting Chintapalli and Pulichintala villages where a "C" class cart-bridge is allowed.

At R.D. 3/4500 is the second fixed point on any practical canal and this is a saddle in the steep sided Mondibodu ridge. In the centre of the saddle the cutting is 91½ feet in depth, but the total length of the cutting is only 1,800 feet. From surface indications the amount of quartzite in the cutting is estimated and a separate high rate given for this. Immediately after reaching this saddle, the canal turns south on a curve whose radius is 1,000 feet, and skirts the foot of the ridge at a gradually increasing distance from its crest.

After leaving the Mondibodu cutting, the country passed through is comparatively quite flat and easy, but to save height of banks at stream crossings and in order to make it possible to run at a flatter slope and thus command a larger area the canal depth is now reduced from 15 feet to 11 feet and the velocity from 4.75

to 3.91 feet per second. To effect this change the bed is raised 4 feet on a grade of 1 in 50 from R.D. 3/8280 to R.D. 3/8480 and the bed width is gradually increased from 118 feet to 200 feet in the same distance. Up to this point the canal including Buga vagu dam and surplus costs Rs. 30,75,170.

10. *Main canal from R.D. 3/8280 to 10/0580.*—Beginning with this section and a maximum bed width of canal of 200 feet, the minimum radius used is now 1,980 feet or 3 inches on the village map scale, and wherever a curve less than 20 times the bed width is made use of, the outer side of the curve is provided with revetment unless it is in cutting in hard material.

Forest reserve land is left for the first time near R.D. 4/0000 where ryotwari land is entered.

Owing to the cross slope of ground near the Mondibodu ridge and the want of good earth for banks, the latter are revetted with masonry up to R.D. 5/37-90 wherever the depth of cutting is less than 5 feet, and this will prevent leakage.

It is impossible to keep the drainage off the ridge from entering the canal up to R.D. 4/9000 where a syphon aqueduct is allowed and in this distance the canal receives a discharge of 758 cusecs off an area of 0.66 square mile. To permit of the canal carrying safely this extra quantity of water, the free board is increased gradually from 3 feet to 4 feet up to 4/9000, where a surplus escape will let off all excess water. Below this point no drainage is allowed into the canal and the subsequent surplus works permit discharge of canal into the drainage system when heavy rains occur in the irrigated area or when no water is required for irrigation. The surplus escape at 4/9000 has a discharging capacity of 760 cusecs by means of 3 vents worked by hand by screw-gear shutters and these are sufficient to discharge all surplus water in the canal due to rain.

Irrigation on the left bank of the canal begins with 309 acres under a small pipe sluice at 3/6300 and there are sluices irrigating small areas at R.D. 3/6960, 4/0590, 5/2140, 5/4450, etc.; there is no irrigation on the right of the canal anywhere.

At R.D. 6/2100 to 6/3800 the canal has to pass in cutting through solid gneiss in order to avoid Tallacheruvu village-site. Several other cuttings occur in granite, but in spite of the building material that will be thus made available for works in the vicinity, the estimated rates for these works do not take this into account in order to err on the side of safety.

A foot-bridge is provided for this village at 6/4120 and traffic can also go under the aqueduct at 6/0880 whose vents are 9 feet high and 6 feet wide, while a C class bridge for cart traffic is provided at 7/0030, where there is an existing cart-track.

The first aqueduct of any size is that at 7/4970 for a drainage area of 12 square miles; it has 7 vents 12 feet high $\times$ 6 feet wide and its cost is Rs. 71,100. This is the last stream bed crossed by the canal, which has real sand in its bed. Rivers crossed further down the canal do not have pure sand in the beds, but a fine debris similar to sand and formed by the detritus of granitic gneiss rock. It is nearly as good for a building material as pure sand.

Chigurupad channel takes off at 8/8700 and irrigates 3,737 acres, and is the first major distributary taking off the canal.

11. *R.D. 10/0580 to R.D. 15/5504.*—In this length is included the most expensive cutting in the whole length of main canal. The top of this, Velpur cutting, is at R.D. 10/4870 where it is $23\frac{1}{4}$ feet deep, and the high cost is due to the quantity of excavation in granite.

In paragraph 6 it was pointed out that Bandarupalli cutting at R.D. 29/6435 was a fixed point on any practicable upland canal and the cost of this is increased by any lowering of the canal offtake or such as might be caused by an unnecessarily tortuous course for the canal. Two alternatives to this cutting were estimated for at this point and were abandoned for the following reasons:—

Alternative No. 1.—For a contour canal round the end of the ridge. Such a canal would have to pass through Velpur village-site, it would be 2.8 miles round instead of the 1.1 mile it now is. All through Velpur village on a contour, or if

taken in slight cutting above the village-site, the alignment is sprinkled with gigantic granite boulders some of as much as 35 feet in height, and they would cost as much to remove as would a cutting in solid rock. Finally the estimate showed that whereas the cost by alternative route was about the same as the short route, the Bandarupalli cutting was increased in cost and the irrigable area was diminished.

Alternative No. 2.—This proposal was to deepen the canal from 11 feet to 14 or 15 feet and to make it steep enough to run at the correct critical velocity for the increased depth, returning to normal depths and velocities at the end of the cutting. Now it is probable that if no surplus vents are allowed in the main dam, rolled sand will eventually find its way into the upland canal and the critical velocity for Kistna sand is 1.2 times V_c the critical velocity for Kistna silt. A depression of 4 or 5 feet in the bed of the canal would fill up with sand unless the canal velocity were 1.2 V_c . This velocity needed such a large surface slope for the alternative straight cut that over a foot of head was lost by this method and Bandarupalli cutting was consequently more expensive. Moreover, the saving in granite cutting was not very great, since the canal, though narrower, went deeper into the granite, and so by this method the economy was confined to the comparatively cheap excavation in the soils overlying the granite and did not save the excess cost involved at Bandarupalli.

Only two sets of trial pits were run over the ridge for the canal alignment and the one involving least rock cutting was selected. Before making a final selection for construction, a large number of additional pits should be sunk.

The village cart-track intersected at 10/4300 to 11/0000 will be diverted and re-made along the outer edge of the left canal bank.

After getting through the Velpur cutting, the canal runs through the foreshore of the Krosur village tank which in very favourable years irrigates about 40 acres. The two streams that serve this tank are passed under the canal, there is thus no interference with existing supplies and the canal will supplement the present supply as may be required.

At R.D. 11/8490 a stream draining 23.5 square miles is crossed and 10 vents of 12 feet width are provided to convey the maximum possible discharge of 8,205 cusecs under the canal. Owing to the absence of a hard sub-soil here the vents are provided with inverts. For this, as for other large drain crossings, alternative estimates are submitted, one allowing for contraction of the canal over the aqueduct and one allowing normal waterway, and for further remarks on this point, see part B Technical. The two estimates are respectively Rs. 1,29,200 and Rs. 1,49,400; so the saving by contracting the canal is over Rs. 20,200 in this case. Contraction of the canal allows for increasing its velocity from normal to 5 feet a second.

At R.D. 12/3925 is a drainage crossing for 20 square miles, which requires inverts for its vents and the cost of this for contracted and normal waterways is Rs. 1,02,900 and Rs. 1,16,900 respectively; so the economy due to contraction at this syphon aqueduct is Rs. 14,000.

The canal is all of normal type along this length with the exception of the number of large drainages crossed by it, and cart and foot bridges are provided at suitable intervals throughout.

At R.D. 14/2560 and 15/5500 are two streams draining respectively 60.5 and 84.5 square miles. These two meet below the canal to form the Eddu vagu which runs north-east into the Kistna. The first of them requires inverts for its vents due to absence of hard sub-soil, and the second which is built on granite or hard schist requires no floor and advantage is taken of this hard foundation to put surplus shutters in the sides of the aqueduct at the rate of two surplus vents to each aqueduct vent. The cost of the first of these when contracted and normal is Rs. 1,32,800 and Rs. 1,50,000 respectively, and the cost of the second is Rs. 1,50,200 and Rs. 1,73,100 respectively. It is impracticable to cut one into the other on account of the high ridge between at R.D. 14/5300, where the canal cutting is $21\frac{1}{4}$ feet deep in decomposed granite. The surplus sluices in the second of these aqueducts have a maximum discharge of 4,192 cusecs.

included in the typical area worked out for a distributary system. Owing to the canal having been taken too deeply in soil at this offtake, R.D. 29/9075, the same mistake was made about the branch, which can also be cheapened by being taken further out of soil. There are no further works of importance on this reach of canal.

14. R.D. 31/6950 to R.D. 40/7200.—Up to this point the canal has been entirely in Sattenapalli taluk. This reach begins in Guntur taluk with the canal 11 feet deep and 152 feet bed width and the irrigation below its head extends to 466,561 acres. At the tail of this reach the canal is 10 feet deep and 104 feet bed width and the irrigation below the tail is 276,602 acres. The earthwork in this reach and those below is far less expensive than in those above, as there are no more large cutting; also, since the greater part of this section runs at the foot of the range of granite hills called Kondavid, the drainage basins crossed are very small.

For the cart track from Guntur to Peddapalakalur, a "C" class bridge is provided at R.D. 32/2450.

Guntur branch canal takes off at R.D. 32/7700 and irrigates 122,200 acres with a discharge at the head of 1,692 cusecs. This is the largest single offtake from the canal. At this point the canal is reduced in width to 110 feet and for the rest of its length, its bed width is about 10 times its depth.

The Madras and Southern Mahratta metre gauge railway from Guntur is crossed at R.D. 33/0550, and in order not to interfere with the present grading of the line, the canal is taken 5 feet below rail level in a 16 feet cutting. The estimate for this bridge was made by the Chief Engineer of the metre gauge line and amounts to Rs. 26,000. This includes cost of temporary diversion, signals, etc.

Below the Guntur branch the canal depth decreases to 10 feet and the change is effected by keeping the same surface slope but with the bed horizontal for about $1\frac{1}{4}$ miles. This prevents loss of head.

At 35/3400 is a surplus escape which with the regulator below, will be very effective.

At 33/3500 an important District Board metalled road is crossed and a wide masonry bridge is provided. On account of the size of the Guntur branch offtake just above, it is desirable to have a regulator close below it, so one is combined with this bridge. The regulator is composed of 26 vents of 6 feet span, and screw geared shutters are provided. To prevent any loss of head at this regulator the waterway through it is the same as in the canal.

At R.D. 35/3500 the trunk road to Madras is crossed and a "B" class bridge provided, and afterwards the canal runs along the lower side of the road for about 4 miles.

The largest drainage catchment crossed in this reach is $4\frac{1}{2}$ square miles at R.D. 36/8200 and the small drain at 36/4800 is cut into this.

A large distributary irrigating 10,077 acres takes off at 36/5700, and two others irrigating 21,000 and 12,450 acres, respectively, take off at R.D. 37/9700 and 39/5200 and there are no other important works in this reach. At 39/2200 the line leaves Guntur taluk and enters Narasaraopet taluk.

The Guntur-Madras road is again crossed by a "B" class bridge at R.D. 39/8300.

The average width of land occupied in this reach is 349 feet and the average cost of earthwork is Rs. 6.56 per foot run.

15. R.D. 40/7200 to R.D. 54/7700.—This reach is 10 feet deep up to R.D. 47/7500 where it is gradually reduced to 9 feet and remains at this depth for the rest of the reach.

The most noticeable feature of this length is the catchment area of cross drainages which amounts to 435 square miles for 14 drains.

There are nine "C" class and one "B" class bridge in the reach.

From this reach onwards the radii of curves are always more than twenty times the bed width and so no revetment is necessary for protection of the canal bank on the concave side at any curves from R.D. 40/7200 to the end of the canal.

The whole section lies in the Narasaraopet taluk.

At R.D. 42/5000 and 45/5000 where the canal is in bank, the distance from the neighbouring cuttings is too great or the quantity of cutting is insufficient to tram earth to form banks and the banking material has to be obtained from borrow pits. This is exceptional.

At 42/8100 is a syphon aqueduct crossing a drainage of 44.5 square miles and costing Rs. 71,600, and at R.D. 44/4600 is a similar work costing Rs. 77,400.

A large offtake at 47/7500 irrigates 33,280 acres and a regulator combined with a bridge is placed on the canal just below the offtake to adjust the discharge correctly between the canal and the branch. The cost of the combined bridge and regulator is Rs. 16,000. This is the second regulator from the head of the canal.

The 21 feet deep cutting at 46/9200 is necessary to avoid the important Nadella village site, and the 19 feet cutting at 49/9500 is necessary to avoid Kavur village.

A "B" class bridge at R.D. 50/0400 is provided for the District Board metalled road which connects Narasaraopet and Chilakalurpet.

At R.D. 50/6700 is a large syphon aqueduct over a stream draining 100.5 square miles. The cost of this if the canal is contracted and velocity increased to 5 feet a second, is Rs. 89,600; if canal is retained at normal section, the cost would be Rs. 1,10,550. This is the second largest drainage crossed by the canal.

At R.D. 53/8800 is the largest stream crossed anywhere by the canal. It drains 212.5 square miles. Owing to soft sub-soil, inverts have to be provided. The vents are 12 feet span and the length of the aqueduct between abutments is 368 feet 6 inches.

Its cost with a contracted canal section is Rs. 1,72,100 and if uncontracted, the additional cost would be Rs. 34,000 more. This shows the great economy that can be derived by canal contraction if adopted. This is the most expensive cross drainage work on the canal.

At R.D. 52/1700 a major distributary irrigating 7,126 acres takes off.

16. R.D. 54/7700 to R.D. 77/6500 (the end).—At the head of this length is the largest portion of the canal in banks that is allowed at any place. This banking is necessary to avoid Boppudi village site. If the alignment is taken above the village, it would require cutting in granite.

From 56/0500 to 57/0500 the canal on a curve cuts off part of the Guntur-Madras trunk road which will be diverted round the left bank and the bank will be metalled.

At R.D. 56/3700 a branch canal irrigating 60,066 acres takes off leaving the canal to irrigate 162,867 acres. The main canal is then reduced in depth from 9 to 8 feet.

The canal is now more or less normal from here up to R.D. 59/3000, where a large syphon aqueduct is allowed for a stream having a catchment basin of 59.3 square miles. With a contracted canal the cost of this work is Rs. 1,13,000, and if uncontracted, the cost will be Rs. 1,32,125.

There is another large aqueduct at R.D. 61/6560 over a drain with a basin of 31.4 square miles; the cost is Rs. 62,000 if contracted or Rs. 73,950 if uncontracted. From this point on the canal down to the end, there is no other stream of more than 7 square miles catchment area at the point of canal crossing and so no contraction of the canal is proposed at any of them.

Besides 10 "C" class bridges in this reach, there is one "B" class bridge at R.D. 61/2900 on the Guntur-Madras trunk road.

At R.D. 64/7000 is an offtake for a major distributary irrigating 19,961 acres. At R.D. 65/7000 is another major irrigating 27,585 acres and another at R.D. 66/0250 irrigating 2,280 acres.

Immediately below this is a regulator combined with a bridge and the canal is reduced in depth to 7 feet and the irrigation below the regulator is 101,160 acres.

At R.D. 66/5000 the canal leaves Narasaraopet taluk and enters Bapatla, but leaves this to enter Ongole taluk at R.D. 67/5000.

At R.D. 67/6000 is a branch canal offtake irrigating 25,586 acres and immediately below this the canal is reduced in depth to 6 feet.

There are no other works of any importance on the canal except the offtakes of some large distributaries at 73/1000 and 75/9000 below which the canal decreases to 5 feet in depth.

The end of the canal tails into the Kanuparti branch which is also 5 feet deep and irrigates 28,410 acres. A major distributary runs on a contour till it meets the Addanki-Ongole road which forms the boundary of irrigation and this distributary takes off at R.D. 77/6500 which is the end of the canal.

17. *Branch canals.*—The following branch canals are required in the upland canal system:—

Name of branch.	Cost.	Length in feet.	Area irrigated.
	Rs.		Ac.
1. Tadikonda	2,60,725	74,000	54,913
2. Guntur	2,59,900	76,400	
3. Ankireddipalem	1,47,260	34,750	122,200
4. Elur	1,53,220	68,500	33,280
5. Boppudi-Annavaram	70,895	20,200	
6. Anantavaram	25,845	6,700	60,066
7. Buggapad	55,970	16,000	27,585
8. Kanuparti	46,515	15,810	28,573
Total ..	10,18,880	58½ miles.	..

Of these, part of Tadikonda branch and the whole of Kanuparti branch come into the typical system in which areas for irrigation have been set out in detail.

Except in the typical block no irrigation details have been set out and the averages of the typical blocks are adopted as suitable for the balance; thus, the typical blocks show that pipe sluices on branches irrigate 100 acres each on an average and that there is one pipe sluice every 1,577 feet. Consequently the whole direct irrigation from branches is 20,000 acres. All branches and major distributaries are marked on the 2" to 1 mile irrigation map drawings Nos. V. 1 (1), 1 (2), 1 (3), 1 (4) and 1 (5).

There are no special remarks to make about branches which are irrigation channels, other than the main canal, of over 300 cusecs capacity.

The falls in branches which are aligned along the principal watersheds in the commanded area are less steep than in the case of minor ridges, and there are few places where cross drainages are necessary.

18. The plans furnished with the estimates for the main canal and branches are—

Sheets of survey and longitudinal sections, main canal	56
Do. do. branch canal	24
Special survey sheets, main canal, excluding contour maps	2 (H ₂ & H ₃).
Cross sections sheets, main canal	230 sheets.
Typical cross section sheets, main canal	4
Plans of masonry works, main canal	54
Type plans of masonry works, main canal	10
Plans of masonry works, branches	32
Bugga Vagu Dam, main canal	5
Subsidiary dam	1

All the above are contained in portfolio Nos. 7 to 10 and 16 to 19.

The portfolios of office copies contain the cross sections of main canal along its whole length, but the copies submitted with the estimate include only 13 typical cross sections of main canal of different depths.

B.—Technical.

19. *Velocity suitable to main canal and branches.*—The critical velocity adopted is 1.0 V_c (V_c is Kennedy's Critical Velocity for Punjab sand). This is adopted from observations made in the Kistna delta canals during the last 3 years.

20. *Depth of canal.*—From R.D. 0/00-00 to R.D. 3/82-80 the canal passes through difficult country turning through sharp curves and the depth of the canal is therefore kept as high as 15 feet, so that the bed width and consequently the curve radius may be as low as possible. Beyond R.D. 3/82-80, where the canal gets into open country, the depth is 11 feet. This depth gets gradually reduced as the canal becomes smaller. The maximum velocity of the canal from R.D. 0/00-00 to R.D. 3/82-80, where it runs through shale cutting, is 4.75 F.S. and below that point the maximum velocity carried in unprotected side slopes is 3.91 F.S. and it is considered not safe to exceed this.

21. *Fall of canal.*—The normal surface and bed falls given to the main canal to give the above velocities vary from—

0.151 per 1,000 near the head to
0.190 per 1,000 in the tail reach.

22. *Coefficient of rugosity.*—The coefficient of rugosity (N) in Kutter's formula, on which calculations have been made is:—

For canals over 600 cusecs capacity N = 0.020.
Do. under 600 do. N = 0.0225.

23. *Standard side slopes.*—The standard side slopes worked to are—

For cuttings in	1. Red earth 2. Black cotton 3. Decomposed lime stone 4. Kankar 5. Gravel	1 to 1
Do.	1. Decomposed granite 2. Hard kankar	½ to 1
Do.	1. Schist 2. Shale	½ to 1
Do.	Hard granite	Vertical.

For purposes of discharge, computations have been made as if the side slopes were ½ to 1, except where the canal is in cutting through shale or schist where the side slope is taken as ¼ to 1.

24. *Standards of banks and berms.*—The general standard adopted for banks, berms, etc., is shown in the following table:—

TABLE showing standard dimensions of banks, berms, etc., for the main and branch canals.

Items.	Main canal and branches.			Remarks.
	10,000 to 1,000 cusecs.	1,000 to 400 cusecs.	400 to 300 cusecs.	
Width of berm of canal	$4 + \frac{Qd}{1,000 \times 2}$ d = depth of cutting & Q = discharge in cusecs.	$4 + \frac{d}{2}$	$4 + \frac{d}{2}$	When velocity exceeds 2.21 F.S. add D, depth at F.S.L., to berm width.
Crest width of widest bank	23 feet with dowel on inner edge.	15	15	Dowel 1½ feet top, 1 foot high and side slopes 1½:1.
Crest width of other bank	15	10	8	
Free board	3	2½	2½	
Depth of earth over hydraulic gradient.	4	3	3	Should the outer slope not give enough earth over the hydraulic gradient the slope is stepped out end berms.
Width of land to be acquired clear of banks when canal is in cutting deeper than balancing depth.	15	Half height of bank subject to a minimum of 5 feet.		The width to be computed to nearest whole foot.
Width of land to be acquired clear of banks when canal is in less than balancing depth of cutting.	15 feet and in addition the full height of bank above ground.	5 feet and in addition the full height of bank above ground.		

25. *Full supply capacity of canals.*—The canals are designed to carry the water required at the lowest duty for the whole area to be irrigated with additional allowance for "Seepage". The duty fixed as the "lowest" is 73 acres per cusec at the head of distributaries on "direct offtakes" from main or branch canals.

26. *Allowance for seepage.*—The nature of soils through which the canals run varies considerably, but generally consists of black cotton earth of varying depths, over a bed of decomposed limestone or gravel; except from R.D. 0/00-00 to R.D. 3/82-80, where the canal passes through shale. In some parts of the branch canals there is a subsoil of red earth. The following losses are allowed for the several soils as noted below :—

Black cotton soil	...	...	...	No seepage.
Shale or gravel	...	...	...	6 cusecs per million square feet of wetted area.
Red earth	...	...	...	4 cusecs.
Rock	...	...	...	2 cusecs.
<i>Total seepage loss—</i>				
Main canal	...	...	...	488 cusecs.
Branches	...	...	...	32 cusecs.
Total				520 cusecs.

Wherever a channel is less than 300 cusecs capacity, there is no allowance for seepage made.

27. *Surveys.*—The alignment of the Kistna Upland Canal System is based on the following surveys :—

(a) Block maps 8" = 1 mile. These maps are compiled from the revenue survey village maps and on these are plotted at intervals of about $\frac{1}{4}$ mile, lines of levels termed "block levels" or "country levels".

With the aid of these levels and the plotted lines of drainages, contours at 5 feet intervals (2 and even 1 foot intervals in cases of flat country) were interpolated on the block maps showing the configuration of the country.

These maps reduced to 2" to a mile are the contour maps accompanying the estimates. From these maps the general alignment of the main canal and branches was laid out first on the map and then on the ground.

Resurvey and levelling on the ground of the lines so tentatively adopted followed, and realignment in such respect as seemed desirable carried out.

In tracing the main canal, endeavour to run at near balancing depth has been made, while the radius curves have been restricted to a minimum of about 20 times bed width, or in default the outer slopes of such curves have been protected with revetment.

When finally levelling the alignment of main canal, cross sections of considerable length have been taken at about 500 feet intervals so as to allow of minor alterations being made in office, should such prove to be desirable.

Branch canals have been generally aligned on the crest of ridges without cross sectioning, but for short lengths where the ridge crest has been left, these canals have been laid out on the same general lines as the main canal.

28. *Preliminary expenses (A).*—As in the case of the head works, these expenses are of two classes—

(a) Expenditure already incurred in the investigation on surveying, levelling, digging trial pits, and in the preparations of plans and estimates accompanying this report.

(b) Expenditure which will be incurred after sanction of the estimates by the Secretary of State, such as setting out works, clearing work sites, additional survey and levelling if found necessary, and lockspitting boundaries of land to be acquired for the information of the Revenue Department.

Including investigation for the delta extension scheme the total cost of investigation was 3.14 lakhs and the amount assumed to have been spent on alignment, etc., of main canal is Rs. 68,000. This amount is added as a separate figure in the sub-head Preliminary expenses.

The amount still to be spent is estimated for at the following rates :—

		Rs.
Main canal	147 $\frac{1}{4}$ miles at 100 rupees a mile =	14,725
Branches	58 $\frac{1}{4}$ miles at 60 " a mile =	3,585
	Item (b) ...	18,310
	Item (a) as above ...	68,000
	Total ...	81,310

29. *Land (B).*—*Land widths and general cost of land.*—The width of land proposed to be acquired is in conformity with the width of banks, berms, etc., given in the statement appended under paragraph (6). The general cost of land to be acquired as given by the Special Revenue officer is as follows :—

Name of taluk.	Present sale value per acre.	Compensation value per acre including 15 per cent. for compulsory acquisition.	Rate of acquisition per acre for wet lands under tanks.
Guntur	Rs. 128	Rs. 150	Rs. 225
Bapatla	110	125	185
Ongole	95	110	165
Narasaraopet	85	100	150
Sattenapalli	84	100	150

The total area occupied by the main canal, Buga Vagu Reservoir waterspread and side drains is as follows :—

	ACS.
Forest reserve	719
Other land	5,878.5
The area occupied by branches is	919
Total	7,516.5

30. *Regulators and sluices (D).*—*The head regulator.*—The head regulator of the Kistna Upland Main Canal consists of 6 vents 16' x 16' provided with Stoney's shutters and the six vents are capable of discharging the full supply of 8,878 cusecs.

With a difference of water level in front and rear of not more than one foot the sill of the regulator and the canal bed level are + 174.50, while the floor level of sluice is + 173.50 (i.e.) one foot below sill; the piers are nine feet thick.

31. *General type of regulator and sluices.*—The other regulators and sluices will be of the ordinary type with vents not more than six feet wide, regulated by screw-gearing shutters of the ordinary Madras type.

32. *Discharge capacities of sluices.*—All sluices with heads in the main canal are designed to be capable of passing full supply through the sluice from half supply level in the parent canal. This applies to all canals of over 300 cusecs capacity.

From branch canals and distributaries, however, the sluices are designed to pass full supply only with full supply level in the parent channel. These sluices are however designed on a type facilitating economical arrangement of the tunnel, should this become desirable.

Sluices for "direct irrigation" will be pipe sluices with masonry head and tail walls, and with a vent stone in the head wall. In places where the F.S.L. in the canal is more than eight feet, "tower heads" are provided in front instead of head walls.

Where canals are of over 1,000 cusecs capacity, pipe sluices are designed with cast-iron pipes. For smaller canals earthenware pipes are used.

33. *Regulators across the main canal.*—Regulators across the main canal are provided below points of offtake of branch canals and at places where there are changes in the depths of water. Such regulators are provided on the main canal below the heads of—

(i) Guntur branch canal	At R.D. 33/34-00
(ii) Elur branch canal	At R.D. 47/77-50
(iii) Daggupad branch canal	At R.D. 65/48-00

34. *Falls and weirs.*—The number of falls on branch canals are noted below:—

	Length. MILES.	Number of falls.
(i) Tadikonda branch canal	14.6	Nil.
(ii) Guntur branch canal	14.5	7
(iii) Ankireddipalem branch canal	6.6	9
(iv) Daggupad branch canal	3.0	2
(v) Boppudi Annavaram branch canal	3.8	5
(vi) Ellur branch canal	13.0	11
(vii) Anantavaram branch canal	1.3	2
(viii) Kanuparti branch canal	3.0	1

The falls and drops with data of designs adopted for the branch canals are given in detail in drawings in portfolio No. 10.

35. *Computation of run-off from cross drainages.*—For computing the necessary capacity for cross drainage works for the Kistna Upland Canal, the discharge given by a coefficient 1,000 with Ryves' formula has been adopted. The choice of this coefficient is fully discussed in Part I, section IV, paragraph 173.

36. *Velocity through culvert.*—It has been considered prudent to design the cross drainage works for a maximum velocity in the culverts of 10 F. S., although a greater velocity could be occasionally safely passed and this gives a margin of safety beyond the discharge computed from the above coefficient.

37. *Cross drainage works (F)—Types of cross drainages.*—The types for cross drainage works provide generally for passing the drainage under the canals. In one case only near Kotapad at R.D. 69/3460, is the main canal syphoned under the drainage.

38. *Objections to drainage syphons and how dealt with.*—In order to avoid carrying the canal in bank for long lengths, the drainage is generally syphoned under the canal, the floor of the drainage culverts being below the natural bed of the stream.

The objections to such a type of work is the tendency to fill the barrel up with silt to the level of the stream bed below the work, and there is a risk, where the crown of the culverts is below or almost level with this bed level, that almost all water-way in the culverts may be filled up with sand, etc. There is danger in a case of a sudden flood heading up and breaching the canal or submerging the country above it, before the flow through the syphon can clear for itself sufficient water-way.

To guard against this, on the recommendation of the Inspector-General of Irrigation, a standard rule of design has been adopted that the underside of the crown of the arch of the culvert must not be at a lower level than three feet above the bed of the stream at the outfall end of the work. In the works estimated for, this rule frequently necessitates cutting out the bed of streams below the works to suitable falls and widths to conform to it and to carry off the computed maximum discharge through the work and such excavations are, where necessary, provided for in the estimates for the syphon aqueducts. The estimates provide for masonry, built of coursed rubble in surki mortar plastered with portland cement all round the tunnel and pointed with ordinary mortar all about the exterior of the work.

In all cases of impervious soil or sub-soil no floors are provided for these works, but if the sub-soil happens to be pervious, the work is made to rest on masonry inverted arches over lime surki concrete slab foundations. The inverts are so designed as to be sufficiently strong to resist the blowing up pressure on the culvert floor.

39. *Data of designs—Cross drainage works.*—The pressures allowed on coursed rubble in arches or piers have been limited to an average over the sectional area taking the weight of about four tons per square foot and the thickness of piers and arches are proportioned so as not to exceed this. Banks and bank connection allow a hydraulic gradient of one in five. The pressure tending to blow up the arch over the culverts is computed from the maximum water level below the work plus the head required to overcome friction in the culverts. Velocity through the culverts is restricted to ten F.S.

The calculations for the heading up above syphon culverts is computed by Dr. Unwin's formula with co-efficient of loss on entry of .505 and neglecting all velocity of approach.

It not infrequently happens that the computed maximum water level above a work calculated as above, leaves too little depth over the crest of the drop wall (or the top of the inlet slope) to allow of the flow over these of the maximum computed flood.

In such a case the drop wall has been considered as a broad-crested weir, discharging without velocity of approach and the depth over the drop wall required to discharge the maximum flood has been taken as the M.F.L. above the work, when this is higher than due to other computed level, which is the depth in the cistern between the drop wall and entrance of the culverts.

40. *Types of cross drainage works.*—The general types of syphon aqueducts or culverts adopted may be classified under three heads—

Type I.—The culvert carries the drainage under the canal and its banks without any contraction or alteration of the cross section of the latter. This type is adopted for works of small capacity.

Type II.—The canal at full width and its earth banks is carried over the drainage culverts, but the outer slopes of the canal banks are cut off and retained by face walls and the top widths of banks limited to 15 feet. In both these types the entry and exit of the drainage water in the culverts is generally by slopes not steeper than 1/3 and culverts are of spans of 6 feet and 4 feet.

Generally these slopes are run under the banks thus diminishing the total length of culvert required.

Type III.—The canal either with full bed width or with contracted bed is carried over culverts between masonry walls providing over them a foot-way on one side and a cart road on the other.

This type is in most cases restricted to a standard span of culvert of 12 feet with arches with 2 feet rise. The entry of drainage is by a drop wall, but exit is by a slope not steeper than 1 in 4. The type is economical in the cases of drainages of such large discharge capacity that the total linear floor width of culvert waterway exceeds 54 feet.

41. *Contraction of canals in aqueducts.*—It is recognised that contraction of the canal through an aqueduct may be made where material difference of cost is realized, and in estimating the cost of aqueducts on the main canal, the full waterway is allowed without any contraction whatever only for types I and II and for aqueducts of type III combined with surplus arrangements.

The extra cost of these works, when the canal is not contracted in the aqueducts of type III is also worked out and entered in each estimate.

The general data of design for cross drainage works are dealt with at more length in Special Superintending Engineer's note No. 116-I/111, dated 12th September 1910, in which further details regarding types adopted will be found.

42. *List of cross drainage works.*—The list of the cross drainage works, with full details regarding waterway, discharges, areas intercepted will be found in Volume III, appendix I.

43. *Bridges (G)—Types of bridges.*—The road bridges provided are divided into two classes:—

(a) *Bridge B class—carrying existing District Board roads over canal.*—These are 14 or 16 feet between wheel-guards, generally the former and can carry two lines of cart traffic. (They are capable of carrying B class loads as specified in Chief Engineer's circular No. 4473-C. dated 15th September 1908.)

(b) *C class bridges.*—These are 10 feet wide between wheel-guards and can carry only a single line of cart traffic.

They are provided for existing cart tracks and elsewhere when cart bridges are considered necessary. (They can carry C class loads.)

It is recognised that road bridges over canals of the ordinary stone arch type are usually most economical both as regards first cost and upkeep where the foundations stand on good soil. Stone-arched bridges, however, are not so very quickly erected as those in which the road way is carried on rolled-steel beams over masonry piers, while the amount of masons' labour is materially less.

As the amount of masonry to be built in connection with this project canal system is great, it is considered prudent to provide for bridges of the latter class, and economise in masons' labour. If no difficulty exists as regards this, the sums provided will more than cover the cost of stone-arched bridges which can be substituted for the type estimated for.

44. *Different classes of bridges.*—The following instructions regarding types of bridges with the two attached statements give details on which the types of bridges have been designed.

The spans in all cases have been limited to a maximum of 40 feet clear, and the decking is Westwood's trough plates supported by rolled steel beams of standard sections.

Where bridges are 10 feet wide, piers are provided 4 feet longer than necessary to carry the beams: and where 14 feet wide, 2 feet longer to give facilities for widening the roadway at any future time.

45. *Design of bridges.*—(i) "*C*" class bridges.—Ten feet between wheel-guards of one type throughout as below:—

These are made of two rolled steel beams over the span at 8 feet centre. The flooring to be $10\frac{1}{2}$ feet long; Westwood's trough plates $\frac{5}{8}$ inches deep $\frac{1}{4}$ inch thick, 2 feet 8 inches centres between sections and 1 foot 4 inches between centres of troughing. This weighs 15.52 lb. per square foot.

This will be filled with concrete of Portland cement mortar 1 to 3 to 2 inches over the top of plate or a total average $4\frac{1}{2}$ inches of concrete.

(ii) "*B*" class bridges.—Generally 14 feet width between wheel-guards and to be carried always on three rolled-steel beams spaced at 6 feet centre to centre.

Flooring to be trough plates $14\frac{1}{2}$ feet long and of same section and thickness as for the C class bridges (viz.) 15.52 lb. per square foot filled with cement concrete to similar depth.

(iii) "*B*" class bridges.—For 16 feet wide road bridges four main girders will be used and the flooring plates will be 4 inches deep, $\frac{1}{4}$ inch thick of 13.95 lb. per square foot. No other alteration is made.

(iv) *For all bridges.*—For spans exceeding 30 feet, the rolled beams will be cross-braced in two places with an angle iron frame $2\frac{1}{2}'' \times 2\frac{1}{2}'' \times \frac{3}{8}''$ dividing the span into three.

Statement showing the rolled-steel girders and trough plates chosen for various spans of "C" class bridges.—Width of roadway = 10 feet between wheel-guards equivalent of maximum load including weight of flooring plates = 208 lb. per square foot.

There will be two girders 8 feet centres, and the trough plates will be section I, $\frac{1}{4}$ inch thick, weighing 15.52 lb. per square foot for all spans.

Span in feet ..	15 to 22	23 to 24	25 to 26	27 to 30	31 to 35	36 to 40
Roller-steel beam	$15'' \times 5'' \times 42$ lb.	$14'' \times 6'' \times 57$ lb.	$16'' \times 6'' \times 62$ lb.	$18'' \times 7'' \times 76$ lb.	$20'' \times 7\frac{1}{2}'' \times 89$ lb.	$24'' \times 7\frac{1}{2}'' \times 100$ lb.

Statement showing the rolled steel girders chosen for the various spans of B class bridges mentioned below:—

bridges mentioned below:—

Trough plates	B class	14 feet width of roadway between wheel-guards. 16 feet width of roadway between wheel-guards.	Section I, $\frac{1}{4}$" thick weighing 15.52 lb. per square foot. Section K, $\frac{1}{4}$" thick weighing 13.95 lb. per square foot.				
Number of girders	B class	14 feet : 3 girders 16 feet : 4 girders	5 feet centres. 5 feet centres.				
Spans in feet	15 to 21	21 to 23	24 to 25	26 to 29	30 to 33	34 to 37	37 to 40
4' wide roadway 3 beams 6' centres.	Central $15'' \times 5'' \times 42$ lb. Sides $15'' \times 5'' \times 42$ lb.	Central $14'' \times 6'' \times 42$ lb. Sides $15'' \times 5'' \times 42$ lb.	Central $16'' \times 6'' \times 62$ lb. Sides $16'' \times 6'' \times 62$ lb.	Central $18'' \times 7'' \times 76$ lb. Sides $16'' \times 6'' \times 62$ lb.	Central $20'' \times 7\frac{1}{2}'' \times 89$ lb. Sides $18'' \times 7'' \times 76$ lb.	Central $24'' \times 7\frac{1}{2}'' \times 100$ lb. Sides $20'' \times 7\frac{1}{2}'' \times 89$ lb.	$24'' \times 7\frac{1}{2}'' \times 100$ lb.
Span	15 to 22 feet	23 to 25 feet.	27 to 31 feet.	32 to 35 feet.	36 to 40 feet.		
16 feet wide roadway. Four beams at 5 feet centres.	Central $15'' \times 5'' \times 42$ lb. Sides $15'' \times 5'' \times 42$ lb.	Central $16'' \times 6'' \times 62$ lb. Sides $16'' \times 5'' \times 42$ lb.	Central $18'' \times 7'' \times 76$ lb. Sides $16'' \times 6'' \times 62$ lb.	Central $20'' \times 7\frac{1}{2}'' \times 89$ lb. Sides $18'' \times 7'' \times 76$ lb.	$24'' \times 7\frac{1}{2}'' \times 100$ lb. $20'' \times 7\frac{1}{2}'' \times 89$ lb.		

N.B.—Above are calculated for load (including weight of floor plates) of 208 lb. per square foot.

46. *Foot bridges.*—These are designed to carry an external distributed load of 80 lb. per square foot.

The type selected and estimated for consists of 2 rolled beams of span not exceeding 34 feet and spaced at 5 feet centre to centre carried on masonry pillars.

The decking is carried on the lower flange of the beams and consists of bent corrugated iron sheets 18 gauge butted on to the girders on each side and filled over with 6 inches of gravel. The rolled beams are prevented from spreading by angle iron stays passing under the beams and connecting the standards carrying the hand rails.

The standards are spaced at 8 feet apart. Intermediate between these, a tie of 1 inch square iron passing under the beams bent round their lower flanges adds additional stiffening.

After some years the corrugated sheets will rust through; it is then proposed to remove the gravel and lay 9 inches brick jack arches over the corrugated iron and fill up level with lime concrete. This is an inexpensive work and will be a charge against "Maintenance."

It will be cheaper to put in stone arches originally, but it is not proposed so as to save masons' labour required for other works.

Generally spans for foot bridges will be 20 feet and over up to 34 feet.

The steel beams required are—

Span 20 to 27 feet	...	...	...	...	$12'' \times 5'' \times 32$ lb.
Span 28 to 34 feet	...	...	...	...	$15'' \times 5'' \times 42$ lb.

47. *Number of bridges.*—Details regarding the numbers of bridges provided and their distribution on main and branch canals will be found in appendix II, Vol. III, of the report.

48. *Escapes*.—At R.D. 3/00-00, the whole of drainage of Buga Vagu is intercepted by a masonry dam and absorbed into the main canal and this drainage from a catchment of 10 square miles is disposed of by means of an automatic surplus sluice at the left end of the dam. They are designed to be automatic in action as in the Darna dam sluices, with a view to prevent the canal water from rising above the F.S.L. and thus causing breach or damage to the canal banks. Excepting this, and also two small drainages one at Pulichintala ridge and the other at Mondibodu ridge of catchment areas 0.20 and 0.66 square miles, respectively, it is nowhere proposed to admit drainage into the main canal. The drainage at Pulichintala ridge is got rid of at the Buga Vagu dam surplus sluices; and that at the Mondibodu by the side vents in the aqueduct at R.D. 4/90-00.

In addition to these surplus arrangements an outlet weir 250 feet long is also proposed on the left bank of the canal at R.D. 6/51-10.

It is, however, considered advisable to provide some escapes in the shape of surplus where convenient, at intervals along the canal line and above the regulators so that in cases of emergency, such as breaches and leaks, water may be cut off at once. With this object, escapes in the shape of surplus sluices are provided at R.D. 3/00-00, 15/55-04, 33/34-00, 46/47-00 and 65/48-00 on the main canal.

49. *Buildings (K)*.—The length of the main canal is 147½ miles and the length of the branches aggregate to 59.8 miles.

Fifteen permanent bungalows are provided. In addition to these, provision is made for temporary inspection sheds at an estimated cost of Rs. 15,000 which will be required during execution. The permanent bungalows will be located at every 10 miles along the main canal line. The temporary sheds will be located at intermediate places and in the tracts served by the distribution system.

Three sets of permanent quarters for staff are proposed at a cost of Rs. 50,000 each set. The staff will consist of Executive Engineer, Assistant Engineers, Upper Subordinates and Office establishment.

In addition to these, lascars' sheds are provided at sites of all regulators and surplus sluices.

50. *Earthwork (L)*.—The nature of the soil to be cut through is generally black cotton of varying depths overlying a bed of gravel, kankur, decomposed lime stone, or granite. From head to R.D. 3/82-80 of the canal where it passes through reserved forest, the soil and sub-soil are shale of different hardness. There are four other places which will be dealt with separately later on, where the canal passes through deep cutting and the soils and the sub-soils at those places are different from the general character noted above.

Different data for the rates to be allowed have been prepared to suit the nature of the soil, lead, and lift, and these rates have been entered in the estimates. But as the nature of the country which the main canal traverses is highly undulatory, the earth cut out of ridges is generally jammed off to fill up the adjoining valleys and any balance left is thrown on the spoil banks. The following are the initial rates allowed for the various soils as noted below:—

	Per unit.		
	Rs.	A.	P.
(i) Black cotton soil	3	14	0
(ii) Gravel or kankur or decomposed stone	8	8	0
(iii) Decomposed granite	16	0	0
(iv) Yellow shale, Rs. 15 to	25	0	0
(v) Blue shale, Rs. 25 to	35	0	0
(vi) Hard kankur, laterite, etc.	35	0	0
(vii) Schist	40	0	0
(viii) Hard granite	70	0	0

The cost of each extra "lead" or "lift" is As. 4-6 for black cotton earth or other light material and As. 5-8 for other heavier materials per unit. The initial rate for tramming up to a furlong's distance is Rs. 3-8-0 for all materials for unit and for distances beyond that As. 13-0 per unit for every additional furlong.

51. *Plantations (M)*.—Plantations are proposed for the purpose of providing avenues along canal banks which may be used as roads. The provision made works out to Rs. 350 per mile.

52. *Miscellaneous (O)*.—Under the head of (O) miscellaneous, provision is made for the following works:—

(i) *Fixing demarcations stones along main and branch canals*.—These will be revenue survey stones and will be fixed at all field boundaries where the land is acquired and the fields are sub-divided. This work will, as usual, be done by the Revenue Department, the Public Works Department paying the cost.

(ii) *Fixing mile and furlong stones along main and branch canals*.—For the purpose of ready identification of localities during inspection, mile and furlong stones are provided for along the inspection or left bank.

These mile and furlong stones will serve as permanent bench marks.

(iii) *Sluices for direct irrigation*.—Sluices at heads of distributary channels go under the main head "3. Distributaries"; sluices at heads of "water-courses" not maintained by Government or included under the main head "2. Main canals and branches", sub-head "O. Miscellaneous."

53. *Maintenance (P)*.—Under the head "(P) Maintenance", the charges likely to be incurred on maintenance during construction, i.e., from date of completion of any section to date of its being brought into operation, have to be provided for. A provision of Rs. 1,00,000 for the main canal, and Rs. 200 per mile for the branch canals, has been made on this account.

54. *High banks*.—The canal banks on all approaches to big drainage crossings are generally high, being out of soil and are designed to have a hydraulic gradient of 1 in 4, with 4 feet of dry earth over this. The banks in the immediate vicinity of cross drainage works are designed to have a hydraulic gradient of 1 in 5.

55. The only cuttings which call for special mention occur in the first 56 miles, i.e., from R.D. 0/00-00 to R.D. 29/64-35, of the main canal. And they are—

(1) *Mondibodu cutting* from R.D. 3/36-60 to R.D. 3/56-40 maximum depth of cutting at R.D. 3/45-30 is 91.74 feet. The soil of cutting is quartzite to about 20 feet depth from the surface and the sub-soil is hard shale. The contents from Mondibodu cutting will be trammed and carried to the Buga Vagu reservoir, where a portion of it will be utilized in forming the shale bank in continuation of the right flank of the dam.

(2) *Velpur cutting* from R.D. 10/25-60 to R.D. 10/78-40. The greatest depth of cutting is 23.4 feet at R.D. 10/45-40. The surface soil is black cotton to 5 or 6 feet depth, with a sub-soil of granitoid gneiss.

(3) *Hussenagaram cutting* from R.D. 18/61-40 to R.D. 19/36-90. The maximum depth of cutting at R.D. 18/84-30 is 32.28 feet. The surface soil of cutting is black cotton to about 5 feet depth, and the sub-soil is micaceous schist and gneiss.

(4) *Bandarupalli cutting* from R.D. 29/37-75 to R.D. 30/17-15. The maximum depth of cutting at R.D. 29/64-35 is 23.39 feet. The surface soil is black cotton and the sub-soil is schist and granite.

Other alternative alignments of the main canal at these four places of heavy cutting, were contemplated and their cost worked out, but finally abandoned for reasons stated in paragraphs 6 and 11 of Vol. I, Part III, "Main Canal and Branches—A. General".

56. *A mass dam for the Buga Vagu reservoir*.—The F.T.L. of the Buga Vagu reservoir is + 185.00; but for purposes of calculation, an F.T.L. of + 188.00 is assumed and top of dam is + 189.00. The foundations have been taken from 10 to 17 feet below the surface of the ground, which is all hard shale. The specific gravity of the masonry in the buttresses and arch is taken as 2½.

The Buga Vagu valley is about 3,800 feet broad, 1,800 feet of which is deep and below + 175.00.

The height for which this gravity dam is designed is 81 feet + 108.00 being the deepest level of foundations and + 189.00, the level of top of dam. A shale bank, 1,440 feet long, with a masonry revetment wall on the reservoir side, will connect this gravity dam from its right extremity to the canal bank.

To prevent the possibility of a sudden drainage in the Buga Vagu raising the F.T.L. and thus causing injury to the canal banks, an automatic surplus sluice of six vents, 14' x 6' each, capable of discharging 5,000 cusecs, is proposed to be built at the left end of the dam.

The automatic action of the sluice shutters as well as other details of construction of this surplus work are mentioned in paragraph 9 of Vol. I, Part III, "Main Canal and Branches, A General".

All calculations and details of design regarding the Buga Vagu dam, will be found in Vol. III, appendix III — *vide* plan Nos. 65 to 69, port folio No. 7.

57. *Programme of expenditure necessary in construction of the Upland Canal System.*—In paragraphs 229—235 of part I of this volume, the general scheme of construction of the canal system is worked out and in paragraphs 237—240 the staff required is given.

The following statement shows the actual expenditure that must be incurred year by year in order to work up to the programme proposed.

PROGRAMME of construction and expenditure in thousands of rupees—Upland Canal System.

Year of construction programme.	Area for which main canal, branches and distributaries are to be completed.	Area for which minor distributaries are to be completed.	Length of main canal to be completed.	Estimated cost of works excluding land compensation.					Total cost with 20 per cent. for unforeseen contingencies.	Amount required for expenditure each year for works other than land.	Approximate amount required for land compensation.	Total amount required for expenditure each year.	Remarks.
				Main canal.	Branches.	Major distributaries.	Minor distributaries.	Total.					
1	2	3	4	5	6	7	8	9	10	11	12	13	14
4th year	..	..	..	77	..	..	..	2.03	2.03	..	2.00	2.00	..
5th "	..	..	..	..	..	..	..	..	..	..	5.00	17.03	..
6th "	..	..	..	..	..	..	..	..	..	..	5.00	23.00	..
7th "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
8th "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
9th "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
10th "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
11th "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
12th "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
13th "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
14th "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
15th "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
16th "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
17th "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
18th "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
19th "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
20th "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
21st "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
22nd "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
23rd "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
24th "	..	..	..	..	..	..	..	..	..	..	..	18.00	..
Total	..	..	..	1,78.58	8.78	27.25	16.99	2,29.60	2,75.12	2,75.12	21.00	2,96.21	..

Thousands of Rupees.													
4th year	..	..	..	..	..	..	..	..	..	..	..	..	..
5th "	..	..	..	..	..	..	..	..	..	..	..	..	..
6th "	..	..	..	..	..	..	..	..	..	..	..	..	..
7th "	..	..	..	..	..	..	..	..	..	..	..	..	..
8th "	..	..	..	..	..	..	..	..	..	..	..	..	..
9th "	..	..	..	..	..	..	..	..	..	..	..	..	..
10th "	..	..	..	..	..	..	..	..	..	..	..	..	..
11th "	..	..	..	..	..	..	..	..	..	..	..	..	..
12th "	..	..	..	..	..	..	..	..	..	..	..	..	..
13th "	..	..	..	..	..	..	..	..	..	..	..	..	..
14th "	..	..	..	..	..	..	..	..	..	..	..	..	..
15th "	..	..	..	..	..	..	..	..	..	..	..	..	..
16th "	..	..	..	..	..	..	..	..	..	..	..	..	..
17th "	..	..	..	..	..	..	..	..	..	..	..	..	..
18th "	..	..	..	..	..	..	..	..	..	..	..	..	..
19th "	..	..	..	..	..	..	..	..	..	..	..	..	..
20th "	..	..	..	..	..	..	..	..	..	..	..	..	..
21st "	..	..	..	..	..	..	..	..	..	..	..	..	..
22nd "	..	..	..	..	..	..	..	..	..	..	..	..	..
23rd "	..	..	..	..	..	..	..	..	..	..	..	..	..
24th "	..	..	..	..	..	..	..	..	..	..	..	..	..

Notes.—(1) Figures entered against fifth year in columns 6-9 and 10 are the amount of preliminary expenses.
 (2) Figures in column 10 give the minimum amount that has to be spent which will permit the necessary forecasted extension of irrigation.
 (3) In the fifth year a start will be made on all the biggest cuttings.
 (4) The figures in column 12 are only approximate.

SECTION II.

UPLAND CANAL—DISTRIBUTION SYSTEM.

A.—General.

58. *General description.*—This is given in section IV, Part I. paragraphs 165. *et seq.* It may be added that nearly the whole area to be irrigated is black cotton soil, apparently of a character closely resembling that of the neighbouring delta, and that there is every reason to believe it highly suitable for irrigation, while the naturally large declivity of the streams draining the area ensures good drainage. The surface soil varies in depth from great unknown depths near the Kistna river and the existing delta to as little as one foot near that part of the upland canal where irrigation begins. Practically the whole area is occupied on ryotwari tenure.

Of the gross area commanded about 75 per cent. has been declared irrigable by the Revenue Officer after making reservations for actual and all future communal requirements.

The total irrigable area is 610,000 acres, and a fully worked out scheme for a typical area of 63,951 acres has been made and estimated for, and from this typical area is deduced the probable cost of the whole system.

59. *Typical area estimated for.*—The typical area comprises the following blocks:—

Name of block.	R.D. of head sluice on main canal. FERT.	Area irrigated. ACS.
Chigurupad	8/87/00	5,394
Siripuram	25/43/40	12,059
Tadikonda (a part of)	29/56/40	17,971
Kanuparti	77/65/00	28,527
Total		63,951

The first three of these are near the head of the canal and located over some of the steepest ground to be irrigated and in consequence are proportionately more expensive than if situated in less undulating country where the number of falls would be fewer. It follows that estimates for the remaining area based on the above are sure not to be exceeded and may be relied on as safe.

60. *Terms used.*—A “block” is the entire area irrigable under any one sluice on the main canal and is irrigated by a parent channel bearing the name of an important village fed by it, such as the “Chigurupad channel” or “Kanuparti branch”. Offtake channels from the parent channel bear a name if they bifurcate into two or more channels, but if there is no bifurcation, the offtake channel is called by a number. By this means any portion of the system is readily identified (*e.g.*, “No. 10 distributary, Kanuparti block”).

Field distribution channels are called *water courses* and are that portion of the system not constructed at Government expense.

Distributaries are channels of less carrying capacity than 300 cusecs, but if they are less than 25 cusecs, they are called *minors* and if above 25 cusecs, are called *majors*.

Branches or branch canals are offtakes from the main canal of above 300 cusecs carrying capacity.

61. *System of mileage.*—The whole scheme of distribution is based on village maps which the Revenue Survey Department published on a scale, generally, of 8 inches to the mile, or one square inch = 10 acres. Reduced distances on all distributaries are therefore stated in statute miles and feet from the head of each channel.

62. *Method of levelling the country.*—From the standard G.T.S. bench mark in Guntur Municipal travellers' bungalow, lines of levels were run along each metalled road in the irrigable area and subsidiary bench marks established on each mile and furlong stone. With these as a base, each village was separately levelled over on lines two furlongs apart, where the slope was clearly defined, and at one furlong intervals where the country was flat, and the results were marked on the village maps on which contour lines were then inserted. These maps were then reduced to a scale of 2 inches to one mile and combined to form the contour map of the whole irrigable area, see separate Roll Drawings Nos. 1 (1), 1 (2), 1 (3), 1 (4) and 1 (5).

63. *Method of fixing alignments, etc.*—The contour map clearly exhibits the principal water-shed lines along which the important channels will run, and distributaries were aligned along minor spurs or down the slopes in such a way that usually no field is more than half a mile from its Government source. These channel alignments were transferred to the village maps on which every individual field is marked, and the fields were formed into groups of about 110 acres to delimit the irrigable area under each pipe sluice and each of these groups was distinguished by a different colour. This decided the position of each pipe sluice.

The village map so marked was then handed over to a Revenue Inspector who computed the irrigable area under each pipe sluice from the registers of irrigable fields prepared by the superior revenue officers. These detailed figures were written up in leather bound books for permanent record and supply information on which to compute the size of channels and offtakes.

The proper depth of drops was then found, having regard to the position of offtakes already settled, and although one deep drop is a cheaper arrangement than two of half that depth, yet the position of offtakes frequently prevents adoption of the most economical arrangement, that is to say, efficiency has been preferred to economy.

The number and height of drops having been fixed, it only remains to settle their position in such a way as to attain the greatest economy in earthwork and this occurs when the standard section of banks just above each particular drop is of the same area as the section of cutting just below that drop. This completes the process adopted in laying out the distribution system.

64. *Chigurupad block.*—This block comprises the following channels:—

Name of channel.	Number of pipe sluices.	Length of channel.	Average fall.	Cost.	Area irrigated.	Classification.
Chigurupad	8	MLS. 2	0	Rs. 14,615	416	Major.
No. 1 distributary	3	0 3,036	1/764	1,570	519	Minor.
No. 1-a do.	4	0 4,290	1/523	2,620	865	
No. 2 do.	6	1 1,716	1/232	7,055	937	
No. 3 do.	7	1 1,056	1/163	5,830	1,592	
No. 4 do.	10	2 1,452	1/231	9,785	547	
No. 4-a do.	4	0 2,904	1/153	2,155		
Total	42	8 3,894	..	43,430	5,394	

65. *Description of Chigurupad block.*—This is a small and fairly compact block in which no high land and consequently no cross drainage occurs. The irrigated fields lie in seven villages between the canal and the Kistna river and vary in level from + 171 to + 94. The chief feature of this block is its steep ridges involving numerous drops. The depth of surface soil is very small near the canal and terracing irrigable lands will be more difficult for the ryots here than elsewhere. There are no roads in this tract now, but syphon well drops in the minors provide cart crossings in this as in all other blocks and 2 road culverts are provided in Chigurupad channel the only major distributary in the block. The cost per acre for the distribution system of this block is Rs. 8.05.

66. *Siripuram block* comprises the following channels :—

Name of channel.	Number of pipe sluices.	Length of channel.	Average fall.	Cost.	Area irrigated.	Classification.
		Mls. FT.		Rs.	ACS.	
Siripuram channel	28	8 2,640	1/761	64,985	3,525	Major.
No. 1 distributary	4	0 3,894	1/2007	1,455	514	
No. 2 do.	6	0 2,708	1/174	2,230	462	
No. 3 do.	7	1 2,508	1/407	5,065	1,002	
No. 4 do.	4	0 3,432	1/154	3,335	474	
No. 5 do.	4	0 3,597	1/181	2,250	341	
No. 6 do.	5	0 4,688	1/155	4,150	568	
No. 7 do.	6	0 4,488	1/2504	1,835	810	
No. 8 do.	4	1 330	1/171	4,655	686	
No. 9 do.	5	0 3,630	1/196	2,495	507	
No. 10 do.	4	0 3,498	1/137	3,380	646	
No. 10-a do.	4	0 3,696	1/132	3,010	572	Minor.
No. 11 do.	4	0 3,300	1/116	2,615	353	
No. 12 do.	4	0 4,620	1/444	2,895	490	
No. 12 do.	4	0 3,300	1/116	2,615	353	
Total	99	20 3,003	1/573	4,710	1,109	
				1,08,685	12,059	

67. *Description of Siripuram block*—This is a straggling block having a major channel running down a long water-shed and twelve minors taking off it. besides the 11th and 12th distributaries into which two minors the major channel bifurcates at its tail.

There are about 120 acres of high land on the crest of the ridge at $4\frac{1}{2}$ miles from the head of the major which skirts one side of it on a contour. No cross drainage is provided here as the small amount of drainage can run away to the north end of the high land and so does not need to cross any irrigation channel. The irrigated fields, which are between the levels of + 142 and + 79, lie in 13 villages situated between the main canal and the Kistna river. Owing to the length of the block compared with its width, it is more expensive to irrigate than the Chigurupad block which has cross slopes of ground of nearly equal declivity. Three girder bridges and a culvert crossing are provided on the major channel and the syphon well drops on the minors supply facilities for reaching any of the area. There are no metalled roads at present.

The drops at the head of the channel are not exactly to type, having to be modified in the foundations in several places to suit the sub-soil. The cost per acre of the distribution system of this block is 9.01 rupees.

68. *Tadikonda block*.—In the part of this block estimated for is included a part of the Tadikonda branch canal from which 1,490 acres are irrigated direct by 15 pipe sluices, and the balance of the block is irrigated by major and minor distributaries. Since all branches are separately estimated for in detail, the cost of this branch must not be included in the cost of the typical distribution system.

Excluding the branch canal, this block comprises the following channels :—

Name of channel.	Number of pipe sluices.	Length of channel.	Average fall.	Cost of channel.	Area irrigated.	Classification.
		Mls. FT.		Rs.	ACS.	
Tadikonda	24	4 5,082	1/400	41,375	2,931	Major.
No. 1 distributary	2	0 660	1/3000	1,426	270	
No. 2 do.	13	2 3,566	1/280	1,887	1,350	Minor.
No. 3 do.	10	1 3,234	1/174	1,707	1,02	
Kaneru	1	0 3,366	1/2900	9,260	1,671	Major.
No. 3 distributary	16	2 4,158	1/1301	21,155	987	
No. 4 distributary	12	3 1,254	1/228	15,455	1,721	Minor.
No. 5 do.	9	1 1,716	1/682	4,590	1,047	
No. 6 do.	7	1 3,300	1/183	1,102	1,275	Minor.
No. 7 do.	8	1 4,488	1/1973	5,750	1,118	
Total	130	26 2,312	1/1809	4,650	1,230	
				1,37,620	16,481	

It will be observed that Nos. 1, 2 and 3 distributaries which start as majors change to minors after certain distances when their capacity becomes less than 25 cusecs.

69. *Description of Tadikonda block*.—The block is a large one, and moderately compact, with irrigable lands in ten villages and varying in level from + 147 near the main canal to + 62 near the Kistna river. A part of the lower area is liable to short periods of submergence by the Kistna when floods occur of above normal height, but such floods are generally of so short a duration that no serious harm is done to any crops submerged. The increasingly flat character of the country as the distribution system gets further from the main canal, is exemplified in the flat slopes possible in distributaries Nos. 4 to 8.

No. 2 distributary tails into Tadikonda tank which is a very old tank silted up to such an extent that it is probable the greater part of it will be abandoned and converted into ryotwari holdings. The Kaneru channel will pick up water again from the deepest bed of this tank and is really an extension of No. 2 distributary.

There are two large granite hills in the block, but they necessitate no special cross drainage works.

Syphon well drops provide access over all minor distributaries at frequent intervals and road bridges or culverts are provided over the majors. A metalled district board road runs through the block and bridges or culverts are provided at all channel crossings on it.

Excluding the branch canal the cost of distribution in this block works out to Rs. 8.29 per acre.

70. *Kanuparti block*.—In this block is included the Kanuparti branch canal which is three miles long and irrigates direct 1,373 acres by means of 14 pipe sluices. Excluding this branch the block comprises the following channels :—

Name of channel.	Number of pipe sluices.	Length of channel.	Average fall.	Cost of channel.	Area irrigated.	Classification.
		Mls. FT.		Rs.	ACS.	
Kanuparti	45	10 1,914	1/913	1,08,870	5,864	Major.
Peddaganjam	17	4 2,079	1/442	28,290	1,550	
Nagulappalpad	8	2 4,884	1/2959	17,935	1,379	
Chiruvannappalpad	3	0 4,158	1/525	6,810	436	
Arumanabrole	3	0 5,214	1/324	5,655	220	
No. 16 distributary	3	0 4,092	1/2902	7,005	306	
No. 16 do.	11	1 264	1/2843	2,810	1,801	
No. 1 do.	3	0 3,630	1/163	8,860	409	
No. 2 do.	12	2 4,356	1/845	7,795	1,331	
No. 3 do.	14	2 792	1/1056	11,965	939	
No. 4 do.	10	2 198	1/1008	9,205	1,699	Minor.
No. 5 do.	10	2 1,501	1/299	1,745	423	
No. 6 do.	2	0 2,508	1/226	1,265	631	
No. 7 do.	2	0 1,782	1/349	3,050	1,592	
No. 8 do.	3	0 4,422	1/232	11,355	409	
No. 9 do.	12	2 66	1/263	1,430	1,615	
No. 10 do.	1	0 2,310	1/325	6,215	1,484	
No. 11 do.	10	2 2,211	1/918	8,005	1,770	
No. 12 do.	12	2 1,955	1/2292	830	584	
No. 13 do.	15	2 4,191	1/1475	1,124		
No. 14 do.	3	0 1,980	1/2000			
No. 15 do.	8	1 4,422	1/5665			
Total	207	45 1,449	..	2,59,335	27,154	

It will be observed that No. 16 distributary which starts as a "major" changes to a "minor" after a short distance when its discharge becomes lower than 25 cusecs.

71. *Description of the Kanuparti block*.—Kanuparti block is the fifth largest block in the new upland canal system and the largest of the typical blocks estimated for.

Fourteen villages are partly or wholly irrigated in the block which irrigates lands between levels + 78 and + 4. It is the southernmost block in the upland canal system being bounded on the south by the Gundlacumma river. On the east it is bounded by the (salt water) Buckingham navigation canal, which connects Madras with the Kistna western delta system of irrigation canals at the Peddaganjam lock, north-east of this block.

There is a large patch of high land, amounting to 1,704 acres, which is unirrigable in the centre of the block and as irrigation channels skirt this high land on a contour on each side, four considerable cross drainage works are provided. There are

two small patches of high land in Kanuparti village in the south-east corner of the block where ragi crops are now grown, but as they are very flat and the soil here is nearly pure sand, which absorbs all rainfall, no cross drainage works are provided for them.

The standard gauge railway line connecting Madras and Calcutta runs through the block and expensive culverts and syphons are allowed at the channel crossings as well as the cost of rail diversions, special temporary signals, etc., but as the channels run down ridges where the railway banks are of minimum height, diversions will be cheap. Kanuparti channel runs through the Ammanalolu station compound and crosses two lines of rails, but the ridge just below the station is being quarried for laterite and will be probably unsuitable for irrigation when the project is carried out and an ordinary cheap drop and culvert will then be substituted for the expensive syphon allowed, since less head in rear will be permissible.

On the steep slope near the head of No. 9 Distributary it is impossible to have deep drops on account of the proximity of granitic gneiss to the ground surface but the drops here are cheap as they require no flooring.

One of the villages in this block Paridipad Parasangulapad belongs to the Venkatagiri zamindari, the others are all Government villages.

The cost of irrigation in this block is Rs. 9.53 per acre.

72. *General summary of cost of distributaries.*—In summarizing details of the distributaries in typical blocks, the following results are obtained:—

Name of block.	Total length of distributaries.	Cost of distributaries.	Area irrigated.	Cost per mile.	Cost per acre.
	Mls. Ft.	Rs.	Ac.	Rs.	Rs.
Chigurupad	8 3,894	43,430	5,394	4,969	8.05
Siripuram	20 3,003	108,665	12,059	5,282	9.01
Tadikonda	26 2,312	137,630	16,481	5,171	8.29
Kanuparti	45 1,449	259,335	27,164	5,728	9.55
Total	101 98	549,060	61,088		

And therefore the average cost per mile is Rs. 5,435
And the average cost per acre is Rs. 8.99

73. *Total area irrigable by distributaries.*—The main canal has 32 pipe sluices in it each of which discharges less than 5 cusecs and therefore the cost to Government of distribution systems to the 6,225 acres under these pipe sluices is nil. The cost of the pipe sluices themselves is included in that of the main canal.

The branch canals in the typical blocks are two in number as below:—

	Length of branch.	Area irrigated direct.	No. of pipe sluices.
Tadikonda branch (part of)		Ac. 1,490	15
Kanuparti branch		1,373	14
Total		2,863	29

It seems that each pipe in a branch canal irrigates approximately 100 acres and that there are about 3 pipes in every 4,731 feet of branch. (For further remarks on this head see paragraph 17 on branch canals.)

The total length of all 7 branches is 315,590 feet and at a ratio of 300 acres of irrigation in every 4,731 feet of channel, the area irrigated direct by branches is 20,000 acres. The cost of the pipe sluices for this irrigation is included in that of the branch canals and so nothing further has to be allowed for this area.

Therefore under the—

Main canal	ACS.
Branch canal	6,225
	20,000

or for a total of 26,225 acres

the cost of distribution is included in the estimates for the main and branch canals respectively, and since the total irrigable area under the upland canal is 610,000 acres, the estimate for the distribution system has to provide for the balance or 583,775 acres.

74. *Cost of distribution system on an acreage basis (first estimate).*—The above paragraph shows that only 583,775 acres out of the total of 610,000 acres have to be separately provided with a distribution system and paragraph 72 shows that the average cost per acre in the typical area is Rs. 8.99. The cost of the distribution system under the upland canal may be estimated at Rs. 52,48,600.

75. *Second method of calculating cost of distribution system.*—The Inspector-General of Irrigation has expressed the opinion that the acreage basis is not so reliable as a cusec mile basis for computing costs of distributaries, but to do this accurately involves setting out in detail the distribution scheme of the whole area, including adding up areas of each field to obtain total areas under each individual pipe sluice. Owing to the delay in submission of the project estimate if this were carried out, an acreage basis has been adopted for minor distributaries and a cusec mile basis for majors, but since the details of areas have been scaled off the 2 inch to 1 mile irrigation map, the estimates for all channels are provisional and not final except in the typical blocks.

It is obvious that a cusec mile basis will be as unreliable as the acreage rate unless the average fall of country over which each channel will run is specially taken into account, and in order to see what effect slope produces, it is necessary to study the estimated cost of distributaries by sub-heads. This is done in Part B.—Technical.

B.—Technical.

76. Detailed cost of minors arranged by sub-heads—

STATEMENT showing the estimated cost of "Minor Distributaries" in rupees.

Names of channels.	Ayacut.	ex- A. Preliminary penses.	Sub-heads.							Total.
			B. Land.	C. Works.			L. Earthwork.	O. Miscellaneous.	P. Maintenance.	
				Falls and weirs.	Cross drainage works.	Other works.				
1	2	3	4	5	6	7	8	9	10	11
	ACRES.	RS.	RS.	RS.	RS.	RS.	RS.	RS.	RS.	RS.
Chigurupad Block.										
Chigurupad No. 1	519	10	350	400	..	450	310	35	15	1,570
" " 1-A	518	10	550	980	..	335	680	45	20	2,620
" " 2	865	15	910	4,010	..	845	1,155	80	40	7,055
" " 3	937	15	890	2,870	..	435	1,310	75	35	5,630
" " 4	1,692	25	1,900	3,605	..	650	3,520	125	60	9,785
" " 4-A	547	5	385	840	..	355	520	35	15	2,155
Total cost	4,978	80	4,985	12,705	..	2,970	7,495	395	185	28,815
Cost per acre	..	.02	1.00	2.55	..	.60	1.51	.08	.04	5.79
Siripuram Block.										
Siripuram No. 1	514	10	345	..	..	680	355	45	20	1,455
" " 2	462	5	320	1,030	..	500	325	35	15	2,230
" " 3	1,002	20	1,140	2,150	..	845	775	85	40	5,055
" " 4	474	10	690	1,475	..	330	770	40	20	3,335
" " 4-A	341	10	380	975	..	355	470	40	20	2,250
" " 5	568	10	630	2,230	..	445	755	55	25	4,150
" " 6	810	10	400	..	..	370	275	55	25	1,635
" " 7	686	15	625	2,735	..	380	800	70	30	4,655
" " 8	507	10	410	1,090	..	420	500	45	20	2,495
" " 9	646	10	415	1,880	..	415	610	35	15	3,380
" " 10	572	10	455	1,300	..	540	645	40	20	2,645
" " 10-A	353	10	350	1,410	..	395	420	40	25	2,695
" " 11	490	10	585	705	..	520	795	55	45	4,710
" " 12	1,109	20	1,020	1,580	..	955	1,045	95	45	5,710
Total cost	8,534	180	7,765	18,510	..	7,650	8,540	735	340	43,700
Cost per acre	..	.02	.91	2.17	..	.90	1.00	.09	.04	5.12

39

Statement showing the estimated cost of "Minor Distributaries" in rupees—cont.

Names of channels.	Ayacut.	Sub-heads.									Total.
		A. Preliminary expenses.	B. Land.	C. Works.			L. Earthwork.	O. Miscellaneous.	P. Maintenance.		
				Falls and weirs.	Cross drainage works.	Other works.					
1	2	3	4	5	6	7	8	9	10	11	
		ACRES.	RS.	RS.	RS.	RS.	RS.	RS.	RS.	RS.	RS.
Tadikonda Block.											
Tadikonda No. 4	..	1,102	20	1,770	215	..	920	1,510	105	50	4,590
" " 5	..	1,275	15	1,670	..	..	920	1,680	80	35	4,300
" " 6	..	1,118	25	2,390	280	..	885	2,020	135	65	5,750
" " 7	..	1,220	20	1,830	270	..	620	1,765	100	45	4,650
Total cost	..	4,715	80	7,560	715	..	3,345	6,975	420	195	19,290
Cost per acre	..	..	02	1.60	15	..	70	1.48	09	04	4.09
Kanuparti Block.											
Kanuparti No. 1	..	409	10	475	1,330	..	340	585	50	20	2,810
" " 2	..	1,331	30	2,250	1,680	..	1,875	2,790	160	75	8,860
" " 3	..	1,167	25	1,680	840	..	3,285	1,790	120	55	7,795
" " 4	..	939	25	1,460	725	5,170	2,860	1,550	120	55	11,965
" " 5	..	1,599	25	1,840	4,035	..	2,195	920	180	80	9,205
" " 6	..	423	5	310	800	..	285	300	30	15	1,745
" " 7	..	521	5	190	625	..	270	140	25	10	1,265
" " 8	..	631	10	580	1,100	..	505	780	50	25	3,050
" " 9	..	1,592	25	1,525	3,705	..	3,910	2,025	115	50	11,855
" " 10	..	409	5	260	670	..	265	195	25	10	1,430
" " 11	..	1,615	25	1,760	1,000	..	1,150	1,985	145	60	6,215
" " 12	..	1,484	25	1,820	250	..	1,080	2,010	130	60	5,375
" " 13	..	1,770	30	2,340	640	..	1,800	2,960	160	75	8,005
" " 14	..	584	5	250	..	..	300	240	25	10	830
" " 15	..	1,124	20	1,700	..	..	1,095	2,400	105	45	5,365
Total cost	..	15,598	270	18,440	17,490	5,170	21,215	20,670	1,390	625	85,270
Cost per acre	..	..	02	1.19	1.12	33	1.36	1.32	09	04	5.47

77.

Statement No. I.

TOTAL cost of minor distributaries arranged by sub-heads.

Name of block.	Ayacut.	Sub-head.								Total.
		A. Preliminary expenses.	B. Land.	C. Works.			L. Earthwork.	O. Miscellaneous.	P. Maintenance.	
				Falls and weirs.	Cross drainage works.	Other works.				
1	2	3	4	5	6	7	8	9	10	11
Chigurupad block ..	acs. 4,978	rs. 84	rs. 4,985	rs. 12,705	rs. ..	rs. 2,970	rs. 7,495	rs. 395	rs. 185	rs. 28,815
Siripuram ..	8,534	160	7,765	18,510	..	7,350	8,540	735	340	43,700
Tadikonda ..	4,715	80	7,560	715	..	3,345	6,975	420	195	19,290
Kanuparti ..	15,598	270	18,440	17,490	5,170	21,215	20,670	1,390	625	85,270
Total ..	33,825	590	38,815	49,425	5,170	24,560	43,680	2,940	1,345	1,77,076
Cost per acre ..	..	0.02	1.13	1.46	0.15	1.04	1.29	0.09	0.04	5.24

Notes.—This table does not include

Note.—This table does not include any part of Nos. 1, 2, and 3 distributaries of the Tadikonda block nor any part of No. 16 distributary of Kanuparti block which start with discharges of more than 25 cusecs.

78. *Effect of slope on cost of minors.*—Minor distributaries can run on slopes of 1/2,000 to 1/2,400 without any need for masonry drops, as for instance in Siripuram block Nos. 1 and 6 and Kanuparti block No. 14, and in such distributaries the cost per acre is from Rs. 1 1/4 to Rs. 3 against an average of Rs. 5.22 for the whole area.

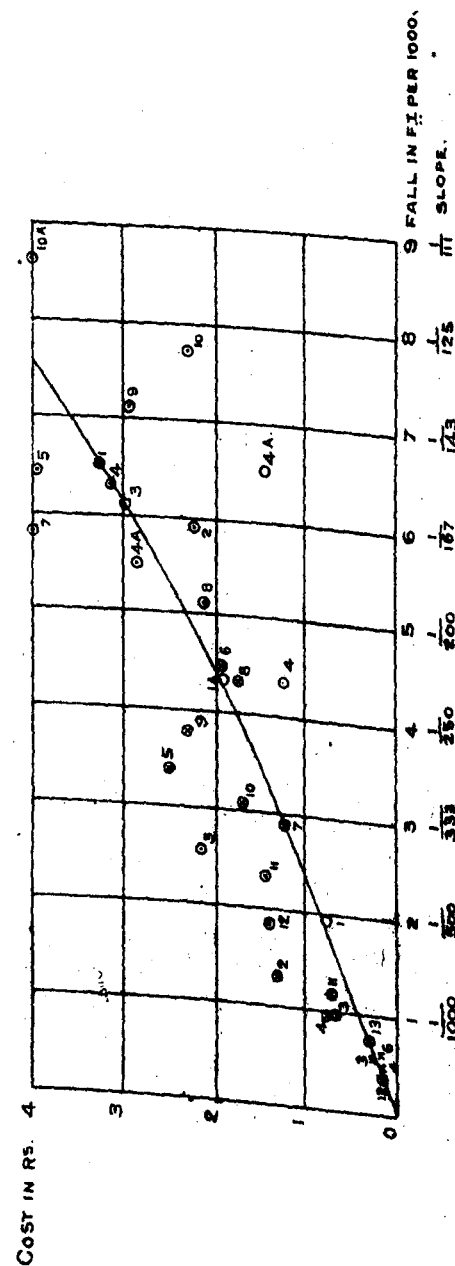
Conversely where the slope is steep, the cost increases rapidly as the following cases show:—

Siripuram No. 5, slope 1/155—cost per acre Rs. 7.31; cost of drops per acre Rs. 3.93.

Siripuram No. 7, slope 1/171—cost per acre Rs. 6.79; cost of drops per acre Rs. 4.

The slope is observed to have no effect on "Preliminary expenses," "Miscellaneous" and "Maintenance" and very little effect on every other sub-head except "Falls and weirs."

By plotting cost of drops per acre for varying slopes a curve can be drawn as below to show average cost under this sub-head, and this and an acreage rate applied to the whole distributary area would give an estimate probably as reliable as if based on the cusec-mile. As there has not been sufficient time available to set out the distributary system of the whole upland canal, an acreage rate has been used for distributaries, but the diagram would be useful in checking the estimates now submitted, if at any time the whole distribution system is set out on the irrigation map.



REFERENCE

Chigurupad Channel o
Siripuram Do. o
Tadikonda Do. x
Kanuparti Do. •

Vandhyke, Survey Office, Madras.
1912

Reg. No. 1947
Copies — 153

Diagram showing cost per acre of drops in minor distributaries for different slopes of ground.

This curve is a reliable one owing to the large number of distributaries from which it is derived and to the comparatively small difference in size of minors.

79. *Detailed cost of majors arranged by sub-heads.*—For the sake of comparison with the Cauvery Project estimates which were prepared on an acreage basis, the following two statements are now given :—

Statement No. II.

Cost in rupees of major distributaries including the minor channels that take off from them.

Names of channels.																			
1	2	3	4	5	6	7	8	9	10	11									
											A. Preliminary expenses.	B. Land.	C. Works.				L. Earthwork.	O. Miscellaneous.	P. Maintenance.
													Falls and weirs.	Cross drainage works.	Other works.				
Sub-heads.																			
Total.																			
Chigurupad	ACS.	RS.	RS.	RS.	RS.	RS.	RS.	RS.	RS.	RS.									
Siripuram.	5,394	160	6,810	14,995	8,080	12,495	505	385	43,430										
Tadikonda	12,059	490	18,325	28,445	8,150	21,025	29,870	1,200	1,08,665										
Do. No. 1	5,269	245	12,970	8,675	..	12,855	15,915	505	610	51,775									
Do. No. 2	1,957	35	3,140	5,480	..	2,205	2,930	150	85	14,025									
Do. No. 3	3,123	105	6,000	7,475	..	2,290	6,415	285	250	26,330									
Neerukonda	2,708	85	5,770	7,050	..	4,155	6,480	280	250	24,345									
Kanuparti	3,424	100	6,050	7,050	..	2,290	6,480	250	210	21,155									
Distributary No. 5	7,991	445	15,990	14,220	20,830	34,715	28,810	720	1,110	1,16,810									
Pedaganjam	1,599	25	1,840	4,035	..	2,195	920	130	60	9,205									
Naguluppapad	5,395	270	10,485	14,490	..	12,790	15,165	695	655	59,720									
Chiruvannuppapad	4,127	160	5,555	5,430	5,170	6,880	7,645	350	385	33,605									
Ammanabrore	2,460	65	2,800	4,085	7,220	3,120	3,520	215	150	13,955									
Distributary No. 16	3,475	95	5,180	2,470	..	5,145	5,560	350	235	19,035									
Total	2,107	75	1,950	..	..	1,865	2,960	105	50	7,005									
Cost per acre	61,088	2,355	1,02,835	1,22,920	41,370	1,23,100	1,45,145	5,740	6,595	5,49,060									
	..	04	1.69	2.01	0.67	2.02	2.38	0.09	0.09	8.99									

Statement No. III.

Cost in rupees of major distributaries excluding the minor channels that take off from them.

Names of channels.	Ayaout.	A. Preliminary expenses.	B. Land.	C. Works.				L. Earthwork.	O. Miscellaneous.	P. Maintenance.	Total.
				Falls and weirs.	Cross drainage works.	Other works.					
		3	4	5	6	7	8	9	10	11	
Chigurupad ..	ACS. 416	Rs. 80	Rs. 1,825	Rs. 2,290	Rs. 5,110	Rs. 5,000	Rs. 110	Rs. 200	Rs. 14,615		
Siripuram ..	3,625	330	10,560	2,935	8,150	13,375	21,830	465	820	64,965	
Tadikonda ..	2,930	200	8,750	8,175	..	11,850	12,130	270	500	41,375	
Do. No. 1 ..	1,957	35	3,140	5,480	..	2,205	2,930	150	85	14,025	
Do. No. 2 ..	3,123	105	6,000	6,070	..	5,800	6,415	285	250	26,330	
Do. No. 3 ..	2,708	85	5,770	7,475	..	2,290	6,480	250	210	21,155	
Neerukonda ..	3,424	100	6,050	6,070	..	4,155	6,480	280	250	24,345	
Kanuparti ..	7,991	445	15,990	14,220	20,830	34,715	28,810	720	1,110	1,16,810	
Pedaganjam ..	1,599	25	1,840	4,035	..	2,195	920	130	60	9,205	
Naguluppapad ..	5,395	270	10,485	14,490	..	12,790	15,165	695	655	59,720	
Chiruvannuppapad ..	4,127	160	5,555	5,430	5,170	6,880	7,645	350	385	33,605	
Ammanabrore ..	2,460	65	2,800	4,085	7,220	3,520	3,520	215	150	13,955	
Distributary No. 16 ..	3,475	95	5,180	2,470	..	3,120	5,560	350	235	19,035	
Distributary No. 16 ..	2,107	75	1,950	..	..	5,145	2,960	105	50	7,005	
Total ..	27,268	1,765	64,080	73,500	86,200	86,920	1,02,465	2,500	4,250	3,71,985	
Cost per acre ..	..	0.06	2.36	2.71	1.33	3.20	3.77	0.10	0.16	13.69	

80. *Cost of distribution system on an acreage basis (second estimate).*—The rate per acre for majors and minors combined as exhibited in statement No. II is precisely the same as that in paragraph 74.

The acreage rates of statements numbers I and III can be combined to obtain another estimate of cost of the distribution system.

81. Paragraph 16 shows that 583,775 acres are irrigated by the distribution system and statements Nos. I, II and III show that in the typical area out of 61,088 acres, 33,825 are irrigated by minor distributaries at an average cost of Rs. 5.22 per acre and 27,263 by majors at an average cost of Rs. 13.69. If the proportionate area irrigated by majors and minors is the same for the whole area as for the typical area,

then 260,533 acres are irrigated by majors at Rs. 13.69
and 323,242 " " " " minors at Rs. 5.22

583,775

Cost of majors Rs. 35,67,000

Cost of minors Rs. 16,87,000

or Rs. 52,54,000 is the total cost of distribution, which agrees very closely with the result already arrived at in paragraph 74.

82. *Cusec mileage rate.*—To obtain a cusec mileage rate for major distributaries, statement No. IV is compiled giving particulars of all majors in the typical area arranged according to the blocks in which they occur.

Statements V and VI re-arrange these channels according to size.

Statement No. IV.

PARTICULARS of major distributaries.

Block.	Channel.	Discharge in cusecs.			Length of channel.		Cusec in miles.	Cost of channel in rupees.	Cost per cusec mile in rupees.	Slope.	Direct irrigation from major acres.	Remarks.
		At head.	At tail.	Average.	Miles feet.	Miles.						
Chigurupad ..	..	73.85	34.65	54.25	2-0	2.00	108.50	14,610	135	1/764	416	
Siripuram ..	..	165.2	21.8	93.50	8-2640	8.50	794.75	64,965	82	1/764	3,525	
Tadikonda	Tadikonda	156.18	32.07	94.12	4-5082	4.96	466.83	41,375	89	1/400	2,931	Cost per cusec mile for Tadikonda block is Rs. 133 and average slope is about 1/860.
	No. 1 Distributary a part of..	26.80	23.10	24.95	0-660	0.125	3.12	625	200	1/3000	270	
	No. 2 Distributary a part of..	42.80	24.30	33.55	1-3234	1.61	54.02	14,650	271	1/174	1,350	
	No. 3 Distributary a part of..	37.10	23.60	30.35	1-1254	1.24	37.63	11,195	297	1/228	987	
	Neerukonda	46.90	32.50	39.70	1-3300	1.625	64.51	15,455	240	1/183	1,047	
	Total	..	..	..	..	..	626.11	83,300	..	..	6,585	
Kannuparti	Kannuparti	276.51	45.20	169.85	10-1914	10.36	1666.41	108,870	66	1/913	5,864	Cost per cusec mile for whole block is Rs. 80 and average slope is about 1/990.
	Peddaganjam	73.90	28.96	51.38	4-2679	4.61	231.72	23,290	122	1/442	1,660	
	Nagulapalad	56.53	30.50	43.51	2-4884	2.92	127.06	17,956	141	1/959	1,379	
	Chiruvannupalad	33.70	27.70	30.70	0-4158	0.79	24.25	6,310	260	1/525	436	
	Ammanabrolo	47.60	44.58	46.09	0-5214	0.99	45.63	5,655	124	1/324	220	
	No. 16 Distributary a part of..	28.90	24.70	26.80	0-4092	0.77	20.63	2,495	121	1/2902	306	
	Total	..	..	..	..	..	3,645.05	332,430	..	..	20,281	

Therefore the average cost of majors in the typical area is 91.2 Rs. per (cusec mile.)
Average slope in last column is taken as $\frac{1}{2}$ (cusec-miles $\times$ slope) $\div$ 2 (cusec miles.)

Statement No. V.

PARTICULARS of major distributaries of less average capacity than 50 cusecs.

Name of channel.	Average discharge cusecs.	Cusec miles.	Cost.	Cost per cusec mile.	Average slope.
No. 1 distributary— Tadikonda	24.95	3.12	Rs. 625	Rs. 200	1/3000
No. 16 distributary— Kannuparti	28.80	20.63	2,495	121	1/2902
No. 3 distributary— Tadikonda	30.35	37.63	11,195	297	1/228
Chiruvannuppalapad	30.70	24.25	6,310	260	1/525
No. 2 distributary— Tadikonda	33.55	54.02	14,650	271	1/174
Neerukonda	39.70	64.51	15,455	240	1/183
Nagulappulapad	43.51	127.06	17,935	141	1/2959
Ammanabrolo	46.09	45.63	5,655	124	1/324
Total	..	376.84	74,320	197 average cost per cusec mile.	

Statement No. VI.

PARTICULARS of major distributaries of average capacity between 50 and 100 cusecs.

Name of channel.	Average discharge cusecs.	Cusec miles.	Cost.	Cost per cusec mile.	Average slope.
Peddaganjam	51.38	231.72	Rs. 28,290	Rs. 122	1/442
Chigurupad	54.25	108.50	14,610	135	1/764
Siripuram	93.50	794.75	64,965	82	1/765
Tadikonda	94.12	466.83	41,375	89	1/400
Total	..	1,601.80	1,49,240	93 average cost per cusec mile.	

The only major of above 100 cusecs average capacity in the typical area is Kannuparti channel with an average discharge of 160.85 cusecs, average slope 1/913 and cost Rs. 66 per cusec mile.

83. Remarks on statements Nos. V and VI.—In statement No. V the two majors of smallest discharge happen to be of very short length and are hardly comparable to the others, and neglecting those two, it is obvious that the cusec-mileage rate decreases as the discharge becomes larger, while the slope of the channel affects the rate less.

In statement No. VI this is still more obvious as Chigurupad channel with a discharge of 54.25 cusecs has a cusec mileage rate of Rs. 135, while Siripuram channel which has the same slope, but a discharge of 93.50 cusecs, has a rate of only Rs. 82.

84. Cusec-mileage rates adopted.—The following rates are adopted in this estimate.

For channels having the following average discharges between the head and tail:—

(i) Between 25 and 50 cusecs	Rs. 200 per cusec mile.
(ii) " 50 and 100 " "	95 "
(iii) Over 100 cusecs	66 "

85. Cusec miles in majors and estimated cost of majors.—These are given in the following table.

MAJOR distributaries of Kistna Reservoir Project.

Description.	Gross area in acres.	Nett area.	Percentage of nett gross area.	Capacity at 73 acres per cusecs.	Nett area at tail.	Capacity at tail at 73 acres per cusecs.	Average capacity in cusecs.	Length in miles.	Cusecs miles.	Rate in rupees per cusec mile.	Amount in rupees.
1	2	3	4	5	6	7	8	9	10	11	12
Chigurupad block major distributary		Acres. 5,199									14,610
Kastala distributary	11,520	95.38	82.8	130.7	2,583	35.4	88.05	6.15	510.76	95	48,522
Parapalli distributary	2,664	2,388	90.0	32.7	1,826	25.0	28.85	0.5	14.43	200	2,886
Vijayapalli distributary	4,266	3,737	87.8	51.2	1,826	25.0	38.1	2.05	78.11	200	15,622
Balmara	4,664	4,377	94.0	60.0	1,880	25.8	42.9	2.05	87.95	200	17,590
Lingapuram distributary	2,880	2,340	77.8	30.7	1,820	25.0	27.85	0.6	16.71	200	3,342
Attalur distributary	4,848	3,772	77.8	51.7	1,705	28.4	37.55	3.0	112.65	200	22,530
Amravati distributary	24,288	18,904	77.8	258.9	2,240	30.7	144.80	8.9	1,288.72	66	85,056
Pedakurupad distributary	2,386	2,136	91.4	39.2	1,813	24.8	28.0	1.25	35.0	200	7,000
Nevalikalla	3,760	3,260	86.7	44.7	1,830	25.0	34.85	1.55	54.02	200	10,804
Siripuram block distributary		11,931									64,965
Ravala Endraya	120.80	104.75	86.7	143.5	2,288	31.4	87.45	9.8	857.01	95	81,416
Rayapudi distributary	3,712	2,476	66.7	33.9	1,813	25.0	29.45	1.15	33.87	200	6,774
Anantavaram Venkatayapallyam distributary		22,092	66.7	143.7	1,812	25.0	84.35	16.3	1,374.91	95	130,616
Krishnayapalli distributary	34.76	2,517	66.7	31.8	1,825	25.0	28.4	1.6	45.44	200	9,088
Sakamur distributary	5,792	3,861	66.7	62.9	1,825	25.0	38.95	2.45	95.43	200	19,086
Velagapudi distributary		24,304	66.7	151.9	1,813	25.0	88.45	5.25	464.36	95	44,114
Sadikonda block distributary		54,913									83,300
Devarapalli distributary No. 1	2,656	2,125	80.0	29.1	1,728	23.7	26.4	0.95	25.08	200	5,016
Pedavallapudi distributary	2,912	2,484	85.3	34.0	1,822	25.0	29.5	1.40	41.30	200	8,260
Vaddeswaram	5,792	4,941	85.3	67.7	1,979	27.1	47.4	2.0	94.8	200	18,960
Patamangalagiri-Kolakkalur distributary		21,155		289.8	1,822	25.0	157.4	15.1	2,375.74	66	156,865
Kasa distributary	3,056	2,607	85.3	35.7	2,425	33.2	34.45	0.5	17.23	200	2,448
Kuragalla distributary	4,016	3,426	85.3	46.9	2,416	33.1	40.0	0.7	28.00	200	6,600
Nidumarru-Navalur distributary	10,512	8,967	85.3	122.9	2,647	36.2	79.05	7.4	588.67	95	55,924
Gollamudi distributary	2,368	2,020	85.3	27.7	1,822	25.0	26.35	0.65	17.13	200	3,426
Nambur	5,040	4,299	85.3	58.9	1,822	25.0	41.95	1.7	71.32	200	14,264
Polakakani	3,456	2,948	85.3	40.4	1,822	25.0	32.7	2.0	65.40	200	13,080
Agatavaram distributary	6,240	5,323	85.3	72.9	1,822	25.0	48.95	1.0	48.95	200	9,790
Lam distributary	7,296	6,223	85.3	85.2	1,822	25.0	55.1	2.45	135.0	95	12,825
Devarapalli distributary No. 2	3,040	2,593	85.3	35.5	1,822	25.0	30.25	0.7	21.18	200	4,236
Takkalapudi distributary	4,000	3,412	85.3	46.8	1,822	25.0	35.9	3.5	135.65	200	27,130
Misaragadda-Anantavaram distributary	9,392	8,011	85.3	109.8	1,822	25.0	67.4	5.2	350.48	95	33,296
Guntur block		192,200									1,039,191
Guntur distributary	17,856	15,231	85.3	208.7	1,822	25.0	116.85	6.85	800.42	66	52,828
Pallapadu distributary	2,752	2,229	81.0	30.5	1,885	23.1	26.8	1.20	32.16	200	6,432
Chamallamudi distributary	3,104	2,614	81.0	34.4	2,138	29.3	31.85	1.25	39.81	200	7,962
Etukur distributary	3,760	3,046	81.0	40.7	2,462	33.7	37.2	0.7	27.04	200	5,208
Akkireddipallyam-Kolimarla distributary	20,800	16,845	81.0	239.8	2,229	30.5	130.65	10.2	1,309.11	66	86,401
Salapad	6,896	5,686	81.0	76.6	1,918	26.2	51.4	7.8	400.92	95	38,087

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Major distributaries of Kistna Reservoir Project—cont.

Description.	Gross area in acres.	Nett area.	Percentage of nett of gross area.	Capacity at 73 acres per cusecs.	Nett area at tail.	Capacity at tail at 73 acres per cusecs.	Average capacity in cusecs.	Length in miles.	Cusecs miles.	Rate in rupees per cusec mile.	Amount in rupees.
1	2	3	4	5	6	7	8	9	10	11	12
Budampad distributary	3,424	Acres. 2,774	81.0	38.0	1,918	26.3	32.15	1.0	32.15	200	6,450
Muttalur do.	3,760	3,046	81.0	41.7	1,918	26.3	34.0	1.45	49.8	200	9,860
Anantavaram distributary	4,080	3,389	81.0	46.4	2,074	28.4	37.4	2.0	74.80	200	14,960
Patharedipalem do.	26,300	21,301	81.0	291.8	2,786	38.2	165.00	7.3	1,204.5	66	79,497
Isavalkavaram do.	6,712	6,179	92.1	84.7	2,815	38.5	61.60	2.04	123.20	95	11,704
Enamadallapallapadu distributary	11,520	10,077	87.5	238.0	2,632	36.0	87.00	7.0	609.0	95	67,855
Piratipad distributary	3,520	3,021	85.8	41.4	1,760	24.1	32.75	0.8	26.2	200	5,240
Ravaiapad do.	4,400	3,696	84.0	50.6	3,226	44.2	47.40	0.8	37.92	200	7,584
Vallur do.	2,480	2,103	84.0	28.8	1,814	24.9	26.85	0.75	20.14	200	4,028
Kartapad distributary	9,568	8,037	84.0	110.1	1,882	25.8	67.95	3.4	231.03	95	21,948
Vangipuram do.	25,008	21,000	84.0	250.0	1,949	26.7	138.35	11.55	1,597.94	66	1,06,464
Ganikipudi do.	2,880	2,480	86.1	34.0	2,282	31.2	32.6	0.4	13.04	200	2,608
Karotsola do.	2,608	2,107	80.8	20.9	1,791	24.5	26.7	0.8	21.36	200	4,272
Vunnava annaparra distributary	14,464	12,450	86.1	170.5	2,204	30.2	100.35	6.5	652.28	66	43,050
Lalodi distributary	3,290	2,915	91.1	39.9	2,216	30.3	35.1	1.70	59.67	200	11,934
Edlapadu distributary	7,520	6,851	91.1	93.9	2,216	30.3	62.1	1.30	80.73	95	7,569
Cherumanilla distributary	3,312	2,767	83.2	37.8	1,917	26.2	32.0	0.65	20.8	200	4,160
Nedella distributary	4,480	3,921	87.5	53.7	2,520	34.5	44.1	1.25	55.13	200	11,026
Nadella Pedanandipad block		33,280									
Charkur distributary No. 1	3,840	3,141	81.8	43.0	1,827	25.0	34.0	4.60	156.40	200	31,280
Kondapatur do. No. 2	2,448	2,002	81.8	27.0	1,827	25.0	26.2	1.0	26.20	200	5,240
Do. do. No. 1	11,216	9,175	81.8	125.7	1,827	25.0	75.36	4.35	327.77	95	31,138
Kakumanur do.	9,120	7,460	81.8	102.20	3,206	43.9	73.05	4.20	306.81	95	29,147
Ballukandupalem distributary		21,681	81.8	297.0	2,290	31.4	164.20	6.75	1,108.35	66	72,151
Boppudianantavaram block		60,066									
Manikondavaripalem distributary	8,688	7,126	82.0	97.6	1,837	25.2	61.40	4.70	288.58	95	27,415
Churkur distributary No. 2		5,226	92.0	71.6	1,766	24.2	47.90	7.35	352.07	100	70,414
Inagallu do.		3,415	92.0	46.8	1,825	25.0	35.9	2.65	95.14	200	19,028
Edubad agharam distributary No. 2		2,134	92.0	29.2	1,825	25.0	27.1	1.15	31.17	200	6,234
Edubad distributary No. 1		6,434	92.0	88.1	1,825	25.0	58.55	4.65	262.96	95	24,981
Annavaram distributary		21,948	92.0	300.3	1,825	25.0	62.65	10.1	1,638.73	66	1,08,156
Ramanayapalem distributary	3,872	3,485	90.0	47.7	1,829	25.0	36.35	1.20	43.62	200	8,724
Virannapalem do. No. 1	3,440	3,096	90.0	42.4	1,829	25.0	33.70	1.65	55.61	200	11,122
Do. do. No. 2	3,120	2,808	90.0	38.5	1,829	25.0	31.75	1.70	53.98	200	10,796
Anantavaram do.		21,900	90.0	300.0	1,829	25.0	162.50	13.75	2,334.38	66	1,47,469
Enamadala distributary	3,632	2,726	75.0	37.3	1,824	25.0	31.15	2.15	66.97	200	13,394
Edanapudi distributary No. 2	3,232	2,785	86.2	38.2	2,069	28.3	33.25	1.0	33.25	200	6,650
Nutukpad do.	8,000	6,000	75.0	82.2	2,280	31.2	66.70	3.45	195.62	95	18,584
Ponnur do.	3,792	2,843	75.0	39.0	1,740	24.0	31.50	2.10	66.15	200	13,230
Jagariamudi do.	26,672	19,961	75.0	273.4	1,740	24.0	148.70	12.45	1,851.32	66	1,22,187

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Major distributaries of Kistna Reservoir Project—cont.

Description.	Gross area in acres.	Nett area.	Percentage of nett of gross area.	Capacity at 73 acres per cusecs.	Nett area at tail.	Capacity at tail at 73 acres per cusecs.	Average capacity in cusecs.	Length in miles.	Cusecs miles.	Rate in rupees per cusec mile.	Amount in rupees.
1	2	3	4	5	6	7	8	9	10	11	12
Kesavaspad distributary No. 2	3,680	3,430	93.2	47.0	2,908	40.0	43.50	1.30	56.55	200	11,310
Daggupad do. do.	..	11,344	..	155.4	1,826	25.0	90.20	6.25	563.75	95	53,535
Iwarra do. do.	2,480	2,310	93.2	31.7	1,820	25.0	28.35	1.25	35.44	200	7,088
Pemidipad do. do.	2,512	2,341	93.2	32.1	1,820	25.0	28.65	1.40	39.97	200	7,994
Do do. No. 1	3,360	3,132	93.2	42.9	2,624	36.8	39.85	1.00	39.85	200	7,970
Idulapad distributary	..	29,865	93.2	185.9	1,849	25.3	105.60	6.4	675.84	66	44,606
Dronadala do.	..	2,280	82.0	31.2	1,826	25.0	28.1	1.30	36.53	200	7,306
Inkollu block	..	25,686	82.0	25.5	1,771	24.3	24.9	0.20	4.98	200	996
Inkollu distributary adjoining village	..	12,426	82.0	170.2	1,800	24.7	97.45	8.35	813.71	95	77,302
Do do.	..	13,160	82.0	180.3	2,860	36.3	108.30	7.25	785.18	66	51,822
Jangavaram distributary	..	4,448	85.0	51.8	1,904	26.1	38.95	3.00	116.85	200	23,370
Jangalur do.	..	3,088	90.0	35.1	1,800	24.7	31.40	1.70	53.38	200	10,678
Vijalapalli do.	..	11,488	90.0	141.7	1,828	25.0	83.35	4.70	391.75	95	37,196
Bandaluru do.	..	4,640	75.0	47.7	..	24.7	36.20	2.50	90.50	200	18,100
Kachapudi do.	..	2,832	75.0	29.1	..	25.3	27.20	0.90	24.48	200	4,896
Kutlagunta do.	..	14,912	75.0	162.7	1,740	23.8	88.25	4.70	414.78	95	39,404
Chinnaganjam do.	..	28,410	..	73.6	..	27.4	50.50	3.33	165.65	95	1,69,575
Lampati block do.	..	6,720	80.1	38.1	1,997	..	27.4	2.30	75.23	200	15,066
Lothakotta do.	..	3,668	83.9	143.2	..	25.7	84.45	8.20	692.49	95	65,787
Idumanur do.	..	10,452	..	..	..	..	..	..	..	..	..
Idripad do.	..	..	..	..	..	..	..	..	..	..	..
Total	..	565,089	..	..	..	..	..	..	..	..	30,93,805
Area irrigated by branches	..	30,000	..	..	..	..	..	..	..	..	..
Balance	..	5,45,089	..	..	..	..	..	..	..	..	..

Column 2 is the gross area of each block in acres, as measured by the planimeter from the 2" irrigation map.

" 3 is the nett irrigable area of each block in acres as given by the Revenue Department.

" 4 is the centage of nett to the gross area of each block, i.e., column 3.

" 5 is the capacity of the distributary in cusecs, got by dividing the nett irrigable area by 73.

" 6 is the nett irrigable area at the tail end of the distributary which is obtained first by measuring the gross area at the tail end by a planimeter and then multiplying it by the centage of column 4.

" 7 is the capacity of the distributary required at the tail end which is $\frac{\text{column 6}}{73}$." 8 is the average of the capacities at head and tail, i.e., $\frac{\text{col. 5} + \text{col. 7}}{2}$.

" 9 length as measured by an ordinary inch scale.

Column 10 is the product of the average capacity and the length in miles, i.e., col. 8 X col. 9.

The areas in column 3 under brackets are included in the areas of those blocks of which they form part.

Total area of majors in this statement	..	545,089
Total nett area of minors irrigated by main canal	..	38,686
Total nett area of pipe sluices in main canal of less discharge than 5 cusecs.	..	6,216
Nett area irrigated by branches	..	30,000
Total area irrigated	..	610,000

Cost of distribution system excluding pipe sluices and branches.

Total area of majors in this statement = 545,089 acres.

From statement No. 3 shows that in the typical area of 61,088 acres, 33,825 are irrigated by minor distributaries.

(i.e.) the percentage of irrigated area by "minors" to the total area = $\frac{33,825}{61,088} = 55.37$ per cent.∴ area irrigated by "minors" in the total area contained in this statement = $\frac{545,089 \times 55.37}{100} = 301,816$ acres.

Nett area of minors irrigated by main canal = 38,686 "

∴ Total area irrigated by "minors" = 340,502 acres.

Cost of "minor" distribution system at Rs. 5.22 per acre

= 340,502 X 5.22 = Rs. 1,77,420

Cost of "majors" as per this statement = .. 30,93,805

∴ Total cost of distribution system = Rs. 48,71,225

or Rs 48½ lakhs.

86. *Total cost of distribution system.*—Three separate estimates on different data, all of which are based on the estimates for channels in the typical area have now been made as follows:—

(i) with acreage rate for the whole system of majors and minors.	Rs. 52,48,000
(ii) with separate acreage rates for majors and minors	52,54,000
(iii) with an acreage rate for minors and a cusec mile rate for the majors	48,75,000

No. (ii) estimate is the largest and is therefore taken for the project estimate, but to allow for unforeseen items and probable increase in cost of labour before construction is complete, 20 per cent. is added to the cost of each sub-head except preliminary expenses in order to get the final estimate.

Statement No. VII.

Sub-head.	Rate per acre on 583,775 acres.	Total amount.	Add 20 per cent. for unforeseen items.	Grand total.
A. Preliminary expenses ..	Rs. 21	Rs. 12,207	Rs. 1,22,097	Rs. 1,22,097
Do. investigation ..	1.68	9,80,121	1,96,080	11,76,151
B. Land ..	4.89	27,39,618	5,47,930	32,87,548
C. Works ..	..	60,000	10,000	60,000
K. Buildings ..	2.40	14,02,424	2,80,490	16,82,914
L. Earthwork ..	0.09	55,125	11,030	61,155
O. Miscellaneous ..	0.09	54,615	10,920	65,535
P. Maintenance ..	..	..	..	..
Total ..	..	..	..	64,80,400

Or the estimated rate is Rs. 11.66 per acre.

87. *Bench marks and surveys.*—As in all other parts of the project, the datum of all levels is taken from the Great Trigonometrical Survey bench mark in the verandah floor of the Guntūr Municipal dāk bungalow and its level is + 89.73.

When block levelling with the aid of village maps subsidiary bench marks were recorded on the maps on most of the larger village boundary and kundam stones. These village maps are filed in two large brass bound teak wood boxes in the office of the Chief Engineer for Irrigation.

When lines of levels had been taken, contours were interpolated and the longitudinal sections of majors and minors are taken directly off these maps without re-levelling along the channel alignments as was done for branch and main canals.

Velocities were taken at Kennedy's V, which is sufficient for Kistna silt, if sand is kept out of the canals and channels.

88. *Data for banks, berms, slopes, etc.*—Particulars as regards data for design of a channel are furnished in the accompanying tabular statement.

STATEMENT showing standards of channel cross sections.

Determining standards of channel cross sections.					
Item.	Major distributary.		Minor distributary.		Remarks.
	200 to 150 cusecs.	150 to 25 cusecs.	25 to 10 cusecs.	Below 10 cusecs.	
Width of berm of channel ..					
Crest width of wider bank (left bank) ..	$4 + d/2$ 12'	$2 + d/2$ 6'	$2 + d/2$ 4'	$2 + d/2$ 3'	Where d. = depth of bed below ground level in feet. Kutter's co-efficient of Rugosity has been taken as 0.0225 above 50 cusecs capacity and .025 below 50 cusecs.
Crest width of other bank (right bank) ..					
Free board ..					
Depth of earth over hydraulic gradient 1 to 4. ..	6' $2\frac{1}{2}'$ 1'	6' 2' 1'	4' 2' 1'	3' $1\frac{1}{2}'$ 1'	
Width of land to be acquired clear of banks when channel is in cutting deeper than balancing depth.	Half the height of bank subject to a minimum of 5'.				
Width of land to be acquired clear of banks when channel is in less than balancing depth of cutting.	5' in addition to the full height of the bank above ground.				
NOTE.—It has been settled that minor distributaries ..					

NOTE.—It has been settled that minor distributaries should include only distributaries of under 25 cusecs capacity.

89. *Preliminary Expenses (A).*—As in main canal and head works, this sub-head is divided into two classes of expenditure—

(i) Expenditure already incurred in the investigation, such as block levelling the whole commanded area, digging trial pits at sites of proposed masonry works and preparation of estimates for the project. Out of the sum of 3.14 lakhs which the present investigation has cost, it is assumed that Rs. 1 lakh was the cost of investigation of the distributary system and this item is added separately to the estimate for that system.

(ii) Expenditure to be incurred. This includes items such as setting out the channels, lockspitting the boundaries of land to be acquired for information of the Revenue department, clearing sites and digging any additional trial pits necessary. The allowance for this work is Rs. 10 per mile for minor distributaries and Rs. 40 per mile for majors. It is only this item of expenditure which is included in the estimates of which details have been given in the preceding paragraphs and statements.

90. *Land (B).*—The widths taken up are shown in the preceding table and the valuations made by the Special Revenue Officer are average values for each taluk as follows:—

	Rate per acre.	Add 15 per cent. for compulsory acquisition.	Total value per acre.
Sattenapalli ..	84	16	100
Guntūr ..	128	22	150
Tenali ..	..	..	100
Narasaraopet ..	85	15	125
Bāpatla ..	110	15	110
Ongole ..	95	15	110

Where land is required temporarily for digging pits to form banks, that is, when the amount of channel cutting is insufficient, its cost is allowed for at a rate per unit of earthwork. This is the usual practice in the south of Madras Presidency. In this project a rate of Rs. 10 per unit is provided which is equivalent to Rs. 81.62 an acre for pits 3 feet deep, and this rate is sufficiently liberal to allow for permanent acquisition in the few places where permanent injury may be done by pit digging. The total area permanently required is 7,192 acres.

91. *Types of sluices and pipe sluices.*—(i) The sluices proposed at the heads of distributary channels are of the ordinary Madras type provided with screw-gearing shutters. The barrels are generally wider than the ventway and straight splayed wings in rear procure the necessary reduction in velocity between the sluice vent and the earthwork channel.

(ii) Pipe sluices discharge on an average about 1 1/2 cusecs and are not provided with shutters; there is a head and tail wall built round the ends of earthenware pipes laid under the channel banks. Pipe joints will be closed with cement.

The above types of sluices are embodied in plans Nos. D 1 T to D 7 T.

92. *Falls and weirs.*—(i) *The open fall with water cushion.*—This type is adopted for all drops exceeding 2 feet vertical height and of capacity exceeding 25 cusecs.

Data for design.

Length of cistern to foot of reversed slope $(\frac{4}{3} \sqrt{Dd} + 2d)$.

Where d = depth of channel above fall.

D = difference of bed level above and below.

Depth of cistern below bed of channel $= \frac{D+d}{3}$.

Reverse slope at tail of cushion 1 in 5.

All revetments carried up to 1 foot above F.S.L.

Length of side revetment above fall $5 + 4d$.

" " below fall $(20 + 6d \sqrt{D})$.

Pitching on channel bed to a length of half the revetment.

Water flow regulated by trapezoidal notches as described and computed in Nethersole's tables.

A spreading lip to be provided for notch projecting 1 foot.

Wings and bank connections to suit a hydraulic gradient of 1 in 5.

(ii) *Open fall without cushion.*—This type is adopted for all capacities of channel above 25 cusecs where D is less than 2 feet and below 25 cusecs where d is

less than 3 feet. The apron is masonry or dry stone of a length of $\left(\frac{4}{3} \sqrt{Dd} + 2d\right)$ and all other arrangements as in type (i).

(iii) *Syphon well drop*.—This type is used on all minor distributaries, and, though a novelty in Madras, has been adopted, after experimenting with one at Red Hills reservoir, as it is cheaper than an open fall, provides a bridge over the channel and has less turbulent motion of water in rear than other kinds of falls. It was also adopted as a type on the Cauvery project.

The type is shown in plans Nos. D 9 T to D 20 T.

The drop well varies from 4 to 7 feet in diameter according to amount of drop and size of channel, the delivery well is in all cases 4 feet in diameter. The drop well has a trapezoidal notch and lip as in the other types, and pitching and revetment are also similar.

93. *Cross drainage works*.—Though most channels are aligned on ridges, a few run on contours round isolated high mounds and the small drainages intercepted are and outlets.

In the typical area only one minor distributary, Kanuparti No. 16, intercepts any drainage, and four majors do so likewise. In the case of Kanuparti channel waterways underneath the channel are provided owing to (i) the importance of the channel at the site of the crossings, (ii) the relatively large area irrigated below so that no risk of damage to the channel can be taken. Portfolio 12, plans Nos. D 49 to D 53.

94. *Bridges*.—Bridges are provided for all District Board roads and the minimum width of roadway for such bridges is 14 feet. Where there are no such roads, bridges are provided at existing cart-tracks at an average rate of one in every 2 miles. When channels are 2 feet or less in depth, paved ramps are provided in place of bridges at cart-track crossings. Masonry bridges are provided when the span is less than 15 feet, for larger spans steel beam bridges are allowed.

95. *Buildings*.—Though there are now several District Board and other dak bungalows in the irrigable area, it will be necessary to increase the number in order to supervise efficiently the distribution of water. The Madras Government permit rest-houses of a capital cost not exceeding Rs. 5,000 each and ten inspection bungalows are provided at this rate; their exact location will be fixed at the time of execution of the distribution system when they will be most needed.

96. *Miscellaneous*.—Under this head provision is made for demarcation (Revenue Survey) stones, and mile and furlong stones.

97. *Maintenance*.—Provision is made at the rate of Rs. 100 per mile for major distributaries and Rs. 25 per mile for minors for maintenance of completed portions of channel during construction.

98. *Proportions of channels adopted in the estimate*.—The following table shows the proportions of distributaries adopted in this project for channels of varying size. All side slopes are taken at $\frac{1}{2}$ to 1 for hydraulic calculations, but for earthwork quantities they are taken as 1 to 1.

Capacity cubic	Bed width in feet.	Depth in feet.	Slope to produce velocity V_0 .	V_0 .	Co-efficient "n" in Kutter's formula.
300	28	4.5	1/4,940	2.20	N = .0225
200	22	4.0	1/4,700	2.04	
100	15	3.25	1/4,320	1.79	
75	13	3.0	1/4,200	1.70	
50	10	2.75	1/3,150	1.60	
40	9	2.5	1/2,890	1.51	N = .025
30	8	2.25	1/2,950	1.41	
20	7	2.0	1/2,920	1.30	
10	5	1.5	1/2,630	1.00	
5	3	1.5	1 2 140	1.00	

99. *Rates for materials*.—These are given in detail in section V, part I, of this volume in paragraphs 197—201. It is unnecessary to make any observation on the materials obtainable which are of excellent quality and usually available within 2 miles of any work.

MADRAS,
20th June 1911.

C. T. MULLINGS,
Executive Engineer, Kistna Reservoir Project.

UPLAND Canal system.

	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.
	1	2	3	4	5	6	7	8	9	10	11
I. Works—											
Works ..		1,203	1,800	1,800	1,800	1,800	1,800	1,800	1,800	2,000	2,000
Land ..	200	500	500	500	..	..	50	50	50	50	50
Total ..	200	1,703	2,300	2,300	1,800	1,800	1,850	1,850	1,850	2,050	2,050
II. Establishment—											
Ordinary ..	..	250	114	414	414	414	414	414	414	460	460
Special ..	29	19	29	28	..	4	2	2	3	2	3
Total ..	29	259	443	442	414	418	416	416	417	462	463
III. Tools and plant—											
Ordinary ..	..	15	27	27	27	27	27	27	27	30	30
Special ..	..	50	50	20	20	20	20	20	..	..	..
Total ..	..	65	77	47	47	47	47	47	27	30	30
IV. Suspense ..	..	25	25	20	20	10	..	..	..	..	..
V. Receipts ..	..	..	2	2	3	5	5	5	5	5	5
Total ..	229	2,052	2,843	2,807	2,278	2,270	2,308	2,308	2,289	2,537	2,538

	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.	XXIII.	XXIV.	—
	12	13	14	15	16	17	18	19	20	21	22
I. Works—											
Works ..	2,000	2,000	1,500	1,500	1,200	1,000	150	150	150	59	17,512
Land ..	30	30	30	25	25	19	..	..	..	..	2,109
Total ..	2,030	2,030	1,530	1,525	1,225	1,019	150	150	150	59	29,621
II. Establishment—											
Ordinary ..	460	460	345	345	276	230	35	34	35	13	6,281
Special ..	3	2	3	3	4	4	5	5	..	..	160
Total ..	463	462	348	348	280	234	40	39	35	13	6,441
III. Tools and plant—											
Ordinary ..	30	30	22	23	18	15	3	2	2	1	410
Special ..	..	..	..	..	..	..	..	..	..	..	200
Total ..	30	30	22	23	18	15	3	2	2	1	610
IV. Suspense ..	..	..	10	15	15	10	10	..	..	..	40
V. Receipts ..	5	5	5	5	4	2	1	..	..	..	64
Total ..	2,518	2,517	1,885	1,876	1,504	1,256	182	191	187	73	26,048

PART IV.

NOTE BY THE CHIEF ENGINEER FOR IRRIGATION.

PART IV.

Note by the Chief Engineer for Irrigation.

KISTNA RESERVOIR PROJECT.

A.—GENERAL.

A brief description of the project.—The Kistna Reservoir project as now prepared provides for (i) a reservoir on the Kistna at Pulichintala having a waterspread area of 122 square miles and a gross capacity of 163,586 millions cubic feet, (ii) an upland canal taking off direct from the reservoir to irrigate 610,000 acres in the Guntūr district, (iii) an extension of the distribution system in the Kistna delta under the Bezwada anicut to irrigate newly 125,000 acres of long crop and 167,000 acres of a short late crop or second crop. The Special Superintending Engineer's report describes the project in great detail and the more important points in it will be dealt with in the following notes.

2. *Necessity for the project.*—The water-supply for the existing irrigation in the Kistna delta under the Bezwada anicut is frequently insufficient towards the close of the irrigation season and its failure has limited the extension of the irrigated area although more land is available. This situation is likely to grow worse in course of time and the existing irrigation in the delta may be seriously affected by the construction of new reservoirs on the river and its tributaries in Bombay and Hyderabad. Further the scanty discharge in the river after the month of January till the appearance of the first flood which occurs sometimes only very late in June, precludes the possibility of cultivating any considerable area of second crop or late short crop in the delta. The construction of a reservoir is necessary to remove the above disabilities as well as to irrigate a new tract of country in the Guntūr district.

3. *Determination of the best form of project and its scope.*—The proposal to construct a reservoir on the Kistna has been made on several occasions, but the first definite scheme was that put forward by Mr. Reid for one at Daida. This was however abandoned on the recommendation of the Inspector-General of Irrigation, project and it was considered that the cost of carrying the main canal through the very difficult country traversed in the first 40 miles of its length had been greatly under-estimated and would when corrected make the total of the estimate prohibitive. A search for a site lower down the Kistna was instituted so as to avoid the great length of difficult country which the Daida site entails. No less than five dam sites of more or less promise were found in the Pulichintala-Muktiala loop of the Kistna river and on further investigation the dam site near Wadana-palli proved to be the best, and has been adopted for preparing the designs and estimates of the head-works. The effect which the deposition of silt would have on the life of the reservoir had not hitherto been considered as it was believed that the high floods which are most silt-laden could be passed through the sluices in the main dam with water at a low level. Owing to the high level of the upland canal-offtake and the unsuitability of the rock below for surplusing large volumes of water through powerful scouring sluices in the main dam, this method of dealing with the surplus was given up. Arrangements have therefore been made to locate the surplus sluices in the saddle on the left side of Wadanapalli hill where napa rock is available and can be relied on for surplusing large volumes of water. The surplus sluices have been so designed as to allow the level of water in the reservoir to be maintained at a nearly constant level throughout the whole of the silt-carrying season, this level being such as to give just the requisite supply for the upland canal system. The rest of the discharge of river will be passed down through the surplus

sluices and the impounding of water in the reservoir will be commenced towards the close of the flood season in time to get an adequate and if possible a full supply in the reservoir. The rules regarding the working of the reservoir are given at end of section II, Vol. I of report, Kistna Reservoir Project, and are suitable. Regarding the scope of the project, as many as six alternatives were considered, estimated for roughly and their financial forecasts worked out. Considering the satisfactory working of the reservoir, the capital cost of the project and the revenue returns derivable therefrom, it was decided to omit all irrigation of second crop under the upland canal and provide for the irrigation of 610,000 acres of first crop under the upland canal, 125,000 acres of first crop and 167,000 acres of second crop or short late crop as extensions in the Kistna delta under the Bezvada anicut.

4. *The silt problem.*—The method of dealing with the enormous quantity of solid matter carried in suspension in the river water was considered in great detail as affecting seriously the proposals for the height of the main dam and the arrangements for passing down the river flow. The investigations made by the Special Superintending Engineer have furnished instructive results and the calculations made of the rate of silting and the life of the reservoir on certain assumptions appear to be very safe.

5. *The position of the main dam, its alignment, description, etc.*—These are described at length in paragraphs 53—58 of the Special Superintending Engineer's report and the main point which affected the design is the decision arrived at regarding the unsuitability of the shale foundations to withstand the action caused by a rush of water flowing over it with a high velocity or the impact of water falling in great masses. This has necessitated the dam being so aligned as to admit of the surplus sluice being located on the left of the Wadanapalli hill where hard napa rock is met with. The alternative arrangement of having surplus sluices in the main dam with a cushion dam below, which will have to be built in any case to protect the river bed during construction, has been discussed fully in paragraphs 64—67 of the Special Superintending Engineer's report, and as stated therein it is in deference to the strongly-expressed opinion and specific desire of the Inspector-General of Irrigation that the arrangement of surplus sluices on the ridge line to the left of Wadanapalli hill has been made. The Chief Engineer for Irrigation considers that, if the site originally selected is adhered to, the proposals of the Special Superintending Engineer are the better. An alternative site for the main dam across the river was investigated at the instance of the Inspector-General of Irrigation about 250 feet below the alignment adopted. The object of this was twofold—

(i) To cut out the first 2 miles of the Upland main canal round Pulichintala ridge where the country is very difficult.

(ii) It would allow an earthen bund to be raised on the silt deposited in the reservoir along the line of dam now adopted, if it should turn out that the rate of silt deposit was more rapid than that estimated by Colonel Ellis.

It is however pointed out that the impervious silt deposits which take the place of water will cause a reduction of pressure on the dam which will admit of raising the full reservoir level and the top of the masonry dam, thus prolonging the life of the reservoir almost indefinitely. Taking an angle of repose of 30° for the silt deposited in the reservoir, the calculations made go to show that the full lake level of the reservoir and the top of dam might be raised by the following heights when the silt deposits rise up to the levels shown against them—

Height by which the full reservoir level might be raised.	Level of silt deposit in the reservoir.
(2302-5) 4-75	180-50
(235-50) 10-00	170-00
(239-50) 14-00	190-00

Unfortunately it was not possible to complete fully the investigation as boring through shingle proved a very tedious and slow operation and several difficulties were encountered. But the results of the borings made so far were sufficient to indicate that the rift or gully in the river bed is continuous and cannot be avoided.

and that no material advantage would be gained by the adoption of the alternative line for the dam across the river. With the data available an approximate estimate of cost was made out for the alternative line and it showed an excess of Rs. 11,20,940 on works over the one for the alignment adopted in the project estimate. The above estimate being based on insufficient data cannot be considered very accurate, but it may be safely assumed that the estimate based on more detailed borings will be not less than that now made and may be considerably greater. In case the alternative line is adopted there would be difficulty in keeping the approaches to the head regulator of the Upland Canal free from obstruction and it is probable that this would necessitate constant clearance and dredging in the approaches to it. Considering these facts, it is thought unnecessary to pursue the investigation in connection with the alternative line for the main dam any further and the estimate for the alignment already adopted is recommended for sanction.

6. *The Construction of dams, methods proposed and the materials to be used in,—* The methods of construction proposed and the materials proposed to be employed, have received careful consideration and may be accepted generally as being suitable.

7. *Revenue forecast and financial aspects.*—The report on the revenue aspect of the project will be found printed in Part V (G.O. No. 2435, Revenue, dated 8th August 1911). The question has been fully considered by the Special Revenue Officer (Mr. Turing) and the Board of Revenue. Mr. Turing estimated that the net irrigable area under the project would be 974,001 acres, while the figure has been raised by Government in the Revenue Department to 987,834 acres by treating as irrigable the lands set apart for grazing, following the principle adopted in the case of the Divi Pumping system and Cauvery Reservoir Project. The reservoir as finally designed is capable of supplying 902,300 acres (760,394 acres for single crop and 141,906 acres of second crop) as shown below :—

	ACS.
Upland canal	610,000
Extension in the delta ordinary crop	125,300
Short late crop	25,094
Second crop in the delta	Total ... 760,394
	141,906
	Grand total ... 902,300

As was done in the case of the Cauvery Reservoir Project, the forecast has been framed not with reference to the assessment now in force, but to the rates of assessment, which may be imposed at the resettlement, as the Kistna and Guntur districts which are to be benefited by the project will be due for resettlement by the time irrigation under the reservoir is fully developed.

8. *Programme of construction and the proposed construction staff.*—This has been described in detail in paragraphs 216 to 243 of the Special Superintending Engineer's report.

The work will be placed in charge of an Engineer-in-Chief with a Superintendent of Works under him and with the necessary Engineering and Subordinate staff. A provision of Rs. 2,25,600 has been made for the Special Revenue officer and the staff for taking up the land required for the project. A sum of Rs. 4,40,840 has also been allowed for the necessary Medical, Police and Forest staffs.

The programme has been carefully considered by the Special Superintending Engineer and may be accepted.

9. *Land compensation.*—This question has been dealt with thoroughly in paragraphs 120 to 132 of the Special Revenue officer's report. The proposals appear suitable and may be accepted. The question of the acquisition of the land in His Highness the Nizam's territory to be submerged by the reservoir is under the consideration of Government.

10. *Financial*.—The total cost of the project is as detailed below :—

<i>Direct charges.</i>						RS.
I. Works—						
(a)	Head works	...	...	...	...	3,10,07,488
(b)	Upland canal system	...	...	...	...	2,98,21,000
(c)	Distributaries under delta extension	...	...	...	...	33,61,800
II. Establishment (ordinary)						6,39,90,288
Do. (special)						1,27,26,429
III. Tools and plant (ordinary)						6,66,440
Do. (special)						8,49,855
Suspense						21,00,000
Less receipts on Capital account						90,000
Total, Direct charges						7,96,88,350
<i>Indirect charges.</i>						
Abatement of land revenue						18,24,905
Leave and pension allowances						18,75,001
Total, Indirect charges						36,99,906
Grand total						8,33,88,256

The net revenue anticipated (*vide* paragraph 11 of G.O. No. 2435, Revenue, dated 8th August 1911 printed in Part V) is Rs. 49,92,453 which represents a return of 5.98 per cent. on the Capital outlay.

The usual financial tables Parts I to IV have been prepared in accordance with the figures of the growth of revenue given in G.O. No. 2435, Revenue, dated 8th August 1911 referred to above and are appended.

It will be observed from table IV that at the end of 10 years after the completion of the project, there is after deducting interest charges, an accumulated surplus of net revenue of Rs. 32,18,752. The annual net revenue of Rs. 49,92,453 more than covers the annual interest of Rs. 33,35,530 calculated at 4 per cent. on the capital invested. The project therefore amply satisfies the conditions of a Productive Public Work as laid down in Code paragraph 1889 and may be recommended for sanction.

11. *General remarks*.—Great credit is due to Colonel Ellis, R.E., Special Superintending Engineer, Mr. C. T. Mullings, Executive Engineer, and the staff engaged on the work for the thorough and complete manner in which the project estimates have been worked out. The question of the effect which the enormous quantity of silt carried in the river will have on the reservoir has been dealt with by Colonel Ellis very thoroughly and neither time nor trouble has been spared by him to ensure trustworthy results.

B.—TECHNICAL.

12. *Supplies available for the Kistna Reservoir Project*.—These have been determined from the actual surpluses recorded at the Bezwada anicut after making suitable deductions for all projected works upstream of the dam site in the Kistna and the Tungabhadra basins. The methods of calculating the discharges of river at the Bezwada anicut and the deductions made for the up-river projects are detailed in parts I and II of volume II and may be accepted as reasonable and sufficient.

13. *Duty of water*.—This question is dealt with fully in part III, volume II. From the results of the gauging observations made on an elaborate scale in the Kistna delta Western section during the years 1907–1909, the quantity of water actually used was ascertained and the half monthly requirements of an acre of rice crop (early) were fixed. These figures were taken as a guide in fixing the duties for the early or the first crop under the upland canal and in the delta. Regarding the duties for the second crop or the short late crop, for both have been treated alike, no such data were

available; but the supply requirements have been considered carefully and allowed for. They are found to be very liberal when compared with the results of some observations since made in some of the channels of the Gódavari delta where second crop is grown extensively. The duties adopted may therefore be accepted, any error being on the side of safety.

14. *Working tables of the reservoir*.—These are detailed in part III, volume II, and show clearly the working of the reservoir having an effective capacity of 50,107 millions cubic feet had it been executed and in operation in the 16 years from 1894–1909. The gross capacity of the reservoir is 163,586 millions cubic feet and the effective capacity noted above is the forecasted capacity of the reservoir at the commencement of the final stage of silt deposit. The rules drawn up for the working of the reservoir are suitable and may be accepted. The working tables show at a glance how useful the reservoir is in (1) starting the cultivation of the early crop in the delta without waiting for the first floods in the river which gives time for a second crop to be grown, (2) giving the supplies required towards the close of the irrigation season for the first crop in the delta. With the balance of the supply stored in the reservoir, a short late crop or second crop will be grown to a varying extent, the average area grown for the 16 years being 167,000 acres.

15. *Principles of design Main dam*.—These are detailed in paragraphs 117–126 of Special Superintending Engineer's report. The profile of the dam has been determined as for a gravity type, according to the latest theories on the subject. The maximum compressive stresses have been computed both according to Unwin's and Bouvier's theories, the pressure being limited to 12 tons per square foot in the former method and to 8 tons per square foot in the latter. In the narrow V shaped rift in the river bed, the pressure rises to 14.76 tons and 9.03 tons per square foot and these are not considered objectionable, considering the stresses calculated in some of the existing and undoubtedly stable works in similar narrow rifts.

16. *Temperature stresses joints, etc.*—These are dealt with fully in paragraphs 127–140 of Special Superintending Engineer's report. The necessity for providing for temperature or expansion joints has been proved and the proposals made for spacing these joints at the time and mode of filling them appear suitable and may be accepted.

17. *of surplus sluice and head regulator*.—In calculating the stability of the pier weight of all masonry upstream of the grooves on which roller paths are fixed, not been taken into account and this may be accepted as an assumption on the safe side. The upstream face walls between the piers are proposed to be built of napa stones on edge (vertical bedding) so as to act as arches against both horizontal and vertical thrusts due to the pressure of water. To ensure their behaviour as flat arches under the pressure of water, it is considered advisable to build them in blocks with radial joints excepting the top 10 feet or so where the pressure of water is little or nothing at all. These remarks apply also to the screen wall in front of the vents in the portion of the dam to the left of the surplus sluices. The extra cost of the above proposal will be but small and can be easily met from the provision for unforeseen works made in the estimate.

18. *Delta Extensio*.—The additional area of early first crop which will be irrigated in the Kistna delta under the Bezwada anicut through the Kistna reservoir project is 125,000 acres, of which 73,000 acres are in the Eastern section and 52,000 acres are in the Western section. There will also be the irrigation of a second crop to the extent of 197,456 acres and a short late crop to the extent of 25,000 acres, with the supply stored in the reservoir. The works required are the improvements of the head works at Bezwada and of the systems of the existing canals, branches and distributaries in the two sections of the delta so as to command the new areas in addition to the existing ones.

19. *Head works—Bezwada anicut falling shutters*.—The proposals made for extension of area to be irrigated in the two sections of the delta involve a height of water in rear of the head sluices which would necessitate falling shutters 7 feet high (effective height 6.75') over the anicut crest including the allowances made for loss of head in

the approach channels in river and at the head sluices. These have been provided for in the project estimate. The type of shutter proposed and the methods of working them have been determined after careful consideration and in correspondence with Messrs. Ransomes and Rapier and may be accepted. In this connection, it may be stated that the height of the existing shutters is not sufficient to supply satisfactorily the area irrigated under the existing system, much less the ultimate ayacut fixed for it. Shutters 5 feet high are found necessary to successfully supply the ultimate ayacut of the two sections of the delta and so the cost of these 5 feet-shutters will be a fair charge on the capital cost of the Kistna delta system. The difference in cost between the 7 feet and 5 feet shutters will be the correct charge to be debited to the project estimate and not the whole cost of the 7 feet shutters. The installation of the 5 feet shutters required for the delta has been postponed till the estimate for the Kistna reservoir project is disposed of, as in case the latter is to be executed at an early date, the 7 feet shutters required for the project might as well be erected in the first instance. If, on the contrary, there is no near prospect of the execution of the Kistna reservoir project, it will be necessary to install the 5 feet shutters required for the delta at once.

20. *Eastern section.*—The ultimate ayacut in this section of the delta under the Bezwada anicut is 420,000 acres and the extension proposed under the project is 73,000 acres, thus bringing the total area to be supplied to 493,000 acres. The grading proposed for the main and branch canals to carry the increased discharges is suitable and may be accepted. The velocity obtained in the above proposal is $0.9 \times V_o$ (Kennedy's critical velocity for Punjab Sand) which is considered suitable for the silt met with in these canals. No new masonry works are required in the main or branch canals excepting the regulator at the head of the Ellore canal for which a lump sum provision has been made. This work is necessary and is a correct charge on the project estimates. The provision made is sufficient. The alterations required in the case of some of the existing works have been estimated for and included in the project estimates and are suitable.

21. *Distribution system.*—Excepting an area of 49,000 acres proposed to be irrigated under the East Bank Canal, the rest of the area lies in 11 blocks distributed all over the delta and will be commanded mostly by improving and extending the existing channels and excavating new ones in a few cases. Detailed plans and estimates have been prepared for the irrigation of a block of 6,000 acres and the acreage rate arrived at has been applied to the rest of the area with some modifications suited to the different circumstances in each case, such as the cost of land, the nature of country traversed, etc. The designs for the masonry works are of the usual type and call for no remarks.

22. *East Bank canal.*—This has been estimated for separately. The grading and alignment proposed are suitable. The designs for the masonry works in it have been copied from the existing works in the delta and call for no remarks.

23. *Collair area.*—An area of 20,000 acres is proposed to be cultivated with a short late crop in the bed of the lake as the level of water falls and the proposals made for excavating distributaries to command these lands are the best under the circumstances and may be accepted. It is probable that more detailed investigation will show that a larger area in the Collair lake can be profitably commanded. If this is so, it may be added to the late first-crop area, that of second crop being proportionately decreased. It has not been thought necessary to delay the submission of the project to make the necessary investigation.

24. *Western section.*—The ultimate ayacut in this section of the delta under the Bezwada anicut is 305,000 acres and the area of extension proposed under the Kistna reservoir project is 52,000 acres, thus bringing the total area to be supplied to 357,000 acres. The existing canals and branches require little or no alterations to carry the increased discharges; the grading proposed and the velocities obtained are suitable and may be accepted. No new masonry works are required in the main and branch canals.

25. *Distribution system.*—The area of extension in this section of the delta under the Kistna reservoir project is 52,000 acres and it lies in small patches scattered all over the delta and will be commanded mostly by improving and extending the existing

channels and excavating new ones in a few cases. The cost of these works has been estimated for in detail and in it is included also the cost of such works as are required to improve the existing system. Strictly speaking the cost of the latter is not a fair charge on the project estimates. By the time the estimate for the project is likely to be sanctioned and executed, many of these works may have been carried out and the estimates prepared now would require to be altered considerably. It appears sufficient for the present to state that the provision made in the project estimate is greater than what is likely to be required and may therefore be accepted as being on the safe side.

26. *Masonry works.*—Type designs have been prepared for each class of work proposed and they are of the usual pattern excepting the one fact that ferro-concrete is put in mostly as slabs in all possible places. The rate allowed for it includes a provision, As. 8 per cubic foot for "forms," and this is hardly necessary in the case of slabs as they can conveniently be moulded in the ground without any special forms. Further there is no object in the use of these ferro-concrete slabs when brick or concrete arches are cheaper. In some cases, the thickness of the slabs carrying the face or side walls is not sufficient and will have to be increased. Generally speaking, brick or masonry arches should be used wherever they are cheaper and the ferro-concrete slabs in other cases taking care to design the thickness of the slabs properly. The above alterations will not entail any increase in cost, and as many of these works may have been carried out to improve the existing system by the time the Kistna reservoir project will be sanctioned and executed, it has not been considered necessary to alter the designs.

Another special feature in the proposals is the provision made on a large scale for Mr. Kennedy's patent gauge outlets in place of the pipe sluices as the discharges through the former are unaffected by the variations in the water levels in rear, an advantage which is not to be ignored in a large distribution system like that of the Kistna. But in view of the experience of these modules in the Bombay Presidency where it is reported that the irrigators are able to close the air-vent and thus increase the discharge by nearly 50 to 75 per cent., it is not considered advisable to adopt these outlets until means can be devised at moderate cost to prevent their being thus tampered with. As their cost will more than cover that of the pipe sluices, the provision made in the estimate is sufficient and may be accepted.

27. *The Upland canal—Kistna Reservoir Project.*—The main canal which is 147 miles long, runs in a tortuous course following the contour of the country crossing the drainages and has a carrying capacity diminishing from 8,878 cusecs at the head to 515 cusecs at mile 147. The cross drainages have been kept out of the canal, except in two places where it has not been possible to do so; proper arrangements have been made in both the above cases to dispose of the drainage without any risk or danger of breaching the canal or damaging it otherwise. The cross drainage works are unavoidably numerous as the intervening ridges are too steep to admit of the grouping of the drainages. In the first six miles of the canal the country traversed is very undulating and in order to minimise as far as possible the heavy cost of cutting in hard shale the canal is run with a greater depth and less width and with curves of shorter radii than are accepted in ordinary practice. Below this, the country presents no special difficulties and the alignment, grading, etc., of the canal have been carefully thought out and may be accepted as suitable in every respect. In all cases where deep cuttings are encountered, estimates for alternative lines for a contour canal were made out and rejected either owing to their extra cost or the diminution of the irrigable area due to the loss of head in the longer contour canal and the consequent increase in the cost of the cuttings lower down the canal. The provision made for bridges is very liberal and if any more are considered necessary at particular places where they have not been provided for, there should be corresponding reductions elsewhere.

28. *Critical velocity.*—The results of observations made in the Kistna delta canals during the years 1907—1909 show that critical velocity obtained in the main and branch canals vary from $0.9 \times V_o$ to $0.7 \times V_o$. As the silt which will be met with in the upland canal will be slightly coarser than that met with in the delta, the velocity adopted is V_o and this is considered suitable.

29. *Cross section of canal.*—The values taken for the co-efficient of rugosity (N) in Kutter's formula, the standards of side slopes of excavation, banks, berms, crest widths, free board, etc., adopted for the main and branch canals and the allowance for seepage are according to accepted practice and call for no remarks.

30. *Run-off from cross drainages.*—These have been computed by using Ryves' formula $Q = C (m)^{\frac{2}{3}}$ with a value of 1,000 for C. This no doubt appears very high in the case of small areas such as those for which cross drainage works have been designed; but considering the effect of a heavy downpour falling in a very short time over a country with rather steep slopes, it does not appear advisable to take a less value.

31. *Masonry works.*—These have been designed and estimated for completely in the case of the main canal. The data adopted in designing the several kinds of works are detailed fully in each case. Type designs were also made out for each class of work on the lines approved for the Cauvery project and they embody all the improvements evolved by the experience of many years. They are all economical and may be accepted as being suitable in each case.

32. *Distribution system—Upland canal.*—The total area to be irrigated under the upland canal is 610,000 acres. Of this an area of 26,225 acres will be served directly by means of pipe sluices in the main and branch canals, leaving an area of 583,755 acres to be served by the distribution system.

33. *Method of estimating the cost of the distribution system.*—Detailed plans and estimates were prepared for the distribution system for a typical area of 63,951 acres—whole system. In so doing, three different methods were adopted, viz. (1) with acreage rate for the whole system of majors and minors arrived at in the typical area, (2) with separate acreage rates for majors and minors arrived at in the typical area, (3) with an acreage rate for minors and a cusec mile rate for the majors arrived at in the typical area, and the largest of the three estimates has been taken for the project estimate to be on the safe side, and may be accepted. The total estimated cost of the whole distribution system is Rs. 64,60,400 or Rs. 11.66 per acre.

34. *Distribution system for the typical area.*—The typical area comprises four blocks and each block consists of several channels and distributaries. These have been described fully in paragraphs 169 to 172 of report. The grading, alignment, etc., proposed for the several channels are suitable in every respect. The standard dimensions of channel cross sections agree with what are usually accepted in such cases and call for no remarks. The type-designs for the masonry works have been prepared on approved lines and are economical.

35. *Rates.*—The rates for works in (1) the head works, (2) the upland canal system, (3) the delta extensions, are dealt with fully in section V, paragraphs 191 to 210, Special Superintending Engineer's report, Volume I. They are fixed materially higher than the current local rates so as to meet what would probably have to be paid in the early stages of the work, were actual work commenced within the next year or two. An allowance has been made under the heading of "Unforeseen charges" to provide for the possible further rise in rates in the future, the allowance being limited to 10 per cent. on works excepting preliminary expenses and manufactured structural steel in the case of head works and to 20 per cent. on works, excepting preliminary expenses in the case of the upland canal system and delta extensions. These provisions may be accepted as reasonable and sufficient to complete the project works.

30th November 1911.

H. E. CLERK,
Chief Engineer for Irrigation.

KISTNA RESERVOIR PROJECT.

CONDENSED Abstract.

	Head Works.	Upland Canal System.	Delta Extension.	Total.
<i>Direct Charges.</i>	Rs.	Rs.	Rs.	Rs.
1. Works	3,10,07,488	2,96,21,000	33,61,800	6,39,90,288
2. Establishment—Ordinary	58,31,715	62,80,945	6,13,769	1,27,26,429
Do. Special	5,00,840	1,60,800	5,000	6,66,440
3. Tools and Plant—Ordinary	4,05,957	4,09,627	34,271	8,49,855
Do. Special	19,00,000	2,00,000	..	21,00,000
4. Suspense	50,000	40,000	..	90,000
5. Receipts on Capital Account	3,98,96,000	3,67,12,172	40,14,840	8,04,23,012
	— 6,70,000	— 64,662	..	— 7,34,662
Total, Direct charges	3,90,26,000	3,68,47,510	40,14,840	7,96,88,350
<i>Indirect charges.</i>			E 1,02,155 W 39,974	18,24,905
Abatement of Land Revenue	10,46,902	6,35,874	1,42,129	18,75,001
Leave and Pension Allowances	8,86,558	9,01,816	86,827	36,99,906
Total, Indirect charges	19,33,460	15,37,690	2,28,756	8,33,88,256
Total, Direct and Indirect charges	4,09,59,460	3,81,85,200	42,43,596	8,33,88,256

* 23 per cent. on works, Rs. 55,29,429; 10 per cent. on shutters and steel works, Rs. 3,02,286.

Forecast of Financial Prospects

PART I.—Summary of the estimated Direct Charges to Capital Account.

Year.	Works.			Establishment.	Tools and plant.	Suspence.	Less receipts on Capital Account.	Total, i.e., columns 4 + 5 + 6 + 7 — 8.
1	2	3	4	5	6	7	8	9
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
First year	36,000	9,05,000	9,41,000	1,82,000	4,61,000	30,000	13,000	16,04,000
Second "	..	10,09,000	10,09,000	2,52,000	6,45,000	70,000	15,000	19,63,000
Third "	..	17,87,000	17,87,000	4,45,000	2,42,000	50,000	19,000	31,45,000
Fourth "	2,45,000	21,58,000	24,03,000	5,59,000	1,62,000	45,000	19,000	46,07,000
Fifth "	5,00,000	31,63,000	36,63,000	7,34,000	1,84,000	45,000	21,000	71,80,000
Sixth "	10,85,000	47,38,000	58,13,000	11,39,000	1,99,000	30,000	21,000	66,28,239
Seventh "	7,24,239	46,33,000	53,57,239	11,14,000	1,48,000	20,000	22,000	63,56,000
Eighth "	6,10,000	38,37,000	43,47,000	9,10,000	1,01,000	10,000	24,000	42,76,000
Ninth "	..	33,77,000	33,77,000	7,85,000	1,06,000	..	24,000	50,26,000
Tenth "	4,48,000	30,36,000	34,84,000	7,26,000	90,000	..	24,000	51,79,350
Eleventh "	2,61,000	38,26,000	40,87,000	8,35,000	1,27,000	..	24,000	49,23,251
Twelfth "	7,36,000	36,20,350	43,56,350	7,89,000	78,000	— 20,000	44,000	48,23,251
Thirteenth "	2,27,000	36,94,211	39,21,211	8,78,769	89,271	— 20,000	44,000	41,51,000
Fourteenth "	2,05,000	40,73,000	42,78,000	8,62,000	85,000	— 30,000	44,000	42,11,000
Fifteenth "	1,85,000	32,79,000	34,64,000	7,48,000	78,000	— 30,000	44,000	41,51,000
Sixteenth "	1,85,000	32,32,000	34,17,000	7,36,000	72,000	— 30,000	44,000	41,42,000
Seventeenth "	1,85,000	24,80,000	26,65,000	6,90,000	29,967	— 55,000	1,10,000	28,21,829
Eighteenth "	1,79,000	19,13,810	20,92,810	4,68,555	18,000	— 15,000	2,000	14,10,291
Nineteenth "	1,79,000	12,00,000	13,79,000	2,80,000	..	— 10,000	..	3,45,388
Twentieth "	1,73,291	10,00,000	11,73,291	2,34,000	15,000	— 10,000	1,662	3,45,000
Twenty-first "	1,54,000	1,50,000	3,04,000	40,000	..	..	..	3,40,678
Twenty-second "	1,54,000	1,50,000	3,04,000	39,000	..	..	..	72,881
Twenty-third "	1,53,678	1,50,000	3,03,678	35,000	..	..	..	..
Twenty-fourth "	..	58,709	58,709	13,546	627	..	..	..
Total	65,25,208	5,74,65,080	6,39,90,288	1,33,92,869	29,49,355	90,000	7,48,662	7,96,88,350

PART II.—Summary of the estimated Indirect Charges to Capital.

Year.	Capitalization of Land Revenue abated.	Charges for leave and pension allowances.	Total.
First year	Rs. 10,080	Rs. 25,480	Rs. 35,560
Second "	"	35,280	35,280
Third "	"	62,300	62,300
Fourth "	"	78,260	1,46,840
Fifth "	68,600	1,02,760	2,42,760
Sixth "	1,40,000	1,59,460	4,83,260
Seventh "	3,03,800	1,55,960	3,58,747
Eighth "	2,02,787	1,27,400	2,70,200
Ninth "	1,42,800	1,09,900	2,27,080
Tenth "	"	1,01,640	1,89,980
Eleventh "	1,25,440	1,16,900	3,16,540
Twelfth "	73,080	1,10,460	1,86,808
Thirteenth "	2,06,080	1,20,680	1,78,080
Fourteenth "	63,560	1,04,720	1,56,520
Fifteenth "	57,400	1,03,040	1,54,840
Sixteenth "	51,800	82,600	1,34,400
Seventeenth "	51,800	65,598	1,15,718
Eighteenth "	51,800	39,200	89,320
Nineteenth "	50,120	32,760	81,281
Twentieth "	50,120	5,600	48,720
Twenty-first "	48,521	5,460	45,777
Twenty-second "	43,120	1,895	1,895
Twenty-third "	40,877	"	"
Twenty-fourth "	"	"	"
Total ..	18,24,905	18,75,001	36,99,906

PART III.—Estimate of growth of Irrigation and Revenue Receipts and Charges.

Year of construction.	Irrigated area at end of year.	Revenue receipts and charges.					
		Gross revenue due to works.			Net revenue due to works.		
		Direct receipts.	Enhanced land revenue or indirect revenue.	Total.	Including enhanced land revenue.	Excluding enhanced land revenue.	
1	2	3	4	5	6	7	8
Eighth year	15,000-D	Rs. 1,05,000	Rs. 8,861	Rs. 1,13,861	Rs. 23,366	Rs. 90,495	Rs. 81,634
Ninth "	30,000-D	2,10,000	17,722	2,27,722	46,732	1,80,990	1,83,268
Tenth "	45,000-D	3,15,000	26,583	3,41,583	69,098	2,71,485	2,45,902
Eleventh "	60,000-D	4,20,000	35,444	4,55,444	93,464	3,61,980	3,28,536
Twelfth "	75,000-D	5,25,000	44,305	5,69,305	1,16,830	4,52,475	4,08,170
Thirteenth "	90,000-D	6,30,000	53,166	6,83,166	1,40,296	5,42,870	4,92,574
Fourteenth "	105,000-D	7,35,000	62,027	7,97,027	1,63,757	6,33,270	5,69,513
Fifteenth "	120,000-D	8,40,000	70,888	9,10,888	1,87,218	7,23,670	6,36,452
Sixteenth "	135,000-D	9,45,000	79,749	10,24,749	2,10,679	8,13,070	7,02,391
Seventeenth "	150,000-D	10,50,000	88,610	11,38,610	2,34,139	9,04,471	7,70,332
Eighteenth "	165,000-D	11,55,000	97,471	12,52,471	2,57,600	9,94,871	8,37,271
Nineteenth "	180,000-D	12,60,000	106,332	13,66,332	2,81,060	10,85,271	9,04,211
Twentieth "	195,000-D	13,65,000	115,193	14,80,193	3,04,521	11,75,671	9,70,151
Twenty-first "	210,000-D	14,70,000	124,054	15,94,054	3,27,982	12,66,071	10,38,091
Twenty-second "	225,000-D	15,75,000	132,915	16,07,915	3,51,443	12,56,471	10,05,031
Twenty-third "	240,000-D	16,80,000	141,776	17,21,776	3,74,904	12,46,871	9,71,971
Twenty-fourth "	255,000-D	17,85,000	150,637	18,35,637	3,98,365	12,37,271	9,38,911
Twenty-fifth "	270,000-D	18,90,000	159,498	19,49,498	4,21,826	12,27,671	9,05,851
Twenty-sixth "	285,000-D	19,95,000	168,359	20,63,359	4,45,287	12,18,071	8,72,791
Twenty-seventh "	300,000-D	21,00,000	177,220	21,77,220	4,68,748	12,08,471	8,39,731
Twenty-eighth "	315,000-D	22,05,000	186,081	22,91,081	4,92,209	11,98,871	8,06,671
Twenty-ninth "	330,000-D	23,10,000	194,942	24,04,942	5,15,670	11,89,271	7,73,611
Thirtieth "	345,000-D	24,15,000	203,803	25,18,803	5,39,131	11,79,671	7,40,551
Thirty-first "	360,000-D	25,20,000	212,664	26,32,664	5,62,592	11,70,071	7,07,491
Thirty-second "	375,000-D	26,25,000	221,525	27,46,525	5,86,053	11,60,471	6,74,431
Thirty-third "	390,000-D	27,30,000	230,386	28,60,386	6,09,514	11,50,871	6,41,371
Thirty-fourth "	405,000-D	28,35,000	239,247	29,74,247	6,32,975	11,41,271	6,08,311
Thirty-fifth "	420,000-D	29,40,000	248,108	30,88,108	6,56,436	11,31,671	5,75,251
Thirty-sixth "	435,000-D	30,45,000	256,969	31,01,969	6,79,897	11,22,071	5,42,191
Thirty-seventh "	450,000-D	31,50,000	265,830	32,15,830	7,03,358	11,12,471	5,09,131
Thirty-eighth "	465,000-D	32,55,000	274,691	33,29,691	7,26,819	11,02,871	4,76,071
Thirty-ninth "	480,000-D	33,60,000	283,552	34,43,552	7,50,280	10,93,271	4,43,011
Fortieth "	495,000-D	34,65,000	292,413	35,57,413	7,73,741	10,83,671	4,09,951
Forty-first "	510,000-D	35,70,000	301,274	36,71,274	7,97,202	10,74,071	3,76,891
Forty-second "	525,000-D	36,75,000	310,135	37,85,135	8,20,663	10,64,471	3,43,831
Forty-third "	540,000-D	37,80,000	318,996	38,99,996	8,44,124	10,54,871	3,10,771
Forty-fourth "	555,000-D	38,85,000	327,857	40,13,857	8,67,585	10,45,271	2,77,711
Forty-fifth "	570,000-D	39,90,000	336,718	41,27,718	8,91,046	10,35,671	2,44,651
Forty-sixth "	585,000-D	40,95,000	345,579	42,41,579	9,14,507	10,26,071	2,11,591
Forty-seventh "	600,000-D	42,00,000	354,440	43,55,440	9,37,968	10,16,471	1,78,531
Forty-eighth "	615,000-D	43,05,000	363,301	44,69,301	9,61,429	10,06,871	1,45,471
Forty-ninth "	630,000-D	44,10,000	372,162	45,83,162	9,84,890	9,97,271	1,12,411
Fiftieth "	645,000-D	45,15,000	381,023	46,97,023	10,08,351	9,87,671	8,91,111
Fifty-first "	660,000-D	46,20,000	389,884	48,10,884	10,31,812	9,78,071	8,58,051
Fifty-second "	675,000-D	47,25,000	398,745	49,24,745	10,55,273	9,68,471	8,24,991
Fifty-third "	690,000-D	48,30,000	407,606	50,38,606	10,78,734	9,58,871	7,91,931
Fifty-fourth "	705,000-D	49,35,000	416,467	51,52,467	11,02,195	9,49,271	7,58,871
Fifty-fifth "	720,000-D	50,40,000	425,328	52,66,328	11,25,656	9,39,671	7,25,811
Fifty-sixth "	735,000-D	51,45,000	434,189	53,80,189	11,49,117	9,30,071	6,92,751
Fifty-seventh "	750,000-D	52,50,000	443,050	54,94,050	11,72,578	9,20,471	6,59,691
Fifty-eighth "	765,000-D	53,55,000	451,911	56,07,911	11,96,039	9,10,871	6,26,631
Fifty-ninth "	780,000-D	54,60,000	460,772	57,21,772	12,19,500	9,01,271	5,93,571
Sixtieth "	795,000-D	55,65,000	469,633	58,35,633	12,42,961	8,91,671	5,60,511
Sixty-first "	810,000-D	56,70,000	478,494	59,49,494	12,66,422	8,82,071	5,27,451
Sixty-second "	825,000-D	57,75,000	487,355	60,63,355	12,89,883	8,72,471	4,94,391
Sixty-third "	840,000-D	58,80,000	496,216	61,77,216	13,13,344	8,62,871	4,61,331
Sixty-fourth "	855,000-D	59,85,000	505,077	62,91,077	13,36,805	8,53,271	4,28,271
Sixty-fifth "	870,000-D	60,90,000	513,938	64,04,938	13,60,266	8,43,671	3,95,211
Sixty-sixth "	885,000-D	61,95,000	522,799	65,18,799	13,83,727	8,34,071	3,62,151
Sixty-seventh "	900,000-D	63,00,000	531,660	66,32,660	14,07,188	8,24,471	3,29,091
Sixty-eighth "	915,000-D	64,05,000	540,521	67,46,521	14,30,649	8,14,871	2,96,031
Sixty-ninth "	930,000-D	65,10,000	549,382	68,60,382	14,54,110	8,05,271	2,62,971
Seventieth "	945,000-D	66,15,000	558,243	69,74,243	14,77,571	7,95,671	2,29,911
Seventy-first "	960,000-D	67,20,000	567,104	70,88,104	15,01,032	7,86,071	1,96,851
Seventy-second "	975,000-D	68,25,000	575,965	72,01,965	15,24,493	7,76,471	1,63,791
Seventy-third "	990,000-D	69,30,000	584,826	73,15,826	15,47,954	7,66,871	1,30,731
Seventy-fourth "	1,005,000-D	70,35,000	593,687	74,29,687	15,71,415	7,57,271	9,71,111
Seventy-fifth "	1,020,000-D	71,40,000	602,548	75,43,548	15,94,876	7,47,671	9,38,051
Seventy-sixth "	1,035,000-D	72,45,000	611,409	76,57,409	16,18,337	7,38,071	9,04,991
Seventy-seventh "	1,050,000-D	73,50,000	620,270	77,71,270	16,41,798	7,28,471	8,71,931
Seventy-eighth "	1,065,000-D	74,55,000	629,131	78,85,131	16,65,259	7,18,871	8,38,871
Seventy-ninth "	1,080,000-D	75,60,000	637,992	79,99,992	16,88,720	7,09,271	8,05,811
Eightieth "	1,095,000-D	76,65,000	646,853	81,13,853	17,12,181	7,00,071	7,72,751
Eighty-first "	1,110,000-D	77,70,000	655,714	82,27,714	17,35,642	6,90,471	7,39,691
Eighty-second "	1,125,000-D	78,75,000	664,575	83,41,575	17,59,103	6,80,871	7,06,631
Eighty-third "	1,140,000-D	79,80,000	673,436	84,55,436	17,82,564	6,71,271	6,73,571
Eighty-fourth "	1,155,000-D	80,85,000	682,297	85,69,297	18,06,025	6,61,671	6,40,511
Eighty-fifth "	1,170,000-D	81,90,000	691,158	86,83,158	18,29,486	6,52,071	6,07,451
Eighty-sixth "	1,185,000-D	82,95,000	700,019	87,97,019	18,52,947	6,42,471	5,74,391
Eighty-seventh "	1,200,000-D	84,00,000	708,880	89,10,880	18,76,408	6,32,871	5,41,331
Eighty-eighth "	1,215,000-D	85,05,000	717,741	90,24,741	19,00,069	6,23,271	5,08,271
Eighty-ninth "	1,230,000-D	86,10,000	726,602	91,38,602	19,23,530	6,13,671	4,75,211
Ninetieth "	1,245,000-D	87,15,000	735,463	92,52,463	19,47,091	6,04,071	4,42,151
Ninety-first "	1,260,000-D	88,20,000	744,324	93,66,324	19,70,552	5,94,471	4,09,091
Ninety-second "	1,275,000-D	89,25,000	753,185	94,80,185	19,94,013	5,84,871	3,76,031
Ninety-third "	1,290,000-D	90,30,000	762,046	95,94,046	20,17,474	5,75,271	3,42,971
Ninety-fourth "	1,305,000-D	91,35,000	770,907	97,07,907	20,40,935	5,65,671	3,09,911
Ninety-fifth "	1,320,000-D	92,40,000	779,768	98,21,768	20,64,396	5,56,071	2,76,851
Ninety-sixth "	1,335,000-D	93,45,000	788,629	99,35,629	20,87,857	5,46,471	2,43,791
Ninety-seventh "	1,350,000-D	94,50,000	797,490	100,49,490	21,11,318	5,36,871	2,10,731
Ninety-eighth "	1,365,000-D	95,55,000	806,351	101,63,351	21,34,779	5,27,271	1,77,671
Ninety-ninth "	1,380,000-D	96,60,000	815,212	102,77,212	21,58,240	5,17,671	1,44,611
One hundredth "	1,395,000-D	97,65,000	824,073	103,91,073	21,81,701	5,08,071	1,11,551

Column 2.—D denotes ordinary first extension in the delta; U = area of irrigation in upland; Sh = area irrigated in the short late crop area; S = second crop area in the delta.
 Column 4.—It has been assumed that the area of waste lands that will be brought under irrigation will be proportionate to the total area irrigated in the year. The figures in this column include interest on sale-proceeds of waste lands.
 Column 6.—The figures in this column are made up of working expenses at As. 12 per acre and collection charges at 11 per cent. of gross receipts excluding interest on sale-proceeds.

PART III.—Estimate of growth of Irrigation and Revenue Receipts and Charges—cont.

Revenue receipts and charges.							
Year.	Irrigated area at end of year.	Gross revenue due to works.			Charges, both direct and indirect against revenue account.	Net revenue due to works.	
		Direct receipts.	Enhanced land revenue or indirect revenue.	Total.		Including enhanced land revenue.	Excluding enhanced land revenue.
1	2	3	4	5	6	7	8
		Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Eighteenth year	125,000-U 216,000-U 25,000-Sh. 81,800-S 125,000-D 252,000-U 25,000-Sh. 95,200-S 125,000-D 288,000-U 25,000-Sh.	29,04,497	2,26,731	31,31,228	6,06,804	25,24,424	22,97,693
Nineteenth "	108,000-S 125,000-U 324,000-U 25,000-Sh. 122,400-S 125,000-D 380,000-U 25,000-Sh. 136,000-S 125,000-D 396,000-U 25,000-Sh. 142,000-S 125,000-D 432,000-U 25,000-Sh. 142,000-S 125,000-D 468,000-U 25,000-Sh. 142,000-S 125,000-D 504,000-U 25,000-Sh. 142,000-S 125,000-D 540,000-U 25,000-Sh. 142,000-S 125,000-D 576,000-U 25,000-Sh. 142,000-S 125,000-D 610,000-U 25,000-Sh. 142,000-S	32,21,097	2,31,979	34,53,076	6,69,009	27,84,067	25,52,088
Twentieth "		35,57,697	2,37,227	37,74,924	7,31,219	30,43,711	28,06,484
Twenty-first "		38,54,297	2,42,475	40,96,772	7,92,418	33,03,354	30,60,879
Twenty-second "		41,70,897	2,47,723	44,18,620	8,55,822	35,62,998	33,15,275
Twenty-third "		44,51,397	2,52,971	47,04,368	9,13,856	37,90,512	35,37,541
Twenty-fourth "		47,03,397	2,58,219	49,61,616	9,68,954	39,92,662	37,34,443
Twenty-fifth "		49,55,397	2,63,467	52,18,864	10,24,053	41,94,811	39,31,344
Twenty-sixth "		52,07,397	2,68,715	54,76,112	10,79,151	43,96,961	41,28,246
Twenty-seventh "		54,59,397	2,73,963	57,38,360	11,34,250	45,99,110	43,25,147
Twenty-eighth "		57,11,397	2,79,311	59,90,608	11,89,348	48,01,260	45,22,049
Twenty-ninth "		59,49,397	2,84,463	62,33,860	12,41,407	49,92,453	47,07,990

PART IV.—Estimate of net financial results of ten years after the probable date of completion of the work.

Year.	Direct capital outlay during the year.	Direct capital outlay to end of year.	Simple interest at 4 per cent. on capital outlay to end of previous year plus half outlay during year.	Net revenue including enhanced land revenue, column 7 of Part III.	Simple interest less net revenue.	Net revenue less simple interest.
1	2	3	4	5	6	7
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
First year ..	16,04,000	16,04,000	32,080	..	32,080	..
Second ..	19,63,000	35,67,000	1,03,420	..	1,03,420	..
Third ..	25,09,000	60,76,000	1,92,860	..	1,92,860	..
Fourth ..	31,45,000	92,21,000	3,05,940	..	3,05,940	..
Fifth ..	46,07,000	1,38,28,000	4,60,980	..	4,60,980	..
Sixth ..	71,80,000	2,10,08,000	6,96,720	..	6,96,720	..
Seventh ..	66,28,239	2,76,36,239	7,72,885	..	7,72,885	..
Eighth ..	53,56,000	3,29,92,239	12,12,570	..	12,12,570	..
Ninth ..	42,54,000	3,72,46,239	14,04,770	90,495	11,32,075	..
Tenth ..	42,76,000	4,15,22,239	15,75,370	1,80,990	12,23,780	..
Eleventh ..	50,25,000	4,65,47,239	17,61,390	2,71,485	13,03,885	..
Twelfth ..	51,79,350	5,17,26,589	19,65,477	3,81,980	13,99,410	..
Thirteenth ..	48,23,251	5,65,49,840	21,65,599	4,52,475	15,13,002	..
Fourteenth ..	51,51,000	6,17,00,840	23,65,014	8,16,604	13,48,385	..
Fifteenth ..	42,11,000	6,59,11,840	25,62,254	12,31,041	11,33,273	..
Sixteenth ..	41,51,000	7,00,62,840	27,19,494	16,45,489	9,06,765	..
Seventeenth ..	31,42,000	7,32,04,840	28,65,364	20,05,137	7,14,857	..
Eighteenth ..	23,21,322	7,55,26,162	29,74,820	22,64,780	6,00,574	..
Nineteenth ..	16,58,000	7,71,84,162	30,64,206	25,24,424	4,60,196	..
Twentieth ..	14,10,291	7,86,94,453	31,15,572	27,84,067	2,70,139	..
Twenty-first ..	3,35,338	7,89,29,791	31,50,434	30,43,711	71,861	..
Twenty-second ..	3,45,000	7,92,74,791	31,64,092	33,03,354	1,52,870	..
Twenty-third ..	3,40,878	7,96,15,469	31,77,805	35,62,998	3,98,908	..
Twenty-fourth ..	72,881	7,96,88,350	31,87,534	37,90,512	6,12,707	..
Twenty-fifth ..	..	7,96,88,350	31,87,534	39,92,662	8,08,586	..
Twenty-sixth ..	..	7,96,88,350	31,87,534	41,94,811	10,07,277	..
Twenty-seventh ..	..	7,96,88,350	31,87,534	43,96,961	12,09,427	..
Twenty-eighth ..	..	7,96,88,350	31,87,534	45,99,110	14,11,576	..
Twenty-ninth ..	..	7,96,88,350	31,87,534	48,01,260	16,13,726	..
Thirtieth ..	..	7,96,88,350	31,87,534	49,92,453	18,04,919	..
Thirty-first ..	..	7,96,88,350	31,87,534	49,92,453	18,04,919	..
Thirty-second ..	..	7,96,88,350	31,87,534	49,92,453	18,04,919	..
Thirty-third ..	..	7,96,88,350	31,87,534	49,92,453	18,04,919	..
Thirty-fourth ..	..	7,96,88,350	31,87,534	49,92,453	18,04,919	..
Total ..				1,48,23,837	1,80,42,589	

Difference, i.e., accumulated net revenue at the end of the year after completion

Capital invested on the project is—		
(a) Direct charges ..	..	32,15,752
(b) Indirect charges ..	..	..
(c) Arrears of interest ..	..	7,96,88,350
	..	86,99,906
	..	Nil.
Total ..		8,33,88,256

NOTE.—Interest at 4 per cent. on the capital invested amounts to Rs. 32,15,752 which is more than covered by the annual net revenue of Rs. 49,92,453 anticipated from the project from the fifth year after its completion. The project therefore satisfies the conditions of a productive public work as required by paragraph 1889 (a) of the Public Works Department Code, Volume II.

PART V.

SPECIAL REVENUE OFFICER'S REPORT ON THE KISTN RESERVOIR PROJECT, WITH THE PROCEEDINGS OF THE BOARD OF REVENUE AND THE ORDERS OF GOVERNMENT THEREON.

PART V.

Special Revenue Officer's Report on the Kistna Reservoir Project, with the Proceedings of the Board of Revenue and the orders of Government thereon (G.O., No. 2435, Revenue, dated 8th August 1911).

I

Official Memorandum No. 307-C/10-1, Revenue, dated 17th February 1910.

The Board of Revenue is requested to report when Mr. Turing's report on the Revenue Investigation of the Kistna Reservoir Project may be expected to reach Government.

(By Order.)

F. NOYCE,
Ag. Under Secretary to Government.

To the Board of Revenue (Revenue Settlement).

II

**Proceedings of the Board of Revenue (R.S., Sur., L.R. and Agri.),
Mis. No. 626, dated 21st February 1910.**

The Hon'ble Mr. A. E. CASTLESIVART STUART, C.S.I.

Read—the following paper :—

Memorandum—from Government, Revenue Department.
No.—307-C/10-1.
Dated—the 17th February 1910.

Resolution—Mis. No. 626, dated 21st February 1910.

Mr. Turing's report on the Kistna Reservoir Project has been received by the Board and referred to the Collectors of Kistna and Guntur for remarks. The reply from the Collector of Kistna is still due and he has been reminded. The report will be submitted to Government with the Board's remarks as soon, after the receipt of reply from the Collector of Kistna, as practicable.

(True Extract.)

L. D. SWAMIKANNU,
Secretary.

To the Secretary to Government, Revenue Department.

III

G.O., No. 54 I., dated 28th February 1910.

Read—the following papers :—

(i)

G.O., No. 458 I., dated 9th December 1908.

ABSTRACT.—The complete investigation of the Kistna Reservoir Project as recommended by the Chief Engineer for Irrigation, sanctioned, and a copy of the proceedings ordered to be forwarded to the Government of India.

(ii)

G.O., No. 200 I., dated 8th May 1909.

ABSTRACT.—Communicating to the Superintending Engineer on Special duty for information and guidance letter from the Government of India forwarding a copy of a note by the Inspector-General of Irrigation on the proposed Kistna Reservoir Project.

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(iii)

G.O., No. 229 I., dated 2nd June 1909.

ABSTRACT.—Communicating, with remarks, to the officers concerned letter from the Government of India forwarding for consideration a note by the Inspector-General of Irrigation regarding the silting up of the Kistna Reservoir.

(iv)

Letter—from Mr. J. BENTON, C.I.E., Inspector-General of Irrigation.
To—the Chief Engineer for Irrigation.
Dated—Camp Raipur, the 21st January 1910.
No.—10 I.G.

With reference to Public Works Department Code, Volume II, paragraphs 1906 and 1909, I have the honour to forward for your information advance typed copies of the following :—

(ii) Note on the Kistna Project.

2. I would specially invite your attention to paragraph 7 of the note (ii) *supra* regarding the principal levels to be adopted for the river dam and canal, since these have to be decided on before aligning the latter; I regret that this very important question was not more fully discussed by us when I was in Madras; however, I trust that, on examining it in the light of the information furnished by the plans, you will be able to decide on amended levels which will afford a greater life for the reservoir and probably also a greater area of second crop possibilities in the delta than the present levels promise to give. I observe that the percentage of second crop in a good many of your works exceeds that which the present amount of storage will admit of in the delta. Even if a greater area of second crop was considered improbable, an extended life for the reservoir appears to me to call for some change in the levels.

(v)

To the Superintending Engineer on Special duty, dated 27th January 1910, R.O.C. No. 2624 of 1909.

(vi)

Letter—from Mr. H. M. WILLMOTT, Under Secretary to the Government of India—Public Works Department (Civil Works—Irrigation).
To—the Joint Secretary to the Government of Madras, Public Works Department (Irrigation Branch).
Dated—Calcutta, the 3rd February 1910.
No.—82-1.

I am directed to forward, for the information and consideration of the Governor in Council, a copy of a note,* dated the 15th January 1910, by the Inspector-General of Irrigation, on the Kistna River Storage scheme.

Order—No. 54 I., dated 28th February 1910.

The letter from the Government of India last read above will be communicated to the Superintending Engineer on Special duty for information and guidance.

(True Extract.)

C. A. SMITH,
Joint Secretary to Govt., P.W.D.,
Irrigation Branch.

To the Chief Engineer for Irrigation.
" Superintending Engineer on Special duty.
" Superintending Engineer, II Circle.
" Examiner, Public Works Accounts.
" Revenue Department.
" Board of Revenue (Revenue Settlement).

* Printed in Appendix I of the Volume.

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IV

Official Memorandum No. 307-C/10-2, Revenue, dated 12th May 1910.

The Board of Revenue is requested to report when Government may expect to receive Mr. Turing's report on the revenue aspects of the Kistna Reservoir Project.

(By Order.)

F. NOYCE,
Ag. Under Secretary to Government.

To the Board of Revenue (Revenue Settlement).

V

Proceedings of the Board of Revenue (R.S., Sur., L.R. and Agri.),
No. 249, dated 14th May 1910.

The Hon'ble Mr. A. E. CASTLESTUART STUART, C.S.I.

The Hon'ble Mr. W. O. HORNE.

The Hon'ble Mr. R. B. CLEGG.

The Hon'ble Mr. R. H. SHIPLEY.

Read—the following papers :—

(i)

Letter—from J. M. TURING, Esq., I.C.S., Special Revenue Officer, Kistna Reservoir Project, Guntur.
To—the Secretary to the Commissioner of Revenue Settlement, Survey, Land Records and Agriculture.
Dated—the 8th December 1909.
No.—Dis. 340.

I have the honour to submit my report on the revenue investigation of the revised Kistna Reservoir Project. I was deputed to the special duty of this investigation in G.O., No. 276 P., dated 24th April 1909, and extensions of the time originally given were granted in G.O., No. 273 I., dated 28th June 1909, and G.O., No. 422 I., dated 1st October 1909. The full period occupied in the investigation has been 7 months.

2. I divide my report into nine parts—

Part I—is introductory and is chiefly devoted to explaining the system of investigation pursued and the statements attached to the report;

Part II—deals with the upland area; and

Part III—with the delta extensions generally including a description of certain special areas.

In Part IV—are discussed the questions of pasturage, of fodder and manure crops and the effect of the possible reduction in the quantity of the Kistna silt.

Part V—deals with second crop and short late crop in the delta.

Part VI—deals with general questions affecting both upland and delta, viz., communications, soils, crops, prices, population, labour supply and the readiness of the ryots to irrigate.

Part VII—is devoted to the probable rate of development, sales of land, and water rates.

Part VIII—contains a description of the reservoir-submerged-area and a discussion of the probable rates of compensation for the area to be taken up for the canal and for other engineering works.

Part IX—contains a few notes of the remunerative aspect of the project, and a brief summary of my recommendations.

PART I.—INTRODUCTORY.

3. *Establishment employed.*—As anticipated by Government in G.O., No. 166 I.,

Designation of officers.	Sanctioned scale of establishment.	Establishment actually employed.
Revenue Divisional-officer	1	1
Tahsildars	3	2
Revenue Inspectors	9	6 + 1 *
Clerks under the Special Revenue officer	3	5 + 2 †
Attender	1	1
Masalehi	1	1
Peons under the Special Revenue officer	5	5
Clerks under Tahsildars	6	4
Peons under Tahsildars	9	6
Peons under Revenue Inspectors	9	6 + 1 *
Total	47	41

* One Revenue Inspector and one peon were entertained for 2½ months only.
† Four extra clerks on Rs. 20 each. Of these, two clerks worked for less than 2½ months.

G.O., No. 483 F., dated 10th October 1908, by entertaining two, and for a short time four, extra clerks to work in my own office, in lieu of the third Tahsildar's clerical establishment and of the Revenue Inspectors not employed. These extra hands were needed for the office check of Mr. Braidwood's accounts.

4. I think it probable that, had I known from the first exactly what work had to be done, I should have entertained the full establishment allowed, and that the whole investigation might then have been completed a month or six weeks earlier. It was not possible to do this, however, owing to the uncertainty that continued during the earlier months of my deputation regarding the exact scope of my work.

I was placed on special duty in the first week of May, but at that time out of the areas now dealt with in my report only about half the delta area was known for certain to require my investigation.

It was decided in G.O., No. 273 I., dated 28th June 1909, that I should reinvestigate the upland area, and the duty of estimating the compensation to be paid for the reservoir-submerged-area was included in my work in G.O., No. 328 I., dated 16th August 1909.

The other delta areas were given me by the officers of the Public Works Department at different times from May to August 1909, and certain areas already investigated by me were withdrawn from the project area in the latter month.

Extensions of irrigation in Divi island were added to my duty in G.O., No. 337 I., dated 16th August 1909, but were withdrawn finally on my representation that it was useless to investigate there till complete levels had been taken.

These changes, I am aware, were unavoidable, and have done no harm beyond making it difficult to distribute my work so as to best economize the time of my subordinates, and rendering it impossible till a late stage in my special duty to be sure exactly what staff would be required or for how long.

METHOD OF INVESTIGATION PURSUED.

5. As the Board is aware, my revenue investigation of the delta extensions is original work, but my work on the irrigable area of the upland has consisted of a recheck of certain parts of Mr. Braidwood's work, a recheck rendered necessary by the changed conditions of the present project. The whole of the upland area now to be brought under irrigation was commanded by Mr. Reid's project, the revenue investigation of which was done by Mr. Braidwood.

The basis of Mr. Braidwood's records is a register, termed an A register prepared for every village, which shows every field in the village in serial order and, in addition to other information, states whether the field is irrigable or unirrigable, and in the latter case the reason why it is unsuited for irrigation. These registers have been revised, and in a certain number of cases rewritten, by my staff. The extent of revision required has been described in detail in paragraph 17 below.

For the purposes of my own original work in the delta, I have adopted the same system and the same register with a few modifications. I am satisfied that it is in the end more satisfactory to have an exact record as to the fitness or otherwise of every field for irrigation. The advantage of this is obvious in the case of Mr. Braidwood's accounts, since this fieldwar record has rendered it possible to revise his records on certain points, *e.g.*, with reference to the correct levels since taken, without having the village rechecked on the ground. I believe also that these village A registers are likely to be used frequently by the Public Works Department officers in their work, if the project is sanctioned, and the Superintending Engineer on special duty in his letter No. 212 I., dated 28th May 1909, has special¹ asked that a record of the position of unirrigable land may be kept.

These A registers have in the delta been prepared on the ground by the investigating Revenue Inspectors, with some clerical help at times from the karnams, at the information contained in each has been posted in separate abstracts. Statements I and II attached to this report, are substantially the same in form as these abstracts and are filled up from them.

In like manner, the information in Mr. Braidwood's A registers has been abstracted by my staff and entered in statements I and II.

6. In the delta the Executive Engineers, Kistna Eastern and Western Divisions have from time to time supplied me with the necessary information about the area they can command in the delta. In the case of some half a dozen large blocks of unirrigated land, such areas have been defined by boundaries. But most of the lands proposed for delta extension are in patches among the existing irrigation, too small and too scattered to be capable of definition by such means. For the investigation of these I have been supplied with a key map indicating their general position, but the actual identification of the lands commanded has been made through lists of survey numbers supplied by the officers of the Public Works department. No such difficulty arises of course in the upland where the irrigable tract is compact and defined by easily intelligible boundaries or by the upland canal itself.

EXPLANATION OF ENCLOSURES TO THE REPORT.

7. Statements I and II described below are submitted in bound volumes containing the information for each village investigated. Abstracts of these statements showing the taluk totals are attached to the report. In these abstracts the same form is followed as in the village statements, and the columns are given the same numbers, leaving blank such as are not required in the abstracts.

As frequent reference has to be made to these headings, it is necessary that the forms used in the village statements and abstracts should be identical. The explanatory remarks below refer particularly to the village statements.

Statement No. I—Arrangement.—This statement contains all the information regarding the irrigable first crop area and short late crop area and the revenue expected. The Kolair lake which requires separate treatment is not included in this statement. The statement is in the same form for the upland and delta areas, though one or two columns will be found to be applicable only to one or other of these areas.

The villages in each taluk are separated into three different sections, for Government, zamindari and whole inam villages respectively.

Short late crop lands, *i.e.*, lands growing a single crop only, and that in the late or second crop season, are shown at the foot of each taluk, villages containing both ordinary and short late crop lands appearing therefore twice over. The reason for separating these particular lands is that some discussion arises over their water-rates, and the Board may desire to change the rates entered.

Villages partly commanded are marked with an asterisk. By "partly commanded" is meant in the upland area that the village is partly cut off from the project area by the existing canals, by the project canal, or some other natural boundary. I must also explain that unsurveyed hills which are not included within the limits of any village do not appear in the commanded area shown in column 5 of statement No. I. All such hills are unirrigable. The "commanded" area in that column corresponds in the upland to the total surveyed area of the village unless part of the village is cut off as explained above. In the delta "partly commanded" implies simply that the village is already partly irrigated by the delta system.

Nearly all the delta villages are only partly commanded by the reservoir project as distinguished from the existing anicut irrigation.

8. *Village statement No. I—Contents—Columns 1, 2 and 3* show the villages with their serial and taluk numbers.

Column 4 (applicable to the delta only) will not be of any interest to the Board, but is intended as a guide to officers of the Public Works Department, should they afterwards wish to identify in my report the areas given by them for investigation. The Public Works Department in the key maps referred to in paragraph 6 above have given block numbers to the areas selected by them for investigation in the delta. These blocks presumably refer to extensions under different channels. One village frequently falls into 2, 3 or even more blocks.

Column 5 shows the area commanded in each village according to the boundaries or lists of numbers given by the Public Works Department in the delta; in the upland this column shows the full extent of the village, unless it is marked with an asterisk.

Columns 6—11 show the classification of the irrigable extent under occupied Government land, wet and dry, assessed waste, unassessed or poramboke, and minor inam, wet and dry.

Column 12 shows the total extent of all these lands.

Column 6 also exhibits, in non-Government villages, the zamindari lands and lands in whole inam villages belonging to the proprietors of the village as distinguished in both cases from minor inams appearing in columns 10 and 11. As already explained, zamindari and whole inam villages appear in separate sections in each taluk.

Column 13 shows the extent found to be unirrigable in each village. The figure in this column corresponds to that entered in column 23 of statement No. II which classifies the deductions made from the irrigable extent.

Columns 14 to 18 exhibit under different heads the increase of revenue expected to result from the project.

Column 19 shows the total increase of revenue. Of these, the two principal columns are columns 15 and 16 showing the revenue from Government lands and inam or zamindari lands which are now dry and are expected to come under irrigation. The rates in column 15 on Government dry land are calculated on a different system in the delta and the upland; the delta rates for ryotwari land being the actual differential water-rates now in use, separately calculated for each class and sort of land, while the upland rates are Rs. 5 an acre. Inam and zamindari rates are Rs. 5 an acre both in delta and upland. The question of rates is fully discussed in paragraphs 114—119 below.

Column 18 shows the dry assessment on lands now unoccupied which are expected to come under occupation and irrigation. The area of such lands appears in columns 8 and 9. In case such land bears a consolidated wet assessment (a very unusual thing in unoccupied waste; but such lands do exist in the delta), the dry rate and water-rate are detached and shown separately in columns 15 and 18.

Column 14 shows the revenue due to increased water-rate on land already irrigated, the difference in fact between the charge for water now paid under tanks and the probable project water-rate of Rs. 5. In the case of settled wet lands the consolidated wet rate has been separated into dry assessment and water-rate and the water deducted from the project rate. In certain cases in the upland though

Government wet lands appear in column 6, there is no entry in column 14. This means that the wet rate now paid by the land (after separating the dry assessment) is equal to or more than the project rate of Rs. 5.

In the delta, column 14 is always blank, there being no Government permanent wet lands except those already irrigated by the canal system. The latter do not concern the Reservoir Project.

Column 17 is devoted to showing the difference between the rates which lands in column 15 would pay under a first class delta source, and those which they would pay according to the classes given at resettlement to the delta channels, which they are likely to be irrigated. These were often classed at re-settlement 2nd or 3rd, occasionally even 4th, class sources of irrigation. The question of probable change in classification of these sources, which presents some doubts and difficulties is discussed in paragraph 114 below. The total revenue expected after sale of lands appears in column 19.

Columns 20—23.—The remaining columns of the register show the extent of saleable land, its selling value and the revenue at 4 per cent. of the same.

Column 24 shows the grand total of all revenue.

9. *Enclosures to statement No. I.*—This shows for each taluk the irrigable land appearing in column 12 of statement No. I divided under the heads of Government Zamindari, Whole Inam, and Minor Inam for both Upland and Delta.

10. *Statement No. II.*—This register is intended to show as exactly as possible the reasons for treating as unirrigable all the land excluded and shown in column 13 of statement No. I. The headings will, I think, be intelligible without further explanation. Almost all the doubtful points connected with the revenue investigation of any irrigation scheme turn on the necessity or desirability of deductions from the total extent commanded. I hope that this statement will enable the Board or Government when they do not agree with my recommendation, to make the necessary alterations without great trouble and without having to resort to a centage addition or deduction.

In paragraphs 29 to 47 and 51 to 62 below I discuss the deductions made and the necessity for them.

11. *Statements Nos. III-A and III-B.*—Contain all particulars regarding the Kolair lake area. I cannot make these statements fully intelligible without a description of the area concerned. The statement is accordingly explained in paragraph 68 below.

Statement No. IV exhibits the entire area under the project and the total revenue anticipated. This statement in fact shows the areas and revenue taken from statement No. I together with those relating to the second crop area and the Kolair lake area.

Statement No. V indicates the rate of development which I anticipate for the project as a whole, and its enclosures A, B, C and D show separately the expected rate of development in the upland area, delta first crop area, and second crop area and short late crop area respectively. The subject is discussed in paragraphs 106—110.

Statement No. VI gives soilwar particulars for Government lands in the commanded areas, upland and delta (vide paragraph 99 below).

Statements Nos. VII A, B, C and D deal with the estimated compensation for the area to be submerged under the reservoir (vide paragraphs 120—129).

12. *Maps.*—District maps of the districts of Kistna and Guntur are enclosed on which are indicated roughly in colours the area already irrigated by the existing canal systems and the areas now expected to come under irrigation both in delta and upland. The area already irrigated is coloured green; the project irrigable area (first crop) is coloured yellow and the short late crop area red. A map of the Kolair area and its surroundings is also enclosed and is referred to in the paragraphs devoted to the discussion of that area.

PART II.—UPLAND AREA.

Commanded ACS.
926,623

13. *General description.*—This as already stated forms part of the area which was covered by Mr. Reid's scheme. The site of the present project reservoir is about 40 miles further down the Kistna river than was the site of Mr. Reid's reservoir, and the line of the project canal runs, roughly speaking, north and south far to the east of the line taken by Mr. Reid's canal. The canal will first cross the eastern part of the Sattenapalle taluk at no great distance from the Kistna river. It then passes through a corner of the Guntūr taluk, through the Narasaraopet taluk, and through the north-west corner of the Ongole taluk up to the point where it ends in the Gundlacamma river.

It is intended, I understand, that the canal should irrigate scarcely any land on its western side. There are small exceptions to this, but for the purposes of a rough description, the project canal itself, up to the point where it discharges into the Gundlacamma river, may be taken to be the western boundary of the commanded area.

The eastern and north-eastern boundary is the Kistna itself up to the point where the anicut is reached and the canals take off from the river. From this point onwards the eastern or south-eastern boundary of the project area is the most westerly of the existing delta canals, that is the main canal, Nizampatam, Commamur, and Buckingham canals successively, up to the point where the Buckingham canal crosses the Gundlacamma river.

That river forms the south-western and southern boundary of the area commanded.

The land to be irrigated lying within these limits includes the small part of the Sattenapalle taluk which lies between the project canal and the Kistna, the eastern third of the Narasaraopet taluk, the whole of the Bapatla and nearly the whole of the Guntūr taluk, apart from the areas in these two taluks already irrigated by the delta canals, a small part of the Ongole taluk and six villages in Tenali.

The maps attached to the report will show the existing delta irrigated area and the area proposed for irrigation under the project.

Setting aside a few villages in the extreme north of the area commanded, it may be said that the project upland area is a broad belt of land adjoining throughout its length the delta irrigated lands on its eastern side. The belt is of varying breadth but none of the lands are more than 25 miles distant from the existing canal system, and on the average would be less than ten miles distant. The point is of some importance in considering the question of the likelihood of the ryots to take to irrigation.

14. The soils of this area are shown in statement No. VI and their general suitability for irrigation is discussed in paragraph 100.

For the purpose of a brief description I may summarize the whole tract as a belt of black soil, regar clay or regar loam for the most part, with a small area of alluvial soil. The soil is generally lighter and more sandy in character towards its western and southern edges, and the composition of the small hills that crop out of the general level is generally gravelly, with a certain amount of gravelly or sandy land at their base. But these cases are all exceptional. Black clay or black loamy soils are the almost universal rule.

The country is flat on the whole but not with the flatness of the delta. Everywhere there is a perceptible undulation, sometimes very marked, which should greatly assist its natural drainage when under irrigation.

Tenure.—Nearly all the upland tract is held on ryotwari tenure. There are 311 ryotwari villages with a total acreage of 878,656 acres, 6 zamindari villages with an acreage of 10,945 acres and 42 whole inam villages measuring in all 37,022 acres.

15. *Extent of revision of Mr. Braidwood's records.*—The whole of the present upland area was investigated by Mr. Braidwood, and with the exception of the six villages in Tenali taluk, for which no record is forthcoming, the A registers already described exist for every village in this area.

As directed in G.O., No. 166 I., dated 15th April 1909, full use has been made of these records, and no revision on the ground has been made except where absolutely necessary. The extent to which these records have required revision is explained in detail below.

16. *Classification of unirrigable areas.*—My office has had in the first place to abstract the exclusions from the irrigable extent by posting under several heads every field treated as unirrigable in the A registers. This is needed partly for filling up statement No. II attached to this report, partly for the purpose of finding out in what particulars and what villages these deductions needed further examination.

17. *Part-commanded villages.*—Since the eastern and southern boundaries of the area now commanded are quite different from the limits of Mr. Reid's project, it has been necessary to exclude from the areas appearing in Mr. Braidwood's registers all extents lying outside the scope of the present project. This has naturally involved, in the cases of villages through which the new main canal will pass, separating the fields which will lie to the east of it, from those which will lie to the west and will not be irrigated. All such villages were wholly commanded by Mr. Reid's project.

The areas have been distinguished by means of village maps supplied from the office of the Executive Engineer on special duty, having the limit of the commanded area marked on them. Similar action has been taken as regards villages divided by the Gundlacamma river, which runs through the middle of several villages, leaving a portion on either bank.

Adjoining the eastern boundary of the commanded area, which is formed by the delta canals as already stated, there are also a large number of villages cut in half by these canals and therefore only partly commanded by the project.

In these cases, however, Mr. Braidwood's records already separated the extent on the west from that on the east of these canals.

In some of these villages, however, there exists irrigation on the west of the delta canal as well as on the east. This being a variable item, such villages have been examined again on the ground, and the extent now under irrigation ascertained. The treatment of such areas is explained in paragraph 45 below.

18. *Discrepancies owing to re-settlement.*—In the whole upland area a re-settlement has been put in force since the time of Mr. Braidwood's investigation, and the full extent of the villages as recorded by him does not always therefore correspond with the extent recorded in the re-settlement register.

These discrepancies have been rectified. In every taluk except Ongole they are quite trifling, so trifling that I think the re-settlement figures must in part at least have been at Mr. Braidwood's disposal.

Ongole was resurveyed and resettled at a later date than the other taluks and there are material discrepancies between Mr. Braidwood's A registers and the re-settlement registers both as to total extents and the survey numbers of fields. The A registers of all the commanded villages of the Ongole taluk, 43 in number, have accordingly been re-written completely, adopting the re-survey numbers and extents of fields.

19. The other subjects with regard to which these records have been subjected to revision, are those in which Mr. Braidwood's information will not suffice for my report, either on account of more accurate information now at the disposal of the Public Works department, or by reason of the recent orders of Government regarding pasturage exclusions. In some other cases the lapse of 4 years has in ordinary course made the recorded information obsolete. In others a difference in Mr. Braidwood's point of view and my own, very natural in two officers dealing with such a subject, has led me to re-investigate some of the areas excluded by him.

20. *High level lands.*—The most important of these revised items are the lands treated as unirrigable by Mr. Braidwood on account of their high level.

At the time of Mr. Braidwood's investigation no detailed levels had been taken by the Public Works Department, and Mr. Braidwood accordingly roughly estimated the extents in each village which he thought would be too high to be reached by canal water.

I am more fortunately situated in this respect, as levels have now been taken, and the Executive Engineer is in a position to say definitely what lands are and what are not above the level which the Project canal can irrigate. As already reported in my letter No. A.C. 425, dated 17th September 1909, much of this levelling work has proceeded concurrently with my enquiry and the results of it have been communicated to me at different times throughout my work. In fact I only received information regarding the last few villages some three weeks before the termination of my special duty.

My information is, however, now complete upon this point, and my exclusions made upon this ground should be correct, being based entirely on levels professionally taken.

The exclusion of these lands has been done in the same way as the exclusion of lands beyond the project canal line as explained in paragraph 17 above, *i.e.*, by means of village maps showing the high lands, supplied by the Executive Engineer. The survey numbers shown as high lands on these maps have been recorded as such in Mr. Braidwood's A registers in my office and all lands not so shown by the Executive Engineer have been transferred to irrigable, unless there is some other reason rendering them unfit for irrigation.

In the result a large extent of land previously shown as unirrigable owing to its level has been transferred to irrigable.

21. *Unsuitable soils*.—I originally meant to accept Mr. Braidwood's deductions on this ground without further check by my own staff.

Certain experiments made, however, as soon as part of my establishment could be spared from the delta work, convinced me that some of the soils excluded were not really unirrigable, experience in the delta showing that similar soils were irrigated there with complete success. I have accordingly caused the villages where such deductions are largest to be re-investigated, and in the result have transferred to irrigable a large proportion of these exclusions.

My reasons for making these corrections are fully described below in paragraph 42 relating to unsuitable soils.

22. *Unsuitable soils in lands originally described as high lands*.—This is another point which has required investigation on the ground. As already explained, Mr. Braidwood excluded large extents of land as too high, which the levels now prove to be commanded.

It seemed to me probable that these lands though irrigable from an engineering point of view might contain soils unfit for irrigation. There might, I thought, have appeared to be no need to decide the suitability of soils at the original investigation in the case of lands which, it was believed, could not be reached with water. (I should however explain that the point was decided in some cases though not in all, the explanatory note in Mr. Braidwood's registers sometimes giving both reasons, *e.g.*, "too high and soils unsuitable".)

I have had a large percentage of such cases re-investigated, selecting by preference for re-investigation those villages which contain unsuitable soils in other parts of their ayakat, and those which contain hills, round the bases of which these unsuitable soils most frequently occur.

In the result a few fresh cases of unsuitable soils have been discovered, but such instances are rare exceptions. In the vast majority of cases examined, these high lands transferred to irrigable are of a soil quite suitable for wet crops.

23. *Irrigable porambokes*.—Almost all such porambokes, as recorded by Mr. Braidwood, consist of tank-beds. Owing to a change of policy with regard to such tanks in canal-irrigated areas, these tanks will now be required for raising seedlings (*vide* paragraph 35 below).

They have accordingly all been transferred to unirrigable. This is a mere office alteration and has required no field work.

24. *Assessed wastes*.—The extent of these is a matter of considerable importance in view of the expressed wish of Government that all lands still at the disposal of Government and fit for grazing should be retained for that purpose.

The extent of assessed waste is of course a variable item tending continually to decrease as lands are assigned on patta.

As there has been plenty of time between Mr. Braidwood's investigation and my own for this process to materially reduce the extent of land at the disposal of Government, I have had all villages re-investigated in which the extent of such lands as recorded by Mr. Braidwood exceeds 100 acres, with the object of ascertaining what land is still available and what proportion of it is fit for grazing. The result of these enquiries will appear in paragraphs 79-84 below where the whole subject of grazing lands is discussed in full.

25. *Submersible areas*.—These were not ascertained field by field at the time of Mr. Braidwood's enquiry. They form part of the centage deductions proposed by that officer in part IV of his report. I have thought it desirable to have a detailed enquiry made upon the point in the villages adjoining the Kistna river and its tributaries above the flood bank.

The result of these enquiries is discussed in paragraph 41 below.

26. *Mamul wet areas*.—Mr. Braidwood's investigation does not appear to have taken any account of these, that is to say, the extents of inam wet are recorded in his registers, but they are not deducted from the irrigable total. I have had one taluk checked in detail and finding that the inam wet extents were invariably entitled to irrigation free of charge, have treated the whole inam wet extent as a deduction from the revenue-producing area under the project.

27. Apart from the points above described my report on the upland area is based entirely on the information recorded in Mr. Braidwood's records.

The number of villages re-checked on the ground is considerable, 125 out of a total of 359. Some of these however were re-checked only as regards submersible areas or high lands transferred to irrigable (*vide* paragraphs 22 and 25 above), there being nothing else in the village which gave rise to any doubt.

EXCLUSIONS FROM THE IRRIGABLE EXTENT—UPLAND.

28. As explained above, these exclusions are all classified in statement No. II. The necessity for each exclusion is discussed immediately below.

29. *Village-sites, extensions for probable growth of population and dry zones round villages and hamlets*.—(Columns 5-8 of statement No. II—total exclusion on this ground, 27,209 acres).

Apart from the existing village-sites themselves, the exclusions falling under this head are made in accordance with the orders of Government contained in G.O., No. 2470, Revenue, Press, dated 7th September 1909, and communicated with B.P., No. 2918, Mis., L.R., dated 15th September 1909, and in accordance with B.P., No. 3293, Mis., L.R., dated 14th October 1909, which contains some supplementary instructions.

The above orders were passed at a rather late stage of my special duty, after consulting the Collectors of the two districts concerned.

30. *Extensions*.—In these orders Government direct that I shall calculate and exclude from the irrigable area an extent sufficient to allow for probable extensions. It is also directed that round the village including the area (if any) left for future extension I should leave a dry zone 50 yards in breadth, or treat as unirrigable an extent of land equivalent to what this zone would occupy.

A similar dry zone 50 yards in width is left round all hamlets also.

Areas left for extensions of village-site.—The probable extent of these has been arrived at in the following manner:—

It is found by examining a number of typical agricultural villages in the existing delta tracts, villages now fully irrigated, that the number of occupied houses averages about one to every 5 acres of irrigated land. It is assumed that the same

will ultimately be the case with the upland area after it comes under irrigation, and that in the case of lands remaining dry, there will be one house to every 10 acres about the present average.

For each house in the village whether now existing or to be built hereafter I have assumed that an extent of 10 cents will be required, not only for the house itself but for the house, cattle sheds, straw yards, back yards, roads and all other communal purposes.

The future number of houses multiplied by 10 cents will give the village-site that may finally be required.

To take a typical example. Suppose the cultivable area of a village to now measure 3,000 acres, all dry and all coming under irrigation by the project. The number of occupied houses will ultimately be $3,000 \div 5$ or 600, and the ultimate extent of village-site required will be 600×10 cents = 6,000 cents, or 60 acres.

Deducting from this the existing village-site, the area of extension required for entry in column 6 of statement No. II will be arrived at.

As a matter of pure theory, I should be inclined to put the area required at a higher figure than 10 cents per house, as the allowance is to include the land required for roads and all other communal purposes.

But finding that the adoption of a 10 cent. rate resulted on the average in increasing the size of all existing village-sites by half, I became convinced that any higher allowance would be impractical.

It must be remembered that the allowances made provide 10 cents not only for future houses but for existing houses, which may now only occupy 2 or 3 cents. It is of course right that more room should be provided for the house-owners already in the village, but it is not likely that they will all take advantage of it. It must be remembered too that the land will in most cases have to be acquired by Government, if actual effect is at any time given to these proposals, and that the question of expense will limit the areas actually transferred hereafter to village-site.

I think my present proposals are adequate.

The rough and ready method described above will, I believe, indicate fairly the deductions from the irrigable extent to be made on this account over the upland area as a whole. In the case of individual villages, however, the extent must no doubt be revised by the ordinary district staff. It is quite a common thing for a village of small population to have a large cultivated area, much of which is really held by the inhabitants of neighbouring large village.

In such cases the area of extension provided by me for the small village will be too high.

Local knowledge is essential in order to work out the required extensions correctly for individual villages.

The Board, in commenting on my proposals for calculating these extensions, remarked "that the village-sites in the Kistna delta, which I proposed to take as a guide, were not nearly large enough for the houses and population."

This is, however, due to a misconception of the method of calculation. In order to guard against any similar misunderstanding, I should like to emphasize that it is the average number of houses likely to be built in an irrigated village which is based on delta experience, not the extent of house-site that should be allowed to each house. This as remarked by the Board is most inadequate in the delta at present.

31. *Special villages.*—A few villages where the population is not mainly agricultural require separate treatment. Such are Guntur town and Mangalagiri and Addanki, the latter two villages both being Deputy Tahsildar's head-quarters.

It so happens, however, that the two last-named villages require no reservations having either a large unoccupied site or adjoining land which is unirrigable for other reasons.

Adjoining Guntur I have reserved 500 acres or about 50 per-cent. of the extent now built over. The town is growing very rapidly.

32. *Village zones.*—Round the village-site together with the extension discussed above (if such extension is found necessary) runs the dry zone of 50 yards breadth provided for sanitary reasons. The cultivation of wet crops within this zone will be prohibited for the sake of the health of the inhabitants.

Except in the case of the villages noted in paragraph 33 below, this zone is

In case where the village-site or site plus extension	The area of the zone has been assumed to be
Is 5 acres or less	Double the size of the site.
5 " 10 " "	One and half times the size of the site subject to a minimum of 10 acres.
10 " 20 " "	The same size as the site.
20 " 70 " "	Half the size of the site subject to a minimum of 20 acres.
70 " 100 " "	One-third the size of the site subject to a minimum of 35 acres.

worked out (as permitted by Government in G.O., No. 2470, Revenue, Press, dated 7th September 1909) on a rough and ready method given in the margin. I have proved by a number of experiments that this method gives approximately accurate results. The proportion of land occupied by a 50-yard zone as compared with the extent of the village it surrounds varies of course greatly, exceeding the size of the village itself in the case of small village, whereas in the case of large villages the zone may be no more than one-third of the extent of the village.

33. *Localization.*—The extensions and zones described above have been actually localized in my A registers by their survey numbers only in the case of villages visited by my staff after the receipt of B.P., Mis. No. 3293, L.R., dated 14th October 1909. In other cases a deduction from the irrigable extent of the village has been made in a lump, leaving the localization to be done by the ordinary district staff in accordance with the instructions of the Board.

As the deduction will be in almost all cases from land immediately adjoining the villages, the Public Works Department should have no difficulty in taking it into account in aligning their channels.

The localization of these extensions, in so far as they will be due to the increase of population following on irrigation, appears to me a matter that may well be deferred for several years unless the alignment of the distributaries is affected by the question of whether the extension lies on one side of a village or another. It is not expected that the upland area will begin to come under irrigation for at least 15 years, and even after that, the resulting increase of population must of necessity take some years to come about.

I do not refer to cases when the site is already inadequate for the existing population. The provision of site in such cases is a matter for the ordinary district staff.

34. *Roads, paths, railway and boundary porambokes (column 9—2,432 acres)—streams, watercourses and channels (column 10—17,792 acres).*—I have no special remarks to make about either of these classes of exclusions, the necessity for which is obvious. The sufficiency of the roads and paths and the policy to be pursued regarding village roads in irrigated tracts is discussed below in paragraph 98.

The full poramboke extent of streams, watercourses, etc., has been in almost all cases treated as unirrigable. Portions of these extents may prove to be irrigable, but as it is impossible to tell what changes irrigation may make in the drainage of the country, the only safe course is to deduct the whole.

35. *Tank-beds (column 11—25,277 acres).*—At the request of the Superintending Engineer on Special duty, I have excluded all tank-beds from the irrigable extent. The idea is that these sources, though they will cease to irrigate the ordinary wet crops, except possibly during temporary shortage of water in the canals, should be reserved for the growth of paddy seedlings, being filled with water as late as possible in the hot weather, and giving it out for the growth of seedlings under the tanks during the few weeks preceding the opening of the upland canal. It is not certain that this method of utilizing part of the reservoir water in the hot weather will be adopted, but the point is under consideration.

From a revenue point of view there can, I think, be no question that this policy is sound. The early growth of seedlings, and consequent early transplantation, makes all the difference to lands that are liable to excess of water later in the season, the submersion that will kill a young paddy plant being quite powerless to injure it when well grown. At present one of the great difficulties in the delta is to secure the transplantation of such lands sufficiently early in the season, and much of this difficulty is due to want of seedlings.

Further, the water in these tanks will be free from silt, and it is said that such water is healthier for seedlings than the silt-impregnated water brought down by the Kistna in its early freshes.

The only doubt in my mind is whether it is necessary to reserve all tanks, and the whole extent of the largest. I was at first inclined to think that a tank 50 acres in extent would serve all the needs of a village for the purpose of growing seed beds, and that the excess extent in any tank measuring over 50 acres might be treated as irrigable. The Chief Engineer and Superintending Engineer on Special duty, however, are anxious to reserve the whole extent of such large tanks, and I have done so accordingly. If there are more seedlings raised under them than their own village requires, they will no doubt be sold to ryots of other villages as is often done now in the delta.

I have made only one exception. In the village of Tadikonda, Guntūr taluk, there is a tank-bed measuring 822.42 acres, much silted, irrigating an ayacut of only 137.93 acres. It would be absurd to retain all this as unirrigable. I have retained only 100 acres of the bed as tank and 100 acres for the extension of the village-site and zone and shown the rest as irrigable.

I have also treated as unirrigable all small tanks, though it is possible some of them may now be incapable of holding water even through the last few weeks of the hot weather. It may be possible to deepen them, however, and if not required as tanks they will often be useful for grazing.

36. *River beds, islands and lankas* (column 12—27,824 acres).—This particular deduction occurs almost exclusively in the villages of the Sattenapalle and Guntūr taluks adjoining the Kistna river.

It covers cases where a portion of the Kistna river itself is included in the nominal survey area of the village, as is always the case with the villages on the river banks; also islands in the bed of that river completely cut off from the shore, and accretions, commonly called lankas, which gather beside or below the banks, and are liable to be washed away again. A few minor cases of identical nature occur in the Ongole taluk on the banks of the Gundlacamma river.

All the lands are obviously unirrigable, and might indeed be treated as uncommanded areas, and so not appear in my registers at all.

I think it is a convenience, however, that the "area commanded" entered in column 5 of statement No. I should correspond with the full survey area of the village (except where the project canal or other boundary runs through the village), and have accordingly included these areas, as commanded, but shown them as unirrigable in register No. II.

37. *Other communal porambokes* (column 13—2,322 acres).—I have no special remarks to make about these small items. The figures in most villages are so small as to strike one as inadequate, but such items are often included in pattu lands or in the village-site itself, and, where this is not the case, can (with the exception of burial-grounds) be located without objection in the village extension area or dry zone.

38. *Topes* (column 14—5,433 acres).—I have excluded all topes from the irrigable area unless they are only topes in name, the trees having almost or quite disappeared.

I have made an exception in one or two villages where the topes cover a disproportionately large share of the village ayacut.

My reasons for treating them as unirrigable are that I think it desirable to encourage the growth of fruit crops, that the shade the topes afford is useful for cattle, and that the retention of these trees may possibly have a slight bearing on the question of leaf manure. I note also that the Board in passing orders on Mr. Braidwood's report was anxious such topes should be retained [paragraph 3, clause (ii) of Board's Proceedings, No. 210, dated 4th July 1905, page 148 of the printed report]. I am not, however, prepared to certify that the owners of private topes will usually retain them as such. In fact in the delta they have told members of my establishment in many instances that on water becoming available they will cut down the trees and start growing paddy forthwith.

Nor am I, however, prepared to recommend that water should be refused to lands with trees standing on them. Though I have mentioned above reasons for retaining them, and should prefer to keep them as they are, the reasons are not so weighty as to form a ground for interference with the owner's usual power of dealing with his land as he pleases. There will probably also be cases where the owner has no option, as the inundation from surrounding lands may be sufficient to kill the trees in a low lying tope.

Still in the majority of cases I am convinced that the retention of these topes will be for the general good of the village, and in the hope that this idea may gain ground among the ryots, have excluded them from the irrigable extent.

Public topes, a small and unfortunately an ever decreasing item, should certainly be retained. So, I think, should private topes adjoining the village-site, as shade is more valuable here than anywhere else. I would go the length of refusing water to all such topes. Topes adjoining a village-site can generally, like the site itself, be protected from damage through irrigation.

39. *Forest reserves* (column 15—5,141 acres).—With one exception all forest reserves have been excluded from the irrigable area. Indeed, nearly all of them are on the slopes of hills and unirrigable for physical reasons. The exception is an area of 2,939 acres in the village of Pedda Ganjām in the Bāpatla taluk (forest block No. 169) which is reported by my Tahsildar to be absolutely bare of trees and practically bare of grass and to be valueless for any purpose except irrigation.

There may be some idea of planting it with trees fit for firewood, but on this point I think I need only quote the remark of the Board passed on the report of the original Kistna Reservoir Project—

"The majority of the Board considers that to use valuable irrigable land for scrub jungle, fuel or grass is wasteful and retrograde."

I recommend that this area be excluded from the reserve and made available for sale and cultivation.

40. *Hills and high lands* (column 16—35,481 acres).—I have already described the changes made in the areas excluded by Mr. Braidwood on this account.

The areas now finding place in this column are those which the Executive Engineer certifies he cannot reach with water. I have nothing more to say about them.

41. *Lands submersible* (column 17—4,267 acres).—These lands like those described in paragraph 36 above occur in villages of the Sattenapalle and Guntūr taluks, the most northern of the villages coming under irrigation. They are near to, and as a rule actually adjoin, the Kistna river between the site of the projected reservoir and the site of the present anicut, below which the irrigated lands are protected by a flood bank.

Above this flood bank a large and undefined area is liable very occasionally to be inundated by extraordinary floods. It is not proposed, I believe, to raise a flood bank along the river above the anicut, so the liability to flood will continue.

The question is what allowance to make for the damage done by flood.

Extraordinary floods I have omitted altogether from my calculations. They are of rare occurrence and it is impossible to forecast what amount of damage they will do. They will in no way affect the extent brought under cultivation, though they will cause occasional loss of revenue through remissions.

Apart from this, however, there are lands which, though not submerged every year, are submerged every two or three, and on which for this reason a crop is not now usually grown, at least in the months from July to October.

All villages likely to be so affected have been visited by my staff and an effort has been made to ascertain and record these lands as accurately as possible. If the lands are now ordinarily left waste altogether, or, unlike other lands in the village, are only sown after the flood season is over, they have ordinarily been treated as submersible, and excluded from the irrigable extent; the same has been done in cases where the land is sometimes cultivated with a dry crop in the monsoon months but the crop seems to be precarious. The facts about the submersion, evidenced by the crops grown and the date of their sowing, have also been checked by enquiries made of the ryots.

It is not of course quite certain that these lands will be unfit to carry a wet crop, since the latter is less affected by floods than is a dry crop, but I think it is safer to exclude all such lands for the present.

I should mention here perhaps that the officers of the Public Works Department do not expect to irrigate any land in the upland in the second crop season, and therefore these lands, which would be treated in the Delta as short late crop lands, are altogether excluded from the irrigable extent.

42. *Unsuitable soils* (column 18—5,444 acres).—In paragraph 21 above I have referred to the re-check done by my establishment of part of the lands treated as unirrigable by Mr. Braidwood's staff on the ground that the soil was unsuitable.

Mr. Braidwood in paragraph 35 of his report gives as examples of such soils lands consisting of pure sand or gravel.

Rocky soils are also excluded by him. Besides the above three classes of soils there is a very large extent excluded on the ground that it is "soudu" or saline soil.

I will first deal with the case of these saline soils, regarding the irrigation of which I have made careful enquiries throughout my work in the Delta, where the treatment of these soils, and their preparation for paddy cultivation is thoroughly understood.

I have also had an opportunity of discussing the subject with the Director of Agriculture.

If I have correctly understood that officer, the "soudu" or salt in the soil exists usually from the surface downwards for several feet. While the pores and air-passages through the earth are open, the sun draws up the moisture and with it the salt, which, as the moisture evaporates, leaves upon the surface the white salt incrustation which is generally visible upon these soils when left waste.

The effect of cultivation and irrigation on these soils is to break up and fill up these air passages, making between the salt subsoil and the top soil a layer of earth which is comparatively impenetrable and prevents the air and sun drawing the salt from the subsoil into the top soil to any serious extent. Meanwhile by the action of continual flooding and drainage (the more frequent the better) the salts in the top soil are washed out and a layer of soil is left on the surface, which, cleansed of its own salts and receiving but little from below, is fit for raising a paddy crop.

I have met with no cultivator who understood the action of irrigation on soudu soils as I have explained it, but I have found all of them acquainted with the practical effects of irrigation on such soils.

Every cultivator in the delta is perfectly aware of the fact that by ploughing and repeated floodings for one or two seasons all normal soudu land can be made to grow a paddy crop.

So far indeed are they from feeling any apprehension about such lands growing paddy with success, that I have met with cases where the ryots said they actually preferred land with a certain amount of soudu in it. Possibly the salts contain some ingredient which, if present in small quantities only, is beneficial to the paddy plant.

The delta is full of good paddy lands which are said to have been once soudu. Such fields often adjoin lands which are still soudu, because they have not been brought under irrigation.

Such being the facts in the canal-irrigated tracts, I venture to think that Mr. Braidwood was mistaken in thinking such lands unfit for the growth of a wet crop, though, as the lands are invariably useless for dry crops, it is natural that any officer who had not passed direct from work in the delta to work in the upland should come to this conclusion.

Of course incurable soudu lands do exist, but except at the extreme end of the delta irrigation close to the salt creeks, I have found no such lands in the delta, nor have any such been found in the large number of cases re-checked by my staff in the upland.

Ordinary soudu ("pala soudu," as the ryots generally call it) requires two conditions to cleanse it successfully of its salts, frequent flooding and adequate drainage. The latter requirement is not always fulfilled in the delta, especially at the end of the canals. In the upland it will, I should think, owing to the undulating nature of the country, present no difficulties. The country is in fact naturally drained.

I have accordingly transferred all lands excluded on this account to the head of "irrigable".

Sandy lands.—Experience in the delta shows that such lands are practically always irrigable. There are enormous extents of such land on which a good paddy crop is grown in the Bandar and Gudivada taluks, and the quality of these soils is far inferior to that of any sandy lands I have seen in the upland. Such lands have accordingly been transferred to irrigable in cases re-investigated by my staff.

Gravelly lands.—The question of whether such lands can be irrigated is one which must be decided for each separate case on its merits, and is a matter on which there may be a good deal of legitimate difference of opinion. Pure gravel is no doubt unirrigable, but it is not easy to decide what admixture of gravel is sufficient to render the soil unfit for a wet crop. In most cases the fact that the soil now grows a dry crop has been accepted as evidence that it will grow a wet one. Cases have been reported by my staff in which the gravel only existed for a few inches on the surface and could doubtless be removed.

Other cases have been noticed where the gravel was in the subsoil only, with a foot or more of good soil, on the top. These cases are doubtless irrigable. A gravelly subsoil is rather an advantage than otherwise, given sufficient good soil on the top for the roots of the paddy. I have orally consulted the Director of Agriculture on this point also.

Rocky soils have been left unaltered except where the rocks were found to occur only in part of the survey numbers.

No lands excluded as unsuitable soil have been restored to irrigable except after re-investigation, with the exception of some of the soudu soils. Lands excluded by Mr. Braidwood as rocky or gravelly continue therefore to appear as unirrigable in villages not subjected to re-check, i.e., those in which these exclusions were of small extent.

I think the Board may be satisfied that all the land shown by me as irrigable is fit for irrigation so far as the nature of its soil is concerned.

Some doubt is introduced into these conclusions, however, as regards all the above soils, saline, sandy, and gravelly alike by the uncertainty discussed in paragraph 88 below, as to whether the Kistna water will continue to carry anything like its present quantity of silt. Silt is, I believe, of value to all these classes of soil. As, however, the reduction in the quantity of fertilizing silt is doubtful and in any case will not continue for ever, I think these soils may legitimately be treated as irrigable.

48. *General—First crop.*—The increased irrigation expected to result in the delta from the Reservoir Project involves little or no change in the present methods of irrigation under the aieuit.

The reservoir affects the delta in the first crop season in so far as it allows water to be sent down earlier in the season for transplantation, and at other times in the first crop season when the river is naturally at its lowest.

At present extensions of first crop cultivation in the delta are limited by the amount of water carried in the Kistna and though this is ample during most of the first crop season, there is a period in most years of a few weeks' duration, usually in late October and November when the river water is only just sufficient to safeguard the existing delta irrigated area.

The reservoir will make it possible to extend irrigation by creating another source from which the river-bed can be filled during these few weeks when the natural supply may fail.

When the reservoir irrigation begins, therefore, there will be no difference visible in the delta itself between the lands now irrigated solely by the ancient water and those which theoretically the reservoir irrigates. The lands now dry, which it is hoped to bring under irrigation, are credited to the reservoir project, as a convenient method of estimating the value of the help which the reservoir gives to the anicut, but these lands will not of course be irrigated solely with water stored in the reservoir any more than any other lands in the delta.

The above remarks, however, do not apply to the crop grown in the latter months of the fasli, between January and May, which will be grown entirely under water stored in the reservoir. There is practically no irrigated crop grown now in this season in the Kistna delta.

In addition to second crop, i.e., an irrigated crop grown on land on which a first crop irrigated has already been reaped in the same fasli, it is proposed to bring a large extent of swamp or lake land under cultivation in the late crop season. The idea is to wait till such lands are naturally drained of the water which submerges them in the first crop season and then cultivate them with an irrigated crop, generally a three months' paddy crop from January or February up to April or May. Throughout my report this crop is referred to as "short late crop" meaning a wet crop grown in the second crop season on land on which no crop has previously been grown in that fasli.

Tenure.—Unlike the upland the delta area is very largely zamindari in tenure. The figures are as given below (first crop area only):—

							Villages.	Extent commanded. ACS.
Government	...	..	...	...	...	...	147	101,055
Zamindari	...	..	...	...	...	...	136	94,449
Whole inam	...	..	...	...	...	...	47	12,411
						Total	330	207,915

49. Among the lands given me for investigation in the delta there are four blocks of considerable extent requiring separate discussion. All these blocks have been personally investigated by me. These blocks are the Challapalli and Kona blocks (practically one), the Isukapalli area in the Guntur district, the Pedda lanka area in the Kistna district, with a large adjoining extent of short late crop land, and the Kolair lake area. All these blocks receive separate discussion in paragraphs 63 to 78 below. There is also in the Nuzvid taluk a compact block (32 N) known as the Vempad block measuring nearly 6,000 acres. But except for its size there is nothing unusual about it and it requires no discussion. With these exceptions the delta area investigated may be described as a number of patches of dry land varying in size from 100 to 3,000 acres scattered up and down the whole of the Kistna delta, a sort of archipelago of dry islands among the existing irrigation.

a sort of archipelago of dry islands among the existing irrigation.

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[illegible][illegible]

50. With the exception of the four areas noted above, the lands included in the delta extensions present few difficulties and little of interest. In the matter of soil they are identical with lands already regularly irrigated and there is no doubt that they will be grown with wet crops as soon as water can be supplied to them. The only point which I wish to emphasize about these areas is their scattered and fragmentary nature, since this consideration affects certain of the deductions to be made from the irrigable area. Outside the four special tracts above mentioned, there is practically no village affected which is not already partly irrigated. In the vast majority of cases by far the largest part of the village lands is already under irrigation. The dry land which the project will supply with water surrounds in some cases the village or one of its hamlets. Much more frequently it is quite remote from any village-site or only touches it on one side. Again it is purely a matter of chance whether in the portion of the village concerned there occur any roads, paths, or other communal porambokes. No conclusions must be drawn therefore from the deductions made from the total irrigable area in these scattered blocks or from the percentage these deductions bear to the total extent commanded.

This is more particularly the case in western delta where, in sending lists of survey numbers to be investigated, the Executive Engineer omitted in many cases all the deductions from that area.

51. *Deductions from the irrigable extent—Statement No. II.*—I deal briefly below with such of these deductions as have received different treatment in the delta and the upland or require special remark.

52. *Village-sites, extensions and zones.*—Columns 4 to 8 contain, as in the upland, the deductions made on this account. In the case of wholly commanded villages the method of calculation of the extensions and zones is identical with that pursued in the upland, and described in paragraphs 30—32 above. But villages wholly commanded by the reservoir, *i.e.*, not now irrigated at all under the aicut, are rare, only 33 in number in the whole delta, and of these the large majority fall into the Challapalli and Kona blocks, where, as explained in discussing these blocks, the village-sites require no extension.

In the case of villages already partly irrigated, which have a considerable dry area (300 acres or more) coming under irrigation, I have reserved land adjoining the village at the rate of 10 cents for every 10 acres likely to be converted from dry to wet. If there is no project land adjoining the village I have made no reservations.

Land distant from the village will not, as a rule, be suited for village extensions, and as my staff had already left the delta tracts when the orders regarding these extensions were received, I could not make enquiries upon its suitability in individual cases.

The Board in its Proceedings, Mis. No. 3293 (L.R.), dated 14th October 1909, agreed with me that it was not worthwhile to cause villages to be revisited solely to enquire about these extensions.

53. *Dry zones.*—A 50-yard dry zone is provided round all villages and hamlets. Where the project area does not surround the village but only touches it on one or more sides (as is more often the case than not) a belt of 50 yards in breadth is left on these sides only. This will account for the smallness of these zones in the delta as compared with the upland.

54. It may be worthwhile to draw attention to the fact that many of the villages concerned, including almost all the wholly commanded villages, are zamindari villages for the extension of village-sites, the provision of which is customarily held to be incumbent on the zamindari, at least in most zamindaris with which I am acquainted.

But it would be possible, and probably desirable, to refuse canal water to lands in zamindaris suitable for such extensions. Otherwise the lands will almost certainly not be applied to this purpose, whatever may be the need for extension.

I have accordingly treated zamindari and Government villages exactly alike in this respect.

55. *Columns 9 and 10.*—These are inevitable deductions requiring no explanation.

Column 11—Tank-beds (1,455 acres).—In the delta there are scarcely any tank-beds. Where they exist they have been reserved as seed-bed tanks. The desirability of this is fully discussed in commenting on this class of deductions in the upland area, where the tanks form an important item.

Column 12—River-beds and islands and lankas.—This deduction occurs in the upland tract only.

Column 13—Other communal porambokes.—This requires no comment.

Column 14—Topes (1,438 acres).—The remarks in paragraph 38 above regarding topes in the upland are equally applicable to topes in the delta.

56. *Forest reserves (column 15—6,929 acres).*—With one exception all Forest reserves falling within the commanded area have been excluded. The exception is an extent of 665 acres 27 cents in Adavuladivi village, a triangular patch of land quite bare of trees and valueless to the Forest department at present. There may have been some idea originally of planting it with mangrove, which grows freely on adjoining salt swamp, but it would be absurd to retain possible paddy land in order to plant it at some expense with trees fit only for firewood.

There is also a considerable tract of land in the Peddalanka area discussed below which has been notified under section 26 of the Forest Act, but not yet reserved. This also is almost entirely bare of trees and contains no grazing of any value. It should be included in the area irrigable by the project.

In connection with this question of fuel supply in the project areas, a question dealt with at considerable length in the report of the last Kistna reservoir project, it may be worthwhile to indicate a possible solution of the problem. I think this may ultimately be found in the general adoption of coal instead of firewood. There are two ways in which coal may reach the tracts concerned, one by sea from Calcutta to Masulipatam, the other from Singareni to Bezvada. The latter is the only source of supply now actually tapped. I have ascertained that the prices per ton of wood and of Singareni coal at Bezvada are now so nearly equal (Rs. 7½ per ton for wood and Rs. 10 for coal) that, allowing for the very much greater calorific value of the latter, there seems no reason why it should not ultimately displace wood as the fuel in common use.

It is indeed already used for their furnaces by the more advanced of the factory owners in Bezvada, and also in burning chunam. There is a prejudice, I have been told, against its domestic use, but I should think this would disappear in time. I believe coal is commonly applied to domestic purposes in Bengal. With the cheap transport on the canals there would be no difficulty in conveying it all over the delta.

Another source of fuel supply is the private casuarina topes on the sandy lands between the delta and the sea, which are much on the increase, I am told, and are becoming a recognized form of enterprise with the holders of such land.

With these two possible sources open, I think it unnecessary to attach too much importance to the fuel-bearing forest lands, and certainly absurd to exclude from irrigation treeless lands, whether reserved or unreserved, solely on the ground that they may one day be grown with fuel.

57. *High lands (column 16—69 acres).*—This item, of very great importance in the upland tract, is negligible in the delta. Lands above the commanded level have as a rule not been given to me at all for investigation by the officers of the Public Works Department. The few petty items that do find a place in this column are small mounds and the like.

58. *Lands submersible (column 17—3,280 acres).*—Deductions on this account are not very large in the delta, though this is not by any means because submersible lands do not exist. Nothing is commoner than liability to submersion at the extreme end of the delta near the tail of the canals. But the lands that must be excluded from the first-crop area on this account will as a rule grow a short late crop and appear accordingly under that item.

AREAS REQUIRING SPECIAL DISCUSSION.

The exclusions made in column 17 therefore are either—

(1) Lands liable to submersion by salt water, *e.g.*, from creeks running down to the sea.

(2) Lands submersible for too long a period to allow of the sowing even of a late crop.

(3) Submersible lands of such small extent that unless the land immediately adjoining them was growing second crop (a doubtful matter) no one would think of supplying them with water in the late crop season.

(4) Lands at the far end of the canals where the Superintending Engineer has assured me he does not wish to irrigate in the late crop season.

59. *Unsuitable soils* (column 18—132 acres).—In the delta this item is negligible. There are scarcely any soils unsuitable for irrigation—in the whole tract.

Grazing lands (column 19—7,995 acres).—This question as in the upland is reserved for discussion in paragraph 79 below.

60. *Mamul wet* (column 20—4,887 acres).—The nature of these deductions has been explained in paragraph 44 above. I have only to add that in a few cases (noted in the remarks column of village register No. II) it is uncertain whether the land-owner can make good his claim to project water as the settlement source of irrigation has long been out of repair and the lands dry.

Questions of limitation, of a *bond fide* intention to repair the original irrigation source, and the like, may arise in endeavouring to decide this claim, and each case must be settled on its merits.

I think it safer for the present to exclude all such lands from the revenue-producing area under the project.

61. *Other causes* (column 22—1,471 acres).—There are exceptional items which cannot be generally classified. The nature of each deduction is explained in the remarks column.

The chief item which requires some further explanation is the highly-assessed zamindari garden land occurring in the Vallur and Nuzvid zamindaris.

The reason why these lands are not likely to take Government water is that they already grow tobacco, chillies and other valuable crops, generally under wells, and pay to the Zamindar a rent ranging from Rs. 27 to Rs. 29 an acre.

Though it is certain that the power to take the Kistna water to these lands would be appreciated by the ryot, it is doubtful whether he will avail himself of the opportunity on condition of paying Rs. 5 an acre in addition to an assessment two or three times as high as ordinary zamindari rates.

In other cases the zamindar has established by suit a right, often claimed by zamindars in the Kistna district, viz., the right to a half share in all crops, and it is said that it is more profitable to grow dry crops in such cases than incur the Government water-rate and the extra expenses of wet cultivation and then hand over half the wet crops to the zamindar.

I am unable to forecast with certainty whether these lands will or will not take Kistna water ultimately. The zamindar and his tenants may come to a compromise. But it is unsafe to count on it, and I have excluded the lands accordingly.

I have also deducted an area of 755 acres in the village of Lakshmipuram in Bundar taluk. The village is exceptionally unhealthy being infested with mosquitoes bred in the adjoining forest reserve and I doubt its becoming fit for irrigation unless the tree-growth on the salt swamps is removed.

62. *Total deductions*.—The percentage of irrigable area in the delta is 78.7 per cent. of the area commanded and the unirrigable area 21.3 per cent. The deductions are slightly less in proportion than in the upland. The difference in this respect between the two tracts would be greater but for the exceptionally large deductions made in the Challapalli and Kona blocks, discussed immediately below.

To these deductions, as in the upland, must ultimately be added the areas to be taken up for canal extensions and new channels. I can as yet make no definite deduction on this account though in paragraph 133 below, in dealing with the remunerative aspect of the project, I have made a rough centage deduction from the estimated revenue. This however finds no place in any accounts.

63. *Chellapalli and Kona blocks* (blocks 1s and C on Public Works Department maps).—This area, though divided by the Public Works Department into two blocks which were given to me for investigation at different times, is really one continuous tract of land.

It is by far the largest of the delta blocks coming under irrigation by the project, comprising, as it does, a commanded area of 72,409 acres or over one-third of the whole first crop project area in the delta.

It is a triangular shaped block of land with its apex to the north, having for its western and southern boundary the Kistna river itself, and for its eastern boundary roughly speaking the Kanyakala madugu *alias* Dayyapa kalva, a natural drain.

The tract is almost entirely zamindari, including portions of the Vallur, Telaprole and Medur estates, parts of the old Nuzvid zamindari, and almost the whole of the Challapalli zamindari, all of it in fact except the part already irrigated.

All the northern portion of this tract is admirably suited for irrigation, consists of soil of proverbial fertility and is very thickly populated, the population numbering 786 to the square mile. The ryots also are enthusiastically anxious for the introduction of irrigation. I have no doubt that the lands will be converted into wet as quickly as water can be supplied to them.

The tract in this part requires no special works to protect it, and presents no peculiar features except in the matter of village-sites and donkas (bandy tracks).

The peculiarity of the village-sites is that the Survey Department, in surveying the Challapalli zamindari, measured in with the village-sites large extent of adjoining topes, gardens and tanks and showed them as part of the village-site.

As a consequence the village-site, as it appears in the village accounts, is often three or four times as big as is usual with villages of similar population, and only one-third or one-fourth of the site is actually occupied by houses.

I have not treated any part of this so-called village-site as irrigable. As already remarked above in paragraph 38, I think it desirable that topes and gardens when they adjoin the village should be retained as they are. Tank-beds for reasons given in paragraph 35 are always treated as unirrigable.

But the existence of these large adjoining areas, already theoretically forming part of the village-site, renders it unnecessary of course in these particular villages to make any reservations for probable future extensions of village-site.

The adjoining land appearing in the village accounts as village-site but not built upon will be more than ample for such extensions.

Similarly the prescribed dry zone has only been reserved on those sides of the village which adjoin cultivated land. On the sides where the topes or gardens are now standing, the houses, even if the village greatly extends, are not likely to come within 50 yards of the wet cultivation.

Bandy tracks.—The remarkable feature of these is their unusual width. It may be noted that in this tract the deductions on this account (column 9 of statement No. 2) form a much higher percentage of the commanded area than is usually the case.

These bandy tracks judging from the ones I have seen measure 30—40 yards across. I have treated the full breadth as unirrigable. Here for once is an opportunity to make a proper embanked village road, which will not be subject to inundation when the whole tract comes under irrigation, and to do so without incurring enormous expense in the matter of land acquisition, the existing breadth being enough to dig the required earth from the sides and make a raised road in the middle.

Whether advantage is likely to be taken of this opportunity is another matter. I discuss the subject of village roads in irrigated areas in paragraph 98 below.

Among these lands in the villages of Lakshmipuram, Mangalapuram, Pedkallepalli, Annavaram and Pedaprolu there are certain zamindari forest lands.

I have inspected them personally and treated them as irrigable with the exception of 177 acres, having found that the rest was practically useless as it stands. These so-called forests not only contain no timber of any value but are so choked with prickly-pear as to render it impossible for cattle to have access to them in most parts, and are therefore useless also for grazing. They had much better be given up to irrigation. The water will in a year or two kill the prickly-pear. Indeed when water is available this method forms, I believe, the most effective method of getting rid of it.

The excepted area is a large tope, 177 acres in extent, containing rather better timber; it is not choked with prickly-pear, and affords shade for cattle and a certain amount of grazing. The zamindar should be encouraged to retain it as it is. It might be worth his while to irrigate part of it by occasional flooding to improve the grazing.

In the Vallur zamindari in this block occur most of the cases alluded to in paragraph 61 above of highly assessed lands which are not likely to take water unless some arrangement is arrived at between the zamindar and his tenants.

Submersible areas.—Certain areas in the southern portion of the block are liable at present to inundation. It is proposed, I understand, to protect these areas by extending the present Kistna flood bank for some miles down the stream.

Assuming the success of these engineering works there is nothing to prevent the successful irrigation of the lands in question. An extent of 3,211 acres is how- of the drainage water from the deltaic tracts above. This submersion the extension of irrigation is likely to enhance. I had originally classed most of these lands as short late crop. The Superintending Engineer, II Circle, however, has recently assured me that he will not wish to irrigate any land so far from the head of the channel in the late crop season. The lands are therefore totally excluded. A further extent of 2,236.36 acres is liable to submersion by salt water and is therefore unfit for cultivation in any season.

Among these lands liable to submersion a large extent of 5,502 acres appears as a grazing reservation. It forms almost the only large continuous block of land at the disposal of Government which it is possible to reserve for the purpose. I have inspected the block. Undoubtedly it is at present valuable as a grazing land for three or four months in the year and supplies pasturage to some thousands of cattle from Masulipatam and elsewhere. Whether it will continue to be of value for this purpose, if the submersion increases, is doubtful. But it may be treated as grazing land for the present.

In the zamindari villages of Mangalapuram and Majeru I have also reserved certain lands for grazing on the ground that they form the beds and the ayacuts of ruined tanks, growing good grass and now reserved by the zamindar as pasture lands for home-farm cattle.

I cannot, however, of course certify that the zamindar will continue to prefer to retain them as grazing lands.

Communications.—The tract under discussion is not well provided with roads. A road runs from Masulipatam to Challapalli, the zamindar's head-quarters. This road has been extended to Mopedevi and Nadakuduru on the bank of the Kistna in two branches and they are now being metalled. From Nadakuduru either on the top or at the foot of the river flood bank, as is most convenient, a road should run up to Vallur which is now being connected with the Bezwada-Masulipatam road. A branch road is also desirable between Lakshmipuram on the Challapalli-Masulipatam road and Pedakallepalli and from the latter place to Kona.

64. *The Peddalanka area (block 29 C and A block according to the Public Works Department maps).*—The former of these contains an area of 9,317 acres of ordinary crop land still unirrigated which will be brought under irrigation by the project.

Adjoining these lands is a further area of 5,094 acres (mainly in block A) which being lower in level and more liable to submersion in the first crop season, is fit only for short late crop.

Both these areas are situated at the extreme south-east corner of the Kistna eastern delta and are close by the Upputeru river. The Upputeru river divides the Kistna eastern and Gódvári western deltas, both of which slope towards it, and forms the ultimate drain of both deltas.

The lands as might be expected from their position are amongst the lowest lying in the delta, and are all subject in greater or less degree to difficulties of drainage. They are also unfavourably situated as regards the supply of water, owing to their great distance from the head of the canals. In the case of lands included in block 29 C, however, the submersion is not too great to allow of the growth of a paddy crop in the ordinary season, if the lands are transplanted early. In the case of other lands included in block A, the submersion, as already remarked, is so serious as to preclude the growth of an early paddy crop.

The history of the attempt to bring these lands under irrigation, known as the Peddalanka project, may be briefly outlined as follows.

The Peddalanka channel was constructed in the year 1895 and was designed to irrigate 22,500 acres of land, part of which lay in the seven villages under discussion. It was known that the lands adjoining the further reaches of the new channel, those in fact with which my investigation is concerned, were likely to be difficult to bring under irrigation owing, among other reasons, to the scarcity of population in the tract and the great distance of the existing villages from many of the lands concerned.

Efforts were made to counteract these difficulties by setting apart lands for the construction of hamlets, by the free grant of part of the waste lands, and by inviting settlers from among the poorer classes. These efforts were not very successful.

The tract did not rapidly fill up with population, nor were most of the sites selected for hamlets occupied, since I find that the Collector a few years later, refused to convert these lands to poramboke on the ground that there was no demand for house-sites in them.

Much of the land sold by auction and that assigned on free grants were subsequently either relinquished or bought in by Government, and it is said that some of the neighbouring ryots and merchants who had speculated in these lands lost heavily. They found in fact that having got the lands they could not obtain resident tenants or resident labour sufficient to bring them under cultivation. These facts were reported to the Board and are dealt with in B.P., Mis. No. 2145, Land Revenue, dated 24th June 1903.

Many reasons have been assigned in the correspondence for the ill-success of this project. The ryots have consistently complained of an irregular supply of water, and the local Revenue officials have supported them in their complaint. The officers of the Public Works Department, on the other hand, formerly maintained that the water-supply was ample, and assigned the slow progress of irrigation to other causes, putting forward among other reasons the poor nature of the soils. I am able to state definitely that this last reason does not exist, at least to any marked extent.

The soils, regar clay and regar loam mostly, are perfectly well suited to irrigation and are far better in quality than the soils immediately to the south-west which consist of arenaceous sand. The latter have always been readily irrigated and bear a good crop.

If I have correctly understood the views of the Public Works Department officers, who are in charge of the irrigation in this tract, however, they are now prepared to admit that all is not as it should be from an engineering point of view.

They have told me that Peddalanka channel is too long for its fall, which makes it difficult to supply water regularly to the lands at the tail of the channel.

Further I understand that the particular lands under discussion have suffered from an unequal distribution of water between the villages higher up and those lower down the channel. This difficulty, the system of piping about to be introduced immediately is designed to remove.

I have found sufficient proof in the course of my inspection that want of water at the proper times has been, and is still, felt a serious drawback in this tract.

Much of the land under occupation was still being transplanted in the first week of August. These lands being all more or less liable to submersion should have been transplanted four or five weeks earlier.

At the same time these engineering defects, though I do not doubt they played an important part in retarding the development of the tract, are, I believe, all likely to disappear either through the greater supply of water which the reservoir will make available, particularly in the transplantation months, or through improvements which it is designed to make in the channel itself.

Also, the inadequate supply of water has not, as I shall show below, prevented a recent great extension of irrigation in the tract concerned.

Other causes assigned for the temporary ill-success of the project are lack of manure and lack of drinking water. Both of these reasons are genuine, but the latter can be removed, and the former is, or is likely shortly to be, a complaint common to the whole delta.

Apart from uncertainty in the supply of water, I attribute the difficulties encountered in bringing this area under irrigation chiefly to the causes already alluded to, scarcity of population and distance of the lands from any existing village.

These difficulties, which did not yield to the efforts of the local officers some ten or twelve years back, are now rapidly disappearing. The recent high price of paddy has probably been the main factor in producing this result, together with increased knowledge of the possibilities of the tract among the ryot population, and among the floating labouring population that continually visits the delta. Self interest is having its natural effect and beginning to draw population into this area in spite of the continued existence of most of the drawbacks I have mentioned.

The increase in population has, I believe, taken place entirely since the last census, now nearly nine years old, which shows an average population of 185 to the square mile and I am consequently unable to give figures which would indicate the increase, but I have no doubt at all that it has been considerable. Several new hamlets have sprung up by the side of the Peddalanka channel towards its extreme end, one or two of them on the sites originally selected by the local Revenue officers some twelve years back. A community of Native Christians planted in one of these hamlets has flourished. A deserted village called Amaravati has been rebuilt by a community of Upparas (professional earth-diggers) and a body of emigrants from Vizagapatam district has settled in another hamlet, which they have named Bobbili-gudem, after the head-quarters of the Bobbili Maharaja. The two latter communities are doubtless drawn from the great class of imported labourers, which flows annually into the delta for employment during the transplantation and harvest seasons. The major villages are also said to have much increased in size.

These hamlets have brought the resident population somewhat nearer to the outlying parts of the cultivated lands, but the distance is still considerable, often as much as two miles, occasionally as much as three.

The low level of the land is, as it always has been, the difficulty which prevents the erection of villages more convenient in situation. Village-sites in order to be quite secure from submersion have to be constructed of made earth and raised several feet. It is plain, however, that the ryots no longer consider the distance of the lands from their homes prohibitive.

It is worth noting also that some of these lands are held by well-to-do non-resident holders living in the adjoining taluk of Bhimavaram and elsewhere. These men build temporary shelters on raised patches of these lands for the use of themselves and their servants during the transplantation and harvest seasons, and do not visit the lands at other times.

This increase in population has naturally been accompanied by a marked increase in cultivation and irrigation. Over 3,000 acres have been newly brought under irrigation during the two years immediately preceding my investigation.

There still remains as stated above an extent of over 9,000 acres unirrigated which is fit for first crop. For a very large proportion of this, however, darkhasts are, I am informed, already pending, and it has been recently decided to sell the lands or some of them by auction.

This in itself will show that there is no longer any reluctance to take up these lands. Indeed the demand for them is somewhat surprising, since I think it extremely doubtful if water can be supplied to them till after the project is working, and I believe the lands to be quite unfit for growing dry crops. Indeed, water must for the present be refused by the Public Works Department officers. Otherwise they cannot consistently credit the water-rate on the lands to the reservoir and not to the anicut.

When this fact is generally known, no doubt, the demand will be temporarily checked, but its present existence removes all doubt that the lands will be readily taken up as soon as the project secures them from danger of loss through want of water.

I can say with complete confidence that the ill-success of the Peddalanka project is a thing of the past and that every acre fit for ordinary crops which can be supplied with water will be irrigated in the near future.

I am almost equally confident about the future of that portion of the tract (block A) measuring 5,094 acres which is unfit for growing a crop in the ordinary crop season, but which is included in the area fit for short late crop.

It is probable of course that these lands will less eagerly be sought after than those that grow a paddy crop in the normal cultivation season, but I do not doubt that they will all be taken up within a few years after water becomes available in the latter months of the year and the practice of growing a late crop becomes established. Indeed this practice though not actually in vogue in any of the villages concerned, must be perfectly well known to the ryots living in them, since it has been practised for many years in the villages of the Gódvári delta and in the Kolair lake area, both of which are near at hand.

These short late crop lands suffer from the same difficulty as the ordinary crop lands discussed above in the matter of their distance from the nearest villages, and in about the same degree.

The difficulty will doubtless be overcome in this case as it has in the other.

In the matter of population these short late crop lands are more favourably situated, the villages which adjoin them being more populous than are those affected by the Peddalanka project.

In this block occurs an area provisionally notified for reservation under section 26 of the Forest Act.

In paragraph 56 above, I have discussed the question and recommended that it should be treated as irrigable.

Communications.—This area is very badly provided with roads at present. The chief need is a road from Vinjaram on the Polrazu canal (already joined by road to Kaikalur, the Deputy Tahsildar's head-quarters) to Kalidindi and from thence to Upputeru river. This road will for most of its length run along a dry sand ridge and the cost will not be prohibitive. As regards village roads and the necessity of making them in connection with the channels, especially in tracts liable to submersion, the subject is fully discussed in paragraph 98 below.

65. *The Iskapalli area (Public Works Department blocks Nos. 29 and 33).*—This block of land is situated in the Repalli taluk (till recently the Tenali taluk) of the Guntur district almost at the extreme end of the west bank canal. It constitutes, with one small exception, the irrigated land most distant from the head of this canal, and adjoins the salt creeks and mangrove swamps which intervene in this part of the delta between the irrigated area and the sea.

Like the Peddalanka area it is subject to drainage difficulties, and the holders of lands in it constantly complain about the insufficiency and irregular supply of water. As in the case of that area the scarcity of population and the distance of

villages from the lands to be irrigated have retarded the development of irrigation. The census shows a population of only 172 to the square mile.

The history of the efforts made to overcome these difficulties is an almost exact repetition of what took place in the Peddalanka tract.

About the year 1900 the major distributaries taking off from the main canal were constructed. The area which it was intended to bring under irrigation was 15,000 acres.

Owing to lack of population, difficulties regarding irrigation and water-supply and other drawbacks already described in the Peddalanka area, irrigation was slow to develop. Over 5,000 acres was bought at public auction mainly by speculators and over 3,000 acres of this had to be resold owing to the purchaser's default.

As in the case of the Peddalanka project, the difficulties experienced in attracting population to this tract have during the last few years disappeared of themselves, without, I believe, any special official effort, and in this case much more rapidly and completely.

Four new hamlets have been found, and it is believed that the population of the major villages has also much increased since the last census. In some places there is still difficulty about drinking water, but this trouble will disappear when the channels are full throughout the year.

The Executive Engineer informs me that out of the area it was originally designed to irrigate, 15,000 acres, no less than 14,112 are now under irrigation, or nearly the whole area.

The majority of the lands which I have found fit for extension of irrigation under the Reservoir Project in this tract form therefore, I presume, no part of the original Iskapalli project area, but adjoin it and are now practically undistinguishable from it on the ground. These lands measure 9,354 acres in extent.

It may be worth mentioning that most of the lands shown by me as irrigable in this area were at first given to me as short late crop lands on the understanding that they were liable to submersion to such an extent that they would not grow a crop between June and December. The lands were re-inspected and transferred to ordinary crop lands by the Executive Engineer, at my suggestion, as I found that lands of typical level were growing dry crops with fair success.

The ryots themselves say this is the case.

This tract includes one of the rare cases of a Forest reserve area which I would recommend to be excluded from reservation and granted on patta subsequent to sale. This is a small block of 665 acres in the village of Adavuladivi forming an outlying part of the Adavuladivi reserve. The subject is discussed above in paragraph 56.

Another area in Potumeraka village described in the village accounts as Forest, which I have treated as irrigable, is not reserved forest and is therefore available without any special action.

Communications.—All that the tract needs is improved village roads along the banks of the major distributaries. The Executive Engineer, Kistna Western Division, writes to me that an estimate for these has already been sanctioned.

66. I have dwelt at considerable length on the history and peculiarities of the areas covered by the two small irrigation projects above described, at greater length in fact than would be justified by the additional revenue which I expect them to bring into the Kistna Reservoir project.

Two reasons however have induced me to go into such detail.

In discussing the probable rate of development under Mr. Reid's scheme the Board attached considerable importance to Mr. Parsons' remark that "large areas in the Kistna Delta, e.g., under the Peddalanka and Iskapalli project areas have been lying waste for years owing merely to paucity of cultivators" (top of page 155, printed report).

I think it worth while to anticipate any similar criticism of the Kistna Reservoir project development that may be based on the facts relating to the two small projects under discussion.

The history of these two areas has ceased to be a danger-signal. It indicates on the contrary that given patience and profitable prices for paddy, there is no tract so unfavourably situated that it will not come sooner or later under irrigation, if water is made available.

I have another stronger reason for emphasizing the gradual disappearance of obstacles to irrigation in these two tracts. This is that many of the problems which had to be faced in them, notably the scarcity of resident ryots and the distance of the project lands from any village, will be repeated in the much more important Kolair lake area and will there, I feel sure, ultimately find a similar solution.

67. *The Kolair lake area.*—I now come to the Kolair lake, the last and by far the most interesting of the areas in the Delta requiring special consideration.

The Kolair lake is a shallow saucer-like depression lying between the Kistna and Godavari delta systems and receiving part of the drainage of both. It does not however receive the principal part of its supply from these systems but from the Budameru and Tammileru, two natural drains which carry the surface drainage from the Kondapalli and Nuzvid hills. The lake is bounded by the lands of the Ellore, Bhimavaram and Gudivada taluks but its area is wholly included in the last-named taluk.

It is drained at its south-east corner by the Upputeru river, now a very much more effective drain than formerly owing to artificial drains leading into it from the lake, dug some 12 years back by the Public Works Department.

The lake is completely dry by the end of the hot weather and fills gradually from June to August.

The number of months during which it preserves its character as a lake and the depth of water during those months depends naturally on the rains of the two monsoons. Ordinarily, however, it may be said to be filled with water from July to November inclusive.

During these months it is a sheet of shallow water covered thickly in most parts with a growth of rushes and water weeds.

The water-covered-area begins to contract from November onwards and by the end of February practically the whole is free from submersion. The rapidity with which the water drains off could no doubt be increased, if desired, by further drainage works.

A glance at the map will show that the shape of the lake is irregular and diversified by islands and peninsulas, both called lankas, and that, as a consequence except in the eastern part of the lake, the breadth of the water-spread between the mainland and one or other of these lankas is nowhere very great.

The extent of the lake according to the present taluk map is about 83,000 acres exclusive of the lankas. In actual fact, however, it is impossible to define the lake area exactly, as the surveyed paddy lands on the north and west and on other sides at some points slope imperceptibly towards the lake, and at certain times of the year are liable to submersion in the same way as the unsurveyed lands in the lake-bed itself.

In fact I may say that, if the Kolair lake be defined as the area submerged in the rainy season, its area varies season by season and month by month.

68. *Surveyed and unsurveyed areas and explanation of statements.*—My statements III-A and III-B distinguish between these surveyed and unsurveyed lands. The former shows the extent of the surveyed land fit for growing a short late crop. All this area is on the Ellore shore of the lake, and appears on the taluk map as mainland. It is all however too deeply submerged at present to grow a crop of any kind regularly in the first crop season.

Statement III-B shows the unsurveyed land fit for the same crop, and the lands appearing in this statement are all in the lake-bed proper.

When I describe these lands as unsurveyed, I mean not surveyed in detail. I was till recently under the impression that the land in the bed with the exceptions noted below had not been surveyed at all.

The Collector, Kistna, however in his report No. 5319/Gl. of 1904, dated 21st June 1905 to the Board states that the whole lake was surveyed in between 1888 and 1890.

It is probable therefore that a traverse survey was made of the lake-bed. (The records are all in a Civil Court and the Collector cannot give me more specific information.) I shall, however, continue to refer to the greater part of the bed as unsurveyed, to distinguish it from the areas surveyed field by field.

There are now two such areas in the original bed of the lake, i.e., in the water-spread area as it appears on the taluk map.

An area of about 10,000 acres has been surveyed in detail for tirvajasti purposes on the eastern or Bhimavaram side of the lake, and another area of approximately 1,000 acres in the Government village of Pulla in Ellore taluk. Both are shown on the tracing of the Kolair lake area herewith forwarded, outlined in red.

The former of these two areas is now the subject of a civil suit between Government and Nidadavole Estate, and I have taken the area, 10,080 acres, from the survey officer in 1904. Neither Government nor the Zamindar have accepted this officer's decision, each claiming land beyond the limits allowed to them. Government, in fact, if I have correctly understood the correspondence, claim the whole bed as it appears in the taluk map. The red line shown in the tracing forwarded is the line settled by the survey officer, which I believe to also correspond to the limits of the land surveyed in detail.

I have excluded this area from the land to be credited to the Reservoir project, but not for the reason that it is under dispute. Whatever the ownership, it is likely to be irrigated with Government water and pay delta water-rate as it does at present. But the report of my Revenue Inspector shows that the land is already almost all irrigated by Gódávri canal water in the first crop season, by means of small private channels repaired by the ryots themselves, which lead from the lands in question up to the regularly maintained channels on the mainland. I presume that this system is not likely to be disturbed by the advent of the reservoir and that these lands will continue to grow ordinary first crop paddy and possibly a second wet crop under the adjoining Gódávri delta system and not the Kistna system. They will in that case have nothing to do with the reservoir.

The Superintending Engineer, II Circle, agrees with me that this is most likely. The 1,000 acres in Pulla village is included in statement No. III-A as surveyed land fit for short late crop.

Explanation of area adopted.—There are extents in the bed of the Kolair entered in the Settlement registers of the Government villages on the shores of the lake and lankas as "unsurveyed area attached to the village". On the Bhimavaram side the same entry appears in the village adangal accounts of the zamindari villages.

I have particulars of the extents claimed by each village, but I much doubt their being correct, and think they would add nothing to the information of the Board. They do not quite fully account for the whole area of the lake, as taken by instruments off the map, and the Collector informs me that he has no knowledge of any division of the lake between the villages on its shores. Further in so far as the zamindari area is concerned the whole matter has for long been in dispute and it is natural that their village accounts should show the extents which are claimed by the zamindar.

The extent which appears in column 1 of statement III-B is arrived at as follows:—

The extent of the bed, excluding lankas, as arrived at by taking the area with the planimeter off the taluk map is 83,000 acres. Deducting from this 10,000 acres since surveyed and irrigable from the Gódávri channels, as explained above, and 1,000 which has also been surveyed and has passed into statement III-A, the balance of 72,000 acres is arrived at. This is the *unsurveyed* area fit for short late crop.

So far as the irrigation is concerned this figure is likely to be approximately correct, since, as already remarked the dispute about ownership does not affect the fact that the irrigation will be from a Government source and chargeable with water-rate.

But though the same figure 72,000 acres is entered as saleable area, *minus* a reservation of 5 per cent. for free grants, this area may be increased or diminished materially according to the result of the suit. I have followed, as I have said, the survey officer's line. Government claims about another 10,000 acres and if it wins the suit can sell this area. The zamindar claims, judging from the map attached to the plaint, about another 7,000 acres, and should he obtain a decree, will reduce my figure of saleable area by this amount.

The total extent irrigable in the Kolair area, surveyed and unsurveyed together, is 82,963 acres.

Out of this area 9,358 acres are already irrigated by the means described in paragraph 70 and already pay water-rate to Government. In respect of this extent only the difference between the project water-rate and the present water-rate is credited to the project. This will be apparent from column 4 of statement III-B and from the enclosure to that statement.

69. The reservoir project scheme includes the irrigation in the second crop season of the whole of this large area. As in the case of other short late crop lands, the idea is to wait until the water standing on the land during the monsoon months has drained off or become so shallow as to allow of paddy seedlings being transplanted, and then to transplant one of the shorter crops of paddy which will stand on the land for three or at most four months.

The Superintending Engineer, II Circle, assures me that there are no insuperable difficulties regarding the irrigation of the whole area in this season from water held up by the reservoir and sent down the ordinary delta canals.

The irrigation of the lake-bed and the drainage from it of the monsoon flood water will be greatly facilitated by the singular uniformity of the lake's depth. Complete levels have been taken over the whole of its area. The level of the bed varies from 6 inches above mean sea level to 4 feet 6 inches above. But the greater part of the bed varies only between a level of 2 feet and a level of 3 feet 6 inches. This means that the water drains off almost the whole surface of the lake at about the same time.

70. *Cultivation of Kolair bed under present conditions.*—At first sight the introduction of cultivation and irrigation over this enormous area of lake or swamp in a season different to the one customary in the Kistna delta seems likely to present exceptional difficulties. That at any rate was my own first impression. But these difficulties in a great measure disappear as one examines the conditions of the tract more closely.

In the first place, in this area, unlike the rest of the Kistna delta, the practice of growing a crop of paddy in the months of January to April or May is by no means unknown to the local cultivators.

The Kolair area borders, as already stated, on the margin of the Gódávri delta, where such a crop is commonly grown under the Gódávri canals. And in the bed of the Kolair lake itself nearly 10,000 acres of such crop (generally called Dalwa paddy) is now grown under conditions much more precarious than would be the case under the project.

(This is in addition to the cultivation in the excluded area on the Bhimavaram side, which is under dispute with Nidadavole).

Part of this crop is grown under one of the Gódávri delta channels, which crosses a corner of the lake and runs down half the length of the big Agudala lanka irrigating 1,500 acres in the adjoining lake-bed. A small extent is also grown with the assistance of the Kistna drainage water in the Budameru drain, the water being banded up for a few weeks in the drain, after the Kistna canals close.

A further part of the bed is irrigated by rather singular means. The Kolair water, as already mentioned, drains out through the Upputeru, a tidal river, but this river fails to drain off all the water immediately and leaves a certain quantity standing on the lands in the south of the lake which are of slightly lower level than the rest of its bed.

This water is fresh, but is continually pushed back by the action of the tide in the Upputeru along the drains which lead to that river and is led from the drains over the neighbouring fields. The water, though pushed up by tidal action does not itself become brackish.

In other cases the irrigation is simply carried on by baling from low-lying parts of the lake where the water stagnates.

The success of the greater part of this dalwa crop is never altogether certain under present conditions. It depends in a great measure during the last few weeks of its existence on hot weather showers. If these do not fall, the outturn is likely to be reduced by half, though the crop is not totally lost as a rule. The crop irrigated by the action of the tide on the lake water is said to yield a better average outturn than the crop on other lands.

Precarious, however, as much of this cultivation is, it proves immensely attractive to the ryots on the edge of the Kolair and to others living much further afield. The question of the distances from which cultivators will come for the purpose of the cultivation is of such importance to the future of the Kolair that I have gathered as much information on the subject as possible in the villages themselves.

I have full details on the subject, but I do not think they would interest the Board. I may summarize the information by saying that of the cultivators of this dalwa crop 20 per cent. come from villages that do not border on the Kolair lake and nearly 10 per cent. come from villages distant more than 5 miles away from its edge.

I have heard ryots called the Kolair lake a gold mine, and indeed it is a sort of agricultural Klondyke to the more adventurous cultivators for some miles round. The lake-bed is free to all; not a yard of it is held on patta in the unsurveyed part and anybody may "peg out" a claim in it for one year. If the crop succeeds, the profit is enormous. If it fails altogether, the loss is very trifling, and the waste of time no great loss, since there are few other agricultural operations in progress at the time.

The reasons for the attraction which this particular form of cultivation exercises in the neighbourhood are not far to seek. The Kolair bed is astonishingly fertile, more fertile, if the ryots are to be believed, than the best alluvial lands in the delta. The labour and expense involved in the cultivation are very small, as the land only needs puddling and no dry ploughing after its submersion. Lastly the water-rate is low almost to the point of absurdity.

I am not quite sure what is the cause of this exceptional fertility in the Kolair bed lands, but I have no doubt about the fact. The last dalwa crop season was an exceptionally favourable one owing to the fact that there were unusually copious rains in April and the crops consequently did not suffer from the usual scarcity of water in the later part of hot weather. The conditions, however, were not of course more favourable than they would be under project conditions.

The yield of the dalwa paddy at the last harvest in the Kolair area is quite commonly estimated at two putties per acre (a putti = 800 Imperial seers of 80 tolas), not only by the superior Revenue officials but by the village officers and ryots. I have heard it estimated at as much as three putties per acre, but this I think may be an exaggeration, though one experienced delta officer writes to me that he remembers another crop of this outturn.

Land which grows two putties to the acre is not unknown in the delta, but it is generally thought to be rare, a more usual estimate being one putti; and it is most unusual to find any one of the ryot class admitting to such an outturn as 2 putties.

Even allowing for some exaggeration I think it is perfectly safe to assume that the outturn of dalwa crop last season was at least $1\frac{1}{2}$ putties on the average, a gross profit to the cultivator about Rs. 60 per acre at present prices. (The coarser short-rop paddy is said to fetch about four-fifths of the price of the first crop paddy.)

With the gross profit of Rs. 60 per acre in a good year, and an assessment per acre of Rs. 3-8 including water-rate, it is not surprising that the cultivation of the Kolair bed proves attractive, or that the risk of losing the crop on whole or part through insufficiency of water during the later weeks of its growth is in no way a deterrent.

The above description will I hope sufficiently indicate the conditions upon which the existing cultivation in the Kolair bed is carried on.

71. *The Kolair area under project conditions.*—I feel convinced that the attractions which the area offers to cultivators will be much enhanced when the project is in operation.

The supply of water will not only be more copious and regular throughout the cultivation season than is the case with any land now cultivated, but the difficulty felt as regards water in the latest weeks of the crop's growth will altogether disappear. The conditions will be most favourable if the change discussed in paragraph 92 below is introduced and the canals kept open throughout May.

As regards the fertility of the soil, I see no reason why it should diminish. Various explanations have been offered me regarding the reason for this admitted fertility.

One is that the rushes which thickly cover the lake and are cut when the land is brought under dalwa cultivation, rot upon the lands and fertilize it.

This is, I believe, true so far as it goes, but it is probably not the main reason, as these rushes do not grow again upon land regularly cultivated year after year, and many of the lands on the margins have been regularly cultivated for many years without apparently losing their richness.

Another reason suggested is that the cultivators do not cut their paddy close to the root like the paddy on ordinary lands, but cut it close to the ear and leave the stalk to rot. This is also, I do not doubt, a genuine reason, but the practice is one not very likely to continue permanently.

The reason why the straw is now sacrificed I presume to be the trouble of carrying it where there are no roads or paths, the want of sites to stack it in, the fact that comparatively few cattle are used and therefore little fodder is needed, and lastly that many of the cultivators being non-resident take no interest in a by-product that they cannot carry to their own distant villages.

Many of these causes will cease to operate, I hope, under project conditions.

Another factor in producing fertility, and one which may very probably be the principal cause of it, is the water-weeds. The lands while under water cover themselves by degrees with a thick growth of water-plants, and this applies both to the untouched land and the land grown with dalwa. These weeds when the cultivation season begins are ploughed into the land and rot in it, forming in fact a natural manure crop.

I have suggested to the Director of Agriculture that it might be worth while to make some experiments to ascertain the chemical composition and manurial qualities of these weeds, and the Director writes that he has made arrangements to do so.

If, as I hope, it proves that they have powerful fertilizing qualities, the lake bed should continue to be the richest natural soil in the whole delta, and its cultivators being freed from all the difficulties regarding manure supply which the ordinary delta cultivator has to face, will be in a position of singular advantage.

Even if this hope is not fully realized, however, I do not doubt that the lake bed during the months when it is covered with water will continue to absorb fertilizing properties in a great degree, though under regular cultivation it may lose its present characteristics as a virgin soil. The manure difficulty at worst will, I believe, be far less felt in the Kolair than in any other part of the delta.

The other chief cause which tends to reduce the expense of cultivation in this tract will certainly continue to exist under Project conditions. There will still be no dry ploughing needed, and a comparatively small number of ploughing cattle will therefore suffice for the area cultivated.

As regards the water-rate paid, it is not intended of course that the present trifling rates should continue. The question of these rates I discuss below for the whole project area in paragraphs 114 to 119. I may say here however that, whatever rate it is ultimately decided to impose, it will be so low as compared with the ryot's profits when irrigation is assured, that it will, I believe, scarcely be felt.

If the difficulties discussed below can be overcome, I feel no doubt that the whole of the lake bed will ultimately come under dalwa cultivation.

72. *Population and labour supply.*—These difficulties may be summarized as want of resident population, distance of lands from any village, scanty labour supply, scarcity of suitable village sites and scarcity of grazing for cattle.

I have taken figures for the population of an area measuring 500 square miles which includes the Kolair lake itself with its lankas and a breadth of 5 miles round on every side. I find the population to be 224 to the square mile, which is rather low, but not as low as might be expected when it is remembered that out of this area no less than 150 square miles are the actual lake waterspread and much of the rest is more or less submersible. Also the coming census is likely to show a material increase in population.

The fertility of the lake bed, and the facts I have given regarding the distance from which cultivators come to the present cultivation, indicate that the lake bed cultivation under Project conditions will draw in population from much greater distances than 5 miles away.

The history of the Peddalanka area, already described also shows that under far less favourable conditions the ordinary action of self-interest will ultimately bring in the requisite population.

I have no doubt that during the years that follow the commencement of the Reservoir-irrigation, population will drift into the Kolair lankas and margins from every part of the delta.

73. A more troublesome problem is where to house them so that their houses may be above flood level and yet they shall be within reasonable distance of their lands.

The principal use of the tracing that I have forwarded will be to indicate the extent of this difficulty in various parts of the Kolair area.

The most favourably situated part of the whole area is the southern portion of the lake including the narrow passages between the Manuganur lanka and the jutting portion of the Agudala lanka, and embracing the Kolletikota island lanka and the area surrounding it.

This area now carries by far the greatest extent of dalwa crop grown in the Kolair bed (apart from the area disputed), and is the best suited for future extensions of cultivation. Its chief advantage is the comparatively small distance from the habitable lands to the lands to be cultivated.

The accessibility of this part of the lake is due mainly to the fact that the adjoining mainland and the Kolletikota lanka are at all seasons free from liability to submersion.

On the south side adjoining Kaikalur, a Deputy Tahsildar's headquarters, the shore of the lake is for once well defined, being bounded by a distinct sandy ridge, instead of passing imperceptibly into paddy land only a degree less submersible than the lake itself. This ridge extends, from the village of Unikili on the west to that of Alapad on the east and throughout its length is well suited for additional village sites or the extension of old ones.

The Kolletikota lanka contains a high mound several acres in extent and the general level of the lanka is also fairly high.

When the increase of cultivation brings an influx of population therefore there will be ample building sites in this area available for their use.

The tracing will indicate that the question is not so easy of solution in other parts of the lake. Except on the southern shore, the margins of the lake are always more or less liable to submersion, and as a consequence the villages are built at a distance from the lake edge. Along the whole length of the Ellore shore, for example

the villages average four miles in distance from the lake margin as it appears on the map. I expect this difficulty to be solved ultimately in the same way as it has solved itself in the Peddalanka and Isukapalle areas by building hamlets on the margins. My staff has examined carefully the possibilities of this and has found in most villages lands raised somewhat above the general level, which might be suitable for this purpose. But they all require embanking to raise them completely above danger of being swamped.

Probably the employment of temporary labour, temporarily housed, will also be resorted to. I deal more fully with this point below.

At all events, no fears need be entertained about the extreme western part of the lake, that which is joined to the rest only by a narrow isthmus. Much of this area, I am informed, was once under dalwa cultivation and it was only given up because improved drainage had lessened the lake water available in the late crop season. The difficulty of distance evidently did not prove prohibitive in the past and will not do so in the future.

That portion of the lake which lies between the long Agudala lanka and the shore is really more easily reached from the villages on the lanka than from the villages some four miles from the edge on the mainland. The question of the fitness of this lanka to hold an increased population is therefore of importance. I do not regard it as being very well suited for the purpose. It now contains several villages as shown on the map. They are constructed on mounds raised to a height of 10 or 15 feet, much overcrowded with huts clinging to their sides. The whole lanka with the exception of these mounds, and even the lower slopes of the latter, are liable to occasional submersion. No doubt the mounds could be enlarged, the only objection being that the land in the north of the lanka (where enlarged villages will be most needed) is all under wet cultivation and will be costly to acquire. But I think myself that hamlets on the Ellore margin, being much more accessible from the mainland, will be more popular.

The small island to the north locally known as the Bobbili lanka (marked on the taluk map as Agadala lanka, second portion) is of a slightly lower level still. Artificial raising will be required here also to place a village above the reach of flood.

The least favourably situated of all the lake area is that portion on the east between the Agadala lanka and the boundary now in dispute between Government and Nidadavole estate.

The central part of this is not likely to be required for cultivation by the resident population of the Agadala lanka and is at an inconvenient distance from the Bhimavaram shore, six to seven miles away in fact from the nearest Bhimavaram village.

For these reasons I think these lands are not likely to attract a permanent ryot population or to be held on patta by small holders.

74. *Temporary labour and its accommodation.*—But I do not on that account think that it will be found impossible to bring even this last portion of the lake bed under cultivation. On the contrary, I think that, when the more accessible portions of the lake have been taken up, the lands in this block will most likely be bought up by well-to-do ryots or merchants living in the large villages some few miles distant, Ellore for example, or Akuvud, both large centres.

The purchasers of such lands will cultivate them by hired labourers who will not reside on the spot, but will be brought to the lands only at the seasons of transplantation and harvest, and will be temporarily housed at these seasons.

I see nothing improbable about this forecast since it is only an extension of the labour arrangements by which the whole of the Delta is already cultivated. In scarcely any part of the Delta is the resident labour now sufficient for the work of transplantation and harvest, and the majority of the larger landholders in addition to their permanent farm labourers have to regularly engage at these seasons a great number of temporary coolies from other districts, or from the upland tracts of Kistna and Guntur. There is, I think, no reason why this floating labour population should not be attracted into the tract I am discussing.

In describing the Peddalanka area I have already mentioned that part of the land there, is cultivated by exactly this method, by non-resident owners and labourers visiting the lands at transplantation time and harvest, living for the time being in any temporary huts erected on any dry spot they can find.

I am of opinion that this practice will be extensively followed in the less accessible portions of the Kolair lake. Over the whole tract indeed there will probably be many cases where the owner has no intention of living in the Kolair area and prefers to cultivate by temporary coolies, or in the case of small holdings by occasionally visiting his lands with his family. In paragraph 71 above I have described in detail how strongly this practice has already taken hold, in neighbouring villages.

If my surmise is correct, the question of providing sites on which temporary shelters can be erected will sooner or later be of importance.

This is a matter much simpler than the creation of new village sites since it does not greatly matter if a site intended for temporary occupation only is occasionally inundated during the south-west monsoon. It will dry again before it is required for use, which will be between December and June.

Some raising by artificial means will be necessary in order that the coolies may have some dry place on which to put up a hut, while the Kolair bed is still a slough of mud, i.e., at the time when transplantation naturally takes place. But a few feet of raising will be all that is needed.

I would recommend that such mounds should be raised in the eastern part of the bed of the Kolair where it is widest.

All lankas and lake margins should prove high enough for this purpose without raising, though not high enough for permanent village-sites. But land for temporary huts should be acquired on all lake margins and lankas. If the Board agrees with me I would suggest that the raising of such sites where necessary might advisably be done by the Public Works Department when digging the channels required for the irrigation of these parts of the lake bed.

The channel banks will form the natural means of approaching such sites and the extra earthwork and expense involved in their construction would not be very great.

If this action be thought premature, I would in any case recommend that land sufficient for the construction of such sites including the pits from which the earth will be dug should be permanently reserved in the neighbourhood of the channels.

75. *Grazing land.*—If the whole lake bed comes under irrigation a certain amount of land will be required for the housing and grazing of the cattle employed in the work. I have given above reasons for thinking that the number of cattle used will be less than that required for ordinary delta cultivation. Still 80,000 acres or more of land newly brought under cultivation must necessarily employ a large number of cattle, even though the first dry ploughing will be dispensed with.

The lands required must be found either on the lankas or the margins of the lake. In view of this use for the lankas it is unfortunate that so much of them has recently been granted on patta and so much has come under irrigation.

This is not the case with the Kolletikota lanka, where there are large extents of land still available for grazing and regularly used as such. These lands are still at the disposal of Government, though numerous darkhasts for them are pending, I believe.

But the whole northern half of the Agadala lanka is already under wet cultivation, irrigated by one of the Gódávári channels, which crosses from the mainland to the north of the lanka. Much of the remainder is irrigated by means of pumping installations which raise the Kolair water on to the lanka land in the first crop season.

In the villages of Prattikolla lanka and Gudivaka lanka there are still several hundred acres of dry land, but they are held on patta and it is intended to irrigate them by means of pumps immediately.

The same is the case with the whole of the Bobbili lanka, held on patta by a single individual, who intends to erect a pump there.

It is natural enough that this should be so. While there was no idea of cultivating the whole bed of the Kolair lake, there was every reason to encourage the irrigation of the lankas.

But the conditions, if the Kistna reservoir project is sanctioned, will completely change, and as every acre of dry land remaining will be required for grazing, cattle-stands, threshing floors, temporary sheds for coolies and possibly village sites, further extensions of pump irrigation should, I think, be stopped.

I have recommended to the Collector, Kistna, that this should be done and also that no darkhasts for unassigned land on the lankas should be approved till a decision is arrived at regarding the Kistna reservoir project. The Collector writes that he has taken the action I recommend.

76. *Roads and communications.*—There are at present no roads in the bed or on the lankas of the Kolair. Almost the whole submerged area is navigable to sailing boats of shallow draught for three months or more during the south-west monsoon. The three important places at no great distance from the lake margin are Ellore on the north, Akuvid on the south-east, and Kaikalur on the south-west. The question of communications will resolve itself into improving the means of access from the lake to these three places, which will be the natural markets for the grain.

The boat traffic, is and will continue to be, during some four months in the year, a great resource in the matter of moving the grain; it is undesirable for reasons given in paragraph 98 below in discussing communications in general, that it should be the only means available.

The first requirement of the tract will be a road from Kaikalur to Ellore, following the line of the two peninsular lankas which almost divide the lake into two at this point. There is already a Local Fund road from Ellore to Sripuru lanka though it is not in very good order. This needs extension to Kaikalur. The road will need embanking and a large ferry will have to be placed on the isthmus.

Kaikalur is already connected by an unmetalled road with the taluk head-quarters, Gudiváda, and also with the navigable canal system, the Polrazu canal being only 2 miles off.

Kaikalur as already mentioned in discussing the Peddalanka area should be connected with the Upputeru river and so indirectly with Akuvid by means of a road running along the sand ridge.

As regards Akuvid it lies on the navigable canal system of the Gódávári delta and is connected by means of a navigable drain with the Upputeru river. This place will, I believe, continue to be the local market for the sale of most of the grain raised on the east and south-east of the lake area, and the principal means of reaching it will continue to be by boat. What I would suggest here is that the Upputeru river should be provided with a regularly formed tow-path like the navigable canals.

At present boats get up and down by sailing or poling. Towing is much easier and more certain.

Akuvid may be connected if possible by road with the system of roads I advocate below on the banks of the new channels in the bed of the Kolair.

I am strongly in favour of having roads practicable for bandies constructed on the bunds of all the more important distributaries in the Kolair area. Indeed as will be seen from my discussion of the subject in paragraph 98 below, I advocate the adoption of this plan in all highly irrigated tracts.

The case for it is especially strong in the Kolair lake, however, since its waterspread must necessarily be perfectly impassable at all seasons to bandies except on embanked roads. At present according to my information it is only in the month of May that bandies can cross the bed of the lake without sinking in, and when the natural drying of the lake is followed immediately by artificial irrigation, its swampiness must necessarily be increased in degree and duration. It is plainly absurd in the case of such a tract to reserve land for village roads and expect them to be of any use unless embanked.

Embanked roads being therefore essential, my idea is that they would be made most economically by the Public Works Department as part of their regular work in developing the irrigation and could run along the banks of the more important channels.

I think some such measure necessary in order to open up the tract.

77. *Saleable areas.*—Unlike any other very large area coming under the project either in the upland or the delta, the whole of the Kolair lake bed (excluding the portion under litigation with the Nidadavolu zamindari) is at the disposal of Government, to sell or assign as it sees fit.

The same is the case with a moderate extent of 1,688 acres of submersible surveyed land on the margins, which is not now held on patta.

The policy to be pursued in the case of these saleable areas, the amount to be assigned on free grant and so forth, I discuss in a separate paragraph below (paragraphs 112 and 113).

I will here, however, briefly explain my reasons for fixing the average sale price at Rs. 75 per acre.

The singular fertility of the lake bed should make these sales most profitable to Government.

In the course of my investigation I met a Muhammadan, said to be a member of a well-to-do trading family in Akuvid, who offered to take 100 acres of the lake bed land at Rs. 400 an acre, if Government would assure him water for late crop cultivation. Without expecting on the average any sale prices as great as this, I feel sure that the prices realized in the more accessible parts of the lake bed will be very high, provided the sales are not hurried and that time enough is given between each sale for the success of the new cultivation and the profits derived from it to become obvious and widely known in the tract adjoining.

I fully expect the first 30,000 acres sold to realize on an average Rs. 150 an acre. This will include all the land now cultivated with dalwa. The next 20,000 which will be less accessible should fetch on an average Rs. 75 or 100. The demand for the remainder of the lake is a rather uncertain quantity and the sales of these lands should in my opinion be deferred till the cultivation of the rest of the lake is well established. As the sale price for these last lands will probably be a good deal lower than the prices offered for the more accessible portions of the lake, I have estimated the general sale average no higher than Rs. 75 an acre.

The total sale-proceeds on 70,000 acres should therefore be Rs. 52½ lakhs in round figures and the revenue therefrom Rs. 2,10,000 annually, a very considerable addition to the assets of the project.

78. *Supplementary recommendations.*—The first step to be taken, if it be decided to irrigate the lake bed, is undoubtedly to have a detailed survey made of the whole of it.

It is a matter of some surprise that this action has not already been found necessary in the parts cultivated with dalwa paddy, considering their large extent. With no marks at all upon the ground and only imaginary village boundaries, the risk of such crop escaping registration must, one would think, already be considerable.

I would recommend that the lake bed should be demarcated into 5 acre fields, or fields of any other uniform size considered convenient. (I have ascertained that 5 acres is about the average size of each man's sivoyjama cultivation as it appears in the village accounts.) The fields should be rectangular in shape and no notice should be taken of the individual limits of the present sivoyjama cultivation. Owing to the continual submersion and the mud, demarcation with long stones similar to those used in the black cotton tracts of the Kurnool district, will probably be necessary.

At the same time I would recommend that the nominal limits of the unsurveyed tract attached to each village should be altered, with reference to practical convenience and no other consideration.

The villagers now often claim areas at very great distances from their village sites, which it would be more convenient to attach to some nearer village.

It may not be out of place to mention in this connection that the cultivation of the whole Kolair lake will almost certainly involve the splitting of the Gudivada taluk into two. That taluk has now a demand of 13 lakhs and will if the revenue from the lake land be added probably become unmanageable. Kaikalur, now a Deputy Tahsildar's head-quarters, would be the natural head-quarters for the new taluk.

PART IV.—QUESTIONS AFFECTING BOTH UPLAND AND DELTA.

79. *Pasture* (Column 19, Statement No. II, Total exclusions)—

	ACS.
Upland	5,083
Delta	7,995

Though the deductions made on this account from the irrigable extent appear like all others in Statement No. II, I have reserved this item for special discussion, partly because it is necessary to apply to the upland the conclusions arrived at through experience in the delta, partly because the question leads naturally to a discussion of the ryots' other methods of feeding cattle, and so introduces the question of fodder crops and of manure crops.

It is convenient to discuss all these questions together since the chief delta fodder crop is to some extent a competitor of the manure crops.

Pasturage may occur in three descriptions of land—(a) patta land, (b) assessed waste, and (c) poramboke.

Pasturage in patta lands.—As regards the first item, I have received express instructions from Government to make no deductions on this account in patta land. In G.O., No. 1682, Revenue, dated 24th June 1909, Government has directed that deductions for pasturage should be made only from unoccupied land. Accordingly the land which appears in column 19 of Statement No. II is all either assessed waste or poramboke with a few trifling exceptions. The exceptions consist of one case of high level land now used for grazing which the owner already has the opportunity of irrigating if he wishes, but which he prefers to retain as grazing, and one or two cases of zamindari land held as a communal grazing land by the villagers, and which, though occupied land, is not held on private patta.

Apart from these small items, I have treated no grazing in patta land as unirrigable, though I have in the delta tracts collected for my own information figures showing its extent. In the upland villages figures showing the grazing in patta land were recorded by Mr. Braidwood's establishment and are still available.

Although there is no question of excluding these patches of patta grazing land from the irrigable total, I think it desirable nevertheless to say a few words regarding the probable future treatment of them by their owners after the introduction of irrigation. My reason is that if there is any physical cause which renders it impossible to retain them as pasturage in a highly irrigated tract, the same cause will operate as regards much of the waste land also. I shall endeavour to show that there is such a reason.

All over the dry areas investigated in the delta and also in the upland area, such fallows, or portions of holdings deliberately left uncultivated for the purpose of growing grass, are of fairly common occurrence, though the total extent of such land is not a large percentage of the cultivable area, 1 per cent. in the delta dry lands and 8 per cent. in the upland.

But in the highly irrigated villages of the delta such lands are practically non-existent. This is no doubt partly attributable to the fact that it is more profitable to the ryot to grow wet crops on the whole of his holding than to reserve part of it for his cattle. But the ryots believe, and I share their belief, that a much stronger reason operates, and that in a flat tract like the delta, it is physically impossible to reserve small plots for grazing among the paddy lands and induce them to grow pasturage of any value.

The ryots say that the effect of leaving such small plots waste is that the salts from the neighbouring lands are washed into them, and these salts, not being kept down in the sub-soils by cultivation, rise to the surface and effectually kill the grass. In considering the probability of this, a reference may be made to the explanation which I have attempted in paragraph 42 above regarding the action of cultivation and irrigation on saline soils.

I have little doubt that the general belief on this point is well founded, since it is a matter of common knowledge in the delta that dry crops cannot be grown on small patches of unirrigated land surrounded by wet crops, and the submersion and salts that kill the dry crop will be almost equally destructive to the grass.

I do not mean that all soils in the delta contain salts, but a very large proportion, quite apart from the obvious "soudu" soils, do contain small quantities, sufficient at all events when washed into neighbouring unirrigated land to act in the way I have indicated.

In cases where there are no salts in the soil, I believe the continual submersion of these dry lands, when in small patches, from the surrounding paddy land will be almost equally effectual in destroying their value as pasture. Such lands through percolation become simply a sodden mass, and though they may grow a little grass, it is so scanty and of such poor quality that cattle often will not touch it. At any rate, no one would dream of retaining such land uncultivated for the sake of pasture of this class.

There are no doubt exceptions to this rule. An extent of land so large that it can be protected from inundation by percolation, except at the edges, will grow pasture. So will lands raised some feet above the general level. But the latter are of rare occurrence in the delta and the reservation of large continuous areas is naturally impossible in patta holdings.

The intentions of the ryots in the dry tracts of the delta have been subjected to careful enquiry by my staff, with very decisive results. All the ryots alike say that they have no intention of retaining any part of their holdings as pasturage, after the tract is brought under irrigation, and that they will follow the example of their neighbours in irrigated delta villages. As these ryots live near enough to the fully irrigated villages to be perfectly acquainted with the practices obtaining in them, it may be assumed that they can clearly foresee their own intentions upon this point.

80. *Pasturage in unoccupied lands at the disposal of Government—Delta.*—The assessed wastes, which constitute almost the whole of the land at Government's disposal on which pasturage may grow, appear either in column 8 of statement No. I "Irrigable assessed wastes" or column 19 of statement No. II "Lands reserved for grazing." There are also some cases where the assessed wastes are unfit either for irrigation or grazing and appear as unirrigable in some other column in statement No. II, but these lands have no concern with the question of pasturage under discussion.

It may be asked why, in view of the orders of Government above quoted to retain all unoccupied lands fit for grazing, the extent of irrigable assessed waste is put down in the delta as 17,330 acres and the extent of assessed waste reserved as pasture at only 7,995 acres.

The reason is that these lands have been examined and have generally been found to be unfit for grazing. The various reasons which make the land unfit will appear in the remarks column of statement No. I against any large extent of assessed waste treated as irrigable.

One of the commonest of these reasons is the one discussed immediately above, viz., that it is impossible to retain as grazing land small patches surrounded by paddy fields when the level is uniform. This, I have already pointed out, is found impossible in the case of patta lands. It is equally useless for Government to attempt it in the case of wastes.

Another very usual reason is that the land is soudu or saline. I need not labour the point about these saline soils, I think. In paragraph 42 above, in discussing unsuitable soils, I have described how the soudu lands are fitted for nothing but

irrigated crops. Even now they carry no grass worth the name. The salts have killed it.

Then there is the very large class of submersible lands, some of which are so heavily submerged that they are fit for short late crop only. Some are fit for crop in the ordinary season. And by reason of their liability to submergence and consequent uselessness at present, these lands often appear in large continuous stretches of assessed waste at Government's disposal. But except the lands least submerged it would be useless to attempt to reserve them for grazing. Land occasionally and lightly submerged often grows good grass. Land submerged for weeks at a time, even if only to a depth of a few inches, will either grow no grass or grass so coarse and scanty that it is fit only for buffaloes and affords little sustenance even to them.

The submersible lands of the delta are rarely a resource as far as grazing is concerned.

Other items are the sandy lands near the sea and sand ridges further inland. These inferior lands at no time grow more than a stunted growth of grass an inch or two high.

In some rare cases too (duly noted against the villages concerned) the lands are not reserved for grazing because the village adjoins a large tract of similar grazing land which it is not proposed to irrigate.

Poramboles.—In the case of the few irrigable poramboles, the question whether they are of any use for grazing has also been considered, and if they are of use, they have not been treated as irrigable, but entered as pasturage reservation.

81. *Upland.*—The above remarks apply equally to the upland tract with the exception of those relating to the small isolated areas, which will in future be surrounded by paddy lands.

The difference in this case is one of levels. In the delta, where there is practically no difference of level over large areas, I know such lands will become waterlogged and useless as pasture.

In the upland they will have a better chance, as the country is much more undulating and easier to drain. Except, therefore, where actual inspection has shown these lands to be of the same level as those round them, I have given them the benefit of the doubt and retained even the smallest extents of assessed waste as pasture.

Villages containing large extents of assessed waste have been re-inspected on the ground, with the result that the greater part of such wastes have been found to be unfit for grazing. In villages not re-investigated, I have always assumed that the assessed waste was fit for pasturage except unless some fact, "soudu" for example, is recorded in Mr. Braidwood's registers, which proves that, of itself, the lands will bear no grass. These soudu lands in the upland tract form a large proportion of the assessed waste still unoccupied.

82. *Extent of possible reservations.*—In spite, however, of my making grazing reservations in all doubtful cases, the extents reserved as grazing lands in the upland and delta alike are so small as to be almost negligible as a factor in the cattle-feeding of the tract.

The figures are 5,083 acres in the upland out of a commanded area of 926,000 in round figures, or little more than half per cent.

In the delta the figure is 7,995 acres against a commanded area of 2 lakhs in round figures or about 3.8 per cent.

Nor is this area, such as it is, distributed at all evenly over the tract commanded by the project. Of the grazing area reserved by me in the upland, about half occurs in only six villages. The Guntur taluk with 112 commanded villages has a grazing area reserved of only 790 acres.

In the delta the local distribution of this grazing is even less convenient. No less than 6,800 acres are found in only ten villages and these practically in one place.

I do not think the smallness of the grazing areas still available need occasion the least surprise. In these thickly-populated and highly-cultivated tracts land never

is left vacant if it is of service for pasturage or anything else. The ryots themselves, if asked whether their assessed waste lands are of value for grazing, will always give this explanation. "If they had been" they say "we should long ago have taken them on patta."

The Government Order above quoted regarding the grazing reservations directs that I should make my deductions with reference to the extent of irrigable and cultivable land and to the probable future number of ploughing cattle in each village.

The Government Order is, I think, based on the assumption that in most villages there will be a considerable area of unoccupied land apart from porambokes, which can be reserved if so desired. I trust I have made it clear that it is impossible in the particular tracts under investigation to make grazing reservations on any such system. A glance down column 19 of statement No. II (village statement) will show what lands can be reserved for grazing and where they are.

Out of the whole 689 villages concerned, taking upland and delta together, the grazing areas are possibly sufficient for cattle in some 40 villages. In the rest, the grazing, at least on assessed wastes, is a negligible quantity. As already mentioned, however, six villages in the upland and ten in the delta contain considerable reservations, in excess of the requirements of the particular village concerned. These areas supply and will continue to supply pasturage to a number of cattle from villages in the neighbourhood, and should be retained for that reason.

83. *Grazing on porambokes and reserves.*—I need not say that neither the assessed wastes nor the fallows in patta lands necessarily exhaust the possible grazing in a village. Certain classes of poramboke which no one intends to irrigate, and which are not primarily reserved for pasture, supply nevertheless a small amount of pasturage, occasionally an appreciable amount. Such are land under topes, the margins of paths, the edges of drains and the beds of shallow tanks. I should say, however, that this resource tended like others to decrease as the village came under irrigation. In the wet delta villages I have seen little pasture except on the raised banks of the Public Works Department canals and channels, a valuable resource, as the grass is good, but necessarily very limited in quantity. Some villages also have access to the river lankas of the Kistna or the areas between the river and the flood bank, which often contain good grazing. Others are close to a forest reserve or con-hills, I have seen, are almost completely bare of grazing as a rule. In the forest areas within or near the commanded area, permits for 15,000 cattle in round figures were issued last year, but these reserves are used by the cattle of many villages besides those included in the project. Even the reserves are a very limited resource.

84. *General conclusions.*—In fact, all my enquiries and all the figures collected point the same way. In the tracts under investigation even in their present dry condition, the pasturage, whether in patta fallows, assessed waste, poramboke or reserved forests, is not the principal means of support to the cattle. It is at best a supplementary resource, useful during four, or at most five, months in the year, and at no time forms the sole food of the more valuable stock.

It must therefore, I think, be admitted that improved methods of feeding cattle, if necessary at all, must be sought for by some other means and not by reserving areas for pasturage. I believe that the fodder crops are of far greater importance to this question than is the pasture.

85. *Present cattle-feeding practices in the delta.*—The staple food of the better cattle in the delta at present is paddy straw, mixed, if possible, with sunn-hemp and supplemented by a feed of horsegram in the evening.

Green gram is also occasionally given when available, and also fodder cholam, i.e., cholam grown for the purposes of fodder only, thickly sown, cut before the ear forms, and eaten green.

The staple food of the upland tract is dried cholam straw, cut in the usual way after the grain is ripe, and stacked and dried.

It is said that this fodder will keep for two years. That it forms a really good fodder may be considered certain from the fact that it is the staple food of the Nellore breed of cattle, whose breeding ground adjoins the project upland area at its south-west corner in Ongole taluk.

In the delta tracts the practice, fully described by Mr. Braidwood, of sending away some of the cattle to the upland during certain months of the year still continues. The cattle are sent away about July to be grazed in the dry lands of the Nandigama or Nuzvid taluks of the Kistna district, the Sattenapalle or Palnad taluks of the Guntur district or the adjoining areas of the Nizam's dominions. They return about December.

I cannot say from enquiries made that this practice is regarded as very satisfactory by the ryots themselves. These cattle are generally in bad condition, and their owners complain of loss of cattle in the upland and the impossibility of checking dishonesty on the part of the graziers they employ. Also the practice, as pointed out by the Board in reviewing Mr. Braidwood's report [paragraph 5 of B.P., No. 210, Settlement, dated 14th July 1905], inevitably leads to loss of manure. I have indeed met with villages where the practice had been abandoned on account of the loss of cattle when grazing in the upland.

It is however only the comparatively useless cattle that are usually sent away. The ploughing bulls and buffaloes are rarely sent, nor are the milking cows, nor the young stock of the better class.

I do not think myself that these inferior cattle, apart from their manure, have much bearing on the agricultural needs of the delta.

The ryots sometimes breed from the cows, using bulls of better breeds. But otherwise these inferior cattle seem to me to be practically useless, and I venture to think no great harm would follow if they were allowed to die out, thus putting an end to the practice of sending cattle to graze at great distances, and at the same time setting free more fodder for cattle of the better class. It would probably be more economical to confine to the upland the breeding of stock which is useless for ploughing and buy the manure from there, than to maintain such stock half the year in irrigated tracts radically unsuited for their maintenance, and pay for their grazing (at the same time losing all the manure) during the other months of the year.

Probably the superstition which forbids a Hindu to sell or otherwise get rid of a cow has much to do with the continued maintenance of these cattle.

I believe the only problems worth consideration are how to feed the ploughing and milking cattle which remain all the year round in the delta, and how with a reduced stock of cattle to supply the soil with adequate manure. The same problems must a few years later be faced in the upland tract when it comes under irrigation.

In considering the necessity for improving the feeding of these superior cattle, three questions naturally arise—

- (1) Is the paddy straw sufficient in quantity for the cattle?
- (2) Do the delta stall-fed ploughing and milking cattle under present conditions deteriorate?
- (3) Is the paddy straw of itself a sufficient food?

I should answer the first question emphatically in the affirmative. A great deal of straw is exported from the delta to the upland as fodder. I believe the stock is ample.

The other two questions are not so easy to reply to.

As regards the deterioration of the cattle, I believe it is easy to get an exaggerated idea of the extent to which they suffer by the conditions obtaining in an irrigated tract. Certainly stall-fed cattle which remain in the village all the year round show no visible signs of deterioration.

They are generally in good condition, far better than the cattle of some of the poorer dry tracts. Some ryots deny the deterioration altogether, saying, and I think truly, that they take better care of their cattle than the cattle-owners in the upland. Others, however, say that it is true that cattle lose strength in the wet villages, and

do not regard the paddy straw of itself as a strengthening food. As one ryot puts it to me "after the paddy has stood all those months in water, you cannot expect to have much strength left."

I believe there is something in this theory, and that the paddy-straw while supplying the necessary bulk for the stomachs of the cattle needs to be supplemented by some more strength-giving fodder.

This requisite is now supplied with fair success in the delta by the sunn-hemp crop, grown principally for fodder. This crop is very widely grown, all lands being fit for it except the lower-lying lands and the sandy lands of the delta. It is sown on the paddy field about a fortnight before the paddy crop is reaped. It matures with the moisture still in the soil, and is cut about $2\frac{1}{2}$ months later.

The crop will keep for one year. It is given mixed with the paddy straw in the proportions of one part of sunn-hemp to four of paddy. If the manure difficulty does not lead to a change of practice, I think the sunn-hemp crop is a very fair solution of the fodder difficulty.

It is likely that the practice of the delta in this respect will be followed exactly in the upland tract coming under irrigation.

Another most valuable green fodder crop is fodder cholam already referred to at the beginning of the paragraph. This would, I believe, supply all the needs of the cattle as a supplement to the paddy straw if only it were obtainable in sufficient quantities. The difficulty is to raise it in the delta, owing to the fact that it cannot be grown on lands flooded with water. On the rare patches of land raised above the general level it is regularly grown; also sometimes as an early crop on paddy lands with the help of hot weather rains or well water. But the extent all told is very limited.

With regard to this crop the upland will be better situated, the more undulating nature of the ground and the better drainage making it much easier to grow a crop which is liable to destruction through too much water.

My general conclusions regarding the cattle-feeding question in the Project area as it presents itself to me would be—

- (1) That the delta cattle which are really useful, are fairly fed, though scarcely grazed at all;
- (2) that the rest of the cattle are not worth special measures for their preservation;
- (3) that the upland irrigable area would have all the advantages of the delta in this respect and some additional ones of its own; and

therefore, that, if manure were likely to be as easy to procure in the future as it has been in the past, and there was no idea of introducing second crop, no special measures at all would be called for.

But both the manure difficulty and the second crop complicate the question as shown in the subsequent paragraphs.

86. *Manure.*—The question of the continued growth of fodder crops, particularly sunn-hemp, is closely connected with the difficulties relating to a sufficient manure supply, already felt in the delta tracts, and sure to arise later in the irrigated upland area.

The chief methods of manuring employed at present may be summarised as follows:—

- (1) Pati earth.
- (2) Cattle manure, with other refuse from stalls.
- (3) Manure obtained by penning sheep.
- (4) Wild indigo brought from dry lands or indigo refuse.
- (5) Leaf manures used occasionally.
- (6) Castor oil and neem oil cakes.
- (7) Roots and part of the stalk of the sunn-hemp ploughed in.
- (8) Other green manure crops, especially black gram and green gram.
- (9) The Kistna silt itself.

In fact most manures are known to the delta ryot and used by him when they are available. There are indications that he is coming to fully appreciate their value.

The difficulty is that, however keenly the value of manure is appreciated, it is not easy to bring an adequate supply within reasonable distance of the ryot, or to grow upon the land itself the grain crops desired, the necessary fodder crops and the manure crop as well.

As regards Pati earth, that is the earth of village-sites impregnated for years with cattle droppings and other manurial substances, at present by far the most popular manure for paddy crops, the Board is already in possession of all the facts about it from the report, R.O.C., No. 1145, dated 9th April 1909, of the Director of Agriculture, dealt with in B.P., No. 1290, Land Revenue, dated 11th May 1909. I need not deal with it here beyond saying that as a general resource it must in a few years cease to exist. It still remains to be seen whether the delta can do without it. All that can be said with certainty is that the delta ryot will feel the manure difficulty more, even on single crop land, in the future than he has in the past.

The Director's letter above quoted contains an account of certain experiments in chemical manures directed to supplying in part at least the place of the Pati earth. If I remember rightly, however, the Director, when I discussed the matter with him, did not think that any chemical manure, however helpful, would, on account of its lack of bulk, solve of itself the manurial problems of the delta.

Cattle manure and other stall refuse is of course regularly used, but is almost always inadequate in quantity for the size of the holding, and is likely so far as I can see to diminish rather than increase, unless the manure itself can be imported from dry tracts at reasonable expense.

Sheep manure is most valuable but difficult to obtain. There never can be any great number of sheep in a highly irrigated tract, owing to the lack of pasture, and the wider the tract irrigated, the more difficult it becomes to bring the sheep into it from the upland.

Wild indigo is valuable but difficult to import from a distance. The same may be said of leaf manure, which, if used on any extensive scale, must necessarily be brought from outside the delta. And there are no extensive forests nearer than the Nallamalai hills, the Gódavari Agency or the Nizam's Dominions. I fear nothing much can be done with leaf manure.

Oil cakes are most valuable and might be imported much more than they are, being easily portable, but do not, I presume, solve the difficulty about bulk, already alluded to.

There remains the question of growing a manure crop on the land itself before or after the reaping of the principal crop.

I have described above the practice obtaining regarding the sunn-hemp crop, which is an excellent manure crop, if the ryots' other needs will only allow him to use it as such.

As I have explained, however, it is the practice of the Delta to grow it principally as a fodder crop and cut it after about $2\frac{1}{2}$ months close to the root using the leaves and most of the stalk as cattle food. The roots and a few inches of the stalk are left in the ground and some months later are ploughed into it.

Probably this manures the soil to some extent, but is by no means the same thing as growing the crop solely for manure and ploughing in the whole of it. Sometimes indeed the whole crop is not required for the cattle, and the remainder of the crop, stalk, leaves, and all, is thrown on the land again and ploughed into it, but such cases are the exception.

Green gram and black gram or other pulses are also sometimes grown solely as a manure crop at the end of the hot weather with water supplied by the earlier rains.

87. *Possible solutions.*—I hope that an extension of this last practice may to a great extent solve the manure difficulty in the upland and incidentally help the fodder.

difficulty and in the single crop areas in the delta. If the reservoir could afford to spare water sufficient even for a single flooding, say in the month of April, or about the time when the seed-bed tanks are filled, to all the irrigated lands, and this flooding were used for the growth of a manure crop, I believe it would make an enormous difference to the outturn of the ordinary paddy crop that follows. Also it would make it certain that the sunn-hemp could continue to be used as a fodder crop, a point I consider still open to doubt.

Another possible solution is to use the sunn-hemp crop, now grown as fodder, purely as a manure crop, and find some other means of supplying the cattle with the strength-giving food that should be added to the paddy straw. At one time, when I thought there were to be two crops grown in the upland, I had almost decided to recommend that deductions from the irrigable extent should be made on this account, excluding a certain area in each village from the irrigable extent, prohibiting its irrigation and reserving it for the growth of fodder cholam. [By this I mean cholam grown solely as a fodder crop and intended to supplement the paddy straw, not cholam grown for grain, the stalks of which form the staple food of the upland cattle. The latter cannot possibly be grown in sufficient quantity in the irrigated tract.] But now that there is no great likelihood of the upland growing two irrigated crops, I am not convinced of the need of this. The manure difficulties of the upland will be identical with those of the present delta area, growing one paddy crop only, not with those of the future delta growing two irrigated crops. And it is too early yet to assume that the present delta area has reached a stage where the sunn-hemp must be used solely for manure, though it is possible that the exhaustion of the Pati earth supply may compel this change of practice.

Moreover, there is no doubt that fodder cholam could be grown now in great quantities for sale to the delta in the dry villages bordering the present canals; yet it is not done, I understand, to any great extent. This indicates that the delta ryot does not yet feel the manure and fodder difficulty sufficiently to pay high prices for fodder cholam grown elsewhere. Nor is it certain, though it is probable, that on these reserved dry areas, a large amount of green fodder would be grown.

On the whole I think that the manure and fodder problem does not call for any such drastic action as the compulsory reservation of dry areas in the upland for the growth of fodder crops. At the same time, however, I should consider such action much more practicable and profitable than the attempted reservation of areas for grazing (apart from the difficulty of finding any available pasture lands), since the area reserved would support far more cattle if it were raised with fodder crops than if it were grown with grass. Should the Board, therefore, be inclined to think the deductions I have made from the irrigable extent insufficient, I would recommend that any further deductions it thinks desirable should be made for the purpose of raising fodder crops. They should, I think, be made, if at all, in villages containing no cultivable dry lands, i.e., no excluded cultivable high lands, and that only in villages situated more than 2 miles from the project canal and the dry areas beyond it. They should also be made from the lands of the highest level in the village. Such villages could be easily identified from my records if desired.

The difficulty of supplying sufficient fodder and manure is more acute in those parts of the delta where it is proposed to grow two irrigated crops, and is dealt with in Part V of the Report.

88. *Kistna silt.*—Before proceeding, however, to the question of second crop I think it desirable to say a few words on a subject intimately connected with that of manure. This subject is the Kistna silt, its manurial value and the likelihood of its continuing to be carried by the Kistna water after the reservoir is constructed.

At present the Superintending Engineer on special duty considers the whole subject in a conjectural stage, but gives me his own personal opinion, which is that the silt may probably, for several years at all events, be much diminished in volume.

To quote the Superintending Engineer's actual words, "I believe the silt in the existing delta canals will be appreciably reduced if the reservoir is constructed. A large quantity will be deposited in the reservoir, I cannot say what proportion, but 70 per cent. would not surprise me."

"This reduction would take place throughout the year in the earlier stages of the reservoir existence, but gradually as the ineffective part of the reservoir silted up, a larger proportion of the silt would be passed, and after, say, 30 years, a great proportion of the silt would be passed down. This applies both to the upland and delta."

"The silt carried on through the canal will be the finest and lightest of the silt now passed. I believe that the best of the silt will be that carried to the lands, but in greatly reduced quantities."

It will be observed that this forecast, if it is correct, implies a great change in the manurial value of the Kistna water, affecting not only the lands under my investigation but all the 7 lakhs of acres of delta lands already irrigated, always supposing, that is, that the generally accepted view is correct and that the silt in question has a high manurial value.

This is the point that is open to doubt.

The Superintending Engineer, II Circle, has arranged, I understand, for chemical experiments to test the manurial value of the silt, and more particularly to discover if its best manurial qualities lie in the heavy silt that will be deposited in the reservoir, or in the lighter part, much of which will continue to be carried in the water. The result of these experiments is not as yet available, but the Agricultural Chemist, Coimbatore, has reported that the silts in the Hagari river are useless to black soils and thinks that the same may apply to the Kistna silt, an opinion coinciding with the ryots' views as described below.

Until this question came up, I was always under the impression that the Kistna silt, which is very large in volume, far higher, I believe, than that carried by any other river in South India, possessed high and undoubted manurial value. This impression seems to have been shared by the Board, since, in passing orders on Mr. Braidwood's report, the Board accepted the view that sandy and black clay soils were irrigable on the assumption that silt would be brought to them (Paras. 3 (v) and 12 of B.P., No. 210, R.S., dated 14th July 1905).

I have made personal enquiries in the delta and collected a large number of opinions of officials and others reproducing the views of the local ryots. These opinions, rather to my surprise, are practically unanimous upon one point. The ryots almost all think that the silt does more harm than good to the heavy or clay soils. As regards the sandy soils opinion is divided. Most of the ryots however think that these soils benefit by the silt. They are practically unanimous in saying that the silt is of great value in bringing saline soils under cultivation. I cannot say that I am prepared to adopt forthwith the ryots' views upon this point. Had they been less unanimous, I should have suspected that their replies were prompted by a suspicion that Government was about to raise their water-rates and charge them for "liquid manure." But such an idea would hardly inspire all the replies given to a dozen different officers in different parts of the delta.

At the same time it is a matter in which the ryots may be mistaken. I incline to the view expressed by Mr. Paddison, I.C.S., who conducted the last resettlement of the Gantur district, whom I have consulted. He says (discussing the clay and alluvial soils of certain parts of the upland), "All this soil would, I have no doubt, be successfully irrigated. Silt would doubtless raise its strength and improve it, but it could be successfully irrigated without it. As regards silt, it is an advantage, but it can be dispensed with."

And again discussing certain arenaceous sandy soils: "All the arenaceous sand you can reach with water will be irrigated. Perhaps it would not pay a very high water-rate without silt. Silt is of course of greater value here than anywhere."

Whatever view one may take, the question is of great importance, and worth deciding, if a decision is possible, by any experiments that can be carried out on the water itself or on the land itself, should the Agricultural Department be able to arrange for the latter.

Even supposing it proved, however, that the silt will be reduced 70 per cent. in volume and that the manurial value of the heavy silt trapped by the reservoir is high, I do not think these considerations should of themselves be a bar to the execution

of the project. The project will bring under irrigation an area greater in extent than the whole of the present Kistna delta, and the trapping of the silt will not continue for ever, but will be temporary, at all events as compared with the life of the project.

It is unquestionable also that good wet crops are grown elsewhere without the aid of silt. It may be impossible to prevent deterioration in the sandy lands of the Southern delta, but this objection must give way to the general interest. The upland area is almost all of black soils which are the least likely to be affected.

PART V.—SECOND CROP AND SHORT LATE CROP.

89. There is practically no second crop irrigated now in the Kistna delta. This crop, it is proposed to introduce, storing water in the reservoir during the latter part of the monsoon, and sending it down the river and so into the existing delta canals during the hot weather months. This crop is already grown to a very considerable extent in the Gódvári delta.

Originally it was intended to grow two irrigated crops in the upland area also, but, though the point is not yet absolutely settled, this part of the scheme is likely to be abandoned, partly for engineering reasons, I believe. I am assuming in my report that there will only be one irrigated crop in the upland.

It is intended at the same time to grow an identical crop on land submerged in the first crop season, when the flood water drains off it.

Allusion has already been made to this crop in the earlier parts of this report under the name of "short late crop," and a detailed description has been given of the areas where most of it will be grown.

Out of this area about 89 per cent. is the Kolair lake bed, and nearly all the rest in the areas I have described as the Pedda Lanka tract.

There is also an area of 1,848 acres in the Western delta near the West bank canal and a few hundred acres scattered in other parts of the delta. These areas require no special discussion.

90. *Probability of the ryots growing second crop.*—Upon this point a fair amount of personal enquiry has been made in wet villages by myself and my subordinates. The results except in tracts adjoining the Gódvári delta have been rather indefinite.

One ryot will say that he will certainly cultivate if water is available, and another that there is no custom to do so in the Kistna delta. Generally speaking the more intelligent ryots and those acquainted with the Gódvári delta practice say that they will grow two crops.

I rely more on the replies to written enquiries addressed to officials of delta experience and to landholders. The majority of these are convinced that the two irrigated crops will be grown when water for the purpose is made available. Many of them mention the manure difficulty discussed below, but do not seem to think it insuperable, though they offer no satisfactory solution.

A more reliable forecast can however be based on the present practice of the Gódvári delta, than on any opinions collected. I should say that, in the matter of regular water-supply in the second crop season, the Kistna delta under the reservoir would be the better placed of the two deltas, and that in almost all other respects both areas would be identical.

91. *Dates of transplantation and reaping.*—Both the second crop and short late crop areas may be treated as one in respect of the crops likely to be grown and the dates of transplantation and reaping, which are governed mainly by climatic causes.

The best guide as to the probable future practice of the Kistna delta ryot as regards this crop is to be found in the present habits of the Gódvári delta cultivator.

In the Gódvári delta the first crop paddy is transplanted and reaped earlier than is the case in the Kistna delta, mainly it is believed because there are greater facilities in the former area as regards water for transplantation, much of which is done under tanks filled in the latter part of the hot weather before the canals close.

Transplantation begins under the Gódvári system early in June and the crop is reaped from the 20th of November to the 20th December.

In the Kistna delta the transplantation is not generally started till July and many lands are not transplanted till very late in that month or even in August.

First crop paddy is not harvested till the middle of December at earliest and harvesting operations continue till the end of the second week in January. Roughly speaking, all the agricultural operations of the Kistna delta are on an average three weeks later than those under the Gódvári system.

Although however the Gódvári first crop of paddy is harvested so early, this does not, as might be expected, make any difference to the date on which the second crop paddy is transplanted. On the contrary a full six weeks to two months is allowed to elapse between the reaping of the first crop and the planting of the second. Second crop paddy is not transplanted till the first week of February and often later by two or three weeks.

The reason for this peculiarity is climatic. It is the universal belief of the ryots that the cold, or as they put it the cold wind, in December and January kills the young paddy plants. They must wait, they say, till the "Pairu Gali" or crop wind, a warmer wind, begins to blow, and this does not take place in the Gódvári area till the beginning of February. Some of my informants also tell me that experience shows that the crop is more liable to damage by insects before February.

I have collected opinions from a large number of officials and non-officials upon this matter, and they are practically all unanimous in saying that the second crop paddy cannot for climatic reasons be transplanted before the 20th January at earliest. This would be a little earlier than the Gódvári date. It is possible that in the Kistna delta which is 100 miles or so further south on the average than the Gódvári delta, the required warmth may come a little earlier in the season. It would hardly be safe however to assume that transplantation can be general before the 1st February.

I am convinced that the reasons adduced for the Gódvári practice are genuine and likely to be followed in the Kistna delta also. Some of my correspondents mention instances of attempts to grow a late crop as early as the 15th January, which have resulted in the loss of the crop. My own enquiries in certain villages have elicited similar instances.

I would advise therefore that all arrangements for supplying water to second crop and short late crop should be based on the assumption that the transplantation will not begin before 1st February and will close by about the 20th of that month.

The crops most likely to be grown will stand on the land for $2\frac{1}{2}$, 3 or $3\frac{1}{2}$ months, and will be reaped, following the present Gódvári practice, about the 15th May.

The names of the paddy crops now most commonly grown on the Kolair area, which may be taken as fairly typical of the crops of this season, are given below, and the period shown during which each will stand on the land:—

(1) Swarnalu	2 months and 20 days.
(2) Chittha Arlu	Do.
(3) Lambadi Arlu	3 months.
(4) Garaka Sannalu	Do.
(5) Rasungulu	Do.
(6) Arlu	$3\frac{1}{2}$ months.

92. *Closure of the canals.*—A very interesting question arises as to the possibility of changing the present system of closing the canals, in order to suit the changed conditions of the delta when two crops are grown.

According to the present practice the Gódvári canals are closed during the month of May for silt clearance and necessary repairs.

The Kistna canals are usually closed from the 15th March to the 1st June.

The latter system is suited of course only to a single crop, and must be changed in any case. The question that arises is whether, when it is changed, it would be better to adopt the Gódvári system exactly or whether there is some other period in the year when the water is less needed than it is in May.

It will be observed from what I have said that there is now an interval in the Gódvári delta during which no irrigated crop is grown, and the water, as the Engineers themselves say, runs to waste, being used only for purposes of navigation. The harvesting of the Gódvári first crop, as I have said, is mainly over by the 20th December, and the crop requires no water during the last fifteen days before it is reaped.

Almost throughout December and January, therefore, it would seem that the water is not applied to purposes of irrigation except for the raising of seedlings for second crop. As the canals only require to be closed for one month, it is evident that this leaves ample time for their closure between the two crops, should such a course be found desirable and feasible from other points of view.

I am myself inclined to think that keeping the canals open in May will be of great benefit to the second crop and short late crop.

As I have explained, the date for commencing transplantation of this crop is unavoidably late for climatic reasons. The rapidity with which transplantation can be finished is limited by the labour supply. It is likely to take a month to complete fully. Though, therefore, some part of the crop may be reaped by the end of April, the bulk of it is likely to stand on the ground till the middle of May or later. If so, it needs at least one flooding in May, and will not get it if the canals are closed. I have been informed that the crop now grown in this season in the Gódvári delta often suffers from the want of such a flooding.

I have discussed the matter with the Superintending Engineer on special duty who sees no insuperable objection to the change. Indeed the idea is not a new one; it has more than once been considered in the Gódvári delta, I believe.

The chief difficulties anticipated by the Superintending Engineer on special duty are the break the change will cause in navigation at the time it is most brisk, and the difficulty the Public Works Department will find in getting labour for their own work on the channels at that time of year. There is also the question of how to supply double or garden crops in the interval, but unless their extent is large, they could, I think, be supplied from seed-bed tanks.

The matter is one for consideration mainly by the Public Works Department. Looked at solely from the point of view of the double-crop irrigation, I myself think the change would be advantageous.

I have assumed in the above remarks that the Kistna ryot will adopt the practice of the Gódvári delta as regards the dates of the first crop transplantation and reaping, i.e., advance their present average dates by about three weeks and have the crop off the ground by the 15th December. This I fancy they will do, presuming that water is made available earlier for transplantation. Whether this will or will not be the case depends very much on the policy adopted regarding the filling of seed-bed tanks (paragraph 35 above). But the point is of little importance as regards the change of practice in closing the canals, as, even according to the present date of reaping first crop, and with a second crop to follow, the canals could be closed from 20th December to the end of January (always remembering that the first crop paddy need not be watered for fifteen days before reaping).

FODDER AND MANURE CROPS.

93. *Double crop lands.*—The earlier reaping of the first crop paddy is really more necessary in order that a sunn-hemp crop may be grown between the two irrigated crops. If this crop is to be grown, as it is at present, as a fodder crop standing on the land for two and a half months (that is fifteen days before the paddy is cut and two months after), this means that the first crop paddy must be reaped about the 1st—15th December. This is possible, given unlimited water for early transplantation,

though it is a little earlier than the present Gódvári normal usage. Sunn-hemp is, however, already grown on some double crop lands in the Gódvári delta between two paddy crops.

I believe it to be most desirable that this crop or some other crop serving the same purpose should be grown between the two irrigated crops. I have explained its great importance already. It needs no watering, if sown while the ground is still moist. If it is grown as a fodder crop, it is of importance that it should have as long a life as possible. If grown as a manure crop simply, a life of 1-1½ months is sufficient.

On second crop land, the difficulty already alluded to at the close of paragraph 86 presents itself again, of course, the difficulty, I mean, that the sunn-hemp crop is wanted both as a manure and a fodder crop and cannot fully perform both functions.

The manure difficulty must necessarily be most acute on these two crop lands, nor is it open to either of the solutions which I have suggested above in paragraph 87 as possible in the single crop lands.

The first of these solutions is to grow a manure crop slightly irrigated in April—or May.

From the dates I have given, it will be seen that it is impossible to grow five or six months' paddy crop, followed by a two months' fodder crop, followed again by a three months' late paddy crop and then dovetail in a manure crop between the second and first crop of paddy. At least I do not think it could be done without the most mathematical precision, in the dates of sowing and reaping, a precision likely to be unattainable in actual practice, considering that the labour supply is not unlimited.

It is more likely that either the fodder or the manure crop will have to be sacrificed. One or other can be grown without the slightest difficulty in addition to two grain crops.

As regards the other possible solution, that is, to use the sunn-hemp solely as manure and reserve dry lands for the growth of green fodder, I have not suggested it for the delta, since I believe it to be usually impossible to reserve patches of land in the flat delta tract, and grow them successfully with dry crops of any kind. The percolation destroys these crops. I have already referred to this in another connection when discussing pasturage.

I should say that the manure difficulty in these two crop lands might possibly be met by using the sunn-hemp as manure and importing from the Upland the green food for the cattle, an expensive proceeding but not prohibitive to a ryot who obtains a large extra profit by growing two crops on the same land.

Also I should say that the difficulty could be fully met by never growing two fully irrigated crops in the same land in two successive years.

This would allow in the intervening year for the growth of both a fodder and manure crop during the second crop season, for which the moderate amount of water requisite could, I think, easily be found. In view of the comparatively small extent for which I have taken credit as coming under double crop, there should be no difficulty about growing second crop in alternate years on different parts of a holding, or if desired, in quite different parts of the delta.

The manure difficulty will be much less acute in the case of short late crop lands, which will indeed in my opinion be better off in this respect than land growing a single ordinary crop. The Kolair area as already explained is likely to be free of any trouble in this matter.

94. *Extent and localization of second crop.*—The extent likely to be raised with second crop is a point upon which my forecast is necessarily little more than a guess. I am not inclined to put the extent higher than the proportion now grown with this crop in the Gódvári delta, which according to the latest figures is about 24 per cent. of the first crop area.

The present first crop cultivation in the whole Kistna delta approximates to 7 lakhs of acres. Including the areas left for normal extension under the anicut, the irrigation will easily reach this figure at an early date and may even do so in the current year. The project delta areas will add to this an extent of 164,069 acres

first crop, or $1\frac{1}{2}$ lakhs in round figures. The ultimate first crop area in the delta may therefore be taken at $8\frac{1}{2}$ lakhs of acres. 24 per cent. of this extent is 204,000 acres, which extent is accordingly entered in statement No. IV.

The full extent of the short late crop area including the Kolair is 94,000 acres in round figures which, added to the second crop area of 204,000 acres, makes a total of 298,000 acres. It so happens that this area is but little below the acreage for which the Superintending Engineer on special duty expects to be able to find water in the late crop season. His estimate is 317,000 acres.

This is purely a coincidence and both estimates are conjectural, but it is worth noting that if the Superintending Engineer's estimate of his water-supply proves correct, the area under irrigation in the second or late crop season, cannot for engineering reasons, apart from any others, extend much beyond the total estimated in my forecast.

95. *Localization.*—The Public Works Department would prefer to concentrate their second crop as far as possible in certain areas in order to avoid wastage of water. This will be more difficult if the system is adopted of cultivating different parts of a holding or quite distinct parts of the delta with this crop in successive years.

I should say that all the black soils were suited for the growth of two crops, given sufficient manure, but that the sandy lands were not fit for the growth of more than one crop, always remembering that, whatever may happen to the Kistna silt in the first crop season, the water in the second crop season will be free from silt. The alluvial soils are the best suited of all.

This means that the lands farthest from the sea should be given the preference as regards second crop irrigation, that is, in the Eastern delta, Bezvada, Ellore, Nuzvid, and Divi taluks and the more northern part of the Gudivada taluk.

In the Western delta the areas most suitable lie in the Tenali taluk, and the northern half of Répalle and Bapatla.

It is rather unfortunate that so much of the area in the Eastern delta containing these richer soils is zamindari in tenure. All Nuzvid taluk and all Divi, apart from Divi island, are zamindari areas.

Divi taluk, much of which has been investigated by me, is, I should say, admirably suited for the growth of two crops, so far as soil is concerned.

Government villages in Bezvada, Ellore, and where possible, in Gudivada may be given the preference, but as a general rule I would sooner push the growth of second crop among the more fertile areas, even if their tenure is zamindari, than in the Government villages if their soils are markedly inferior.

96. On account of the manure difficulty and the possible exhaustion of the soils, I am a little less sanguine about the success of the second crop than I am about any other part of the project. Some of the officers consulted, it is true, report that the Gódavari ryots or many of them, hold that a second crop paddy does not exhaust the soil, though irrigated gingelly does. It may be true that gingelly is the more exhausting crop of the two, but I cannot believe that two irrigated paddy crops are no more exhausting to the soil than one.

All such apprehensions, however, are open to the argument that what is being done in the Gódavari delta now, can be done in the Kistna delta in the future. In making my forecast I have allowed this consideration full weight. As I have said, I think there will be little difference in the position of the two deltas in the future.

The only possible point of superiority in the Gódavari delta lies in the nature of its silt, which, though less in quantity, is commonly believed to be of greater fertilizing value than the Kistna silt.

It is also possible that, as the growth of a second crop of paddy in that delta is a practice which has become general only in the last six or seven years, its effect upon the fertility of the soils has not yet become fully apparent.

After making allowance for all possible difficulties, however, I do not think that it is too optimistic to anticipate a second crop area equal to 24 per cent. of the first crop.

At the same time I should recommend that if the soil is found to seriously deteriorate, the second crop area should be contracted in preference to any other, and the water utilized instead on manure crops. The latter pay no water-rate under existing rules, the present aim being to popularize manure crops, but there is no reason why, when their value is fully understood, they should not pay a small water-rate like any other crops.

I also venture to think that owing to the importance of getting the first crop paddy transplanted and reaped as early as possible (in order to allow of the sunn-hemp being grown between the two paddy crops) the reservoir should send down water in May for the growth of first crop seedlings to be used on the double crop lands. I presume that this could be done in ordinary course when giving the second crop its last flooding. If there is difficulty about finding sufficient water, the second crop area should be contracted in order to supply the seedlings.

The rates recommended for second crop and short late crop are discussed with other water-rates in paragraphs 117 and 118 below.

PART VI.—OTHER GENERAL QUESTIONS AFFECTING BOTH UPLAND AND DELTA.

97. *Communications—Delta.*—I have indicated above in discussing the Challapalli and Kona blocks, the Pedda lanka and Isukapalli areas, and the Kolair lake, the improvements to the existing communications which I consider desirable. These are the only recommendations I have to make upon this point as regards the delta tract. The remaining small and scattered extensions will make no perceptible difference to the sufficiency or otherwise of existing communications.

98. *Upland.*—The upland area, unlike the delta, must depend entirely on the roads for the transport of its grain, since it is not intended at present to make the project canal navigable. A glance at the Guntur district map will show that the upland tract is well roaded so far as main roads are concerned. It will probably be found desirable to carry the Sattenapalli-Krosur road up as far as the dam site. Otherwise I have no suggestions to offer regarding the main roads. No part of the commanded area will be more than 7 or 8 miles distant from some main road or other.

What I think the tract needs is not more main roads, but some means of transporting grain, straw, fodder, etc., at all seasons from the villages to the main roads.

What I have seen of the Kistna delta convinces me that most parts of it are lamentably deficient in such minor communications.

It is true that Government is careful to maintain the breadth of the existing paths and of the boundary porambokes between villages which might also serve as valuable means of communication. But in a highly irrigated tract I do not regard this as an adequate solution of the difficulty.

More often than not, such paths during about eight months of the year are turned by inundation into an absolute morass, usable perhaps by the village cattle but quite impassable to a loaded cart.

I think this state of things is far from satisfactory and should be guarded against, if possible, before the cost becomes prohibitive, i.e., before the tract comes under irrigation.

Any general improvement in the delta in this respect would now, I believe, prove too costly to attempt.

I am aware, of course, that grain and other produce is most often transported in the dry season, when this difficulty is less felt. At the same time, however, I think it undesirable to narrowly limit the season for such transport by lack of practicable

communications during two-thirds of the year. It is plain that this must place the cultivator and the village grain trader at a disadvantage compared with the grain merchant of the larger towns, since it implies that all the produce must move within a limited time, or else, move under difficulties, or wait for another eight months or more.

In fact it tends to depress prices at one time in the year and raise them at another, to the profit in both cases of the merchant and not of the ryot.

The difficulty is one which according to my view is scarcely likely to be met by Local Boards. These bodies generally have enough to do in keeping up the main roads in any tract and their efforts at maintaining village roads, even when these can be cheaply constructed, are apt to be confined by lack of funds within very narrow limits.

The only sort of village road in a highly irrigated tract which will be of service, will be anything but cheap to construct, if undertaken as a separate work, since it must necessarily be embanked.

The solution I would recommend, is that the Public Works Department in constructing their canals and major distributaries should invariably make one bank of the channel broad enough for use by country carts, gravel the top of the bund, and maintain the road so formed as if it were part of the channel.

I believe that the additional breadth of the land that would have to be acquired would be slight and that the extra expense involved would not be excessive.

In any case it would be moderate as compared with the cost of constructing embanked minor roads as an entirely separate work.

I am aware that my suggestion involves a departure from the established custom of this Presidency by which the Public Works Department keeps up the channels, and the Local Fund Department, the roads. I believe this division to be unsuited, if carried to extremes, to the circumstances of a highly irrigated tract.

The Local Fund Department could not of itself afford to raise the banks required, nor would the Public Works Department be likely to approve of another department keeping up roads running along the banks of irrigation channels.

I may add that I have been told of good authority that the provision of communications after the manner I suggest forms one of the items regularly included in irrigation schemes in Northern India. To me it seems to stand on much the same footing as making the canals navigable, which admittedly adds to the working expenses debitable to a project, but is none the less considered worth the expense on account of the profit these canals bring to the ryot, and indirectly to Government, by cheapening the export of grain.

I need hardly say that I would not press this suggestion, should its adoption increase the cost of the project to the point when it becomes unremunerative or doubtfully remunerative.

It is far better that the ryots should get their irrigation accompanied with some difficulties than that they should go without it because the removal of those difficulties would be costly.

It may, I think, however, reasonably be asked if the increased cost could not, if necessary, be met by a small addition to the water-rate. I feel sure the ryot would be more than reimbursed by cheaper transport and increased prices for his grain, though he might not himself be aware of it.

The objection may be urged, I know, that the ryot already pays a road cess and should not be further taxed on account of communications. There is nothing illogical, however, in recognizing the fact that in a tract where the irrigation has immensely increased the value of land and of crops, and incidentally greatly increased the difficulty and cost of providing communications, the ryot should pay an extra tax for such provision, whether this tax be called a cess, or water-rate, or by any other name.

As I have said in describing the tracts concerned, there are two areas commanded by the project where I regard the adoption of this suggestion as essentially necessary. These are the Kolair lake and the Peddalanka areas in both of which the natural submersion followed by the growth of short late crop will leave no dry season in the area at all.

These are exceptional cases. But I advocate the adoption of the plan in normal irrigable areas also and therefore in the whole upland area.

Bridges and ballacuts (i.e., small ferry boats across canal).—The provision made for these has not yet reached a stage at which discussion is possible. The whole matter is still under revision by the officers of the Public Works Department along with other parts of the forecast estimate.

I have addressed the Collector, Guntur, and he has agreed that the adequacy of the provision under these items should be checked by the ordinary Revenue staff after the Public Works Department officers are able to communicate their intentions.

99. *Soils.*—I have already in paragraph 14 given a brief description of the soils in the upland area and have also in paragraphs 21 and 59 fully discussed the small item of unsuitable soils. I have no more to say upon the subject except to draw attention to statements VI-A and VI-B which give actual figures under each class and sort of soil in the greater part of the commanded area, and to briefly discuss the question whether the clay soils are irrigable. The figures in the statements are for Government villages only, there being no settlement classification for the zamindari and whole inam villages. No figures are given in the upland for parts of villages, where the whole village is not commanded, but I have satisfied myself by examining the soils of the part-commanded villages, i.e., those on the edges of the commanded area, that their prevailing soils do not materially differ from those of the villages fully commanded.

In the Ongole taluk the figures are taken from the old settlement and the totals under classes only, and not sorts, are given. The resettlement classification figures are not available in the Collector's office.

In the delta the figures include rather less than half of the irrigable area, the rest of that area being zamindari or inam.

The result bears out the remark already made in paragraph 14 that practically the whole of the soil of the upland tract is some variety of regar clay or regar loam. No less than 94 per cent. of the soils fall under one or other of these descriptions, (87 per cent. regar clay and 7 per cent. regar loam) the rest being chiefly alluvial or red clay.

As regards the delta, regar clay is the largest item here also but there is more variety of soil. The percentages for Government lands are as shown below :—

	Per cent.		Per cent.
Highly alluvial	23	Arenaceous loam	11
Regar clay	34	Arenaceous sand	19
Regar loam	4	Other soils	1
Regar sand	8		

Generally speaking, the zamindari commanded area in the delta contains lands of better quality than the ryotwari areas. I should say a very high percentage of the former was alluvial or regar clay or regar loam.

100. *Suitability of regar clay for irrigation.*—In a large tract mainly formed of regar clay soil some apprehension may arise as to whether it is fit for the growth of a paddy crop. I believe it is now admitted that the heavy regar clays under the Kurnool-canal really are unsuited to this crop and that the refusal of the ryots to use the water of that canal for irrigation, at least for paddy irrigation, is not based on prejudice.

I do not think that any such result need be feared in the upland area now under discussion. The soils in the upland area are to all appearance, of the same description as those which form the bulk of the land irrigated in the Kistna Western Delta, and would indeed appear to form part of the same belt of soil as the delta lands which they adjoin.

I have already alluded to the opinion given to me by Mr. Paddison, who resettled this area some four years back, that much of the soils is more or less alluvial in character and is in all probability irrigable without the help of silt.

I have also mentioned a widespread, though not necessarily conclusive, belief on the part of the Kistna ryots that the river silt is useless, possibly even harmful, to this class of soils.

The Agricultural department is very likely in possession of full information already regarding the chemical difference between these soils and the unirrigable soils under the Kurnool-Cuddapah canal. If not, such information could, I should think, be easily obtained during the interval between the receipt of my report and the completion of the Public Works department investigation of the Kistna Reservoir project.

The matter is not one on which any doubt should be left unsolved, since, if the upland regar clay is of an unirrigable kind, the whole upland part of the project must necessarily fall to the ground. And as I have pointed out in paragraph 88, the river silt, whatever its value may be, is not to be counted upon. But I am myself convinced that soils of the same description are already freely irrigated in the delta.

101. *Crops*.—The delta area is now cultivated with paddy at present almost to the exclusion of all other crops. I believe this practice not to be entirely the outcome of high prices for paddy or of custom.

It is partly due to the fact that in a tract so flat as the delta, if paddy is once grown on a large scale, it is difficult to cultivate among it any crop which requires less water. The crops which require only occasional floodings are liable to be damaged or destroyed by the excess of water flowing over them from surrounding paddy fields.

The upland area is likely to have the opportunity of growing a greater variety of crops, as its undulating character will render it much easier to protect the fields from submersion.

This will make possible the growth of several crops which can now only be grown in the delta on land slightly raised above the general level, and which at present prices are actually more profitable per acre than paddy. Among the most important of these are chillies, maize and turmeric. Chillies particularly are now largely grown on the more fertile dry lands of the upland tract by the aid of rain water alone. They do not require much water but are the better of a flooding at the time of transplantation and will be readily irrigated to this extent.

This capacity for growing a variety of crops is all to the advantage of the upland tract, and should protect the cultivator from loss owing to fluctuations in the price of paddy.

102. *Prices*.—The price of paddy, which is one of the main factors in affecting the value of land and the anxiety of the ryots to irrigate, has recently been subject to great local fluctuations. I can most easily express these in the prices of the local measures called a putti (equal to 800 Government seers).

The price of a putti rose as high as Rs. 70 at one time last year and averaged Rs. 62 throughout the year. It is now down to Rs. 50 or so, and may be further depressed as it is said that the ryots held back their stocks too long in the hopes of the continuance of the extraordinary prices of last year.

It seems probable that the price will steady at about Rs. 50 a putti.

At all events, there is, I think, no danger that the price will go so low as to seriously diminish the attractions of irrigation, though the exceptional stimulus given to irrigation and land purchase during the last two years or so, may slacken perceptibly.

Indeed, in the upland tracts, I do not think that irrigation need necessarily mean paddy irrigation and the attractions of a regular water-supply should be independent of the prices of any one crop.

103. *Population—Upland*.—The population of the upland area, taking the wholly commanded villages only for the purpose of this calculation, is 344 to the square mile. The most highly populated part of the tract is the Guntur taluk with an average population of 427 to the square mile. The Bapatla taluk, and the parts of the Narasaraopet and Ongole taluks commanded by the scheme, have all about the same average population, just over or under 300 to the square mile, while the few villages in the Sattenapalle taluk are rather more thinly populated, the average to the mile falling here to 237.

In other words, the population over nearly the whole of the tract concerned is above the minimum laid down as sufficient for an irrigated tract, viz., 286 to the square mile. In the case of the Guntur taluk the population is much above the minimum. The figures too are based on the last census and take no account of the natural increase during the past nine years.

The minimum I have taken from paragraph 11 of B.P., No. 210, Revenue Settlement, dated 14th July 1905 (page 155, printed report of last Kistna Reservoir Project). I have no knowledge of how it is arrived at.

Population—Delta.—In all the areas requiring special discussion I have already referred to the population question. The only areas in the delta where the population is lower than the minimum above referred to, are the area surrounding the Kolair lake where the population is 244 to the square mile, and the Peddalanka and Iskapalle areas where the population was 185 and 172 respectively at the last census.

I have already given reasons for believing that even in these tracts the difficulty will rapidly solve itself.

As regards the remaining areas scattered throughout the delta, the population question does not arise. The neighbouring villages will absorb these patches of irrigable area without the least difficulty.

Neither in the delta nor in the upland is scarcity of population likely to prove even a temporary hindrance to the development of the project.

104. *Labour supply*.—This problem is not wholly disposed of by the figures regarding population, since the thickly populated delta tract finds itself at certain seasons unable to do without outside labour and the same will doubtless be the case with all the areas commanded by the project.

The permanent farm labourers employed all the year round continue of course to manage the agricultural operations between the seasons of transplantation and reaping, but at those seasons outside labour is essential at least in the larger holdings. This temporary influx takes place from the upland villages of Kistna and Guntur, from the Vizagapatam district and the Kurnool and Nellore districts. It is an established practice for the labourers of these dry tracts to drift into the delta at these seasons and return home when the transplantation or reaping is over.

The number that comes in amounts to many thousands. I have heard it estimated that such labourers form one-third of the whole labouring population of the delta at these seasons. Even so, however, the demand is greater than the supply, and the difficulty of obtaining labour and the price they have to pay for it, is a continual grievance with the ryots. The wages of an adult male cooly in the transplantation season are now about 6 annas a day, or about twice what they used to be, and twice what they are in dry tracts no more than a hundred miles off.

They have a proverb in the delta now that the housewife is more careful of the farm labourer than of her own husband, which rather quaintly illustrates the strong position in which high prices and growing cultivation and industries have placed the local cooly.

Wages are likely to keep up or to rise higher so long as prices keep up also. I believe that with their enormous profits on their grain, the ryots can perfectly well afford to pay this rate of wages, and can indeed expect nothing else than increased rates.

Nor do I think there need be much apprehension of serious labour difficulties, except for a time at least, owing to the doubling of the areas under wet cultivation.

So long as the profits to be made by a labourer and his family through a visit to the delta of some six weeks' duration are so great, the influx of labour will no doubt increase automatically as the wet area expands.

The labour sources that can be tapped by the railways that radiate out from Bezwada are practically unlimited.

What is most likely to happen is that a portion of the labourers who annually visit the delta will become naturalized there, and their place as temporary coolies coming in for short periods will be taken by other labourers drawn from their own original homes, or areas rather further afield. In describing the Peddalanka area I have mentioned instances of such labourers turning into actual ryots.

An interesting point arises in connection with this labour question and the proposed second crop in the delta. The seasons on double crop lands will as explained in paragraph 91 be roughly as follows:—

First crop reaped in December.
Second crop transplanted in February.
Second crop reaped in May.
First crop transplanted in June.

With a very slight modification of the existing practice, therefore, the temporary labourer could, by coming in a few weeks earlier, reap the second crop and proceed at once to transplant the first crop, and this, I do not doubt, is what will actually take place. It ought to suit the coolies particularly well.

They might find it inconvenient to stop, however, during the interval between the reaping of the first and the transplantation of the second crop or return after this comparatively short interval. But if the second crop is limited to 24 per cent. of the first crop, this area could be transplanted, I think, by the permanent labourers, alone. Perhaps a different set of labourers would come in the month of February to extensive areas like the Kolair short late crop area and the adjoining second crop lands.

I have heard ryots raise objection to the introduction of second crop, saying that during the present hot weather their farm labourers are fully occupied with carting manure and similar agricultural work, and that they could not find labour for two crops.

All such difficulties will find their own solution, I expect, when to surmount them brings an unmistakable money profit.

105. *Readiness of the ryots to irrigate—Delta.*—"Anxious to irrigate" is too mild an expression to describe the attitude of the owners of the lands which are still unirrigated in the delta. They will pursue any officer who might conceivably help to bring them water, and will sometimes offer him home-made schemes of irrigation and drainage, schemes remarkable for their cheerful optimism and their indifference to such small matters as levels or available water-supply. There need not be a moment's doubt about the delta ryot's eagerness to irrigate.

My subordinates and myself have made enquiries in the upland villages reinvestigated regarding the attitude of the ryots. Their replies have practically always indicated that they are willing to irrigate; though many of them scarcely think the subject with serious consideration yet. This is natural enough, seeing that they must have heard the project talked of for several years and nothing as yet has come of it.

I do not personally attach any value to these enquiries and am of Mr. N. S. Brodie's opinion (*vide* paragraph 8 of his letter, page 139, printed report last Kistna Reservoir Project), that the ryot's view of irrigation in a dry tract often varies with the rainfall in that particular season. This season the rains since August have been a failure, and every one appreciates the desirability of canal water.

The real indication of what is likely to take place in the upland area is not what the upland ryots say, but what the delta ryots do. I have myself no doubt that ten years after the project begins to supply water to the upland, the ryots will be as enthusiastic about the water as are the delta ryots now.

As I have already mentioned in giving a general description of the upland tract (paragraph 13), its shape and position must afford great encouragement to the development of irrigation, lying as it does throughout most of its length parallel to and adjoining the tract already irrigated by the delta canals.

Nor is the upland project area anywhere of great breadth. I should say that in over one half of it the ryots, or most of them, must know by ocular demonstration

the difference between the delta irrigated crops and their own, and that the prosperity of the delta ryot must be known, by hearsay at all events, all over the project area.

The conditions in no way resemble those of a canal run through a country where extensive irrigation is unknown. In the case of this project the advantages of irrigation should need no one to trumpet them.

PART VII.—RATE OF DEVELOPMENT—SALES OF LAND AND WATER-RATES.

106. *Rate of development.*—As may be gathered from my remarks in Part VI, I anticipate a fairly rapid rate of development for the whole Project area. The rates, I have adopted, are as shown below:—

Area.	Irrigation commences.	Irrigation fully develops.	Total period of development.
Upland	12th year	31st year	20 years.
Delta, first crop	5th "	14th "	10 "
Delta second crop and short late crop	7th "	21st "	15 "

These rates of progress are exactly those adopted by the Chief Engineer for Irrigation in the original forecast estimate of the present project (*vide* page 19 of G.O., No. 458 I., dated 9th December 1908). The Chief Engineer's conclusions are exactly what I should have drawn independently from the information collected regarding soils, population and position of the tract concerned.

Statement No. V gives the figures showing the expected revenue development for the project as a whole, during the full period of 31 years. Its enclosures A, B, C and D give the same information separately for the upland, for the delta first crop, for the delta second crop and the delta short late crop. The figures both for acreage and revenue in all these statements are rounded into thousands for the year of complete development.

107. *Upland area (statement No. V-A).*—
Irrigation commencing 12th year.
Developing fully 31st year.

I have already put forward my reasons for expecting irrigation to be immediately popular.

But for the size of the tract I should assume a still more rapid rate of progress. The area, however, is over seven lakhs of acres in extent, or about the same as the whole present Kistna delta, and it is scarcely safe to estimate that so great an area will come completely under irrigation in less than 20 years, however favourable the conditions.

108. *Delta first crop (statement No. V-B).*—
Irrigation commencing 5th year.
Developing fully 14th year.

This estimate may err a little on the side of over-caution. I have no doubt that the greater part of the delta first crop extensions will come under irrigation in five or at most seven years, provided water is available.

But parts of the Kona block and the Iskápalle block may be a little slower to develop by reason of the fact that they may come into competition with Divi island from which they are separated only by one or other branch of the Kistna river (Divi island contains 50,000 acres of irrigable land of which about 20,000 acres are now irrigated). Ten years is therefore a reasonable allowance.

109. *Delta second crop and short late crop (statement No. V-C).*—I believe manure, and to some extent perhaps labour, difficulties may hamper the extension of second

crop, at least temporarily, and think it wiser to allow for a longer period of development than is necessary for first crop extensions. I have allowed accordingly 15 years. Irrigation will begin in the 7th year and develops fully in the 21st.

The same period is allowed for the development of the short late crop, but for other reasons. In the Kolair lake which forms 90 per cent. of the short late crop area a more rapid extension would be possible, I feel sure, if desired.

But the land sales in this area will be of such importance to the project revenue that the realization of a high sale price is for once more to be desired than a rapid extension of irrigation. I discuss this point in paragraph 113 where I recommend that the lands should be sold gradually, at intervals of about two years in order not to throw too much at a time on the market.

This is my reason for providing 15 years for full development in the Kolair lake area.

It is indeed possible, as stated in paragraph 73, that the least accessible section, measuring about 10,000 acres, may be ever slower to come under irrigation. On the other hand, it is still more likely, considering the extent already cultivated under sivojama, that 20,000 acres or so may be sold and cultivated in the first two or three years after water becomes available.

These two uncertainties may be held to neutralize one another, and a 15-year period of development may be considered to fairly represent the prospects of the whole Kolair area.

As regards the remaining short late crop extent, it may develop rather more quickly, but the extent, 9,700 acres, is not worth providing with a separate rate.

110. *Maintenance and collection charges.*—The rate at which the former of these two is to be calculated is a matter for the Public Works Department officers to decide. At the direction of the Superintending Engineer on special duty, I have calculated the charge at As. 12 per acre on the first-crop extent (including short late crop), both upland and delta, but not on the second-crop extent which adds nothing to the cost of upkeep.

The collection charges I have calculated at 5 per cent. of the gross revenue, as has been usual in previous projects. I have not been successful in getting any information as to the origin of the 5 per cent. rate which, if it represents solely the cost of the increased village and taluk establishments which the irrigation entails, is, I should think, too high a percentage.

As directed in B.P., No. 225, dated 23rd June 1909, both these charges are contained in one column of statement No. VI.

111. *Sales of land—Upland.*—The total extent saleable is small, only 16,054 acres in all. The chief item which generally appears as saleable in a highly cultivated tract is the tank-beds, and these as already explained, are almost all to continue in use.

I have omitted all cases where the saleable lands in a village measured less than 10 acres, thinking that such trifling extents are not worth the account-keeping they entail if sold for the benefit of the project.

There is also an area of about 7,600 acres assigned on conditional patta which could possibly be sold, if desired. At least the land was assigned after the issue of orders by the Collector that only conditional pattas should be issued, and I conclude that it could be resumed and sold.

I have not taken credit for these items, as I think they may reasonably be regarded as a setoff against the lands to be assigned on free grant as directed in B.P., No. 1—Rev., dated 2nd January 1907. In fact, I should think it would save trouble and much complaint if these lands, which have been the longest under occupation, were selected for free assignment, unless they are required for the channels or for allotment in exchange for lands acquired for the channels.

The whole subject of sales is of small importance however in the upland where the remaining unassigned lands are mostly of saline or other poor soils, and for this reason are priced with few exceptions at a very low sale value of Rs. 20 to 30 per acre.

The delta ryots, as I have explained, have no objection to saline soils, and the upland ryots will soon learn to hold the same view, but the soils require one or two years' flooding before they are cultivated and this must necessarily reduce their sale value.

Delta.—The subject of sales is of more importance in the delta extensions, which include several large tracts of waste lands at the disposal of Government as shown below:—

	ACS.
Kolair lake and its margins (all short late crop)	73,637
Peddalanka area, ordinary crop	4,471
Do. short late crop	5,439
Iskápalle area	2,814
Kona block	1,751

112. *Free distribution.*—In the case of the short late crop lands in the Kolair lake and the Peddalanka area, I have deducted from the areas at the disposal of Government the extents shown below for free distribution:—

Kolair lake—3,800 acres or 5 per cent. of the whole.
Peddalanka—1,086 acres or 20 per cent. of the whole.

I have done so mainly because I think that it may be expedient to assign on free grant a small proportion from time to time in these tracts, in order to prove the possibility of growing the short late crop, and thus stimulate the sales of adjoining lands. This would apply only to the less accessible parts of the Kolair lake; elsewhere the possibility of growing the crop at a large profit is thoroughly proved already. In the Peddalanka area the crop has not yet been tried.

If, however, these free grants are to be of any use for the purpose indicated above, they must be assigned from land at different levels and different distances from the homes of the assignees. If the latter are allowed to have their way, they will select land at the edges of the tracts under discussion, the most valuable lands in fact, where no one doubts the suitability of the land for the crop, or its value if sold by auction.

I have not reserved anything for free distribution from the other saleable lands in the delta. Land has quite an exceptional value in the delta, so soon as its irrigation is even probable, and I hope that the Board will agree with me that free assignments are not called for. The Collector of Kistna has, I believe, addressed the Board recommending that sale should be the ordinary method of disposal of waste land in the delta, and I would strongly recommend that this policy should be pursued as regards the waste lands affected by the project. The prosperity of the delta ryot, as compared with the cultivator of any ordinary tract, is now so proverbial that I cannot think him a suitable subject for charitable grants, and the free assignment of land so valuable is practically nothing less. The acquisition of land for channels, etc., will also be extremely expensive in the delta, and it seems illogical for Government to buy at very high prices the lands which are not at its disposal and give away lands which it might sell.

113. *Sales in the Kolair bed.*—The Kolair bed lands are of far greater importance both in extent and fertility than all the rest of the saleable lands put together, and their sales will require careful management, if their real value is to be realized. I would recommend that they should be sold at intervals, not more than 10,000 acres at a time and not more frequently than every two years.

Otherwise the competition will inevitably be paralysed by too much being thrown on the market at a time, and the history of the Peddalanka and Iskápalle areas will be repeated, the purchasers finding that they cannot immediately get the tenants or the labour they require. The tract must be allowed to develop in its own way, the more accessible portions first and then the less accessible.

The policy I recommend may mean that a good deal of the water runs to waste in the earlier years. This is unavoidable and constitutes no real objection. The average sale price of Rs. 75 per acre, which I have estimated, is equivalent at 4 per cent. to an addition of Rs. 3 to the water-rate on every acre of the lake and is worth waiting for, even at some immediate sacrifice of revenue.

114. *Water-rates—Delta first crop.*—In the case of the delta area, the water-rates are those actually in force in the delta at present, that is to say, in the case of all zamindari and inam lands Rs. 5 an acre and in the case of Government ryotwari land, the actual water-rate as fixed at settlement for the class and sort of soil and for the source under which the dry lands are most likely to be irrigated. From this rate the "inducement" rate of Re. 1 an acre, levied on dry land since the last resettlement, is omitted, being a temporary charge which is intended to vanish when the lands are finally classed as wet.

This is the rate appearing in column 15 of statement No. 1 and the average rate per acre works out to Rs. 4-7-0. This rate is not a fair average for the whole delta. The delta project extensions largely consist, naturally enough, of the poorer soils of the delta tract, and there is also among them an unduly high proportion of lands under second, third and fourth class sources of irrigation.

The question naturally arises whether these sources under project conditions are likely to retain their present low classification.

The existing delta differential water-rates are the outcome of two varying factors—

- (1) The class and sort of soil.
- (2) The class of the irrigation source fixed at settlement, in which is included the drainage.

The class of the irrigation source may be lowered either with reference to the insufficient supply of water or the inadequacy of the drainage. It is not stated in the village settlement registers whether it is the water-supply or the drainage that is considered inadequate in any particular case.

Variations in assessment due to soil classification are unalterable till the next resettlement. Reductions in water-rate due to insufficient water or drainage may be revised during the continuance of the settlement according to the settlement notification, in the event of these drawbacks being removed.

In my view, they are likely to be removed by the time these delta extensions come under irrigation, and I have therefore shown in column 17 of Statement No. 1 the difference between the water-rate which the lands would pay under the neighbouring channels as now classified, and what they would pay under a first-class delta channel.

I understand that the Superintending Engineer, II Circle, has under consideration the question of making the necessary improvements and getting the rates raised during the continuance of the present settlement. In any case, it is unlikely that even the first-crop delta lands, the first to be irrigated under the project, will all come under irrigation earlier than about fifteen years from now, that is to say, about five years before the next resettlement in the case of the Eastern delta and some twelve years before it in the case of the Western delta.

At resettlement, if not before, all improvements will be taken into account in classifying the sources. I think, therefore, it is reasonable to assume that the sources will be delta first-class sources very shortly after these lands come under irrigation. If, however, the Board does not agree with me, the item separately shown in column 17 is easily expunged.

I need scarcely say that the engineering improvements that may produce this result will affect a much larger extent of land than appears in my statements—will, in fact, affect most of the land in the delta which is already irrigated under second, third and fourth class channels. The Collectors of Kistna and Guntur have supplied me with the figures showing the extent of such land which proves to be considerable—94,000 acres in round figures for the permanent wet alone apart from the dry land irrigated.

I have considered and finally abandoned the idea that the project might legitimately be credited with part of the extra revenue resulting from such improvements, in so far as they affect *lands already irrigated*.

Though I feel confident that such improvements will take place and will result in enhanced revenue, certainly at the next resettlement and probably before, it is difficult to make even a guess at the share which the reservoir water will take in

effecting the improvements. The reservoir will, it is hoped, much advance the date of transplantation and in this way neutralize in many cases the drawback of inadequate drainage, because the paddy plants will earlier reach a growth at which submersion is harmless to them. It may also, by increasing the supply of water towards the end of the season, make it possible to change the distributaries at the tail of the canals into first-class irrigation source.

But I believe it to be impossible to guess at how far the resulting increase of revenue should be divided between the reservoir and the aicut, and think the attempt to do so would mean an impossibly complicated piece of irrigation book-keeping.

So far as lands already irrigated are concerned I can only indicate the fact that an increased revenue is likely, and that the reservoir will be helpful in producing this result, but I cannot attempt to reduce the value of its help to figures.

115. *Remissions.*—A rather similar question to the above arises in considering whether any credit should be taken to the project for the extent to which it may render remissions unnecessary in the delta area. The amount of remissions is likely to be reduced after the advent of the project for exactly the same reasons as will operate to raise the settlement classification of the channels, that is, increased water at the end of the season and earlier transplantation to submersible lands.

But the value of the help afforded by the reservoir is equally difficult to forecast, nor is the extent of remissions very great, about 10,000 acres a year on the average for the last five years, including one of exceptional flood. These figures are for both the Kistna and Guntur districts.

It may be noted too that I have made no deduction in the upland area on account of probable remissions, which will doubtless have to be granted on occasion particularly for submersion.

The one item may be set off against the other.

116. *Water-rates—Upland first crop.*—I have provided a uniform rate of Rs. 5 an acre for all lands alike—Government, inam and zamindari.

I assume that in the upland tract a uniform rate for wet crops will be levied at all events during the first years of the life of the project. Rs. 5 an acre is the rate now levied in the delta on all lands to which the system of differential water-rates has not been applied, and is also approximately the average differential rate paid on Government lands in the delta.

Statement No. VI-A will show the soil classification in the upland, but it is not possible to apply the delta rates to this classification exactly, delta soils being divided into five sorts in each class and upland soils into three only.

I may say, however, that the delta water-rates applied to the bulk of the upland soils (over 95 per cent. of which are regar clay or regar loam) would range from Rs. 4-8-0 to Rs. 8 including the inducement rate of Re. 1 and Rs. 3-8-0—Rs. 7, omitting it. The average rate, leaving out the inducement rate, approximates to Rs. 5 an acre, as in the delta.

The question of whether the crops chiefly grown will pay the full wet rate or any lower rate must be taken into consideration.

I have already dealt briefly with this subject and indicated that for physical reasons there is likely to be more variety of crops grown in the upland than is now the case in the delta.

There is always the chance that if crops which take less water, chillies for example, or maize, displace the paddy crop to any great extent, the water-rates payable may be reduced. On the other hand, the danger of this is lessened by the rule that dry crops systematically irrigated shall pay the same as wet crops. Also the land *could* all grow a wet crop, and for this reason will, I presume, ultimately be transferred to permanent wet.

Indeed, I have some doubt whether the concessions allowed to dry crops watered ought to be applied to the upland tract except for a short time. If I have understood the expectations of the Engineers correctly, they anticipate that they will have more than enough water for the seven lakhs of acres in the upland during the first-crop

This fact is clearly recognised in the note appended by the Hon'ble Mr. J. N. Atkinson to Board's Proceedings, No. 410, dated 10th November 1908, which deals with the subject of differential water-rates. Mr. Atkinson writes: "We are apparently on the threshold of an immense development of the irrigation sources of this Presidency, but that development will be impossible unless there is a reasonable prospect of at least avoiding financial loss, or in other words a permanent burden on the tax-payer."

"Our current ideas as to what is a fair charge, a charge which cultivators will gladly pay for irrigation, are altogether out of date. Offers have already been received to pay Rs. 15 and Rs. 20 per acre for water, and as prices rise so will the value of water."

I have nothing to add to this except to say that the delta will supply any amount of evidence confirming these conclusions. I may quote the Atmakur Co-operative Pumping scheme, where the water is paid for, I believe, at Rs. 10 an acre, quite apart from the assessment, and the system in vogue under the pumps on the Kolair lankas, where the pump owner pays the Government water-rate, but his tenants bear all the cultivation expenses and pay him half the gross produce (say Rs. 20 to Rs. 25 an acre). In neither of these cases is the water-supply any better than that under the canal irrigation. I may also instance the frequency with which water is deliberately taken without permission and double rates readily paid.

There seems, as I shall show below, a strong probability that the Kistna Reservoir project at a five rupee water-rate will rank as a productive work, but it is impossible to be certain till the final engineering estimates are ready.

If it should prove that it is not productive at this rate, and Mr. Atkinson's view of our present water-rates is accepted, it seems naturally to follow that the rates may be raised sufficiently to place the project beyond all danger of proving unremunerative.

Indeed I think the rates should be raised apart from the question of obtaining sanction to the project. Every rupee which Government might levy and does not levy for services rendered in the supply of water is an extra burden on the general tax-payer.

I doubt if it is necessary in the upland tract to encourage irrigation by means of low rates, even temporarily. If any such concession is thought desirable, it should be limited to a short period, say, the first ten years after water is first supplied.

PART VIII.—COMPENSATION FOR THE AREA SUBMERGED BY THE RESERVOIR.

120. The site of the project reservoir is about two miles further down stream than Pulichinta village on the British and about half a mile above Vadanapalle village on the Nizam's side, just above the point where the river reverses its previous course in a horse-shoe curve.

The extent of the submergence extends upstream for about 42 miles ending just above the village of Pondugala and the Nizam's village of Vadanapalle, which faces it on the opposite bank.

The greatest breadth of the area submerged at any point is 9 miles, but the average breadth of the submergence is much less than this. (On the British side, the land at many points rises abruptly from the river, often in actual hills. The country on the Nizam's side slopes as a rule more gently towards river, which accounts for the larger area of submergence on that side.)

The total area of submergence according to my estimate is 59,579 acres or 93 square miles, excluding the extent of the present river-bed, which does not appear at all in my accounts. Of this area, 26,630 acres are on the British side and 32,949 acres on the Nizam's side.

A very large proportion of this area is, fortunately for the cost of the project, land covered with forest or scrub, for which no compensation need ordinarily be paid on our side of the river and a lower rate than that required for cultivated land on the Hyderabad side. The area held on patta on the British side is 10,875 acres, while 16,091 acres is forest, waste or poramboke.

The patta land and forest or other waste on the Hyderabad side are 21,980 and 10,825 acres, respectively, but out of the patta lands 7,425 acre are as yet uncultivated and resemble the adjoining forest lands in all respects, except their tenure.

The villages affected number 18 on the British and 24 on the Nizam's side. Eleven of the former and 16 of the latter will have their sites either wholly or partly submerged by the reservoir water.

121. *Statements.*—All the statements are divided into two sections, giving the information separately for the British and the Nizam's side. The totals for each side are reclassified for convenience sake in the general abstract statement No. VII-D.

Statement No. VII-A shows the compensation estimated for lands held on patta with the wells and trees standing on them, as also the land revenue itself (column 5) and the compensation estimated for the loss of it (column 13). On the Hyderabad side compensation for the lands themselves and for the loss of land revenue is worked out in exactly the same way as on the Government side in the case of all lands which are assessed and actually paying assessment to His Highness the Nizam.

Statement No. VII-B shows the extent of the forest reserves, other porambokes and assessed wastes and the proposed compensation, if any.

In the case of Government villages the extents only appear and no compensation is provided as all such lands are at the disposal of Government.

The only case of this kind requiring compensation on the British side is Ketavaram, an aghaharam village, possessing some private forests of considerable value. On the Hyderabad side, all such lands require to be paid for, as also the growth upon them.

Statement No. VII contains the estimated compensation for buildings and village-sites. This statement includes also houses built on patta lands, which as a rule are practically part of the village, though not built on village-site poramboke.

All these statements are abstracts of village registers prepared by my staff which contain a valuation of each field and building separately.

122. *Calculation of extents.*—On the British side the contour lines indicating the probable limits of the submerged area have been marked on the village plans in the office of the Executive Engineer on special duty. There was therefore no difficulty in ascertaining the exact area submerged in these villages.

The same may be said of seven villages among the 24 affected on the Hyderabad side, for which the Engineer's office happened to possess copies of village maps as complete as those in use in our Government villages.

For the other Nizam's villages a contour sheet on the same scale as the village maps was prepared in the Engineer's office, showing the line of submersion, and these were compared in the villages themselves with the village plans.

A surveyor was also lent me by the Executive Engineer and was used to help in identifying the contour by rechecking the levels in cases of doubt.

The extents are not likely to prove perfectly accurate, but are, I believe, correct as regards the cultivated lands, at least in the surveyed villages, and roughly correct as regards the wastes and forests. The lands have all been surveyed except in two villages, but the survey of wastes is often in large blocks.

123. *Method of valuation pursued.*—I have personally gone through the whole area affected and inspected a large proportion of the cultivated lands on both banks, and as many as possible of the Nizam's forests and wastes and of the houses. I have seen enough to be sure that the system of rough valuation adopted gives fairly accurate results.

Patta land.—This is of good average quality throughout (mostly regar clay and regar loam) with occasional alluvial soils. It was bearing excellent cholam crops at the time of my inspection.

The average estimated value per acre excluding the 15 per cent. allowance for compulsory acquisition is Rs. 58 on the British side and Rs. 33 on the Nizam's side.

The lower average in the latter case is not due to any marked difference in the quality of most of the cultivated lands, but to the fact that, as already explained, about one-third of the patta lands on that side are really forest lands of little value apart from the forest growth on them.

In the village registers, which assign a value to each number, a higher value is attached to inam lands than to ryotwari and to lands close to the village as compared to those more distant.

The prices are based partly on the registration figures and partly on my own observation of the lands and crops. The prices are higher than the Sub-Registrar's average recorded prices in the villages themselves or in the taluk generally, and I am satisfied that they must be so, if they are to be equitable. I have seen cases of lands recently sold, according to the registration records, for a price which would scarcely have bought the crop standing on the land at the time of my inspection.

I have had a number of these cases inspected by my Tahsildar, in which the sale prices appeared impossibly low, and in almost all such cases nothing was found in the quality or position of the lands which explained the low price. In fact, many of these land sales are quite fictitious and lower the average below what is reasonable.

I offer some more detailed remarks on this subject in discussing the rates which should be allowed for compensation in the commanded area generally.

It must be remembered in estimating the probable compensation for all lands concerned in the project, that there has been an extraordinary general advance of grain prices during the last two years and in consequence a general rise of land values, the effect of which, I think, has only partly become apparent in the recorded sales.

124. *Forest and waste lands.*—This item is of importance only on the Nizam's side. It is a matter of some difficulty to give even an approximate estimate of the value of these waste lands covered by inferior grass, scrub and tree growth.

I have separated the valuation of the lands themselves with the grass growing on them from the valuation of the timber or scrub jungle and assigned a rough valuation per acre to each.

My reason is that the forest growth may be removed, is in fact likely to be, but that the land and the pasture on it will remain, and the compensation must be paid for it in any case.

My valuation ranges from Rs. 5 per acre for land which bears only inferior pasturage to Rs. 12 per acre for land bearing better grass or which could be cultivated, if cleared. In one case the valuation rises to Rs. 17. Here the land though not held on patta is actually under cultivation.

125. *Tree-growth.*—Setting aside one exceptional case in the village of Vellatur where there is a thick growth of palmyras of unquestionable value, the tree-growth is valued by me at prices ranging from Re. 1 to Rs. 8 per acre, the average value being Rs. 5. In the aghaharam village of Ketavaram, the growth is better and valued at Rs. 13 an acre.

As a rule the growth is most inferior and useful only as firewood. Some of the forest consists of Yepi trees which seem at first sight to be of value, but are really little superior to the rest of the jungle wood in the tract, being almost invariably hollow at heart, and fit only for fuel.

I have consulted the District Forest-officer, Guntur, on the subject. That officer tells me that from experiments made on the other bank of the river close to the dam site, the yield of timber was about 4 tons to the acre, and the profit not more than one rupee per ton or an average of about Rs. 4 to the acre.

The average rate estimated by me for the timber on the Nizam's side, excluding the exceptional item in Vellatur, approximates to the District Forest-officer's figure.

It is impossible to be certain how far the growth on the Nizam's side resembles that on the opposite or British bank, referred to by the District Forest-officer. Still that officer's opinion will indicate how low is the commercial value of low class

timber in the out-of-the-way tract under discussion, and from my own inspection, I should say there was little difference in the average value of the growth on either bank.

I have great hopes that an arrangement may be arrived at by which the compensation to be paid for the timber will not be a dead loss to Government, and at the same time its value may be calculated by means much more accurate than is possible through any valuation by the acre.

I gather from the Executive Engineer on special duty that, in the construction of the reservoir dam, an enormous amount of wood fuel will be used, more in fact than the whole amount that is likely to be standing on the lands to be submerged on both banks. It should be possible to arrange with the Government of His Highness the Nizam that all the timber should be cut under the supervision of his own officials and paid for at the dam site or at fixed depôts on the river bank, from which its carriage to the work spot would be an easy matter.

This arrangement should prove profitable to both Governments, and would result in the disappearance from the estimated compensation of the whole of this allowance for tree-growth amounting in all to Rs. 1,22,906.

If the growth is used in the construction of the dam, the item is not, properly speaking, compensation.

The same arrangement should be made, if possible, as regards the submerged timber in the aghaharam village of Ketavaram on the British side.

126. *Compensation for buildings.*—The houses on both sides of the river are of much the same description, and are generally speaking of a good class. They are constructed almost invariably of stone in mud with either thatched or terraced roofs, and are remarkable for the size and value of the beams used in their roofs, which seem to be of a class much superior to any timber now growing in the neighbourhood.

It has not of course been possible to measure every one of over 4,000 houses for purposes of valuation. All have been inspected and valued according to the number of beams used in their roof construction.

Thus a house built of stone in mud with a thatched roof of one beam has been allotted a value of Rs. 40 or Rs. 60 according to the ease or difficulty with which the building stone was procurable.

A similar house with a terraced roof of one beam is valued at Rs. 80 or Rs. 100.

The value ascends in a regular rate according to the number of beams used, and whether they are laid end to end or parallel in the roof.

Rough as this method sounds, I have satisfied myself by a number of experiments that the number of beams (which are always of practically the same size) represents a perfectly intelligible variation in the size of the houses and in their value.

In fact, short of using actual measurement, it is probably as good a method as can be devised, and has the additional advantage of being the one invariably used by the house-owners themselves in describing the size of their houses.

The average value of a house on the British side is Rs. 99 and on the Nizam's side Rs. 67.

Temples, bungalows and other special buildings have been valued by actual measurement.

I have included in my compensation statements all buildings in villages partly submerged, which stand within 20 yards of the waterspread, and at a longer distance, if the ground is flat. I should say such buildings would not be safe so close to the edge of the water.

I have not attempted to value individual house-sites, but allotted on both sides of the river a lump sum of Rs. 200 an acre for the acquisition of the whole village site. This would be a fair rate in cases where it is necessary to pay such compensation at all.

It is probable that under sites and buildings the estimated compensation may be somewhat reduced in actual fact. Should the village be shifted only a short distance further back from the river, the house-owners will probably prefer to rebuild their houses with the original wood-work, and this will reduce the compensation somewhat.

In such cases also the village-site would probably be provided free by Government and it would be unnecessary to provide compensation under this item. It is unsafe, however, to count too much on such reductions.

127. As to the question of providing fresh lands for the population of the submerged villages it is a difficult problem, to which I can find no satisfactory solution. Out of the 18 villages on the British side, the whole or the greater part of the village lands will be submerged in the case of seven villages and the population of these at all events will have to move elsewhere. The same may be said of 10 of the Nizam's 24 villages.

Even in the Upland taluks of Palnad and Sattenapalle it is very difficult to find cultivable land enough for a fresh settlement.

Parts of the adjoining forest reserve seem to be cultivable land, but not enough I should say, even if surrendered, to prove a great resource.

The waste lands under the project are scanty and scattered in the Upland, and in the delta, are almost all submersible swamp lands.

I doubt if these people from dry villages, a hundred miles away in the Upland, would emigrate to such swamp lands or if they would thrive under such conditions, if they did.

128. *Other possible compensation, Nizam side.*—It is possible that the Government of His Highness the Nizam may claim compensation for the loss of revenue other than land revenue. The two principal items will be Abkari revenue and Customs revenue.

I was informed by the Tahsildar who met me on the Hyderabad side that the Abkari revenue usually exceeded the land revenue. As regards the Customs, almost everything that crosses the river seems to pay duty.

The reduction in such revenue that may result from the reservoir submergence will be due, if it occurs at all, to the emigration of the inhabitants to the British side. I doubt if this will take place. As I have said it will be difficult to find fresh land for the inhabitants of our own submerged villages. I should say there was more land available on the Hyderabad side, as our ryots send cattle there to a great extent for grazing. I do not think it possible to make any estimate, even the rough-est, of the possible loss of revenue under these heads. I would suggest that the Nizam's Government might be approached to supply information as to the average amount realized under Abkari and Customs per head of population and that the British Government might undertake to pay compensation at this rate for all the population that actually leaves Hyderabad territory.

129. *Total compensation.*—The total compensation payable as estimated by me is Rs. 30,07,000 in round figures, of which Rs. 13,47,000 belongs to the British and Rs. 16,60,000 to the Nizam's side. The details are given in statement No. VII-D.

130. *Compensation for canals, channels and other project works.*—I can give no idea of the probable total compensation under this head, since the Public Works Department officers have as yet no information to give me regarding the extent they expect to take up.

All I can do therefore is to endeavour to give an idea of the compensation per acre that will probably have to be paid. The rates all over the tract concerned will be high.

131. *Upland.*—I have carefully gone into the probable compensation in the particular villages through which the project main canal will pass. The Executive Engineer could not give me the exact fields most likely to be taken up, as the line of the canal is not yet finally settled, but the villages through which it will pass are known.

In these villages, 70 in number, I have examined all the sales recorded by the Sub-Registrar during 1908 and 1909 up to date. I have done the same in another 45 commanded villages in the Ongole taluk, where my staff did more work than in any other taluk. In most of these villages the number of recent sales is very large, and forms a good guide to the current price of land to be acquired, not only for the main canal but all through the Upland area. I have already pointed out how singularly uniform in quality are the soils throughout the tract.

In working with the Sub-Registrar's figures, it is impossible to avoid the conclusion that to get any results of value one must omit the highest and lowest sales. The highest generally mean that the land is not entirely agricultural land; the lowest are undoubtedly fictitious. I have already referred to the fact that my staff or myself have checked a number of such sales in the reservoir area and found the prices could not possibly be genuine.

Many causes contribute to these fictitious prices. Probably most of them are sales in discharge of a debt, when neither party has any particular interest in stating the consideration correctly. In other cases I have known the ryots quite frankly admit that they mis-stated the price in order to avoid the full stamp duty.

I have cut out all sales below Rs. 35 an acre for the purposes of getting my average, and all above Rs. 250. To any one who knows the tract it is obvious that normal dry land, if the sale is genuine, must sell between these extremes.

Omitting such items, my average figures for each year in the villages above described are as follows:—

Taluk.	For 1908.		For 1909.	
	Rs.	89 per acre	Rs.	128 per acre.
1. Guntur	89	"	95	"
2. Ongole	77	"	85	"
3. Narasaraopet	69	"	84	"
4. Sattenapalle				

The prices are higher than the District Registrar's averages for the whole taluk, owing to the omission of the impossible sales.

It will be observed that there is, as might be expected, a marked rise in the prices in this year as compared with last year.

The variations between taluk and taluk are also reasonable, the highest figure in 1909 being in Guntur taluk, and the next in Ongole, the averages in the other two taluks, where the lands are rather less accessible, being slightly lower.

As regards the remaining Upland taluk, Bapatla, I have not taken village averages for it, as the canal does not pass through it, but I should place it in the same category as Ongole or slightly better.

The figures of 1909 should be followed as more indicative of the probable future prices than those of 1908.

I recommend accordingly that the figures shown below may be adopted for dry land in the Upland area, both in respect of the main canal and the distributaries.

As regards wet land I would price it at 50 per cent. only above the dry land. The wet lands are almost a negligible quantity in the Upland and the recorded sales so few as to give little indication of their value, but it is not high as compared with the dry land.

The dry crops are proverbially good and the water sources inferior. The following is the scale, I would recommend, for adoption in the Upland:—

	Present sale value as shown above.	Compensation rate per acre in round figures including 15 per cent. for compulsory acquisition.	
		Dry.	Wet. (under tanks.)
	Rs.		
Guntur	128	150	225
Bapatla	110	125	185
Ongole	95	110	165
Narasaraopet	85	100	150
Sattenapalle	85	100	150

132. *Delta.*—I have only the District Registrar's average figures to go upon in this area. I could not go into the subject more in detail as I do not know where the canals or channels are to run. I do not think that different rates for each taluk are suitable to the delta, which has two markedly different classes of soils, the sandy and the black, the latter being clay, loam or alluvial. I think it better to give an average rate for each of these two descriptions of soil.

I recommend accordingly the following rates, which include 15 per cent. for compulsory acquisition :—

	Dry. Rs.	Wet Rs.
All black soils of normal situation ...	175 per acre.	350 per acre.
Sandy lands or lands at the tail of canals or otherwise unfavourably situated (including the Pedda lanka and Isukapalle blocks for example)	40 "	200 "

The latter class of lands is of fair value when irrigated but of little value as dry land.

The rates proposed for the normal black soils are much the same as the average rates for 1908 entered in the District Registrar's returns for the taluks in which the soil is almost exclusively of the better classes. The rate is also slightly in advance of that recommended for the dry lands of the Guntur taluk in the Upland, where the rates as already explained have been worked out on better evidence and a more careful system. I should say that the delta dry lands of fair quality would slightly exceed in price the best upland dry lands, and have made my recommendation accordingly.

PART IX.—REMUNERATIVE ASPECT AND CONCLUDING REMARKS.

133. *Remunerative aspect of the project.*—No final conclusion as to whether the project will prove productive is possible until the Public Works Department investigation is finished, and the probable cost of construction is known more accurately than at present. The Superintending Engineer on special duty, however, writes to me demi-officially that $7\frac{1}{2}$ crores is the outside figure to which the cost is likely to rise.

It may be worth while to indicate roughly the probable yield of the project taking this figure as the estimated cost.

The gross revenue anticipated is entered in statement No. IV and amounts to Rs. 58,61,340.

The net revenue, after deducting the charges for maintenance and collection, amounts to Rs. 48,28,625 including enhanced land revenue.

This figure appears as the last entry in column 7 of statement No. V (statement of revenue development) being the net revenue in the 31st year after commencement.

The figure last quoted would give a return on an expenditure of $7\frac{1}{2}$ crores amounting to 6.4 per cent. This, however, takes no account of the deductions necessary for the Public Works Department channels and other works which will diminish the irrigable area. I have taken no account of these deductions in my report or the statements attached to it; they must be made at a subsequent stage when their extent is known.

I should say, however, that a reduction in the net revenue of 4 per cent. would fairly represent the water-rate lost on the lands to be taken up for the canals and channels. Making this deduction, the net income would be Rs. 46,25,480 which gives on a capital outlay of $7\frac{1}{2}$ crores a return of 6.16 per cent.

Should the Board and Government therefore accept my recommendations regarding the irrigable area and the rates of water-rate, there seems a strong probability of the project proving remunerative.

134. *Concluding remarks.*—I can summarize very briefly all the important points which I have tried to make clear in the preceding paragraphs of my report—

(1) I have endeavoured to account completely for all the land I have treated as unirrigable out of the commanded area, the proportion of which is much the same in the delta and in the upland, about 20 per cent. of the area commanded in each case.

I do not think that these exclusions can be materially reduced in extent, or that the Board is very likely to wish to reduce them.

The extents against each village are, however, shown in the village statements submitted, and the fields themselves (except in the case of village zones and extensions) can be identified from my office records, if desired.

Any additions to my unirrigable areas will probably be made, if at all it is thought desirable to have a higher proportion of dry land in each village than my deductions provide for. I do not advocate any further exclusions, but if they are to be made, I have recommended that they should take the form of refusing water to land suited for the growth of fodder crops. Reservations for pasturage, as I have tried to show, it is impossible to make either in delta or upland on any scale sufficient to affect the question of cattle feeding.

(2) I believe that owing to the exhaustion of the pati earth, it will be found necessary in the near future to grow manure crops over all the delta area, and that the same will be the case with the upland when it comes under irrigation. The same applies with even more force to the delta two-crop land. I am in favour of using the reservoir water for this manure crop, and cultivating different areas with second crop wet in successive years in order to allow of proper manuring in alternate seasons.

(3) While seeing no insuperable objection to the introduction of the growth of two wet crops over a moderate percentage of the delta lands, I think that the services the reservoir may render in the matter of supplying water for the manure crops, the tanks growing seedlings, and for the submersible lands requiring particularly early transplantation, are more valuable to the general well-being of the delta than is the supply of water to an increased extent of second crop. I should recommend that the area under second crop should not be allowed to extend beyond what can be supplied with water *after* providing for the purposes indicated above.

(4) There are also two points on which I would suggest that expert enquiry may be worth making, unless the Board already has the information at its disposal.

The first is the manurial value of the Kistna silt (paragraph 88).

The second is the question of whether the general character of the regar clay soils which form about 90 per cent. of the upland area is the same as that of the irrigated clays of the delta tract or resembles that of the tract under the Kurnool-Cuddapah canal, which I believe to have been found unfitted for irrigation (paragraph 100).

(5) I also think that special care should be devoted to the Kolair lake area, the best means of attracting population and temporary labour to the tract, and the gradual sale of the lands in its bed. Also to the question of embanked village roads in the upland area and the Kolair and Peddalanka areas of the delta, particularly the two latter.

(6) Lastly I would draw attention to the question discussed in paragraph 119 of whether it is not possible in fixing the water-rates for the upland tract to raise them with reference to the recent rise in prices.

135. I have throughout my work received every possible assistance from the District staff of the Kistna and Guntur districts.

I must also add a word of commendation on the work of the two Tahsildars attached to me for special duty, M.R.Ry. K. Nageswara Rao Pantulu Garu of the Kistna district and M.R.Ry. V. Ramakrishnayya Pantulu Garu of the Guntur district. Both these officers have worked indefatigably and I have found their experience of the delta and upland of great value.

TALUKWAR abstract of village statement No. I—Upland area.

Statement of village statement No. I—Upland area.									
Serial number of village.	Name of taluk.	Total area commanded.	Particulars of area irrigable.						
			Government, zamindari or whole inam occupied.		Government assessed waste.	Unassessed or poramboke.	Minor inams.		
			Wet.	Dry.			Wet.	Dry.	
1	2	3	4	5	6	7	8	9	
1	Sattenapalle ..	ACS. 128,822-92	ACS. 472-84	ACS. 82,271-83	ACS. 440-74	ACS. 25-17	ACS. 10,318-43	ACS. 24,098-07	
2	Narasaraopet ..	133,991-25	668-92	83,956-49	2,264-05	356-86	..	36,326-18	29,088-08
3	Guntūr ..	291,853-14	2,461-39	178,405-68	386-40	1,006-42	..	32,691-66	1,372-44
4	Bāpatla ..	212,502-21	..	141,781-04	2,696-89	2,582-77	..	..	..
5	Ongole ..	147,865-97	721-85	79,575-60	6,250-77	158-02	..	..	..
6	Tenali ..	10,587-51	..	5,376-82	2-18	..	..	..	..
	Total ..	926,623-00	4,324-70	571,347-46	12,061-03	4,129-18	..	133,924-84	

Serial number of village.	Name of taluk.	Total area irrigable (total of columns 4-9).	Total area unirrigable.	Additional revenue expected.				Dry assessment on unoccupied land coming under occupation.
				Enhancement of water-tax on Government wet land.	Water-rate on Government dry land.	Water-rate on inam or zamindari land.	Enhancement of water-rate on lands in column 13 due to raising of classes of irrigation sources fixed at settlement.	
1	2	10	11	12	13	14	15	16
1	Sattenapalle ..	ACS. 98,558-81	ACS. 35,264-11	RS. A. 312 0	RS. A. 3,78,144 8	RS. A. 87,286 0	..	RS. A. 458 14
2	Narasaraopet ..	111,344-33	22,646-92	425 14	4,20,591 15	1,32,786 2	..	2,943 3
3	Guntūr ..	218,586-92	73,267-22	700 12	8,63,865 2	2,16,761 10	..	5,849 2
4	Bāpatla ..	176,128-78	37,373-43	..	7,18,989 0	1,61,654 15	..	6,407 12
5	Ongole ..	119,897-93	28,468-04	679 7	3,65,083 13	2,28,296 11	..	4,415 13
6	Tenali ..	6,771-44	3,816-07	..	26,995 0	6,872 3	..	51 1
	Total ..	726,787-21	200,835-79	2,118 1	27,73,669 6	8,33,656 9	..	18,126 13

Additional revenue expected—cont.						
Name of taluk.	Total of columns 12-16.	Extent of saleable land.	Probable average selling value per acre.	Probable sale-proceeds.	Revenue on sale-proceeds at 4 per cent.	Grand total (column 17 + column 21).
1	17	18	19	20	21	22
Sattenapalle ..	RS. A. 4,66,201 6	ACS. 422-94	..	RS. A. 8,458 12	RS. A. 338 2	RS. A. 4,66,539 8
Narasaraopet ..	5,56,746 2	2,615-27	..	52,305 5	2,092 5	5,58,838 7
Guntūr ..	10,85,176 10	1,370-72	..	1,54,447 6	6,167 5	10,91,343 15
Bāpatla ..	8,87,051 11	3,273-87	..	1,56,809 3	6,272 6	8,93,324 1
Ongole ..	5,98,475 12	6,354-88	..	1,80,358 5	7,214 10	6,03,690 6
Tenali ..	32,918 4	16-30	..	3,260 0	130 6	34,048 16
Total ..	36,27,569 13	16,053-96	..	5,05,638 15	20,215 2	36,47,784 15

TALUKWAR abstract of village statement No. II—Upland area.

Abstract of Village statements for 1901

Name of taluk.	Village site of each major village and each hamlet separately.	Extension of village site to be provided for.	Dry zone round each village (including extension if any) and round each hamlet separately.	Total of columns 2-4.	Road, path, railway and boundary poramboke.
1	2	3	4	5	6
	ACS.	ACS.	ACS.	ACS.	ACS.
Sattenapalle	1,650-10	505-61	1,593-98	3,749-69	2,997-80
Narasaraopet	1,578-82	747-52	1,513-21	3,869-55	3,789-50
Guntur	4,090-97	2,038-85	3,210-83	9,605-65	9,590-07
Bapatla	2,145-04	1,224-10	2,267-73	5,636-87	8,212-87
Ongole	1,726-70	1,021-95	1,345-06	1,093-71	1,656-75
Tenali	108-39	54-18	91-78	254-35	356-56
Total ..	11,500-02	5,857-21	10,052-59	27,209-82	29,432-55

Name of taluk.	Streams, water-courses and channels.	Tank-beds.	River-beds, islands and lankas.	Other communal poramboke (burial-grounds, straw yards, etc.).	Topes.	Forest reserves.	Hills and high lands.
	7	8	9	10	11	12	13
	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
Sattenapalle	2,613-13	1,987-83	16,417-06	305-36	766-60	63-28	1,295-57
Narasaraopet	4,446-75	3,326-84	..	361-15	1,129-94	..	3,584-79
Guntur	3,405-93	9,470-53	10,708-16	544-48	1,987-15	3,841-37	18,804-25
Bapatla	3,720-76	5,562-87	..	648-16	529-74	..	8,620-32
Ongole	3,538-06	4,800-14	699-04	454-69	865-72	..	7,229-46
Tenali	68-17	129-26	..	8-20	154-31	1,237-17	946-73
Total ..	17,792-80	25,277-47	27,824-26	2,322-04	4,433-46	5,141-82	35,481-12

Name of taluk.	Lands submersible.	Unsuitable soils.	Land reserved for grazing.	Mamul wet.	Already irrigated by delta canals.	Other causes.	Total unirrigable.
	14	15	16	17	18	19	20
	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
Sattenapalle	2,420-12	1,863-77	717-85	66-06	..	..	35,264-11
Narasaraopet	..	1,370-11	744-88	23-41	..	..	22,646-92
Guntur	1,963-47	1,021-31	789-93	113-01	2,541-86	..	73,267-22
Bapatla	480-00	587-56	2,495-28	..	4,227-71	1,621-29	37,373-43
Ongole	304-26	593-05	324-93	37-35	..	861-88	28,468-04
Tenali	..	8-51	..	..	652-81	..	3,816-07
Total ..	4,267-85	5,444-31	5,082-92	239-82	7,402-38	2,483-17	200,835-79

TALUKWAR abstract of village

Name of taluk.	Total area command- ed.	Particulars of area irrigable.						Total area irrigable (total of columns 3-8).	Total area unirri- gable.
		Government, zamindari or whole inam occupied.		Government assessed waste.	Unassessed or poramboke.	Minor inams.			
		Wet.	Dry.			Wet.	Dry.		
1	2	3	4	5	6	7	8	9	10

Ordinary									
	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
Eastern delta—									
Boswada	4,296-62	2,910-70	1-57			970-46	3,982-73	1,813-89	
Nazvid	25,977-03	18,370-37	28-74			4,457-24	22,856-55	3,120-68	
Diri	32,040-22	13,433-23				1,622-88	46,399-07	16,650-16	
Bandar	51,473-76	12,636-49	3,668-13	322-96		411-20	18,014-73	13,459-02	
Gudivada	21,010-01	11,361-40	1,298-91	272-82		785-77	18,024-74	3,015-27	
Ellore	7,129-76	6,080-01	611-51			29-72	6,671-27	458-49	
Total	151,906-40	93,862-20	9,271-87	3,536-55		8,278-27	118,948-89	38,017-51	
Western delta—									
Tenali	13,035-83	10,307-39	24-45	1-97		1,700-63	12,094-44	941-39	
Répalli	26,508-44	9,747-84	2,955-46	2,091-34		1,959-04	16,753-18	3,755-26	
Répatia	12,394-51	8,941-12	1,077-88	335-20		769-85	11,128-56	1,270-96	
Guntur	151-37	70-84				78-49	149-83	2-04	
Total	46,090-75	29,126-69	4,057-29	2,428-51		4,508-01	40,120-50	5,970-25	
Total, both deltas ..	198,057-15	122,988-89	13,329-16	4,965-06		12,786-28	154,069-39	43,987-76	

Short late									
	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
Eastern delta—									
Boswada	50-79	50-79					50-79		
Nazvid	594-25	594-25					594-25		
Diri									
Bandar	80-52	27-72	52-80				80-52		
Gudivada	6,606-30	1,105-22	3,369-94	2,116-29			6,591-45	14-85	
Ellore	328-53	228-53					228-53		
Total	7,660-39	2,106-51	2,422-74	2,116-29			7,645-54	14-85	
Western delta—									
Tenali	542-26	432-11				85-63	517-74	24-64	
Répalli	1,503-49	501-54	426-95	110-16		140-54	1,179-19	324-30	
Répatia	151-68		151-68				151-68		
Guntur									
Total	2,197-53	933-65	578-61	110-16		226-17	1,848-59	348-94	
Total, both deltas ..	9,857-92	3,040-16	4,001-35	2,226-45		226-17	9,494-13	363-79	
Ordinary crop	198,057-15								
Short late crop	9,857-92	122,988-89	13,329-16	4,965-06		12,786-28	154,069-39	43,987-76	
Grand Total	207,915-07	126,029-05	17,330-51	7,191-51		13,012-45	163,563-52	44,351-55	

statement No. I—Delta Extensions.

Additional revenue expected.										
Enhance- ment of water-tax on Govern- ment wet land.	Water-rate on Govern- ment dry land.	Water-rate on inam or Zamindari land.	Enhance- ment of water-rate on lands in col. 15 due to raising of classes of irrigation sources fixed at settle- ment.	Dry assessment on un- occupied land coming under occupation.	Total of columns 11-15.	Extent of saleable land.	Probable average selling value per acre.	Probable sale- proceeds.	Revenue on sale-proceeds at 4 per cent.	Grand total (col. 16 + col. 20).
11	12	13	14	15	16	17	18	19	20	21

crop.										
RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.
3,895 15	10,707 2	..	..	..	14,603 1	..	..	..	..	14,603 1
1,692 0	1,12,610 5	..	..	..	1,14,302 5	..	..	..	..	1,14,302 5
..	2,25,984 0	..	..	..	2,25,984 0	..	..	..	..	2,25,984 0
52,287 8	29,743 13	1,640 2	4,020 8	37,691 15	3,710-83	..	2,32,805 0	9,312 9	1,05,563 6	21,778 12
64,126 6	6,614 9	16,198 3	8,572 10	93,541 12	6,381-58	..	3,00,694 0	12,021 10	..	..
5,690 7	24,011 11	2,071 7	..	31,773 12	..	..	..	..	..	..
1,25,892 4	4,09,701 11	19,909 12	12,593 2	5,87,896 17	10,092-41	..	6,33,399 0	21,334 3	5,89,231 0	..
54,883 4	12,932 5	122 11	33 13	67,972 1	24-21	..	4,800 0	192 0	68,164 1	..
52,070 4	11,529 6	13,085 12	2,471 13	79,157 3	4,190 62	..	1,09,798 1	4,373 15	82,531 2	..
39,724 14	8,763 15	5,262 13	884 8	54,636 2	1,173-64	..	25,912 2	1,036 3	55,672 5	..
746 11	..	..	..	746 11	..	..	..	..	746 11	..
1,47,425 1	33,225 10	18,471 4	3,390 2	2,02,512 1	5,388-47	..	1,40,110 3	5,602 2	2,08,114 3	..
2,78,117 5	4,42,927 5	38,381 0	15,983 4	7,70,408 14	15,480-68	..	6,73,509 8	26,936 5	7,97,345 3	..

crop.										
RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.
203 3	2,847 13	..	..	2,847 12	..	..	..	..	..	203 3
288 1	..	13 11	39 6	341 5	..	..	..	..	..	288 1
19,863 10	5,907 5	6,981 2	32,702 1	4,383-0	1,31,490 0	5,255 0	..	..	..	19,863 10
665 4	932 8	..	1,739 12	..	..	..	..	..	..	665 4
21,020 2	3,780 5	6,063 3	3,970 8	27,834 2	4,383-0	..	1,31,490 0	5,255 0	43,089 2	..
2,411 1	521 10	..	..	2,932 11	..	..	..	..	..	2,411 1
3,640 9	1,326 0	494 10	335 8	5,796 11	199-21	..	3,446 3	138 0	6,234 11	..
495 6	..	151 10	111 2	758 2	..	..	..	..	758 2	..
..	..	..	..	..	..	..	..	..	..	..
6,547 0	1,847 10	646 4	446 10	9,487 8	199-21	..	3,446 3	138 0	9,625 8	..
27,567 2	5,627 15	6,709 7	7,417 2	47,321 10	4,582-21	..	1,34,936 3	5,392 0	52,714 10	..
2,73,117 5	4,42,927 5	38,381 0	15,983 4	7,70,408 14	15,480-88	..	6,73,509 8	26,936 5	7,97,345 3	..
27,567 2	5,627 15	6,709 7	7,417 2	47,321 10	4,582-21	..	1,34,936 3	5,392 0	52,714 10	..
2,00,684 7	4,48,555 4	45,090 7	23,400 6	8,17,730 8	20,063-09	..	8,08,445 6	32,329 5	8,50,069 13	..

TALUKWAR abstract of village

TALUKWAR abstract of village									
Name of taluk.	Village site of each major village and each hamlet separately.	Extension of village site to be provided for.	Dry zone round each village (including extension if any) and round each hamlet separately.	Total of columns 2-4.	Road, path, railway and boundary porambokes.	Streams, water-courses and channels.	Tank-heds.	River-heds, islands and lankas.	
1	2	3	4	5	6	7	8	9	
Eastern delta—	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	Ordinary
Bezwada	143-07	7-20	143-22	293-49	171-90	16-41	30-46	..	
Nusvid	360-63	66-40	364-66	791-49	798-30	680-23	122-37	..	
Divi	1,929-90	15-00	1,549-48	3,494-38	2,648-01	1,501-84	774-98	..	
Bandar	162-86	30-18	127-34	320-38	485-56	404-33	186-79	..	
Gudivada	79-34	..	102-35	181-69	428-91	563-99	192-13	..	
Ellore	28-56	..	1-44	30-00	48-33	158-57	38-39	..	
Total ..	2,704-26	118-78	2,288-39	5,111-43	4,581-01	3,325-27	1,345-06	..	
Western delta—									
Tenali	126-82	60-68	116-57	304-02	326-65	179-52	50-82	..	
Répalli	144-51	24-90	102-99	272-40	191-12	1,075-40	26-34	..	
Bápatla	16-04	3-40	47-22	66-66	73-21	158-42	..	..	
Guntúr	..	..	..	..	2-64	..	..	..	
Total ..	287-37	88-98	266-78	643-08	598-62	1,413-34	86-16	..	
Total, both deltas ..	2,991-63	207-71	2,555-17	5,754-51	5,174-63	4,738-71	1,431-22	..	
Eastern delta—									Short late
Bezwada	..	..	..	..	..	..	..	..	
Nusvid	..	..	..	..	..	..	..	..	
Divi	..	..	..	..	..	..	..	..	
Bandar	..	..	..	..	..	..	..	..	
Gudivada	..	..	..	..	..	..	..	..	
Ellore	..	..	..	..	..	..	..	..	
Total ..	..	..	..	..	..	14-85	..	..	
Western delta—									
Tenali	13-12	..	0-35	12-47	11-17	..	..	..	
Répalli	1-06	..	12-54	13-60	22-41	..	..	..	
Bápatla	..	..	..	..	..	..	..	..	
Guntúr	..	..	..	..	..	..	..	..	
Total ..	14-18	..	12-89	27-07	33-58	237-16	24-34	..	
Total, both deltas ..	14-18	..	12-89	27-07	33-58	237-16	24-34	..	
Ordinary crop	2,991-63	207-71	2,555-17	5,754-51	5,174-63	4,738-71	1,431-22	..	
Short late crop	14-18	..	12-89	27-07	33-58	252-01	24-34	..	
Grand Total ..	3,006-81	207-71	2,568-06	5,781-58	5,208-21	4,990-72	1,455-56	..	

statement No. II—Delta Extensions.

[illegible]

Enclosure to

ABSTRACT of gross

Name of taluk.	Ryotwari land.				Zamindari land.		
	Wet.	Dry.	Assessed waste.	Poramboke.	Wet.	Dry.	Poramboke.
1	2	3	4	5	6	7	8
Sattenapalle ..	ACS.	ACS.	ACS.	ACS.	(Up		
Narasaraopet ..	472-64	75,176-60	440-74	11-59	ACS.	ACS.	
Guntur ..	668-92	81,497-65	2,284-05	366-80	..	..	
Bapatla ..	2,461-29	171,382-44	386-40	1,006-42	..	..	
Ongole ..	721-85	138,518-11	2,696-89	2,582-77	..	..	
Tenali ..	..	66,607-05	6,250-77	158-02	..	..	
Total ..	4,324-70	538,559-47	12,061-03	4,115-60	..	8,009-10	..
Bezawada ..	..	..	..	..	..	8,009-10	..
Nusvid ..	..	..	..	..	..	..	..
Divi ..	..	871-79	..	1-57	..	1,076-72	..
Bandar ..	..	..	..	..	..	12,570-20	28-74
Gudivada ..	..	7,206-89	3,720-93	..	..	43,401-85	322-96
Ellore ..	..	11,924-55	8,978-68	1,110-72	..	4,369-09	88-89
Tenali ..	..	2,122-00	..	2,389-12	..	..	..
Bapalli ..	..	9,856-41	24-45	1-97	..	4,104-71	611-54
Bapatla ..	..	9,889-41	3,882-41	2,091-34	..	..	..
Guntur ..	..	7,937-52	1,229-04	335-20	..	..	..
Total ..	..	70-84	..	..	..	..	..
Upland total ..	..	49,879-41	17,230-51	5,929-92	..	65,522-57	1,052-13
Delta total ..	4,324-70	538,559-47	12,061-03	4,115-60	..	8,009-10	1,052-13
Grand Total ..	4,324-70	538,438-88	29,391-54	10,045-52	..	73,531-67	1,052-13

Statement No. I.
area irrigable.

Whole inam.			Minor inams.						Grand Total.
Wet.	Dry.	Poramboke.	In Government villages.		In zamindari villages.		In whole inam villages.		
			Wet.	Dry.	Wet.	Dry.	Wet.	Dry.	
9	10	11	12	13	14	15	16	17	18
land.)									
..	ACS.	ACS.	..	ACS.	..	..	..	ACS.	ACS.
..	7,095-23	13-58	..	9,072-35	..	..	..	1,276-08	93,558-81
..	2,158-94	..	..	23,953-41	..	..	..	144-66	111,344-33
..	7,023-24	..	..	36,083-84	..	..	..	242-29	218,585-92
..	3,242-98	..	..	29,017-58	..	..	..	70-50	176,128-78
..	4,958-55	..	..	31,228-81	..	961-45	..	501-93	119,397-93
..	..	..	..	1,372-44	..	..	..	..	6,771-44
..	24,778-89	13-58	..	130,727-93	..	961-45	..	2,235-46	725,787-21
ta.)									
..	112-98	..	..	..	..	..	..	..	3,033-52
..	6,394-42	..	..	448-21	..	522-25	..	639-33	23,450-60
..	51-38	..	..	..	..	3,817-91	..	..	45,399-07
..	1,088-28	99-30	..	..	..	1,622-88	..	..	18,095-25
..	542-07	..	..	179-09	..	232-11	..	33-02	24,616-19
..	181-83	..	..	753-75	..	..	..	4-07	6,999-80
..	943-09	..	..	..	..	..	..	6-30	12,612-18
..	359-47	110-16	..	1,779-96	..	25-65	..	23-88	17,932-37
..	1,003-60	..	..	2,075-70	..	..	..	5-35	11,275-21
..	..	..	..	764-50	..	..	..	..	149-33
..	..	..	..	78-49	..	..	..	..	..
..	10,627-07	209-46	..	6,079-70	..	6,220-80	..	711-95	163,563-52
..	24,778-89	13-58	..	..	..	..	..	..	725,787-21
..	10,627-07	209-46	..	130,727-93	..	961-45	..	2,235-46	163,563-52
..	35,405-96	223-04	..	6,079-70	..	6,220-80	..	711-95	889,350-73
..	..	..	..	136,807-63	..	7,182-25	..	2,947-41	..

STATEMENT No. III-A.—Statement showing the surveyed land on the borders

Serial number of village.	Taluk number of village.	Name of village.	Area irrigable.		Revenue expected.		
			Patta land.	—	Total of columns 4 and 5.	Differential water-rate on Government lands under a first-class delta water source.	Water-rate at Rs. 5 per acre on the zamindari land.
1	2	3	4	5	6	7	8
ELLORE TALUK.							
<i>Government villages.</i>							
1	1	Kaikaram ..	ACS.	ACS.	ACS.	RS. A.	RS. A.
2	2	Pulla ..	482-13	17-88	500-01	1,875 1	..
3	96	Bhimadola ..	958-18	790-20	1,757-38	6,150 13	..
4	99	Potumarru ..	357-57	10-60	368-17	1,380 10	..
5	107	Dosapad ..	2,980-32	38-92	3,019-24	10,567 5	..
6	108	Kovvali ..	604-64	106-20	710-84	2,491 9	..
7	109	Chataparru ..	1,039-00	..	1,039-00	3,805 6	..
8	110	Jalipudi ..	374-86	..	374-86	1,315 9	..
9	111	Katrapudi ..	389-03	..	389-03	1,458 14	..
10	112	Madepalli ..	28-96	..	28-96	108 9	..
11	113	Ponangi ..	262-20	..	262-20	1,358 0	..
12	115	Mupparra ..	780-33	..	780-33	4,037 1	..
13	116	Pedapadu ..	303-40	281-90	585-30	1,336 11	..
			351-06	53-06	404-12	1,228 12	..
		Total ..	9,011-68	1,307-76	10,319-44	37,114 4	..
<i>Zamindari villages.</i>							
14	125	Amabarupeta ..	..	..	..	..	..
15	138	Sathyaroolu ..	781-22	..	781-22	..	3,906 2
16	139	Koniki ..	414-48	..	414-48	..	2,072 6
		Total ..	417-95	..	417-95	..	2,089 12
			1,613-65	..	1,613-65	..	8,068 4
GUDIVADA TALUK.							
<i>Government villages.</i>							
17	171	Ilaparru ..	81-39	156-66	238-05	1,230 12	..
18	170	Polukonda ..	8-10	181-41	189-51	900 2	..
19	176	Mudutanapad ..	..	42-09	42-09	199 15	..
20	197	Siddapuram ..	248-57	..	248-57	1,221 8	..
		Total ..	338-06	380-16	718-22	3,552 5	..
		Total, Government ..	9,349-74	1,687-92	11,037-66	40,668 9	..
		Total, Zamindari ..	1,613-65	..	1,613-65	..	8,068 4
		Grand Total ..	10,963-39	1,687-92	12,651-31	40,668 9	8,068 4

of Kolair lake now liable to submersion and fit for raising a short late crop.

Serial number of village.	Taluk number of village.	Name of village.	Revenue expected—cont.		Extent of salesable land.	Average sale price per acre.	Total sale value.	Revenue on column 13 at 4 per cent.	Grand total of revenue (columns 10 and 14).
			Dry assessment on area in column 6.	Total of columns 7, 8 and 9.					
9	10	11	12	13	14	15			
ELLORE TALUK.									
<i>Government villages.</i>									
1	1	Kaikaram ..	RS. A.	RS. A.	ACS.	RS. A.	RS. A.	RS. A.	RS. A.
2	2	Pulla ..	22 6	1,897 7	17-88	75 0	1,341 0	53 10	1,951 1
3	96	Bhimadola ..	799 3	6,950 0	799-20	75 0	59,340 0	2,397 10	9,347 10
4	99	Potumarru ..	13 4	1,393 14	10-60	75 0	795 0	31 13	1,426 11
5	107	Dosapad ..	38 15	10,606 4	38-92	75 0	2,919 0	116 12	10,723 0
6	108	Kovvali ..	106 3	2,597 12	106-20	75 0	7,965 0	318 10	2,916 6
7	109	Chataparru ..	..	3,805 6	..	..	..	..	3,805 6
8	110	Jalipudi ..	..	1,315 9	..	..	..	..	1,315 9
9	111	Katrapudi ..	..	1,458 14	..	..	..	..	1,458 14
10	112	Madepalli ..	..	108 9	..	..	..	..	108 9
11	113	Ponangi ..	..	1,358 0	..	..	..	..	1,358 0
12	115	Mupparra ..	360 4	4,397 5	281-90	75 0	21,142 8	845 11	5,243 0
13	116	Pedapadu ..	66 6	1,403 1	53-06	75 0	3,979 8	159 3	1,562 4
		Total ..	1,406 9	38,620 13	1,307-76	..	98,082 0	3,923 5	42,444 2
<i>Zamindari villages.</i>									
14	125	Amabarupeta ..	..	3,906 2	..	..	..	..	3,906 2
15	138	Sathyaroolu ..	..	2,072 6	..	..	..	..	2,072 6
16	139	Koniki ..	..	2,089 12	..	..	..	..	2,089 12
		Total ..	..	8,068 4	..	..	..	..	8,068 4
GUDIVADA TALUK.									
<i>Government villages.</i>									
17	171	Ilaparru ..	195 13	1,426 9	156-66	75 0	11,749 8	470 0	1,896 9
18	170	Polukonda ..	226 13	1,126 15	181-41	75 0	18,605 12	544 3	1,671 2
19	176	Mudutanapad ..	52 10	252 9	42-09	75 0	3,156 1	126 4	378 13
20	197	Siddapuram ..	..	1,221 8	..	..	..	..	1,221 8
		Total ..	475 4	4,027 9	380-16	..	28,512 0	1,140 7	5,168 0
		Total, Government ..	1,881 13	42,548 6	1,687-92	..	1,26,594 0	5,063 12	47,612 2
		Total, Zamindari ..	..	8,068 4	..	..	..	..	8,068 4
		Grand Total ..	1,881 13	50,616 10	1,687-92	..	1,26,594 0	5,063 12	55,680 6

STATEMENT No. III-B.—Statement showing the unsurveyed areas in the Kolair lake and the revenue thereon.

Unsurveyed area of the Kolair lake to be cultivated with short late crop. (Area calculated as explained in paragraph 68 of report.)	Area deducted as already cultivated with short late crop.	Net area, column 1-2.	Water-rate at Rs. 4-12-0 per acre, the project rate on land on column 3.	Enhanced water-rate on the extent in column 2, by the adoption of the project rate of Rs. 4-12-0 per acre (vide enclosure to this statement).	Dry assessment on the extent in column 3.
1	2	3	4	5	6
ACS.	ACS.	ACS.	RS. A.	RS. A.	RS. A.
72,000	9,358-00	62,642-00	2,97,649 8	12,765 0	78,302 8
Total of columns 4, 5 and 6.	Extent of saleable land after deducting 5 per cent. (vide paragraph 113 of the report).	Average sale price per acre (vide paragraph 77 of the report).	Total sale value.	Revenue on sale value at 4 per cent.	Grand total of columns 7 and 11.
7	8	9	10	11	12
RS. A.	ACS.	RS. A.	RS. A.	RS. A.	RS. A.
3,88,617 0	68,400-00	75 0	51,30,000 0	2,05,200 0	6,93,817 0

ENCLOSURE showing sources of irrigation and water-rates already levied on lands shown in column 2 of Statement No. III-B.

Sources of irrigation.	Extent.	Water-rates imposed.	Water-rate at Rs. 4-12-0 per acre (project rate).	Difference between columns 4 and 3 (column 5 of Statement III-B).
1	2	3	4	5
	ACS.	Rates.	RS. A.	RS. A.
Goddavari canals	3,268-82	From Rs. 5 to Rs. 2 per acre.	13,413 8	
Kistna canals	131-65	From Rs. 3-4-0 to Rs. 2-12-0 per acre.	382 4	2,087 4
Kolair water	5,962-71	Rs. 3 per acre ..	17,888 2	248 1
Total	9,357-68		31,683 14	10,434 12
			44,448 15	12,765 1

STATEMENT No. IV.—Total revenue from the project under all heads.

Total Revenue from the project under an heads.								
Area.	Season.	Area irrigable.	Revenue expected.					Remarks.
			Direct revenue.	Indirect revenue.			Total revenue, column 4 + column 5 (c).	
				Dry assessment on waste lands.	Revenue from sale-proceeds.	Total.		
1	2	3	4	5 (a)	5 (b)	5 (c)	6	7
Upland	First crop ..	ACS. 725,787	RS. 36,09,444	RS. 18,126	RS. 20,215	RS. 38,340	RS. 36,47,784	Vide column 24 of Statement No. I. Do. do. Twenty-four per cent. of ordinary crop area. Rate Rs. 3-8 per acre—vide paragraph 117 of report. Vide column 15 of Statement No. III-A. Vide column 12 of Statement No. III-B. Vide column 24 of Statement No. I.
Delta .. {	Do. ..	154,069	7,54,425	15,983	26,937	42,920	7,97,345	
	Second crop ..	204,000	7,14,000	..	..	..	7,14,000	
Kolair surveyed. area	Short late crop.	12,651	48,735	1,882	5,063	6,945	55,680	
Kolair area unsurveyed.	Do.	72,000	3,10,314	78,302	2,05,201	2,83,503	5,92,317	
Other areas ..	Do.	9,494	29,904	7,417	5,393	12,810	52,714	
Total revenue ..			54,76,822	1,21,709	2,62,809	3,84,518	58,61,340	
Total area .. {	First crop ..	879,856						
	Second crop ..	204,000						
	Short late crop.	94,145						

STATEMENT No. V showing consolidated figures for revenue development of all lands under the Kistna Reservoir Project.

Year.	Irrigated area at the end of the year.	Revenue receipts and charges.					
		Gross revenue due to works.			Charges—both direct and indirect—against Revenue account.	Net revenue due to works.	
		Direct receipts.	Enhanced land revenue or indirect revenue.	Total.		Including enhanced land revenue.	Excluding enhanced land revenue.
1	2	3	4	5	6	7	8
1st year after completion.	ACS.	RS.	RS.	RS.	RS.	RS.	RS.
2nd do.	..	..	..	..	..	..	..
3rd do.	..	..	..	..	..	..	..
4th do.	..	..	..	..	..	..	..
5th do.	..	..	..	..	..	..	..
6th do.	15,400	75,400	4,300	79,700	15,535	64,165	59,865
7th do.	30,800	1,50,800	8,600	1,59,400	31,070	1,28,330	1,19,730
8th do.	66,074	3,00,400	33,100	3,33,500	66,030	2,77,470	2,44,370
9th do.	101,348	4,50,000	57,600	5,07,600	80,990	4,26,610	3,69,010
10th do.	138,622	5,99,600	82,100	6,81,700	1,05,950	5,75,750	4,93,650
11th do.	171,896	7,49,200	1,06,600	8,55,800	1,30,910	7,24,890	6,18,290
12th do.	207,170	8,98,800	1,31,100	10,29,900	1,65,870	8,74,030	7,42,930
13th do.	278,694	12,28,400	1,57,600	13,86,000	2,17,113	11,68,787	10,11,287
14th do.	350,218	15,58,000	1,83,900	17,41,900	2,73,355	14,68,545	12,79,645
15th do.	421,742	18,87,600	2,10,300	20,97,900	3,38,598	17,59,302	15,49,002
16th do.	477,866	21,41,800	2,32,400	23,74,200	3,85,305	19,88,895	17,56,495
17th do.	533,990	23,96,000	2,54,500	26,50,500	4,31,013	22,19,487	19,64,987
18th do.	590,114	26,50,200	2,76,600	29,26,800	4,76,720	24,50,080	21,73,480
19th do.	646,238	29,04,400	2,98,700	32,03,100	5,22,428	26,80,672	23,81,972
20th do.	702,362	31,58,600	3,20,800	34,79,400	5,68,135	29,11,265	26,90,465
21st do.	758,486	34,12,800	3,42,900	37,55,700	6,13,843	31,41,857	27,98,957
22nd do.	814,610	36,67,000	3,65,000	40,32,000	6,59,550	33,72,450	30,07,450
23rd do.	860,860	38,47,000	3,86,900	42,33,900	6,95,553	35,18,067	31,51,167
24th do.	887,110	40,27,000	3,68,800	43,95,800	7,32,115	36,63,685	32,94,585
25th do.	923,360	42,07,000	3,70,700	45,77,700	7,68,398	38,09,302	34,38,602
26th do.	959,610	43,87,000	3,72,600	47,59,600	8,04,680	39,54,920	35,82,320
27th do.	995,860	45,67,000	3,74,500	49,41,500	8,40,963	41,00,537	37,26,037
28th do.	1,032,110	47,47,000	3,76,400	51,23,400	8,77,245	42,46,155	38,69,755
29th do.	1,068,360	49,27,000	3,78,300	53,05,300	9,13,528	43,91,772	40,13,472
30th do.	1,104,610	51,07,000	3,80,200	54,87,200	9,49,810	45,37,390	41,57,190
31st do.	1,140,860	52,87,000	3,82,100	56,69,100	9,86,093	46,83,007	43,00,907
	1,177,110	54,67,000	3,84,000	58,51,000	10,22,375	48,28,625	44,44,625

STATEMENT No. V-A showing revenue development—Upland area (commences 12th year, completes 31st year).

Year.	Irrigated area at the end of the year.	Revenue receipts and charges.					
		Gross revenue due to works.			Charges—both direct and indirect—against Revenue account.		Net revenue due to works.
		Direct receipts.	Enhanced land revenue or indirect revenue.	Total.	Including enhanced land revenue.	Excluding enhanced land revenue.	
1	2	3	4	5	6	7	8
1st year after completion.	ACS.	RS.	RS.	RS.	RS.	RS.	RS.
2nd do.	..	..	..	..	..	..	..
3rd do.	..	..	..	..	..	..	..
4th do.	..	..	..	..	..	..	..
5th do.	..	..	..	..	..	..	..
6th do.	..	..	..	..	..	..	..
7th do.	..	..	..	..	..	..	..
8th do.	..	..	..	..	..	..	..
9th do.	..	..	..	..	..	..	..
10th do.	..	..	..	..	..	..	..
11th do.	..	..	..	..	..	..	..
12th do.	36,250	1,80,000	1,900	1,81,900	36,283	1,45,617	1,43,717
13th do.	72,500	3,60,000	8,800	3,68,800	72,565	2,91,235	2,87,435
14th do.	108,750	5,40,000	5,700	5,45,700	1,08,848	4,36,852	4,31,152
15th do.	145,000	7,20,000	7,600	7,27,600	1,45,180	5,82,420	5,74,870
16th do.	181,250	9,00,000	9,500	9,09,500	1,81,413	7,28,087	7,18,587
17th do.	217,500	10,80,000	11,400	10,91,400	2,17,695	8,78,705	8,62,805
18th do.	253,750	12,60,000	13,300	12,73,300	2,53,978	10,19,322	10,06,022
19th do.	290,000	14,40,000	15,200	14,55,200	2,90,260	11,64,040	11,49,740
20th do.	326,250	16,20,000	17,100	16,37,100	3,26,543	13,10,557	12,93,457
21st do.	362,500	18,00,000	18,000	18,18,000	3,62,825	14,56,175	14,37,175
22nd do.	398,750	19,80,000	20,900	20,00,900	3,99,108	16,01,792	15,80,892
23rd do.	435,000	21,60,000	22,800	21,82,800	4,35,390	17,47,410	17,24,610
24th do.	471,250	23,40,000	24,700	23,64,700	4,71,673	18,93,027	18,68,327
25th do.	507,500	25,20,000	25,600	25,45,600	5,07,955	20,38,645	20,12,045
26th do.	543,750	27,00,000	26,500	27,26,500	5,44,238	21,84,262	21,55,762
27th do.	580,000	28,80,000	30,400	29,10,400	5,80,520	23,29,880	22,99,480
28th do.	616,250	30,60,000	32,300	30,92,300	6,16,803	24,75,497	24,43,197
29th do.	652,500	32,40,000	34,200	32,74,200	6,53,085	26,21,155	25,86,915
30th do.	688,750	34,20,000	36,100	34,56,100	6,89,368	27,66,213	27,30,682
31st do.	725,000	36,00,000	38,000	36,38,000	7,25,650	29,12,370	28,74,350

STATEMENT No. V-B showing revenue development—Delta area (commences 5th year, completes 14th year).

Year.	Irrigated area at the end of the year.	Revenue receipts and charges.					
		Gross revenue due to works.			Charges—both direct and indirect—against Revenue account.	Net revenue due to works.	
		Direct receipts.	Enhanced land revenue or indirect revenue.	Total.		Including enhanced land revenue.	Excluding enhanced land revenue.
1	2	3	4	5	6	7	8
		ACS.	RS.	RS.	RS.	RS.	RS.
1st year after completion.	..	..	..	..	..	..	..
2nd do.	..	..	..	..	..	..	..
3rd do.	..	..	..	..	..	..	..
4th do.	15,400	75,400	4,300	79,700	15,535	64,165	59,855
5th do.	30,800	1,50,800	8,600	1,59,400	31,070	1,28,330	1,19,730
6th do.	46,200	2,26,200	12,900	2,39,100	46,605	1,92,495	1,79,595
7th do.	61,600	3,01,600	17,200	3,18,800	62,140	2,56,660	2,39,460
8th do.	77,000	3,77,000	21,600	3,98,600	77,675	3,20,925	2,99,325
9th do.	92,400	4,52,400	25,800	4,78,200	93,210	3,84,990	3,59,190
10th do.	107,800	5,27,800	30,100	5,57,900	1,08,745	4,49,155	4,19,055
11th do.	123,200	6,03,200	34,400	6,37,600	1,24,280	5,13,320	4,78,920
12th do.	138,600	6,78,600	38,700	7,17,300	1,39,815	5,77,485	5,38,785
13th do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
14th do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
15th do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
16th do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
17th do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
18th do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
19th do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
20th do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
21st do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
22nd do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
23rd do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
24th do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
25th do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
26th do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
27th do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
28th do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
29th do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
30th do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650
31st do.	154,000	7,54,000	43,000	7,97,000	1,55,350	6,41,650	5,98,650

STATEMENT No. V-C showing revenue development—Second-crop area (commences 7th year and completes 21st year).

Second-crop area (commences 7th year and completes 21st year).							
Year.	Irrigated area at the end of the year.	Revenue receipts and charges.					
		Gross revenue due to works.			Charges—both direct and indirect—against Revenue account.	Net revenue due to works.	
		Direct receipts.	Enhanced land revenue or indirect revenue.	Total.		Including enhanced land revenue.	Excluding enhanced land revenue.
1	2	3	4	5	6	7	8
1st year after completion.	ACS.	RS.		RS.	RS.		
2nd do.	..	..	..	..	..	..	..
3rd do.	..	..	..	..	..	..	..
4th do.	..	..	..	..	..	..	..
5th do.	..	..	..	..	..	..	..
6th do.	..	..	..	..	..	..	..
7th do.	..	..	..	..	..	..	..
8th do.	13,600	47,600	..	..	..	..	..
9th do.	27,200	95,200	..	..	..	..	..
10th do.	40,800	1,42,800	..	47,600	..	..	..
11th do.	54,400	1,90,400	..	95,200	2,380	45,220	45,220
12th do.	68,000	2,38,000	..	1,42,800	4,760	90,440	90,440
13th do.	81,600	2,85,600	..	1,90,400	7,140	1,35,680	1,35,680
14th do.	95,200	3,33,200	..	2,38,000	9,520	1,80,880	1,80,880
15th do.	108,800	3,80,800	..	2,85,600	11,900	2,26,100	2,26,100
16th do.	122,400	4,28,400	..	3,33,200	14,280	2,71,320	2,71,320
17th do.	136,000	4,76,000	..	3,80,800	16,660	3,16,540	3,16,540
18th do.	149,600	5,22,600	..	4,28,400	19,040	3,61,780	3,61,780
19th do.	163,200	5,69,200	..	4,76,000	21,420	4,06,980	4,06,980
20th do.	176,800	6,15,800	..	5,23,600	23,800	4,52,200	4,52,200
21st do.	190,400	6,62,400	..	5,71,200	26,180	4,97,420	4,97,420
22nd do.	204,000	7,09,000	..	6,18,800	28,560	5,42,640	5,42,640
23rd do.	204,000	7,14,000	..	6,66,400	30,940	5,87,860	5,87,860
24th do.	204,000	7,14,000	..	7,14,000	33,320	6,33,080	6,33,080
25th do.	204,000	7,14,000	..	7,14,000	35,700	6,78,300	6,78,300
26th do.	204,000	7,14,000	..	7,14,000	35,700	6,78,300	6,78,300
27th do.	204,000	7,14,000	..	7,14,000	35,700	6,78,300	6,78,300
28th do.	204,000	7,14,000	..	7,14,000	35,700	6,78,300	6,78,300
29th do.	204,000	7,14,000	..	7,14,000	35,700	6,78,300	6,78,300
30th do.	204,000	7,14,000	..	7,14,000	35,700	6,78,300	6,78,300
31st do.	204,000	7,14,000	..	7,14,000	35,700	6,78,300	6,78,300

STATEMENT No. V-D showing revenue development—Short late crop area (commences 7th year and completes 21st year)

Year.	Irrigated area at the end of the year.	Revenue receipts and charges.					
		Gross revenue due to works.			Charges both direct and indirect against revenue account.	Net revenue due to works.	
		Direct receipts.	Enhanced land revenue or indirect revenue.	Total.		Including enhanced land revenue.	Excluding enhanced land revenue.
1	2	3	4	5	6	7	8
1st year after completion.	ACS.	RS.	RS.	RS.	RS.	RS.	RS.
2nd do.	..	..	..	..	..	..	..
3rd do.	..	..	..	..	..	..	..
4th do.	..	..	..	..	..	..	..
5th do.	..	..	..	..	..	..	..
6th do.	..	..	..	..	..	..	..
7th do.	6,274	26,600	20,200	46,800	7,045	39,755	19,555
8th do.	12,548	53,200	40,400	93,600	14,090	79,510	39,110
9th do.	18,822	79,800	60,600	1,40,400	21,135	1,19,265	58,665
10th do.	25,096	1,06,400	80,800	1,87,200	28,180	1,59,020	78,220
11th do.	31,370	1,33,000	1,01,000	2,34,000	35,225	1,98,775	97,775
12th do.	37,644	1,59,600	1,21,200	2,80,800	42,270	2,38,530	1,17,330
13th do.	43,918	1,86,200	1,41,400	3,27,600	49,315	2,78,285	1,36,885
14th do.	50,192	2,12,800	1,61,600	3,74,400	56,360	3,18,040	1,56,440
15th do.	56,466	2,39,400	1,81,800	4,21,200	63,405	3,57,795	1,75,995
16th do.	62,740	2,66,000	2,02,000	4,68,000	70,450	3,97,550	1,95,550
17th do.	69,014	2,92,600	2,22,200	5,14,800	77,495	4,37,305	2,15,105
18th do.	75,288	3,19,200	2,42,400	5,61,600	84,540	4,77,060	2,34,660
19th do.	81,562	3,46,800	2,62,600	6,08,400	91,585	5,16,815	2,54,215
20th do.	87,836	3,72,400	2,82,800	6,55,200	98,630	5,56,570	2,73,770
21st do.	94,110	3,99,000	3,03,000	7,02,000	1,05,675	5,96,325	2,93,325
22nd do.	94,110	3,99,000	3,03,000	7,02,000	1,05,675	5,96,325	2,93,325
23rd do.	94,110	3,99,000	3,03,000	7,02,000	1,05,675	5,96,325	2,93,325
24th do.	94,110	3,99,000	3,03,000	7,02,000	1,05,675	5,96,325	2,93,325
25th do.	94,110	3,99,000	3,03,000	7,02,000	1,05,675	5,96,325	2,93,325
26th do.	94,110	3,99,000	3,03,000	7,02,000	1,05,675	5,96,325	2,93,325
27th do.	94,110	3,99,000	3,03,000	7,02,000	1,05,675	5,96,325	2,93,325
28th do.	94,110	3,99,000	3,03,000	7,02,000	1,05,675	5,96,325	2,93,325
29th do.	94,110	3,99,000	3,03,000	7,02,000	1,05,675	5,96,325	2,93,325
30th do.	94,110	3,99,000	3,03,000	7,02,000	1,05,675	5,96,325	2,93,325
31st do.	94,110	3,99,000	3,03,000	7,02,000	1,05,675	5,96,325	2,93,325

STATEMENT No. VI-A.—Particulars of soils in Government villages—Upland areas
(wholly commanded villages only).

Number.	Name of taluk.	Highly alluvial.				
		Sort 1.	Sort 2.	Sort 3.	Sort 4.	Total.
		3	4	5	6	7
1	Guntūr	ACS. 1,882-86	ACS. 5,606-88	ACS. 1,961-93	ACS. 118-11	ACS. 9,469-78
2	Sattenapalli	157-58	770-76	136-66	..	1,064-99
3	Narasaraopet	..	..	..	..	..
4	Bapatla	..	..	..	..	..
5	Ongole	..	..	..	..	..
	Total ..	2,040-44	6,277-59	2,098-58	118-11	10,534-72

Number.	Name of taluk.	Permanently improved.				
		Sort 1.	Sort 2.	Sort 3.	Sort 4.	Total.
		8	9	10	11	12
1	Guntūr	ACS. 1,086-83	ACS. 767-22	ACS. 120-08	..	ACS. 1,974-21
2	Sattenapalli	113-25	201-37	..	..	404-62
3	Narasaraopet	155-51	148-10	..	..	303-61
4	Bapatla	331-94	399-68	..	..	731-62
5	Ongole	..	..	..	..	49-91
	Total ..	1,687-53	1,606-47	120-08	..	3,463-97

Number.	Name of taluk.	Regar clay.				
		Sort 1.	Sort 2.	Sort 3.	Sort 4.	Total.
		13	14	15	16	17
1	Guntūr	ACS. 63,378-80	ACS. 82,368-60	ACS. 14,212-18	..	ACS. 159,959-58
2	Sattenapalli	25,479-35	13,625-08	1,419-42	..	40,523-85
3	Narasaraopet	27,292-24	23,326-43	2,699-45	..	53,318-12
4	Bapatla	65,160-70	45,202-77	6,625-80	..	116,989-27
5	Ongole	..	..	..	..	40,776-38
	Total ..	181,311-09	164,522-88	24,956-85	..	411,567-20

Number.	Name of taluk.	Regar loam.				
		Sort 1.	Sort 2.	Sort 3.	Sort 4.	Total.
		18	19	20	21	22
1	Guntūr	ACS. 6,040-32	ACS. 2,776-20	ACS. 701-44	..	ACS. 9,517-96
2	Sattenapalli	5,192-66	2,031-68	144-17	..	7,368-41
3	Narasaraopet	2,953-97	1,285-43	355-81	..	4,546-21
4	Bapatla	527-22	552-21	199-20	..	1,278-63
5	Ongole	..	..	..	..	6,968-70
	Total ..	14,714-17	6,595-42	1,400-62	..	29,673-91

Number.	Name of taluk.	Regar sand.				
		Sort 1.	Sort 2.	Sort 3.	Sort 4.	Total.
		24	25	26	27	28
1	Guntūr	ACS. 1,644-61	ACS. 102-53	..	..	ACS. 1,747-14
2	Sattenapalli	..	..	..	..	454-68
3	Narasaraopet	405-69	48-99	..	..	27-08
4	Bapatla	..	27-08	..	..	2,055-26
5	Ongole	..	..	..	..	..
	Total ..	2,050-30	178-60	..	..	4,284-16

General Note.—The part commanded villages do not differ materially in soil from the wholly commanded villages for which figures are given above.

The Ongole taluk figures are taken from the old settlement and the actual classification is "black clay," "black loam," and "black sand."

Statement No. VI-A.—Particulars of soils in Government villages—Upland areas
(wholly commanded villages only)—cont.

Number.	Name of taluk.	Regar sand.				
		Sort 1.	Sort 2.	Sort 3.	Sort 4.	Total.
		24	25	26	27	28
1	Guntūr	ACS. 1,644-61	ACS. 102-53	..	..	ACS. 1,747-14
2	Sattenapalli	..	..	..	..	454-68
3	Narasaraopet	405-69	48-99	..	..	27-08
4	Bapatla	..	27-08	..	..	2,055-26
5	Ongole	..	..	..	..	..
	Total ..	2,050-30	178-60	..	..	4,284-16

Number.	Name of taluk.	Red loam.				
		Sort 1.	Sort 2.	Sort 3.	Sort 4.	Total.
		29	30	31	32	33
1	Guntūr	ACS. 3,421-54	ACS. 1,982-37	..	..	ACS. 5,403-91
2	Sattenapalli	982-64	22-0	..	..	1,004-64
3	Narasaraopet	182-70	7-95	..	..	190-65
4	Bapatla	..	116-70	..	..	116-70
5	Ongole	..	..	..	..	327-50
	Total ..	4,586-88	2,129-02	..	..	7,013-40

Number.	Name of taluk.	Red sand.				
		Sort 1.	Sort 2.	Sort 3.	Sort 4.	Total.
		34	35	36	37	38
1	Guntūr	ACS. 975-10	ACS. 184-29	..	..	ACS. 1,159-39
2	Sattenapalli	..	..	..	..	..
3	Narasaraopet	..	..	..	..	..
4	Bapatla	..	..	..	..	141-98
5	Ongole	..	..	..	..	..
	Total ..	975-10	184-29	..	..	1,301-37

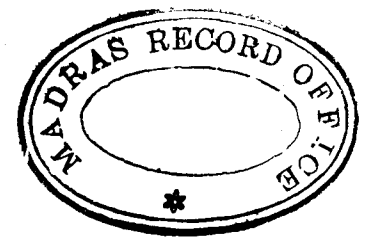
Number.	Name of taluk.	Arenaceous loam.				
		Sort 1.	Sort 2.	Sort 3.	Total.	Grand Total.
		39	40	41	42	43
1	Guntūr	..	..	..	..	ACS. 189,237-55
2	Sattenapalli	..	..	..	..	50,453-88
3	Narasaraopet	..	..	..	..	58,830-17
4	Bapatla	..	..	..	..	119,143-30
5	Ongole	..	..	..	..	50,314-73
	Total ..	..	..	..	..	467,979-63

STATEMENT No. VI-B.—Particulars of soils in delta areas.

No.	Name of delta.	Highly alluvial.					
		Sort 1.	Sort 2.	Sort 3.	Sort 4.	Sort 5.	Total.
1	2	3	4	5	6	7	8
1	Western delta	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
2	Eastern do.	4,205.52	2,894.47	4,768.97	3,016.04	249.06	14,934.06
	Grand Total	4,205.52	2,894.78	5,313.95	3,560.96	307.32	16,282.53
No.	Name of delta.	Regar clay.					
		Sort 1.	Sort 2.	Sort 3.	Sort 4.	Sort 5.	Total.
1	2	9	10	11	12	13	14
1	Western delta	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
2	Eastern do.	203.45	2,072.64	959.74	1,091.41	918.77	5,246.01
	Grand Total	203.45	1,916.69	5,992.42	9,478.84	1,150.69	18,605.40
No.	Name of delta.	Regar loam.					
		Sort 1.	Sort 2.	Sort 3.	Sort 4.	Sort 5.	Total.
1	2	15	16	17	18	19	20
1	Western delta	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
2	Eastern do.	162.24	407.11	252.26	75.65	657.60	897.26
	Grand Total	162.24	407.11	343.10	961.42	657.60	1,967.87
No.	Name of delta.	Regar sand.					
		Sort 1.	Sort 2.	Sort 3.	Sort 4.	Sort 5.	Total.
1	2	21	22	23	24	25	26
1	Western delta	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
2	Eastern do.	471.86	704.36	435.48	189.53	33.12	1,176.22
	Grand Total	471.86	4,002.84	435.48	189.53	33.12	5,206.86
		1,017.76	4,707.20	435.48	189.53	33.12	6,383.08

Statement No. VI-B.—Particulars of soils in delta areas—cont.

No.	Name of delta.	Arenaceous loam.				
		Sort 1.	Sort 2.	Sort 3.	Sort 4.	Total.
1	2	27	28	29	30	31
1	Western delta	ACS.	ACS.	ACS.	ACS.	ACS.
2	Eastern do.	56.68	424.04	2,644.54	..	3,125.26
	Grand Total	244.74	1,321.97	3,427.85	..	4,994.56
		301.42	1,746.01	6,072.39	..	8,119.82
No.	Name of delta.	Arenaceous sand.				
		Sort 1.	Sort 2.	Sort 3.	Sort 4.	Total.
1	2	32	33	34	35	36
1	Western delta	ACS.	ACS.	ACS.	ACS.	ACS.
2	Eastern do.	1,044.83	4,510.69	5,179.90	..	10,735.42
	Grand Total	1,019.79	936.88	769.70	..	2,725.87
		2,064.62	5,447.07	5,949.60	..	13,461.29
No.	Name of delta.	Permanently improved.				
		Sort 1.	Sort 2.	Sort 3.	Total.	Grand Total.
1	2	37	38	39	40	41
1	Western delta	ACS.	ACS.	ACS.	ACS.	ACS.
2	Eastern do.	21.03	..	..	21.03	36,135.26
	Grand Total	21.03	..	..	21.03	34,849.03
		21.03	..	..	21.03	70,984.29



REGISTER No. VII-A.—Statement of estimated compensation

Serial number.	Taluk number.	Name of village.	Extent of land.	Assessment.	Compensation for land.	Average compensation per acre.
1	2	3	4	5	6	7
<i>Sattenapalli taluk.</i>						
1	11	Pulichinta ..	Permanent patta land—Dry ..	ACS. 370-47	RS. A. 633 5	RS. 55
2	10	Kollur ..	Temporary patta land—Dry ..	7-80	16 10	55
3	9	Chityala ..	Patta—Dry ..	1,038-14	1,523 7	57
4	8	Kesavaram Agraharam.	Temporary patta—Dry ..	6-82	6 2	57
5	7	Bodanam ..	Patta—Dry ..	938-47	1,082 6	51
6	6	Ermazigudem ..	Temporary patta—Dry ..	74-43	65 3	54
7	2	Mannesultanpalem ..	Patta—Dry ..	414-16	526 6	57
			Temporary patta—Dry ..	1,845-53	2,477 14	53
			Patta—Dry ..	349-36	240 4	42
			Temporary patta—Dry ..	480-05	432 4	50
			Patta—Dry ..	92-88	91 8	
			Temporary patta—Dry ..	126-71	148 1	
		Total ..	Patta—Dry ..	5,163-33	5,694-62	
			Temporary patta—Dry ..	581-09	7,243 1	2,83,616 4
<i>Palnad taluk.</i>						
8	17	Pillutla ..	Patta .. { Dry ..	229-81	241 14	46
9	16	Akurazupalli ..	Temporary patta—Dry ..	5-58	42 15	44
10	14	Tudutla ..	Patta—Dry ..	95-42	87 3	60
11	13	Chennayapalem ..	Do. ..	12-59	14 2	20
12	12	Vemavaram ..	Temporary patta—Dry ..	1,436-98	2,215 10	61
13	11	Tangeda ..	Patta .. { Dry ..	5-42	9 8	65
14	8	Bhattapalem ..	Temporary patta—Dry ..	123-62	108 2	66
15	10	Madinapadu ..	Patta—Dry ..	1,542-95	2,428 9	62
16	7	Gamalapad ..	Do. ..	23-20	165 3	65
17	6	Ramapuram ..	Patta .. { Dry ..	40-78	139 8	66
18	5	Pondugala ..	Temporary patta—Dry ..	50-84	71 5	66
			Patta—Dry ..	355-90	616 11	66
			Temporary patta—Dry ..	4-81	7 14	66
			Patta—Dry ..	0-70	5 3	66
			Temporary patta—Dry ..	1-00	1 0	66
			Patta—Dry ..	318-40	599 5	66
			Temporary patta—Dry ..	4-02	7 5	66
			Patta—Dry ..	428-97	693 14	66
			Temporary patta—Dry ..	0-59	1 12	66
		Total, Palnad taluk ..	Patta .. { Dry ..	4,505-37	7,461 15	58
			Temporary patta—Dry ..	29-46	2,75,552 10	50
		Total, Sattenapalli taluk.	Patta .. { Dry ..	4,681-01	7,243 1	54
			Temporary patta—Dry ..	148-18	2,83,616 4	54
		Total, British ..	Patta .. { Dry ..	9,668-70	14,705 0	54
			Temporary patta—Dry ..	29-46	5,69,168 14	54
<i>Nisam's villages.</i>						
19	..	Trakugudem ..	Patta—Dry ..	104-31	53 0	35
20	..	Vadapally ..	Do. ..	645-16	878 10	37
21	..	Damaracherla ..	Patta .. { Dry ..	65-88	23 10	44
22	..	Sunypabad ..	Temporary patta—Dry ..	2-22	28 14	42
23	..	Mabankaligudem ..	Do. ..	16-72	11 9	42
24	..	Ravipad ..	Patta—Dry ..	150-69	157 5	42
25	..	Janapad ..	Do. ..	328-46	293 1	42
26	..	Gorlagudem ..	Do. ..	24-95	22 12	42
27	..	Gundlapabad ..	Do. ..	..	639 0	42
28	..	Gundeboyinagudem ..	Dry ..	38-1	22 8	36
29	..	Mattapally ..	Wet ..	143-62	72 1	36
30	..	Pedavid ..	Dry ..	50-93	294 1	36
			Wet ..	461-78	443 10	36
			Dry ..	494-67	479 5	36
			Wet ..	8-14	17 1	36
			Dry ..	50-72	33 8	36

for patta lands with trees and wells standing on them.

Compensation for trees.	Compensation for wells.		Total.	15 per cent. allowance for compulsory acquisition on the amount in column 11.	Loss of land revenue (25 times the amount in column 5).	Grand Total.	Remarks.
8	Number.	Amount.	11	12	13	14	15
RS. A.		RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	
322 8	..	..	20,557 9	3,084 0	16,250 0	39,891 9	
680 8	..	..	59,508 0	8,926 0	38,239 0	1,06,673 0	
139 4	1	200 0	48,782 4	7,317 0	28,689 0	84,788 4	
304 0	1	400 0	23,199 4	3,480 0	13,159 0	39,838 4	
799 8	..	..	1,06,196 8	15,930 0	67,953 0	1,90,079 8	
151 0	..	..	23,068 2	3,460 0	13,086 0	39,614 2	
111 8	..	..	5,412 13	812 0	3,701 0	9,925 13	
2,508 4	2	600 0	2,86,724 8	43,009 0	1,81,077 0	5,10,810 8	
1,789 4	2	100 0	12,792 1	1,919 0	9,300 0	24,011 1	
1,815 0	..	..	527 7	79 0	353 0	959 7	
5 4	1	200 0	88,240 5	13,236 0	55,628 0	1,57,104 5	
1,443 8	17	1,260 0	2,742 7	411 0	2,703 0	5,856 7	
315 0	6	610 0	99,583 6	14,937 0	68,331 0	1,82,851 6	
42 0	..	..	4,220 6	633 0	1,783 0	6,636 6	
27 8	..	..	22,044 5	3,307 0	15,417 0	40,763 5	
..	..	..	356 1	53 0	327 0	736 1	
113 6	..	..	60 0	9 0	25 0	94 0	
1,221 5	..	..	24,178 3	3,627 0	15,165 0	42,970 3	
6,271 14	26	2,170 0	2,83,994 8	42,599 0	1,86,548 0	5,13,141 8	
2,508 4	2	600 0	2,86,724 8	43,009 0	1,81,077 0	5,10,810 8	
8,780 2	28	2,770 0	5,70,719 0	85,608 0	3,67,625 0	10,23,952 0	
6 4	..	..	3,614 11	542 0	1,325 0	5,481 11	
241 2	..	..	24,071 2	3,610 0	9,467 0	37,148 2	
305 0	1	100 0	3,365 3	505 0	1,312 0	5,182 3	
73 2	..	..	705 5	106 0	289 0	1,100 8	
120 8	..	..	10,026 10	1,504 0	3,933 0	15,463 10	
60 0	..	..	17,705 6	2,656 0	7,326 0	27,687 6	
..	..	..	699 0	105 0	569 0	1,373 0	
..	1	25 0	1,379 6	207 0	562 0	2,148 6	
40 0	..	..	7,404 3	1,111 0	9,153 0	17,668 3	
74 6	3	600 0	28,534 4	4,280 0	11,091 0	43,905 4	
104 7	2	115 0	28,640 4	3,546 0	12,409 0	39,595 4	
..	..	..	1,347 10	202 0	955 0	2,504 10	

* 12-00 is forest land held on patta. Not cultivated.

Register No. VII-A.—Statement of estimated compensation

Serial number.	Taluk number.	Name of village.	Extent of land.	Assessment.	Compensation for land.	Average compensation per acre.
1	2	3	4	5	6	7
31	..	Nizam's villages—cont.				
31	..	Gundlapalli ..	Dry ACS. (a) 1,451.83	Rs. A. 676 5	Rs. A. 28,908 4	Rs. 20
32	..	Raghunadhapalem ..	Dry (b) 992.55	854 13	32,938 10	33
33	..	Chintirala ..	Wet (c) 4,657.27	2,209 15	1,01,179 10	22
34	..	Tammavaram ..	Dry 20.84	139 2	1,483 3	45
35	..	Reballe ..	Wet 609.75	513 10	36,804 4	41
36	..	Adlur ..	Dry 1,309.10	846 13	53,711 8	38
37	..	Vellatur ..	Wet 8.00	38 15	316 0	52
38	..	Nemalipuri Agraharam ..	Dry (d) 2,047.03	1,343 15	78,951 5	26
39	..	Vadinepalli ..	Wet 5.28	28 7	555 12	28
40	..	Dondapadu ..	Dry (e) 2,042.04	2,000 6	1,03,841 9	25
	..		Wet 18.94	90 9	2,351 0	25
	..		Dry (f) 1,835.00	70 0	47,654 0	25
	..		Wet (g) 3,001.49	1,990 7	74,961 4	25
	..		Dry (h) 1,177.00	572 14	30,470 0	25
	..		Wet 25.00	192 6	3,850 0	25
	..	Total, Nizam ..	Patta .. { Dry .. 21,851.08 Wet .. 129.83 } 21,980.86	13,404 3	7,18,584 11	33
	..	Grand total ..	Patta .. { Dry .. 31,519.73 Wet .. 168.79 } 32,355.99	28,109 3	12,77,753 9	..
	..		Temporary patta ..			
	..		Dry 677.27			

for patta lands with trees and wells standing on them—cont.

Compensation for trees.	Compensation for wells.		Total.	15 per cent. allowance for compulsory acquisition on the amount in column 11.	Loss of land revenue (25 times the amount in column 5).	Grand Total.	Remarks.
8	Number.	Amount.	11	12	13	14	15
RS. A.		RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	ACS.
4,649 9	..	..	33,557 13	5,034 0	16,908 0	55,499 13	(a) 909.42. Forest land held on patta not cultivated.
2,857 7	..	..	35,796 1	5,369 0	8,870 0	50,035 1	(b) 30.00. "
12,773 2	1	250 0	1,15,685 15	17,353 0	58,727 0	1,91,765 15	(c) 1,495.73. "
90 0	5	1,700 0	38,594 4	5,789 0	12,841 0	57,224 4	
414 8	1	250 0	54,692 0	8,204 0	22,144 0	85,040 0	
7,729 7	2	650 0	87,886 8	13,183 0	34,309 0	1,35,378 8	(d) 499.45. "
3,601 4	..	..	1,10,058 13	16,509 0	52,273 0	1,78,840 13	(e) 221.67. "
265 0	..	..	59,554 0	8,933 0	1,750 0	70,237 0	(f) 1,253.00. "
11,900 0	..	..	93,073 0	13,961 0	49,761 0	1,56,795 0	(g) 2,128.92. "
17,921 12	2	190 0	37,340 0	5,601 0	19,131 0	62,072 0	(h) 875.00. "
3,040 0	..	..					
66,266 14	18	3,880 0	7,88,731 9	1,18,310 0	3,35,105 0	12,42,146 9	7,425.19.
75,047 0	46	6,650 0	13,59,450 9	2,03,918 0	7,02,730 0	22,66,098 9	

STATEMENT No. VII-B.—Statement of estimated compensation for forest

Serial number.	Taluk number.	Name of village.	Forest reserves.					Other	
			Extent.	Average valuation per acre for land with pasture, if any.	Total valuation.	Valuation per acre for tree growth.	Total valuation.	Extent.	Valuation per acre.
1	2	3	4	5	6	7	8	9	10
Sattenapalli taluk.									
11	11	Pulichinta	ACS.	RS.	RS. A.	RS.	RS. A.	ACS.	RS.
10	10	Kollur	..	..	..	..	..	..	..
9	9	Chityala	..	..	..	..	..	..	..
8	8	Ketavaram Agraharam ..	767-00	14	..	..	57-26	..	..
7	7	Bodanam	690-27	..	11,180 0	13	9,920 0	553-87	..
6	6	Eumagigudem	..	..	..	..	..	..	..
5	5	Mannesultanpalem ..	..	..	..	..	..	..	..
4	4	No. 3 Hill	5,615-53	..	..	..	..	240-02	..
3	3	Total, Sattenapalli taluk ..	7,072-80	..	..	..	..	157-56	..
Painad taluk.									
17	17	Pillatta	..	..	..	..	..	..	..
16	16	Akurasupalli	195-61	..	..	..	..	..	..
15	15	Tadutla	31-00	..	..	..	..	..	..
14	14	Vemavaram	1,399-80	..	..	..	..	95-33	..
13	13	Tangeda	600-00	..	..	..	..	..	..
12	12	Bhatnapalem	1,327-40	..	..	..	..	326-83	..
11	11	Madinapad	869-03	..	..	..	..	261-91	..
10	10	Garnalapad	33-20	..	..	..	..	54-77	..
9	9	Ramapuram	220-00	..	..	..	..	45-77	..
8	8	Pondugala	180-00	..	..	..	..	5-00	..
7	7	No. 9 Hill	100-28	..	..	..	..	..	..
6	6	Total, Painad taluk ..	5,126-40	..	..	..	..	128-37	..
5	5	Total, Sattenapalli taluk ..	7,072-80	..	..	..	..	126-54	..
4	4	Total, British	12,199-20	..	11,180 0	..	9,920 0	1,047-52	..
Nizam's villages.									
20	20	Irukugudem	19-05	10	190 8	5	90 0	..	..
19	19	Vadapally	106-45	(a) 17	1,760 4	3	347 0	..	..
18	18	Damarlaacherla	5-00	5	25 0	5	25 0	..	..
17	17	Soonyapabad	20-00	10	200 0	3	60 0	..	..
16	16	Mahankaligudem	..	..	..	..	..	..	..
15	15	Ravipabad	81-85	10	801 12	4	325 0	..	..
14	14	Janapabad	..	..	..	..	..	..	..
13	13	Gorlagudem	78-00	5	390 0	1	148 2	..	..
12	12	Gundlapabad	136-67	9	1,251 6	1	427 9	..	..
11	11	Gundeboyinagudem ..	103-82	10	993 0	4	..	..	..
10	10	Mattapalli	408-67	6	2,043 6	8	3,371 8	..	..
9	9	Pedavid	1,201-07	10	7,128 11	7	4,874 12	..	..
8	8	Gundlapally	883-88	8	8,838 12	4	6,607 0	..	..
7	7	Raghunadhapalem ..	562-40	12	4,373 1	3	2,269 12	..	..
6	6	Chintirala	128-19	10	1,562 0	1	489 13	..	..
5	5	Tammavaram	266-51	9	8,896 8	1	343 10	..	..
4	4	Rehalli	127-05	10	1,270 7	1	137 2	..	..
3	3	Adlur	23-00	5	115 0	5	115 0	..	..
2	2	Chintalapalem	3,277-16	10	22,659 13	22	71,778 0	210-42	6
1	1	Vellatur	315-00	10	3,150 0	8	2,520 0	..	..
0	0	Malkapuram	125-22	7	904 14	5	570 6	..	..
0	0	Vadinepalli	..	..	..	..	..	..	..
0	0	Dondapabad	..	..	..	..	..	..	..
0	0	Total, Nizam	7,968-49	..	..	..	..	0-52	20
0	0	Total, British	12,199-20	..	71,042 6	..	94,447 10	210-94	..
0	0	Grand Total	20,167-69	..	11,180 0	..	9,920 0	2,229-78	..
0	0				82,229 6	..	1,04,367 16	2,440-73	..

(a) Part under actual cultivation though not held on patta.
 * Timber rather better than the average and large extents of palmyra tops.

land, scrub covered land, other porambores and assessed wastes.

porambores.			Assessed wastes.					Total of columns 6, 8, 11, 13, 16, and 18.	Fifteen per cent. allowance.	Grand total.
Total valuation.	Valuation per acre for tree growth.	Total valuation.	Extent.	Valuation per acre.	Total valuation.	Valuation per acre for tree growth.	Total valuation.			
11	12	13	14	15	16	17	18	19	20	21
RS. A.	RS.	RS. A.	ACS.	RS.	RS. A.	RS.	RS. A.	RS. A.	RS.	RS. A.
..	..	..	30-63	..	..	..	..	..	..	..
..	..	..	12-08	..	..	..	..	..	..	..
..	..	..	9-00	..	..	..	..	..	..	..
..	..	..	315-72	..	..	..	..	21,100 0	3,165	24,265 0
..	..	..	111-19	..	..	..	..	..	..	..
..	..	..	10-60	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
..	..	..	489-23	..	..	..	..	21,100 0	3,165	24,265 0
..	..	..	..	..	..	..	..	..	..	..
..	..	..	39-85	..	..	..	..	..	..	..
..	..	..	4-87	..	..	..	..	..	..	..
..	..	..	378-47	..	..	..	..	..	..	..
..	..	..	626-36	..	..	..	..	..	..	..
..	..	..	61-06	..	..	..	..	..	..	..
..	..	..	48-23	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
..	..	..	12-30	..	..	..	..	..	..	..
..	..	..	11-82	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
..	..	..	1,172-96	..	..	..	..	..	..	..
..	..	..	489-23	..	..	..	..	21,100 0	3,165	24,265 0
..	..	..	1,662-19	..	..	..	..	21,100 0	3,165	24,265 0
..	..	..	..	..	..	..	..	..	..	..
..	..	..	26-51	3	69 5	..	..	280 8	42	322 8
..	..	..	18-02	13	237 2	1	22 4	2,176 9	327	2,503 9
..	..	..	..	..	..	..	..	309 6	46	355 6
..	..	..	..	..	..	..	..	260 0	39	299 0
..	..	..	98-92	9	919 10	3	255 0	1,174 10	176	1,350 10
..	..	..	65-00	10	650 0	5	325 0	2,101 12	315	2,416 12
..	..	..	170-00	10	1,700 0	5	850 0	2,550 0	383	2,933 0
..	..	..	1-97	5	9 14	..	..	399 14	60	459 14
..	..	..	52-67	7	373 4	3	140 0	1,912 12	287	2,199 12
..	..	..	100-00	10	1,000 0	2	150 0	2,570 9	386	2,956 9
..	..	..	1,462-67	5	7,338 9	4	6,214 12	18,553 5	2,038	15,586 5
..	..	..	..	..	..	..	..	5,414 14	812	6,226 14
..	..	..	..	..	..	..	..	11,998 7	1,800	13,798 7
..	..	..	608-80	10	5,899 0	7	4,428 8	25,773 4	3,866	29,639 4
..	..	..	0-15	30	4 8	..	..	6,647 5	997	7,644 5
..	..	..	21-17	9	196 11	..	..	2,198 8	330	2,528 8
..	..	..	15-20	20	304 0	1	10 0	4,054 2	608	4,662 2
..	..	..	4-92	27	135 3	..	..	1,542 12	231	1,773 12
1,202 7	1	32 8	..	..	..	..	..	230 0	34	264 0
10 6	..	..	..	..	..	..	..	1,05,670 12	15,850	1,21,520 12
..	..	..	..	..	..	..	..	5,670 0	861	6,531 0
..	..	..	..	..	..	..	..	1,485 10	223	1,708 10
1,212 13	..	32 8	2,646-00	..	18,837 2	..	12,395 8	1,97,974 15	29,696	2,27,670 15
..	..	..	1,662-19	..	..	..	..	21,100 0	3,165	24,265 0
1,212 13	..	32 8	4,308-19	..	18,837 2	..	12,395 8	2,19,074 15	32,861	2,51,935 15

STATEMENT No. VII-C.—Showing estimated compensation for buildings and village

Serial number of village.	Taluk number.	Name of village or hamlet.	Number of buildings.	Average value per building.	Total value of buildings.	Extent of village site.
1	2	3	4	5	6	7
<i>British side.</i>						
<i>Sattenapalle taluk.</i>						
1	11	Pulichinta	In village site	RS.	RS. A.	ACS.
2	10	Kollar	Do.	55	(a) 3,955 8	7.26
3	9	Chityala	Do.	167	(b) 16,356 0	27.73
4	8	Ketavaram Agraharam	Do.	147	(c) 8,442 0	19.65
5	7	Bodanam	In other lands	32	(d) 1,544 0	7.15
6	6	Emmagigudem	In village site	8	(e) 2,116 0	17.84
			In other lands	174	(f) 21,819 0	9.40
			In village site	35	(g) 2,148 0	
			In other lands	73	(h) 3,338 0	
		Total, Sattenapalle taluk.	In village site	1	(i) 60 0	
			In other lands	648	(j) 55,454 8	
				44	(k) 4,314 0	
				692	(l) 59,768 8	89.02
<i>Palnad taluk.</i>						
7	14	Tadutta	In village site	132	(m) 11,108 4	9.42
8	12	Vemavaram	In other lands	62	(n) 5,238 0	25.06
9	8	Bhattapalem	In village site	613	(o) 61,042 14	
10	6	Ramapuram	Do.	111	(p) 3,893 8	21.39
11	5	Pondugala	In village site	26	(q) 1,318 0	19.16
			In other lands	414	(r) 52,196 0	
			In village site	12	(s) 860 0	
			In other lands	218	(t) 30,295 0	
		Total, Palnad taluk	In village site	5	(u) 187 0	
			In other lands	1,377	(v) 1,55,642 2	
		Total, British		216	(w) 11,496 8	74.97
				1,593	(x) 1,67,158 10	
				2,285	(y) 2,26,907 2	164.00
<i>Nizam's villages.</i>						
13		Vadapalli	In village site	132	(z) 19,128 6	8.50
13		Ravipabad	In other lands	22	(aa) 2,127 0	3.85
14		Gundlapabad	Do.	56	(ab) 3,139 0	2.45
15		Gundeboyinagudem	In village site	39	(ac) 894 0	8.00
16		Mattapalli	In other lands	10	(ad) 87 0	7.92
17		Pedavid	In village site	64	(ae) 2,126 4	8.27
18		Gundlapalli	Do.	14	(af) 106 0	11.98
19		Ragunadhapalem	In village site	48	(ag) 1,986 0	4.00
20		Chinbira	Do.	13	(ah) 4,191 0	3.85
21		Tammavaram	In other lands	20	(ai) 202 0	8.27
22		Reballe	In village site	119	(aj) 9,814 0	32.87
23		Adlur	In other lands	201	(ak) 16,714 0	11.98
24		Vellatur	In village site	22	(al) 1,574 0	4.00
25		Nemalipuri	In other lands	314	(am) 14,415 0	32.87
26		Vadinepalli	Do.	204	(an) 18,079 4	4.00
27		Dondapad	In village site	1	(ao) 25 0	8.97
			In other lands	70	(ap) 3,202 12	1.50
			In village site	217	(aq) 15,402 0	
			In other lands	274	(ar) 16,796 0	
			In village site	8	(as) 73 0	
			In other lands	95	(at) 3,809 0	
			In village site	68	(au) 2,217 12	
			In other lands	1	(av) 150 0	
		Total, Nizam	In village site	36	(aw) 5,708 8	
			In other lands	1,898	(ax) 1,27,537 14	142.74
		Total, British		150	(ay) 9,429 0	
		Total, Nizam		2,048	(az) 1,36,966 14	
		Grand total		2,285	(ba) 2,26,907 2	164.00
				2,048	(bb) 1,36,966 14	142.74
				4,333	(bc) 3,63,874 6	306.74

site including buildings on patta lands, assessed wastes and all poramboke lands.

Valuation per acre.	Compensation for village-site.	Total of columns 6 and 9.	15 per cent. allowance for compulsory acquisition on total of column 10.	Grand total.	Remarks.
8	9	10	11	12	13
RS.	RS.	RS. A. P.	RS.	RS. A. P.	RS.
200	1,452	5,407 8 0	811	6,218 8 0	(a) Includes 1 temple valued at 30
..	5,546	21,902 0 0	3,285	25,187 0 0	(b) Do. 1 mosque do. 200
..	3,930	12,372 0 0	1,856	14,228 0 0	(c) Do. 5 temples do. 3,781
..	1,430	5,090 0 0	764	5,854 0 0	(d) Do. 1 temple do. 85
..	3,568	27,535 0 0	4,130	31,665 0 0	(e) Do. 6 temples valued at 2,016
..	1,880	5,268 0 0	790	6,058 0 0	(f) Do. 8 temples do. 5,925
..	..	..	..	..	(g) Do. 3 indigo vats do. 700
..	..	..	..	..	(h) Do. 1 temple do. 50
..	17,806	77,574 8 0	11,636	89,210 8 0	
200	1,884	18,230 4 0	2,735	20,965 4 0	(i) Includes 1 temple valued at 20
..	5,012	69,948 6 0	10,492	80,440 6 0	(j) Do. 9 temples do. 5,831
..	..	..	..	..	(k) Do. 2 rural schools do. 1,210
..	..	..	..	..	(l) Do. 2 indigo vats do. 300
..	4,278	58,534 0 0	8,750	67,084 0 0	(m) Includes 4 temples valued at 165
..	3,820	34,302 0 0	5,145	39,447 0 0	(n) Do. 5 temples do. 3,910
..	..	..	..	..	(o) Do. 1 bungalow do. 2,000
..	..	..	..	..	(p) Do. 1 choultry do. 4,000
..	14,994	1,82,132 10 0	27,320	2,09,452 10 0	
..	32,800	2,59,707 2 0	38,956	2,98,663 2 0	
200	700	21,955 6 0	3,293	25,248 6 0	(q) Includes 2 mosques valued at 5,780
..	..	..	..	..	(r) Do. 1 bungalow do. 1,702
..	770	4,803 0 0	721	5,524 0 0	(s) Do. 3 temples do. 1,600
..	..	..	..	..	
..	87 0 0	13	100 0 0		
..	490	2,722 4 0	408	3,130 4 0	(t) Includes 1 temple valued at 30
..	1,600	7,777 0 0	1,167	8,944 0 0	(u) Do. 3 temples do. 4,207
..	..	..	..	..	
..	..	..	..	..	
..	..	..	..	..	
..	1,584	11,398 0 0	1,710	13,108 0 0	(v) Includes 1 temple valued at 70
..	1,654	19,942 0 0	2,991	22,933 0 0	(w) Do. 2 temples do. 350
..	..	..	..	..	(x) Do. 2 wells do. 300
..	7,090	21,505 0 0	3,226	24,731 0 0	
200	2,396	15,500 4 0	2,325	17,825 4 0	
..	2,396	5,598 12 0	840	6,438 12 0	
..	800	16,202 0 0	2,430	18,632 0 0	(y) Includes 5 temples valued at 777
..	6,574	23,443 0 0	3,517	26,960 0 0	(z) Do. 5 temples do. 4,136
..	..	..	..	..	(aa) Do. 5 temples do. 150
..	400	4,209 0 0	631	4,840 0 0	(ab) Do. 1 temple do. 50
..	1,794	4,161 12 0	624	4,785 12 0	(ac) Do. 1 indigo vat do. 150
..	..	..	..	..	(ad) Do. 2 temples do. 4,099
..	300	6,008 8 0	901	6,909 8 0	
..	28,548	1,65,514 14 0	24,827	1,90,341 14 0	
200	32,800	2,59,707 2 0	38,956	2,98,663 2 0	
200	28,548	1,65,514 14 0	24,827	1,90,341 14 0	
300	61,348	4,25,222 0 0	63,783	4,89,005 0 0	

STATEMENT No. VII-D.—General abstract statement of compensation for land and buildings submerged by Reservoir.

		RS.	A.	P.
British side	Patta land	6,56,327	0	0
	Forest and waste land	12,857	0	0
	Forest growth	11,408	0	0
	Buildings (including sites)	2,98,663	2	0
	Compensation for loss of land revenue.	3,67,625	0	0
	Total	13,46,880	2	0
Nizam's side	Patta land	9,07,041	9	0
	Forest and waste land	1,04,764	5	0
	Forest growth	1,22,906	10	0
	Buildings (including sites)	1,90,341	14	0
	Compensation for loss of land revenue.	3,35,105	0	0
	Total	16,60,159	6	0
	Grand total	30,07,039	8	0

(ii)

Reference from the Board of Revenue (R.S., Sur., L.R. and Agri.), No. 191, dated 20th January 1910.

Referred to the Collectors of Kistna and Guntūr for very early remarks.

L. D. SWAMIKANNU,
Secretary.

To the Collectors of Kistna and Guntūr, with a proof copy of Mr. Turing's report.

(iii)

Letter—from S. W. G. I. MACIVER, Esq., I.C.S., Acting Collector of Guntūr.
To—the Secretary to the Commissioner of Revenue Settlement, Survey, Land Records and Agriculture.
Dated—the 7th February 1910.
No.—R. Dis. 85-GI.

With reference to your Ref. No. 119, dated 20th January 1910, I have the honour to observe that the Engineers furnished the Revenue Officer with information as to the course of the proposed main canal and details of the areas commanded; apparently the water-supply is considered sufficient for the whole area commanded; and the business of the Revenue Officer was to find out what areas would actually be irrigated supposing the work to be completed. The amount of water available and the localities to which it can be brought being given, the general features of the changes to be brought about in the area commanded are already decided. The ideal way to utilise the water that now runs to waste into the sea would be to send it down a main canal so aligned that all the water drawn from the river could be poured on to numerous patches of suitable land scattered about among higher blocks that would remain unirrigated. In this way a large area of mainly dry country would have patches of assured wet cultivation; such a scheme would no doubt be expensive or, perhaps, is altogether impossible, but one cannot help regretting that the water cannot be employed in some such manner in poor country towards Vinukonda and Podili or elsewhere rather than in converting into a paddy swamp the upland area now proposed to be dealt with, which is a tract producing unusually good dry crops. Taking it that the water, if employed at all, must be poured on to the tract proposed, there can still be no question as to the great advantages to be derived from the scheme. A tour through an unirrigated and an irrigated part of the district would convince any one of the greater prosperity of the latter. The value of the water is too obvious to need discussion, and although dry areas for village-sites, roads, burial-grounds, cattle-stands and such like should be reserved on a fairly liberal scale, yet I think it would be bad

economy to reserve any considerable areas for grazing, or for growing dry crops for fodder, or for forests. The delta produces more food both for man and beast than can be consumed by the human inhabitants and the cattle. I believe this would be the case even if the cattle were not sent away during part of the year. The difficulty as regards cattle is that there is no convenient dry ground for the cattle to stand on in the irrigation season, and the paddy straw grown in the delta is said not to be of good quality as fodder. I believe that very little of the soil is unirrigable, that the ryots will take the water eagerly, and think that all the water available should be used rather than that any of it should be allowed to be wasted in order to retain considerable areas of dry land in the area commanded. Mr. Turing's report follows these lines, and I agree with him, always provided that it is impracticable to spread the irrigation over a larger area by extending the canals southwards, without undue expense, and without unduly wasting the water; if this were possible it would obviously be an advantage to retain more unirrigated blocks and have the irrigation in patches as remarked above.

2. It is proposed to employ the new supply of water in three ways—(1) by extension of irrigation to land not now irrigated, (2) by providing water for a second crop in the delta and (3) by providing water for irrigating certain swamps at the late period of the season when they are no longer flooded; provided the engineers can make the growing of wet crops possible by supplying water, and drainage where needed, I have no doubt that the ryots will raise wet crops in all these cases; with change of conditions they will no doubt change their practices where necessary; for instance it would appear that they will need to adopt some new means of preserving the fertility of the soil; the larger area of irrigated land will make it more difficult to obtain dung or pati earth, and if, added to this, the water is likely to be deprived of its silt it would seem to be impossible for the land to fail to become exhausted of the mineral ingredients required for plant life, which cannot be restored by the growth of manure plants on the same soil. This is a question for agricultural experts, but there seems no reason to fear that the wealthy delta ryots will not show sufficient enterprise and intelligence to conquer difficulties of this nature when they become pressing.

3. The area already irrigated and the proposed extension in this district are well provided with main lines of communication in the shape of roads, canals and railways, and the proposed Guntūr-Repalle line will be a further improvement. This circumstance will enable fuel from the mangrove swamps and from the casuarina plantations to be distributed cheaply, and will enable the delta ryots to import cheaply suitable fodder for their animals, and should therefore be of great assistance in enabling them to avoid exhausting the soil, and should, further, remove all fear of extension of irrigation being long delayed on account of lack of population or of labourers. The extension of the road in Sattenapalle taluk northwards from Krosur, suggested by Mr. Turing, is likely to be carried out before long, and his suggestion that the Public Works Department should make one bank of the new canals suitable for a roadway should certainly be acted upon wherever possible.

4. In paragraphs 111 and 112, Mr. Turing deals with the question of the sale of land affected by the Project. In the upland he estimates that 16,059 acres may be sold for an amount which works out to about Rs. 31 per acre; he explains that the lands are mostly of saline or other poor soils. If they are capable of profitable irrigation at all I cannot understand how it can be estimated that they will be worth no more than this small sum when brought under irrigation. Mr. Turing also has omitted all cases where the saleable extent in a village is less than ten acres, and the land already granted on conditional patta, estimated at 7,600 acres. I would include both these items; part of the 16,059 acres will no doubt be given on conditional patta during the fifteen years which are expected to pass before irrigation commences, and I see no reason why the land already granted conditionally should be treated differently to that to be granted in future, nor why some should be given free and some conditionally, and as regards the small areas, ten acres of wet land may perhaps be worth ten thousand rupees or more. As regards the part of the delta in this district, it is estimated that 5,587 acres may be sold for Rs. 1,43,556, or at about Rs. 26 per acre. This rate also seems very much too low. It is not

clear whether land already granted conditionally is included in the estimate or not. If the lands proposed to be sold are really fit for irrigation I should say that they will eventually be worth certainly not less than ten times the amount taken credit for, and probably a good deal more.

5. As regards the lands that have been, or are to be, granted under project conditions, two things may happen; the land itself may be needed for the construction of a channel or path or for some other public purpose connected with the project, or Government may desire to realize the profit obtainable by resuming the grant and selling the land. To cover the latter alternative it seems to me that the present rule is inconvenient, and that it would be better to grant the land outright burdened with the condition that when the land becomes irrigable through the completion of the project the pattadar shall be bound to pay a certain amount to Government or in lieu thereof an annuity that might be calculated under the rules in force under the Loans Acts. The amount to be paid might be declared to be the market value of the land at the time when the amount becomes payable, as fixed by Government, or what I think would be better, an amount to be estimated once for all at the time of assignment. The present rule might continue so far as regards the contingency of the land itself being needed, which would comparatively rarely be the case. The amount of land in this district that can only be granted under project rules is very large, and it is not desirable that for many years no one should be capable of obtaining it on a secure tenure; further, when the time comes, the resumption on a large scale of lands that have been held for many years, with a view to selling them at a profit, will certainly be looked upon as oppressive, and lead to clamour.

6. Except as regards the profits to be derived from the sale of lands I have no reason to question any of Mr. Turing's figures; I agree generally with the views expressed in his report, and in particular I fully agree with his opinion that if the water-rates proposed are insufficient to make the scheme seem deserving of execution, that the rates should be raised rather than that the project should be dropped.

(iv)

Letter—from E. Scott, Esq., I.C.S., Collector of Kistna.
To—the Secretary to the Commissioner of Revenue Settlement, Survey, Land
Records and Agriculture.
Dated—the 14th March 1910.
No.—R.C. 90-B. & G.

With reference to Board's Reference No. 119 dated 20th January 1910, I have the honour to submit the following remarks on Mr. Turing's report. Pressure of work has made it impossible for me to deal more fully with it, but except as noted in my remarks, I concur generally in his statements.

2. Paragraph 54.—In G.O., No. 265, Revenue, dated 23rd February 1905, Government ruled that it can be brought being given the opportunity of village-irrigation about it is not the duty of Government to acquire land for village-zamindari in proprietary estates. It is, however, certainly desirable to refuse canal water to lands adjoining zamindari village-sites and Mr. Turing's treatment of zamindari villages in the same way as Government villages is therefore proper.

3. Paragraph 56.—The area notified under section 26 of the Forest Act in Peddalanka project villages is 10,075 acres. I agree with Mr. Turing in considering that land suitable for irrigation should not be excluded from the project area on the ground that it might be utilised for growing fuel. There is a very considerable area of land near the coast available for casuarina plantations and the planting up of this area is now under consideration.

4. Paragraph 60—Mamul wet area.—Without information as to the areas referred to, I am unable to express any opinion in regard to these deductions, but all questions as to such mamul wet areas should be finally determined before the introduction of reservoir irrigation with reference to G.O., No. 216, Revenue, dated 23rd February 1904. The question of extending the Kistna flood-bank below Pedakallepalli is under correspondence—vide G.O., No. 182 I., dated 20th March 1909.

5. Paragraph 61.—I do not think there is any need to exclude any irrigable area in Lakshmipuram. There is a great demand for land in the village and I have no doubt that any land brought under irrigation would be eagerly taken up.

6. Paragraph 63.—The only roads under construction or under contemplation in the tract in question are the following:—

(a) Under construction.—Metalling of road from Nidumolu to Ayalur.
(b) Under contemplation.—Road from Vallur to Nadakuduru—Rs. 2,14,450—
Estimate sanctioned in G.O., No. 974 W., dated 1st September 1908.

Road from Pamarru to Challapalli—Rs. 35,000.
Road from Nidumolu to Kavutavaram Railway station—Rs. 20,000.

A road from Lakshmipuram on the Challapalli-Masulipatam road to Pedakallepalli is desirable and will no doubt be constructed before long. A road from Pedakallepalli to Kona might possibly become necessary in time, but it is certainly not necessary at present. In any case it would probably be better to connect Kona by a road running in a north-westerly direction with the Masulipatam-Challapalli road.

7. Paragraph 64.—I have no doubt that all the irrigable Peddalanka area will eventually be taken up if sufficient water is available. In 1908, 271.72 acres were sold for Rs. 11,425, while in faslis 1317 and 1318, 8,968 acres were granted on darkhast. In G.O., No. 3428, Revenue, dated 14th December 1909, communicated with Board's Proceedings, Mis. No. 101 (Land Revenue), dated 8th January 1910, Government sanctioned the sale of lands under the Peddalanka project.

The following roads are proposed for construction:—

	Amount of estimate.
	RS.
(1) Kavutavaram via Guraza, to meet the Gudivada-Bantumilli road	30,000
(2) Continuation of Pedana-Munjulur road to Bantumilli via Pandraka	30,000
(3) Kalidindi to Kaikalur	20,000

8. Paragraph 70.—There is considerable competition for the cultivation of Kolair lands. Until recently any one was allowed to 'peg out a claim' as stated by Mr. Turing; but I have stopped this practice now and land is granted annually on application by the Divisional Officer who distributes it equitably among the applicants. There is not the least doubt that the whole bed of the Kolair will be eagerly taken up. I agree generally with Mr. Turing's remarks in paragraphs 71—74.

9. Paragraph 75.—In Board's Reference No. 4621 A/09-1 (Land Revenue), dated 1st March 1910, submitting proposals to Government for the reservation of communal areas in the Divi island, the Board has expressed the opinion that it is not desirable to reserve cultivable land for grazing purposes. The same principle should be adopted in the case of Kolair lands, though it is not in accord with Government Order, Press No. 1682, Revenue, dated 24th June 1909. I have prohibited the assignment of dry lands in the lankas for the present without my permission, with a view to the reservation of areas for village-sites.

10. Paragraph 76.—The routes for new roads will depend mainly on the position of the irrigation channels and it is therefore premature to consider the subject. The roads should certainly run along the channel banks as is being done in the Divi island and is frequently the case in the Gódavari delta, and as soon as the position of the channels has been fixed, it should be determined along which roads should run, and the roads should then be constructed by the Public Works Department with the channel embankments.

11. Paragraph 77.—Mr. Turing's estimate of the amount likely to be realised by the sale of the Kollair lands may be accepted. Any estimate must necessarily be a very rough one, the sale amounts realised in such cases depending upon many

circumstances, some of which are purely temporary. I am inclined to think the sale-proceeds would exceed the figure given by Mr. Turing, but it is best in such cases not to adopt too sanguine an estimate.

12. *Paragraph 78.*—Undoubtedly the procedure in connection with dalwa cultivation is most unsatisfactory. I have recently obtained the sanction of the Board for the localization of the dalwa inams in the Kolair, but have deferred taking any action in regard to other lands as the expense of demarcation will be considerable and no permanent pattas can be issued.

It has already been determined to divide the Gudivada taluk into two with head quarters of the new taluk at Kaikalur.

13. *Paragraphs 79—84.*—The conclusions arrived at in these paragraphs are sound. Not having details of the areas in column 19 of statement II, I can only remark with regard to them that generally speaking the only areas worth reserving for grazing are areas within five or six miles of the coast or along the banks of the Kistna and Upputeru.

14. *Paragraph 85.*—Mr. Turing would seem to imply that the ryots keep cattle they do not require. I do not think this is generally the case, certainly not to any great extent. Otherwise I concur in his remarks in this paragraph and paragraphs 86 and 87.

15. *Paragraph 88.*—It has, I believe, been determined by chemical examination that the Kistna silt has no manurial value.

16. *Paragraph 91.*—I agree generally with Mr. Turing in what he states in this paragraph. The wind from the south began to blow this year at Masulipatam on the 21st January.

17. *Paragraph 92.*—Mr. Turing does not state during what period between the first and second crops he thinks the canals could be closed, but I gather his suggestion is to close them for the whole of January. As he states January is a period during which there is a very considerable traffic on the canals, as the following figures for the Bandar-Bezvada canal for January 1909 will show :—

	Quantity.	Value
	TONS.	RS.
Rice	250½	16,263
Paddy	1,400½	60,000
Other food-grains	133½	6,680
Total	1,784	82,943

It is also a time when there is much work in the fields and would not be very suitable for the execution of repairs on account of the difficulty of procuring labour. Further the canals will have to be open during January to provide water for second crop seedlings unless we assume that the seedlings could be raised entirely by water from seed-bed tanks. I am inclined to consider the proposal to close the canals in January to be impracticable. Probably, too, for the proper maintenance of the canals it is preferable to have them closed for one long period instead of for two short periods. The solution of the difficulty resulting from the want of water in May would seem to be the restriction of irrigation for second crop to paddy which will not require irrigation for more than 3 or 3½ months.

18. *Paragraph 93.*—I do not think the growing of both fodder and manure crops on second crop wet lands needs much consideration. It will certainly be possible to grow a manure crop on such lands between the first and second crops and when transplantation of the first crop is early or the paddy crop is a short one, also a fodder crop. It will never however be necessary to grow both a fodder crop and a manure crop. Mr. Turing estimates the second crop area at less than one-fourth of the total of first crop area and there can be no doubt that the 600,000 acres on which no second crop is

raised will be able to provide sufficient fodder and manure crop, with the fodder or manure crop on the 200,000 acres of double crop land, for the whole delta. This takes no account of the Kolair area of 83,000 acres on which also a fodder or manure crop can be raised. The second crop area is estimated never to exceed 317,000 acres including the late crop area in the Kolair.

19. *Paragraph 95.*—It is a matter of little importance whether the second crop area is Government or zamindari, provided it is certain that the water will be utilized for irrigation. It will, I think, be difficult to work the project if any attempt is made to restrict the second crop to any particular area.

20. *Paragraph 98.*—The construction of a gravelled road along one bank of each canal or major distributary is merely a question of expense. Canal and channel banks should certainly be always made use of for roads in delta tracts when a road is necessary in the locality and the alignment is suitable. Expenditure on roads should, however, always come from local funds though when considered desirable there is nothing to prevent them being kept up by the Public Works Department from grants made from Local funds. It would be a mistake to debit any expenditure incurred in constructing a road on a canal bank to an irrigation project. It is easy to determine in each case what portion of the cost of constructing a canal embankment with a road should be met from project funds and what portion from Local funds. There are in this district several roads maintained by the Local Fund Engineer Department on channel banks in the charge of the Public Works Department.

21. *Paragraph 102.*—It is difficult to forecast prices. The price of paddy has already fallen in some parts of the district to Rs. 35 a putti which is considerably below Mr. Turing's Rs. 50 a putti. I think, however, it may safely be assumed that the success of the project will not be very materially affected by the price of paddy, though it is quite possible it will be affected to some extent through low prices postponing the date by which the irrigable area will be fully taken up.

22. *Paragraph 108.*—The Kona block is not likely to be affected materially by the Divi island, but this will not materially alter Mr. Turing's forecast which is, I think, somewhat sanguine. It is extremely difficult to give a satisfactory forecast as to the rate at which land will be taken up and any forecast must be more or less rough.

23. *Paragraph 112.*—Under G.O., No. 8428, Revenue, dated 14th December 1909, in which Government has sanctioned the sale of lands under the Peddalanka project which are still unoccupied, it is unnecessary to reserve any land in the Peddalanka area for free distribution.

The only area in regard to which I have addressed the Board on the subject of the sale of waste lands is the Peddalanka area, on which orders were passed in the Government Order quoted above. I am, however, considering the question of addressing the Board in regard to the amendment of the darkhast rules so far as this district is concerned so as to do away with all preferences shown to adjoining pattadars or pattadars of the village. At the same time, I am strongly of opinion that all lands in the delta which have a saleable value should be sold.

In the case of Divi island lands I recommended that free distribution should not be resorted to, but Government decided otherwise in G.O., No. 1313, Revenue, dated 12th May 1909. I presume Government will therefore not be prepared to depart from the practice in the case of lands under the reservoir project except in respect to the Peddalanka lands. I would submit however that in the case of the Kolair lands, free distribution is uncalled for as it is a tract to which the ordinary arguments in favour of free distribution can hardly apply. In the case of villages adjoining the Kolair, the usual percentage might perhaps be allowed to those resident pattadars who have been cultivating dalwa lands hitherto and it might also assist the project to allow a small percentage area to ryots from villages at some distance from the Kolair who have similarly had dalwa cultivation. In making a free distribution, however, it will be important to consider individual cases separately and it would be

a great mistake to lay down a hard and fast rule. There are numerous instances in which large areas of land adjoining the Kolair lake have been given on patta to individuals in recent years and there is absolutely no reason why these persons should be granted any further areas. Instances such as those I refer to are the following:—

Name of grantees.	Residence.	Village in which land was granted.	Area granted
			ACRES.
(1) P. Venkayya	Attili	Agadallanka Malluvaram Paidichintapad Kokkirayalanka Korvadalanka	1,769.18
(2) Jaffar Saheb	Ellore	Manngunur lanka Kottada	235.18 218.03
(3) Aravamath Aiyangar	Madras	Kudumula Tippa	552.52
(4) D. Manikyam	Kalakurru lanka	Penumaka	82.02
(5) J. W. Maiden and B. Venkata-sami	Masulipatam		198.78

24. *Paragraph 113.*—The rate at which land should be sold will depend largely upon the demand existing at the time. This demand varies from year to year and it might often be advantageous to sell a much larger area than 10,000 acres in one year. For the purpose of the project estimate, however, the proposal of Mr. Turing may be adopted.

25. *Paragraph 114.*—There is nothing to prevent the wet rate in dry lands brought under project irrigation being fixed at any figure considered desirable. For the purposes of the estimate at least Rs. 5 per acre should be taken as the water-rate. Pending re-settlement, it will probably be found desirable to retain the lands as dry as has been done in the case of the Divi island lands—*vide* G.O., No. 1044, Revenue, dated 15th April 1909. In the case of ordinary wet lands in the delta, the additional revenue from irrigation should be estimated at not less than Rs. 7,70,346 (Rs. 5 per acre on 154,069.39 acres) instead of Rs. 7,54,425 as given by Mr. Turing (column 12 *plus* column 13 *plus* column 14 of statement I). I should like, however, to see a higher rate than Rs. 5 an acre; it will be as easy to get Rs. 6 as Rs. 5 per acre and there is no reason why Government should charge a very much lower rate than any private individual would charge. A charge of Rs. 6 per acre would raise the revenue to Rs. 9,24,416. I do not suppose that Government could sanction any increase in the wet assessment on occupied wet land on account of improved irrigation resulting from the project.

26. *Paragraph 115.*—As far as the Kistna delta in this district is concerned, I think there can be no doubt the project would lessen the amount lost in remissions. The amount involved is however inconsiderable. The remissions on account of loss of crop for the past five years are given below:—

Fasli.	Amount of remission for loss of crop.	Average.
	RS.	RS.
1314.	19,639	12,053
1315.	12,393	
1316.	11,183	
1317.	8,732	
1318.	8,321	

The estimated remission for the current fasli is Rs. 25,000 and as there was no north-east monsoon and the river supply failed at an early date this amount is rarely likely to be exceeded. It would, I think, be fair to credit the project as far as this district delta is concerned with an annual saving of Rs. 14,000 on account of reduction in remissions.

27. *Paragraph 117.*—The charge for second crop on wet land is $\frac{1}{2}$ the wet assessment *plus* Re. $\frac{1}{2}$, the Re. $\frac{1}{2}$ representing half the rate of Re. 1 levied for the irrigation of dry lands in order to induce the pattadars to transfer the lands to wet. There is, however, no reason why a special rate should not be fixed for all second crop irrigation

from the project and it will certainly save labour if a uniform rate is adopted for all lands. Personally, I consider every possible means should be adopted to reduce the work of karnams and taluk establishments. The difference resulting from the fixing of the rate with reference to the wet assessment is not very material to ryots individually, while they understand a fixed rate and are better able to check the charges levied so that as a general rule a fixed rate will be popular. In the Godavari delta, the 2nd crop irrigation was as follows in fasli 1318:—

Taluk.	Non-Government.		Ryotwari.			Non-Government and Ryotwari.	
	At Rs. 5 per acre.	At Rs. 3-2-0 per acre (Rs. 8-2-0 minus Rs. 5).	Ares.	Total charge.	Average rate per acre.	Area.	Average rate per acre.
1	2	3	4	5	6	7	8
Tanuku	ACS.	ACS.	ACS.	RS.	RS. A. P.	ACS.	RS. A. P.
Gudivada	15,930	260	20,584	78,845	3 13 0	36,764	4 5 1
Narasapur	10,533	520	20,629	2,266	4 5 7	520	4 5 7
Bhimavaram	8,350	3	15,175	68,982	3 6 0	31,162	3 14 6
Ellore	70	1,358	50,286	3,964	3 5 0	23,528	3 14 7
Total	34,883	253	58,266	2,03,843	3 8 11	93,402	4 0 11

From these figures it is safe to assume that a second crop water charge of Rs. 4 per acre would not be excessive and that even Rs. 5 would be readily paid. As a matter of fact the existing water-rates could easily be raised by 50 or 75 per cent. This is also clear from Mr. Turing's remarks in paragraph 119. A water charge for second crop of Rs. 4 per acre would mean an annual increase in revenue of Rs. 1,02,000 over Mr. Turing's estimate, while a Rs. 5 rate would result in an increase of Rs. 3,06,000.

28. *Paragraph 118.*—Lands for dalwa cultivation are eagerly taken up, subject to the water charge of Rs. 5 even though success of the crop is frequently very doubtful. I agree therefore with Mr. Turing that late crop areas should be treated in the same way as ordinary lands.

29. *Paragraph 133.*—By fixing the first crop wet rate in the delta at Rs. 6 (*vide* paragraph 25 above) and the second crop wet rate at Rs. 4 (*vide* paragraph 27 above) the return on an expenditure of $7\frac{1}{2}$ crores would be raised to 6.8 per cent., while if a second crop rate of Rs. 6 is adopted the return would be 7.07 per cent.

Resolution—No. 249, dated 14th May 1910.

In the first of the papers read above, Mr. J. M. Turing, I.C.S., submitted his report on the revenue aspects of the revised Kistna Reservoir Project. The Board has obtained the views of the Collectors of Kistna and Guntur on the report and it has had the advantage of considering a note by the Chief Engineer for Irrigation, to whom, at his request, advance copies of the report were furnished. The Settlement Commissioner has also fully discussed the whole of the scheme in person with the Chief Engineer for Irrigation. The full Board has carefully considered all the papers read above and begs to submit the following report.

2. The Kistna Reservoir Project, as originally designed, commanded "a narrow strip of Palnad taluk, the greater part of Sattenapalle and Narasaraopet taluks, the whole of Guntur and Bapatla taluks west of the Kommamur canal, a small corner of

"Vinukonda, the eastern sides of Darsi and Podili divisions, the whole of Ongole taluk, the greater part of Kandukur and Kavali taluks, small portions of Nellore and Atmakur taluks, and insignificant fractions in Kanigiri and Udayagiri" (paragraph 7 of Mr. Braidwood's report printed in G.O., No. 783, Revenue, dated 14th August 1906). It commanded an area of 2,419,000 acres, of which 1,612,000 acres were irrigable and the capital outlay was estimated at 12 crores of rupees. In their letter No. 964 I., dated 24th June 1907, printed in G.O., No. 452 I., dated 14th October 1907, the Government of India observed that the project as it stood did not fulfil the conditions of a productive work and directed that an endeavour should be made to bring it within the definition of such a work by reducing its scope as well as the estimated amount of its total expenditure. They also added that the project canal should not be carried further south than the Gundlakamma river. Further investigation was accordingly made by the Public Works Department on the lines indicated by the Government of India and the scope of the project has been considerably reduced. The site of the reservoir has now been located at a place 40 miles lower down the Kistna river than the original site and it is proposed to take the main canal from this point through the eastern part of the Sattenapalle taluk, a corner of the Guntur taluk, the Narasaraopet taluk and the north-west corner of the Ongole taluk, stopping at the point where the canal will enter the Gundlakamma river. The whole of the Nellore area and the excluded from the area commanded. The area available for extension of cultivation in the Divi island has also been excluded from the scope of the project under the orders conveyed in G.O., No. 420 I., dated 30th September 1909. The revised project is designed to serve for the first time a portion of the upland tract of the Guntur district as well as to extend irrigation in the Kistna delta.

3. *Area commanded.*—The Special Revenue Officer was furnished by the Executive Engineer on special duty with key maps indicating the general position of the area commanded by the project as now revised. In the upland tract where the work of investigation consisted mainly in a revision of the records prepared by Mr. Braidwood in connection with the original project, fieldwar details of the area commanded were obtained from the village A registers prepared by that officer, but in the delta tract, where the work was original, information was obtained from the list of survey numbers supplied by the officers of the Public Works Department. The area commanded has thus been ascertained to be as follows:—

	Upland irrigation.	Delta extension including short late crop.	Kolair lake area (short late crop).
Government	ACS. 378,656	ACS. 101,055	ACS. 83,088
Zamindari	10,945	94,449	1,613
Whole inam	37,022	12,411	Nil.
Total	926,623	* 207,915	84,651

* Includes short late crop area of 9,858 acres.

4. *Total irrigable extent (First crop).*—As the result of the investigation conducted by the Special Revenue establishment, the maximum extent that could be irrigated out of the total area commanded by the project was found to be 725,787 acres in the upland, 163,563 acres in the delta and the whole of the commanded extent in the Kolair lake area or 78,79 and 100 *per cent.*, respectively of the commanded area in each case. Mr. Turing and his Tahsildars made field to field inspections wherever necessary and with the help of the levels taken by the Public Works Department for purposes of the revised project, they have been able to ascertain what lands are below the level of the project canals and consequently irrigable therefrom and what not. Lands coming under the latter category as well as certain other lands have been deducted from the commanded area in arriving at the area irrigable by the project.

5. *Deductions from the commanded area.*—The deductions made by Mr. Turing from the commanded area fall under one or the other of the heads specified in the talukwar abstract (Statement No. II) appended to his report and each item of deduction will be discussed below *seriatim*:—

	ACS.
(1) Existing village-sites—	11,300
Upland	3,006
Delta	
This item calls for no remarks.	
(2) Extension of village-sites—	5,857
Upland	208
Delta	
and (3) Dry zone round each village—	10,053
Upland	2,568
Delta	

In their Order No. 2470, Revenue, dated 7th September 1909, Government directed that, except in the case of 35 villages in the Divi taluk, a dry zone of 50 yards should, after making allowance for probable extension of village-site, be allowed round all villages and hamlets in both the upland and the deltaic tracts. In the excepted villages, the extent of dry zone to be allowed was fixed at 100 yards. Under the orders conveyed in G.O., No. 420 I., dated 30th September 1909, however, the villages in the Divi taluk were, as already stated, altogether excluded from the scope of the present project. As regards the extension of village-site, Mr. Turing in the course of his investigation proposed to calculate the area that would be required for this purpose in the following manner:—to count the number of occupied houses in several wet villages of varying extents in the deltaic tract and, assuming that each dry village in the upland would after the extension of irrigation have the same number of occupied houses as the wet villages of corresponding extent in the delta, to calculate the area required for the extension of village-site, making a liberal provision for the extent of each house and of cattle-stands, straw-yards, etc. The Board in its Proceedings, Mis. No. 3293, Land Revenue, dated 14th October 1909, generally accepted his recommendations in this respect, but pointed out that village-sites in the deltaic tract were not nearly large enough for the number of houses and the population, and requested him therefore to allow a liberal margin in the case of the upland area. Mr. Turing has not, however, worked upon the extent of house-site that should be allowed to each house separately but has calculated the average number of houses likely to be built in an irrigated village, the calculation being based on delta experience. In the result, he has applied a 10 cent rate to each house. Although as a matter of theory he would be inclined to fix the area at a higher figure than 10 cent per house, he rejects the suggestion of a higher rate as being unpractical. In addition to the area required for the extension of village-site, as calculated above, he has reserved a dry zone of 50 yards round each hamlet and village. He points out that many of the villages are zamindari and, as the duty of acquiring land for the extension of village-site in such villages devolves on the zamindars, he proposes to refuse canal water to lands in zamindaris suitable for such extension. The Collector of Kistna agrees with Mr. Turing on this point. The Board accepts the deductions under items (2) and (3) which have been made in accordance with the orders of the Board and Government.

	ACS.
(4) Roads, paths, etc.—	29,433
Upland	5,208
Delta	

The project area is stated to be well provided with main roads but to be lamentably deficient in minor communications designed to facilitate the transport of grain to the nearest market. Mr. Turing suggests certain improvements to existing communications in the Challapalle and Kona blocks, the Peddalanka and Isukapalle areas and the Kolair lake area and adds that the road from Sattenapalle to Krosur should be extended as far as the dam site. He further recommends that the Public Works Department, in constructing the canals and major distributaries,

would be useful for cattle and that the retention of these trees may possibly have a slight bearing on the question of leaf manure. The Board considers that the deduction may stand.

(10) Forest reserves—

[illegible]

All forest reserves, with the exception of areas quite bare of trees and valueless to the Forest Department, have been treated as unirrigable. Forest lands which, though reserved or notified under section 26 of the Forest Act, can be advantageously irrigated have been included in the irrigable area. The Collector of Kistna accepts the deductions under this head. Mr. Turing considers it unnecessary to exclude from irrigation lands quite bare of trees solely on the ground that they may one day be grown with trees fit for firewood. He points out that there are already two rich sources of fuel supply to the project area, viz., Calcutta and Singareni whence coal can be easily brought down, as well as the private casuarina plantations in the delta. As observed by the majority of the Board in paragraph 6 of B.P., No. 210, dated 14th July 1906, it would be wasteful and retrograde to use valuable irrigable land for the growth of scrub jungle, fuel or grass. The Board still adheres to this view and agrees with Mr. Turing that the forest lands included by him in the irrigable area should be made available for cultivation.

(11) Hills and highlands—

[illegible]

This item is of very great importance in the upland, but is insignificant in the delta. These are lands which, with reference to the levels now taken, cannot, according to the certificate of the Executive Engineer, be reached by the water. The deductions under this head should therefore stand.

(12) Submersible lands—

[illegible]

(i) lands liable to submersion by salt water,

(ii) lands submersible for too long a period to allow of the sowing even of a late crop.

(iii) submersible lands of small extent which are not ordinarily likely to be covered with water even in the late season.

(iv) lands at the far end of the canals.

(13) Unsuitable soils—

Upland	...	...	...	...	...	...	...	5,444
Delta	...	...	...	...	...	...	...	132

In the upland tract, about 87 *per cent.* of the soil is regar clay and the rest is either regar loam, alluvial or red clay. In the delta also there is a larger proportion of regar clay, being about 34 *per cent.*, but there is a larger variety of soils here than in the upland. Mr. Turing doubts whether the regar clay soils which cover by far the largest proportion of lands in the upland will be suitable for irrigation and suggests that expert enquiry may be made on this question as well as on the manurial value of the Kistna silt. As regards irrigability, Mr. Turing himself observes that the soils

reference to paragraph 3 of G.O., No. 216, Revenue, dated 23rd February 1904, the mamul wet area should be finally determined before the introduction of reservoir irrigation.

(16) Already irrigated by delta canals—

Upland	...	...	...	...	...	7,402
Delta	...	...	...	...	...	<i>Nil</i>

(17) Other causes—

Upland	...	...	...	...	...	...	...	2,483
Delta	...	...	...	...	...	...	...	1,471

6. The total deductions from the commanded area thus amount to 200,836 acres in the upland and 44,352 acres in the delta. The commanded area as well as the irrigable area under first crop, after applying the deductions detailed above, will stand as shown below :—

	Commanded area.	Deductions.	Area irrigable.	Percentage of deduction.
I. Upland ..	ACS. 926,623	ACS. 200,836	ACS. 725,787	22 per cent.
II. Delta .. { (a) Ordinary crop	198,057	43,988	154,069	} 21 "
.. { (b) Short late crop	9,858	364	9,494	
III. Kolair lake area (short late crop)	84,651	..	84,651	..
Total ..	1,219,189	245,188	974,001	20 per cent.

7. *Second crop*—204,000 acres.—The second crop cultivation will be confined to the delta tract and it is not intended to allow water for the irrigation of second crop in the upland tract mainly for engineering reasons. In paragraphs 91 and 92 of his report Mr. Turing proposes an alteration in the period of closure of the canals for silt clearance in the interests of the proposed second crop irrigation and the short late crop. He suggests that the canals should be closed from 20th December to end of January and not between 15th March to 1st June as is now done. The Collector of Kistna observes that this proposal would be impracticable on account of (1) the difficulty of procuring labour for the execution of repairs at the time of the year suggested, and (2) the necessity of providing water for second crop seedlings in

In G.O., No. 1682, Revenue, dated 24th June 1909, Government directed that deductions for pasturage should be made only from unoccupied land. Mr. Turing has accordingly made all his deductions for grazing from assessed waste and poramboke lands and has reserved only very small areas in patta and zamin lands which are on high level or are already used as communal grazing lands. Even in the case of assessed waste and poramboke lands he has not reserved small patches of lands surrounded by paddy fields, saline lands unsuited for the growth of grass, lands liable to heavy submersion or lands in villages which adjoin large tracts of similar grazing lands which it is not proposed to irrigate. On the whole, the percentage of the areas reserved for grazing in the upland and the delta work out to $\frac{1}{2}$ per cent. in the former and 3.8 per cent. in the latter. Mr. Turing points out that in these thickly populated and highly cultivated tracts it is not possible to make grazing reservations on a larger scale. The cultivation of fodder crops such as sunn-hemp, fodder chulam, etc., furnishes ample food for cattle and is already largely resorted to. The area reserved for grazing would no doubt support far more cattle if it were cultivated with fodder crops than if grass were grown thereon. Mr. Turing states that the deductions for pasturage which he has made should prove amply sufficient. The Collectors of Kistna and Guntūr generally accept Mr. Turing's proposals and the Board agrees with them that the area reserved for grazing may be taken as sufficient.

(15) Mamul wet—																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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These lands which are either zamindari or inam are entitled to free irrigation
and will not yield any additional revenue. The Board would point out that with

January. The question is one for the local Revenue and Public Works Department officers to consider with due regard to the conditions prevailing in, and the special circumstances of, the tract concerned as well as to the wishes of the ryots. But the Board observes that the Superintending Engineer on special duty sees no insuperable objection to the change proposed.

8. *Revenue derivable from the project*—(i) *Water-rate*—(a) *First crop*.—The Special Revenue officer has calculated the water-rate leviable on zamindari and inam lands at Rs. 5 an acre, the rate prescribed in appendix I-B to Board's Standing Order No. 4, while in the case of Government lands he has adopted the differential water-rates prevailing in the delta. The average of these rates is stated by Mr. Turing to approximate to Rs. 5 an acre (except in the "unsurveyed" Kolair lake area where it comes to Rs. 4-12-0). The same procedure has been applied to the upland tract also on the assumption that the lands in the latter tract which are now assessed very low will, after the introduction of the project, enjoy equal facilities with the delta lands and will therefore be able to pay the delta water-rates. The revenue derivable from first crop works out to Rs. 47,62,822 as shown below:—

	Rs.
Upland	36,09,444
Delta	7,54,425
Short late crop	3,98,953
Total	47,62,822

(b) *Second crop*.—As pointed out in paragraph 7 *supra* it is expected that second crop will be raised on 204,000 acres in the delta. As explained in paragraph 117 of his report, Mr. Turing has calculated the charge for second crop at an average rate of Rs. 3-8-0 per acre. At this rate the revenue derivable from the project under this head comes to Rs. 7,14,000.

(ii) *Dry assessment on unoccupied lands likely to be brought under cultivation*.—The assessment on unoccupied lands likely to be brought under cultivation is an item of revenue which should be credited to the project and this has been calculated to be Rs. 1,21,709.

(iii) *Revenue from sale-proceeds of waste lands*.—Mr. Turing has excluded all tank-bed lands, lands reserved in the delta for free distribution to ryots, lands already granted on conditional patta and all plots of saleable land measuring less than 10 acres each. The extent of saleable lands has, after such deduction, been arrived at 16,054 acres in the upland tract and 90,151 acres in the delta. The sale value of the lands in the upland tract has been estimated at rates varying from Rs. 20 to Rs. 30 an acre and that of lands in the delta at Rs. 75 per acre and the total sale value is estimated at Rs. 65,70,678, the 4 per cent. thereon creditable to the project being Rs. 2,62,809. The Collector of Guntur sees no reason why lands already granted conditionally should be treated differently from those to be granted in future, nor why some should be given free and some conditionally, and further points out that the small areas of wet lands measuring less than 10 acres each may perhaps be worth Rs. 10,000 or more. He strongly objects to the rate of sale value per acre fixed by Mr. Turing for lands in the upland area and considers it much too low. He states that, if the lands proposed to be sold are really fit for irrigation, they should eventually be worth not less than 10 times the amount taken credit for and probably a good deal more. The Collector of Kistna states that the sale price of land will depend largely upon the demand existing at the time and that, for the purposes of the project estimate, Mr. Turing's proposals may be adopted. According to Mr. Turing, the lands selected by him for sale are mostly saline and will not fetch high prices. On the whole, for purposes of an estimate, it would be safer to adopt the lower rates. Under the discretion vested in him by G.O., No. 3428, Revenue, dated 14th December 1909, the Collector of Kistna considers that it is not necessary to reserve any extent in the Peddalanka area for free distribution. The extent of 1,086 acres reserved by Mr. Turing for free distribution may, the Board considers, be included therefore in the saleable area. In the case of the Kolair lake area, the Collector considers that free distribution is uncalled for. Mr. Turing states that the reservation he has made in the Kolair lake area is necessary in order to prove the

possibility of growing "short late" crops and thus to stimulate the sale of adjoining lands. The extent reserved by Mr. Turing for free distribution seems rather high and the Board would reduce it, say, to 2,000 acres, thus setting free an additional area of 1,800 acres for sale. The revenue under this head would therefore come to Rs. 2,71,467.

(iv) *Savings on account of remission*.—Mr. Turing has not taken into account the savings on account of remission which should necessarily be credited to the project. The Collector of Kistna states that an average amount of Rs. 14,000 may be taken into account, while the Collector of Guntur gives no information on this point. But from the jamabandi statements it would appear that season remission amounting to Rs. 14,300 on an average had during the last five years been granted in the Guntur district. Seeing that six out of the eight taluks of the district will be protected by the project, this amount may also be taken into account for purposes of an estimate. The total savings on account of remission thus amount to Rs. 28,300.

9. The total revenue derivable from the project will amount to Rs. 58,98,298 as shown below:—

	Rs.
(i) Water-rate	47,62,822
(ii) Second-crop charge	7,14,000
(iii) Dry assessment on unoccupied lands	1,21,709
(iv) Interest on sale-proceeds of waste lands	2,71,467
(v) Savings on account of remission	28,300
Total	58,98,298

Deducting therefrom the charges on account of maintenance and collection at the rates adopted by Mr. Turing, viz.—

	Rs.
(1) Maintenance charges at 12 annas per acre on 974,000 acres	7,30,500
(2) Collection charges at 5 per cent. on the gross revenue	2,94,915
Total	10,25,415

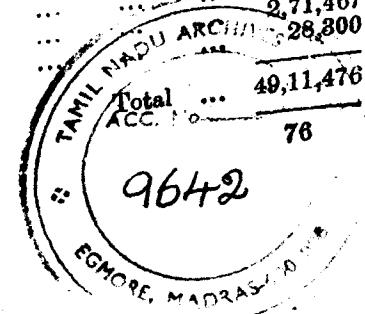
the net revenue will come to Rs. 48,72,883, which on an estimated outlay of Rs. 7½ crores gives a return of 6.5 per cent. as against 6.4 per cent. arrived at by Mr. Turing.

10. From the note furnished by the Chief Engineer for Irrigation referred to in paragraph 1 *supra*, the Board finds that the Public Works Department proposes to reduce the areas likely to be irrigated by the project as shown below. This step is rendered necessary by the adoption of special methods of working the reservoir owing to the large quantity of silt that has to be dealt with.—

	Mr. Turing's figures.	Public Works Department figures.
	ACS.	ACS.
Short late crop	94,000	60,000
Second crop	204,000	80,000
Upland first crop	725,000	628,000

Adopting the areas proposed by the Public Works Department and assuming that the amounts of dry assessment on unoccupied lands and interest on sale-proceeds of waste lands creditable to the project as thus revised will be the same as that given in paragraph 8 *supra*, the revenue derivable from the project will be reduced to Rs. 49,11,476 as shown below:—

	Rs.
Water-rate on 842,000 acres at Rs. 5 an acre	42,10,000
Second crop charge on 80,000 acres at Rs. 3½ per acre	2,80,000
Dry assessment on unoccupied lands	1,21,709
Interest on sale-proceeds of waste lands	2,71,467
Savings on account of remission	28,300
Total	49,11,476



APPENDIX.

Deducting working expenses (inclusive of collection charges) at Rs. 1-4-0 per acre, as recommended by the Chief Engineer for Irrigation, the net revenue from the project works out to Rs. 38,58,976, which represents a return of 5.1 per cent. on a capital outlay of Rs. 7½ crores, or, in other words, will make the project barely productive. The return will be further reduced if it is found necessary to curtail still more the area to be irrigated or if, as is not unlikely, the outlay now estimated is found ultimately to require enhancement.

11. It would thus be impossible to meet the wishes of the Government of India in regard to this valuable project, *viz.*, to bring it well within the category of a productive work, unless it is made more remunerative by the application of water-rates higher than those now obtaining in the Delta area. Mr. Turing himself admits that the average water-rates applied by him are too low. The Collector of Guntūr observes that if the water-rates proposed by Mr. Turing are insufficient to make the scheme productive, the rates should be raised rather than that the project should be dropped. The Collector of Kistna also would like to have a higher rate than Rs. 5 per acre and adds that it will be as easy to get Rs. 6 as Rs. 5 per acre and that there is no reason why Government should charge a very much lower rate than any private individual would charge. In the present case, the market value of water will considerably increase owing to the enormous outlay of capital required for the execution of the work and to the improved facilities for irrigation which the project would afford. The Board would accordingly recommend that, in order to ensure the project being productive, a lump addition of Rs. 2 per acre may be made to the average differential water-rate of Rs. 5 arrived at by Mr. Turing and charged for the first crop as well as the short late crop, and that a similar addition of Re. 1 per acre may be made to the average second-crop rate of Rs. 3-8-0. From paragraph 119 of Mr. Turing's report it would appear that the ryots would be willing to pay an enhanced water-rate and the Board does not consider that the rates just proposed are in any way excessive. At these rates the revenue derivable from the project will come to Rs. 66,90,280—

	Rs.
Water-rate on first crop on 842,000 acres at Rs. 7 an acre	58,94,000
Enhanced water-rate on 7,402 acres of existing wet lands at Rs. 2 an acre— <i>vide</i> paragraph 5 (14) <i>supra</i>	14,804
Second-crop charge on 80,000 acres at Rs. 4½ an acre	3,60,000
Dry assessment on unoccupied lands	1,21,709
Interest on sale-proceeds of waste lands	2,71,487
Savings on account of remissions	28,300
Total	66,90,280

Deducting working expenses at Rs. 1-4-0 per acre, the net revenue will come to Rs. 56,37,780, which will give a return of 7.5 per cent. on the capital outlay as now estimated, thus ensuring not only a safe margin of profit, but the execution of a most valuable work.

12. *Growth of irrigation.*—Different rates of development of irrigation have been adopted by Mr. Turing for the upland and the deltaic tracts as well as for the short late crop and second-crop areas, but in view of the reduced areas contemplated by the Public Works Department the Board would adopt those proposed by the latter.

13. A consolidated revenue forecast statement in Public Works Department Form No. 155 is enclosed.

(True Extract.)

L. D. SWANIKANNU,
Secretary.

To the Secretary to Government, Revenue Department, with Mr. Turing's village-wise statements in original, copy of Chief Engineer's u.o. note and three maps.
Copy to the Chief Engineer for Irrigation.
" J. M. Turing, Esq., I.C.S.
" Board of Revenue (Land Revenue).

ESTIMATE of growth of irrigation and revenue receipts and charges.

Year.	Irrigated area at the end of the year.	Revenue receipts and charges.					
		Gross revenue due to works.				Net revenue due to works.	
		Direct receipts.	Enhanced land revenue due to irrigation inclusive of 4 per cent. on the sale-proceeds of tank-bed lands.	Total	Charges both direct and indirect against revenue account.	Including enhanced land revenue.	Excluding enhanced land revenue.
1	2	3	4	5	6	7	8
	ACS.	RS.	RS.	RS.	RS.	RS.	RS.
1st	..	..	..	..	..	..	..
2nd	..	..	..	..	..	..	..
3rd	..	..	..	..	..	..	1,24,550
4th	..	..	..	..	..	..	2,83,600
5th	..	..	..	..	..	..	4,42,650
6th	..	23,400	1,43,800	5,690	1,49,490	19,250	1,30,240
7th	..	52,800	3,29,600	42,570	3,72,170	46,000	3,26,170
8th	..	82,200	5,15,400	79,450	5,94,850	72,750	5,22,100
9th	..	111,600	7,01,200	1,16,330	8,17,530	99,500	7,18,030
10th	..	141,000	8,87,000	1,53,210	10,40,210	1,26,250	9,13,960
11th	..	201,800	12,93,310	1,92,720	14,86,030	1,92,250	12,93,810
12th	..	262,600	16,99,680	2,32,230	19,31,910	2,58,250	16,73,660
13th	..	323,400	21,06,020	2,71,740	23,77,760	3,24,250	20,53,510
14th	..	384,200	25,12,360	3,11,260	28,23,610	3,90,350	24,33,260
15th	..	445,000	29,18,700	3,50,760	32,69,460	4,56,250	28,13,210
16th	..	482,400	31,31,240	3,84,580	35,65,820	5,03,000	30,62,820
17th	..	513,800	34,01,780	3,87,210	37,88,990	5,42,250	32,46,740
18th	..	545,200	36,22,320	3,89,840	40,12,160	5,61,500	34,50,660
19th	..	576,600	38,42,860	3,92,470	42,35,330	6,20,750	36,14,580
20th	..	608,000	40,63,400	3,95,100	44,58,500	6,60,000	37,98,500
21st	..	639,400	42,83,940	3,97,730	46,81,670	6,99,250	39,82,420
22nd	..	670,800	45,04,480	4,00,360	49,04,840	7,38,500	41,66,340
23rd	..	702,200	47,25,020	4,02,990	51,28,010	7,77,750	43,50,260
24th	..	733,600	49,45,560	4,05,620	53,51,180	8,17,000	45,34,180
25th	..	765,000	51,66,100	4,08,250	55,74,350	8,56,250	47,18,100
26th	..	796,400	53,86,640	4,10,880	57,97,520	8,95,500	49,02,020
27th	..	827,800	56,07,180	4,13,510	60,20,690	9,34,750	50,85,940
28th	..	859,200	58,27,720	4,16,140	62,43,860	9,74,000	52,69,860
29th	..	890,600	60,48,260	4,18,770	64,67,030	10,13,250	54,53,780
30th	..	922,000	62,68,800	4,21,500	66,90,300	10,52,500	56,37,800
31st	..	..	..	..	..	..	..

FORECAST OF FINANCIAL PROSPECTS (REVISED).

Kistna Reservoir Project (total of upland area and delta extension including second crop).

PART III.—Estimate of growth of irrigation and revenue receipts and charges.
[Corresponding to V of Mr. Turing's tables.]

Year.	Irrigated area at end of year.	Revenue receipts and charges.					
		Gross revenue due to works.			Charges both direct and indirect against Revenue account.	Net revenue due to works.	
		Direct receipts.	Enhanced Land Revenue or Indirect Revenue.	Total.		Including enhanced Land Revenue.	Excluding enhanced Land Revenue.
1	2	3	4	5	6	7	8
1st year after commencement.	ACS.	RS.	RS.	RS.	RS.	RS.	RS.
2nd do.	..	..	..	..	..	..	..
3rd do.	..	..	..	..	..	..	..
4th do.	..	..	..	..	..	..	..
5th do.	..	..	..	..	..	..	..
6th do.	..	..	..	..	..	..	..
7th do.	..	..	..	..	..	..	..
8th do.	23,400	1,03,400	4,300	1,07,700	20,650	87,050	82,750
9th do.	52,800	2,32,200	27,900	2,60,100	48,800	2,11,300	1,83,400
10th do.	82,200	3,61,000	51,600	4,12,600	76,950	3,35,650	2,84,050
11th do.	111,600	4,89,800	75,100	5,64,900	1,05,100	4,59,800	3,84,700
12th do.	141,000	6,18,600	98,700	7,17,300	1,33,250	5,84,050	4,85,850
13th do.	201,400	9,08,300	1,28,950	10,37,250	2,00,650	8,36,600	7,02,550
14th do.	262,800	11,88,000	1,49,200	13,37,200	2,68,050	10,69,150	9,19,950
15th do.	323,400	14,72,700	1,74,450	16,47,150	3,35,450	13,11,700	11,37,250
16th do.	384,200	17,57,400	1,99,700	19,57,100	4,02,850	15,54,250	13,54,550
17th do.	445,000	20,42,100	2,24,950	22,67,050	4,70,250	17,96,800	15,71,850
18th do.	506,000	23,26,800	2,49,200	25,76,000	5,37,650	20,38,350	18,23,050
19th do.	567,000	26,11,500	2,73,450	28,84,950	6,05,050	22,79,900	20,56,350
20th do.	628,000	28,96,200	2,97,700	31,93,900	6,72,450	25,21,450	22,89,000
21st do.	689,000	31,80,900	3,21,950	35,02,850	7,40,850	27,62,000	25,22,150
22nd do.	750,000	34,65,600	3,46,200	38,11,800	8,09,250	30,02,550	27,63,300
23rd do.	811,000	37,50,300	3,70,450	41,20,750	8,77,650	32,43,100	30,04,450
24th do.	872,000	40,35,000	3,94,700	44,29,700	9,46,050	34,83,650	32,45,600
25th do.	933,000	43,19,700	4,18,950	47,38,650	10,14,450	37,24,200	34,86,750
26th do.	994,000	46,04,400	4,43,200	50,47,600	10,82,850	39,64,750	37,27,900
27th do.	1,055,000	48,89,100	4,67,450	53,56,550	11,51,250	42,05,300	39,69,050
28th do.	1,116,000	51,73,800	4,91,700	56,65,500	12,19,650	44,45,850	42,10,200
29th do.	1,177,000	54,58,500	5,15,950	59,74,450	12,88,050	46,86,400	44,51,350
30th do.	1,238,000	57,43,200	5,40,200	62,83,400	13,56,450	49,26,950	46,92,500
31st do.	1,299,000	60,27,900	5,64,450	65,92,350	14,24,850	51,67,500	49,33,650
32nd do.	1,360,000	63,12,600	5,88,700	69,01,300	14,93,250	54,08,050	51,74,800
33rd do.	1,421,000	65,97,300	6,12,950	72,10,250	15,61,650	56,48,600	54,15,950
34th do.	1,482,000	68,82,000	6,37,200	75,19,200	16,30,050	58,89,150	56,57,100
35th do.	1,543,000	71,66,700	6,61,450	78,28,150	16,98,450	61,29,700	58,98,250

FORECAST OF FINANCIAL PROSPECTS (REVISED).

Kistna Reservoir Project (Upland canal only).

PART III.—Estimate of growth of irrigation and revenue receipts and charges.

[Corresponding to V-A of Mr. Turing's tables.]

Year.	Irrigated area at end of year.	Revenue receipts and charges.					
		Gross revenue due to works.			Charges both direct and indirect against Revenue Account.	Net revenue due to works.	
		Direct receipts.	Enhanced Land Revenue or Indirect Revenue.	Total.		Including enhanced Land Revenue.	Excluding enhanced Land Revenue.
1	2	3	4	5	6	7	8
1st year after commencement.	ACS.	RS.	RS.	RS.	RS.	RS.	RS.
2nd do.	..	..	..	..	..	..	..
3rd do.	..	..	..	..	..	..	..
4th do.	..	..	..	..	..	..	..
5th do.	..	..	..	..	..	..	..
6th do.	..	..	..	..	..	..	..
7th do.	..	..	..	..	..	..	..
8th do.	..	..	..	..	..	..	..
9th do.	..	..	..	..	..	..	..
10th do.	..	..	..	..	..	..	..
11th do.	..	..	..	..	..	..	..
12th do.	31,400	1,55,900	1,650	1,57,550	39,250	1,18,300	1,16,650
13th do.	62,800	3,11,800	3,300	3,15,100	78,500	2,36,600	2,33,300
14th do.	94,200	4,67,700	4,950	4,72,650	1,17,750	3,54,900	3,49,950
15th do.	125,600	6,23,600	6,600	6,30,200	1,57,000	4,73,200	4,66,000
16th do.	157,000	7,79,500	8,250	7,87,750	1,96,250	5,91,500	5,83,250
17th do.	188,400	9,35,400	9,900	9,45,300	2,35,500	7,09,800	6,99,900
18th do.	219,800	10,91,300	11,550	11,02,850	2,74,750	8,28,100	8,16,550
19th do.	251,200	12,47,200	13,200	12,60,400	3,14,000	9,46,400	9,33,200
20th do.	282,600	14,03,100	14,850	14,17,950	3,53,250	10,64,700	10,49,850
21st do.	314,000	15,59,000	16,500	15,75,500	3,92,500	11,83,000	11,66,500
22nd do.	345,400	17,14,900	18,150	17,33,050	4,31,750	13,01,300	12,83,150
23rd do.	376,800	18,70,800	19,800	18,90,600	4,71,000	14,19,600	13,99,800
24th do.	408,200	20,26,700	21,450	20,48,150	5,10,250	15,37,900	15,16,450
25th do.	439,600	21,82,600	23,100	22,05,700	5,49,500	16,56,200	16,33,100
26th do.	471,000	23,38,500	24,750	23,63,250	5,88,750	17,74,500	17,49,750
27th do.	502,400	24,94,400	26,400	25,20,800	6,28,000	18,92,800	18,66,400
28th do.	533,800	26,50,300	28,050	26,78,350	6,67,250	20,11,100	19,83,050
29th do.	565,200	28,06,200	29,700	28,35,900	7,06,500	21,29,400	20,99,700
30th do.	596,600	29,62,100	31,350	29,93,450	7,45,750	22,47,700	22,18,350
31st do.	628,000	31,18,000	33,000	31,51,000	7,85,000	23,66,000	23,33,000

* Calculated at Rs. 1-4-0 per acre.

V-B. REVISED.—FORECAST OF FINANCIAL PROSPECTS, CORRESPONDING TO MR. TURING'S STATEMENT,
SHOWING REVENUE DEVELOPMENT—DELTA AREA EARLY 1ST CROP COMMENCING 7TH YEAR.

PART III.—Estimate of growth of irrigation and revenue receipts and charges.

Revenue receipts and charges.							
Year.	Irrigated area at end of year.	Gross revenue due to works.				Net revenue due to works.	
		Direct receipts.	Enhanced land revenue or indirect revenue.	Total.	Charges both direct and indirect against Revenue account.	Including enhanced land revenue.	Excluding enhanced land revenue.
1	2	3	4	5	6	7	8
1st year after commencement.		ACS.	RS.	RS.	RS.	RS.	RS.
2nd do.	..	..	..	..	..	..	..
3rd do.	..	..	..	..	..	..	..
4th do.	..	..	..	..	..	..	..
5th do.	..	..	..	..	..	..	..
6th do.	..	..	..	..	..	..	..
7th do.	..	..	..	..	..	..	..
8th do.	15,400	75,400	..	..	..	..	..
9th do.	30,800	1,50,800	4,300	79,700	..	..	..
10th do.	46,200	2,26,200	8,600	1,59,400	19,250*	60,450	56,150
11th do.	61,600	3,01,600	12,900	2,39,100	38,500	1,20,900	1,12,300
12th do.	77,000	3,77,000	17,200	3,18,800	57,750	1,81,350	1,68,450
13th do.	92,400	4,52,400	21,500	3,98,500	77,000	2,41,800	2,24,600
14th do.	107,800	5,27,800	25,800	4,78,200	96,250	3,02,250	2,80,750
15th do.	123,200	6,02,200	30,100	5,57,900	1,15,500	3,62,700	3,36,900
16th do.	138,600	6,78,600	34,400	6,37,600	1,34,750	4,23,150	3,93,050
17th do.	154,000	7,54,000	38,700	7,17,300	1,54,000	4,83,600	4,49,200
18th do.	154,000	7,54,000	43,000	7,97,000	1,73,250	5,44,050	5,05,350
19th do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
20th do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
21st do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
22nd do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
23rd do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
24th do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
25th do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
26th do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
27th do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
28th do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
29th do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
30th do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
31st do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
32nd do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
33rd do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
34th do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500
35th do.	154,000	7,54,000	43,000	7,97,000	1,92,500	6,04,500	5,61,500

* Calculated at Rs. 1-4-0 per acre

* Calculated at Rs. 1-4-0 per acre

FORECAST OF FINANCIAL PROSPECTS (REVISED).

Delta extension second crop only.

PART III.—Estimate of growth of irrigation and revenue receipts and charges.

[Corresponding to V-C of Mr. Turing's tables.]

Year.	Irrigated area at end of year.	Revenue receipts and charges.					
		Gross revenue due to works.			Charges both direct and indirect against Revenue account.	Net revenue due to works.	
		Direct receipts.	Enhanced land revenue or indirect revenue.	Total.		Including enhanced land revenue.	Excluding enhanced land revenue.
1	2	3	4	5	6	7	8
	ACS.	RS.		RS.	RS.	RS.	RS.
1st year after commencement.	..	..	..	..	..	..	..
2nd do.	..	..	..	..	..	..	..
3rd do.	..	..	..	..	..	..	..
4th do.	..	..	..	..	..	..	..
5th do.	..	..	..	..	..	..	..
6th do.	..	..	..	..	..	..	..
7th do.	8,000	28,000	..	28,000	1,400 *	26,600	26,600
8th do.	16,000	56,000	..	56,000	2,800	53,200	53,200
9th do.	24,000	84,000	..	84,000	4,200	79,800	79,800
10th do.	32,000	1,12,000	..	1,12,000	5,600	1,06,400	1,06,400
11th do.	40,000	1,40,000	..	1,40,000	7,000	1,33,000	1,33,000
12th do.	48,000	1,68,000	..	1,68,000	8,400	1,59,600	1,59,600
13th do.	56,000	1,96,000	..	1,96,000	9,800	1,86,200	1,86,200
14th do.	64,000	2,24,000	..	2,24,000	11,200	2,12,800	2,12,800
15th do.	72,000	2,52,000	..	2,52,000	12,600	2,39,400	2,39,400
16th do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000
17th do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000
18th do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000
19th do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000
20th do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000
21st do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000
22nd do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000
23rd do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000
24th do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000
25th do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000
26th do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000
27th do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000
28th do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000
29th do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000
30th do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000
31st do.	80,000	2,80,000	..	2,80,000	14,000	2,66,000	2,66,000

* Calculated at 5 per cent. on direct receipts.

FORECAST OF FINANCIAL PROSPECTS (REVISED).
Kistna Reservoir project (short late crop only).
PART II.—Estimate of growth of irrigation and revenue receipts and charges.
 [Corresponding to V-D of Mr. Turing's tables.]

Year.	Irrigated area at end of year.	Revenue receipts and charges.					
		Gross revenue due to works.			Charges both direct and indirect against revenue account.	Net revenue due to works.	
		Direct receipts.	Enhanced land revenue or indirect revenue.	Total.		Including enhanced land revenue.	Excluding enhanced land revenue.
1	2	3	4	5	6	7	8
1st year after commencement.	acs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
2nd do.	6,000	25,400	19,300	44,700	7,500	37,200	17,900
3rd do.	12,000	50,800	38,600	89,400	15,000	74,400	35,800
4th do.	18,000	76,200	57,900	1,34,100	22,500	1,11,600	53,700
5th do.	24,000	1,01,600	77,200	1,78,800	30,000	1,48,800	71,600
6th do.	30,000	1,27,000	96,500	2,23,500	37,500	1,86,000	89,500
7th do.	36,000	1,52,400	1,15,800	2,68,200	45,000	2,23,200	1,07,400
8th do.	42,000	1,77,800	1,35,100	3,12,900	52,500	2,60,400	1,25,300
9th do.	48,000	2,03,200	1,54,400	3,57,600	60,000	2,97,600	1,43,200
10th do.	54,000	2,28,600	1,73,700	4,02,300	67,500	3,34,800	1,61,100
11th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
12th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
13th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
14th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
15th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
16th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
17th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
18th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
19th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
20th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
21st do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
22nd do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
23rd do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
24th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
25th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
26th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
27th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
28th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
29th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
30th do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000
31st do.	60,000	2,54,000	1,93,000	4,47,000	75,000	3,72,000	1,79,000

VI

Memorandum, Ref. on Cur. No. 2135/10, dated 20th June 1910.

The Chief Engineer for Irrigation has the honour to forward to the Special Superintending Engineer a copy of the Board's Proceedings, No. 249, Press, dated 14th May 1910, regarding the revenue aspects of the Kistna Reservoir project for early remarks.

2. It may be noted that the rate Rs. 1-4-0 per acre of "working expenses" referred to in paragraph 11 of the Board's Proceedings was calculated for an assumed water-rate of Rs. 5 per acre. The rate of working expenses will require revision with reference to the proposal to enhance the water-rate. The revision of the rate should be on the same line as for the Cauvery Project, i.e., the actual maintenance charges kept separate from the percentage charges of 5 and 6 per cent. on gross revenue.

C. A. SMITH,
Chief Engineer for Irrigation.

To the Special Superintending Engineer,
with a complete copy of the Board's Proceedings.

VII

Letter—from Col. W. M. ELLIS, R.E., Special Superintending Engineer.
To—the Chief Engineer for Irrigation.
Dated—the 22nd June 1910.
No.—216-I.

[Your No. 2135/10, dated 20th June 1910.]

I submit the following remarks on the Board's Proceedings:—

Board's Proceedings, paragraph 7.—The closure of Kistna canals contemplated is two months from 1st December to 31st January yearly.

The alternatives would be closure one month to six weeks in April and May as is done in the Gódávri. The proposed time of closure would suit both the needs of the crops and economy of storage better.

The objection as regards water for the seedlings required for the second crop area I do not think can be sustained. There are numerous small tanks which would be full at the time of closure, under which seedlings for the second crop can be raised as is now done in the Gódávri.

This is not now possible in the Kistna to raise seedlings under tanks because the closure is three months in the hottest time of the year.

The fields have been dry for three months before closure commences. If closure were for December and January the coldest months of the year and the whole country was thoroughly wet and the tanks filled at the end of November it is in my mind a certainty that no difficulty as regards water in January for raising seedlings for second crop need be feared.

As regards the labour question for repairs,—this would affect silt clearance of the principal canals but not to any great extent other repairs which could be done at any time between December and May except in channels actually carrying water for second or late crop.

There will, it may be admitted, be more difficulty and materially greater expense in getting work especially earth-work done in December and January than in April and May. The advantages of this closure are in my opinion sufficient to override this.

Board's Proceedings, paragraph 10.—I do not know why the late crop acres 140,000 was recommended by the Chief Engineer for Irrigation to be divided into short late crop 60,000 and second crop 80,000.

It would pay better and be generally more satisfactory from an agricultural point of view to cultivate a larger area of short late crop. Probably information received from the Superintending Engineer, II Circle, who is investigating the distribution system for the proposed short late crop has led the Chief Engineer to the recommendation made to limit short late crop to 60,000 acres.

2. The papers are being referred to the Executive Engineer, Kistna Reservoir Project, for remarks and he is being requested to check the revised area 628,000 acres under the upland canal.

VIII

Memorandum, R.O.C. No. 2135/10, dated 28th June 1910.

With reference to the latter portion of paragraph 1 of his letter No. 216 I., dated 22nd June 1910, the Superintending Engineer on Special duty is informed that the division of the late crop area into 60,000 acres of short late crop and 80,000 of second crop is based on the Special Superintending Engineer's un-official note, dated 7th March 1910, extract of which is enclosed for information.

2. The remarks of the Executive Engineer, Kistna Reservoir Project, said to have been called for are awaited.

C. A. SMITH,
Chief Engineer for Irrigation.

To the Superintending Engineer on Special duty.

ENCLOSURE.

Extract un-official note, dated 7th March 1910, of the Superintending Engineer on Special duty on Rough Financial tables, Kistna Reservoir project.

The working tables show that the total late crop is below 70,000 acres in two years out of seventeen and in these years there is no water for late crop. Thus the "short late crop" balance $(140,000 - 60,000) = 80,000$ acres to be second crop proper. The annual revenue from late crop will be on average area—

60,000 acres short single crop.
80,000 " second crop.

W. M. ELLIS, Col., R.E.,
Special Superintending Engineer.

IX

Letter—from Col. W. M. ELLIS, R.E., Special Superintending Engineer.
To—the Chief Engineer for Irrigation.
Dated—the 2nd July 1910.
No.—232 I./118.

[Your No. 2135/10, dated 28th June 1910.]

I send a copy of Mr. Mullings' letter No. 428 of 28th June 1910 and offer comments on it and further remarks on the whole question as below.

2. The Executive Engineer, Kistna project, writes under a misunderstanding regarding the proposed eventual capacity proposed for the reservoir which is 34,000 million cubic feet and not 13,000.

The area in his 1 (i) should be $(34,000 - 6,000) \times 5.3 = 148,400$ acres second crop.

3. Going into the question of the newly-proposed conditions which were not before the Board of Revenue when making their recommendations, I enclose a statement deduced from working tables for sixteen years showing how these new conditions would work with full deduction for upriver projects and also if the water reserved for Kurnool canal extension were instead impounded.

From this we see that in the sixteen years

Including all deductions late crop supply fails in three years.

Excluding these three years the minimum late crop area is 26,500 acres and the average including all years is 97,387 acres.

Not deducting for Kurnool canal extension.—There is absolute failure of late crop in one year only. Excluding this the minimum area cultivated is, 1908-1909—22,250 acres.

The average late crop area is 110,977 acres.

4. I agree with Mr. Mullings' remarks about December and January closure and think it ought to be adhered to.

5. I do not think credit should be taken on remissions in the case of the Kistna project. There might be, I think, less damage from submersion after the reservoir is in operation because the first crop will be a month earlier and thus less likely to damage by submersion. The reservoir will not be an efficient "flood moderator".

6. As regards the rate to be paid by the short late single crop in view of the occasional failure of supply, I doubt whether these lands should be assessed at as high a rate as the early long single crop lands which will be practically immune from failure.

The matter is a Revenue one to be considered along with the table now furnished.

7. It is to be noted from the figures now given by the Executive Engineer, Kistna Reservoir Project, that the net irrigable area under the upland main canal is reduced to 610,000 acres.

8. As regards the distribution of late crop between second crop proper and short late single crop—

The total average now deduced is 97,387 acres (or with Kurnool extension water 110,977 acres, say 111,000 acres). Taking the latter figure as the more probable this might be distributed at 40,000 acres short late crop and 70,000 second crop, the latter expanding in good years up to 108,400 acres.

If the area of short late crop is restricted to narrow limits, the assessment charged might justifiably be higher as the supply becomes more secure.

ENCLOSURES.

(i)

TABLE showing area of late crop which in last 16 years could have been grown under a reservoir at Pulichintala of effect in capacity 34,000 millions cubic feet making full deductions for upriver project.

(The last 2 columns give extra area if deduction up to 3,000 cusecs when available for Kurnool canal extension is not made.)

Year.	Water in reservoir on 1st February, M. c. ft.	Acres, late crop.	Extra if Kurnool canal extension not allowed for.		
			M. c. ft., water available for.	Extra acres which could have been cultivated.	Remarks.
1893-1894	Full reservoir.	148,400	..	..	Reservoir full.
1894-1895	Do.	148,400	..	..	
1895-1896	Do.	148,400	..	..	
1896-1897	20,000	74,200	14,000	74,200	
1897-1898	Full.	148,400	..	..	Would have been issued to I crop.
1898-1899	Do.	148,400	..	..	
1899-1900	6,000	..	5,290	..	
1900-1901	6,000	..	12,609	61,480	1,000 would have been issued to I crop.
1901-1902	20,000	74,200	6,510	34,503	
1902-1903	Full.	148,400	..	..	
1903-1904	Do.	148,400	..	..	
1904-1905	28,000	127,000	..	3,180	..
1905-1906	11,000	26,500	600	..	
1906-1907	Full.	148,400	..	25,440	
1907-1908	18,500	65,200	4,800	18,560	
1908-1909	6,700	3,700	3,600	..	217,360
Total 16 years	..	1,558,200	..	13,584	
Average	..	97,387	..	..	

Duty taken as 5.3 acres per million cubic foot available for issue on 1st February to late crop over and above the 6,000 million cubic feet required for early seedlings in delta.

(ii)

Letter—from the Executive Engineer, Kistna Reservoir Project.
To—the Superintending Engineer on Special duty.
Dated—the 28th June 1910.
No.—428.

[Reference—Your No. 216 I., dated 22nd June 1910.]

I have the honour to state that four subjects for remark occur to me after reading the Board's review and your note as follows.

1. (i) With the single Pulichintala reservoir as proposed by you having diversion level at 190.5 and impounding level of 215.5 it is believed that after a short period, say 60 years, the ultimate stage of silting is reached, and the reservoir then holds only about 13,000 millions cubic feet which is enough to safeguard first crop.

Except on the few occasions when safeguarding first crop, when no water is available, this capacity is enough for not more than 70,000 acres of second crop, but the Board's figures in paragraph 10 allow for 140,000 acres including short late crop. The Board's figures are incorrect.

(ii) After sixty years no water during second crop can be absolutely guaranteed, and the short late area is therefore similarly placed to the ordinary second crop lands and can only get water when any happens to be available. Lands so watered can hardly be expected to pay first crop rates.

(iii) Since there is no possibility of water being required for irrigation in December and January it is better to have closure then, and conserve the fairly good supply of those months so that the reservoir may be as full as possible at the start of second crop. Keeping canals open in January and December when water is of no value except for navigation is merely throwing away storage for which over 300 lakhs are proposed to be spent. Five thousand million cubic feet is the minimum December and January flow (combined), and this volume can irrigate 26,000 acres or is worth Rs. 1,04,000 a year if stored.

(iv) I believe the Board to be wrong in adding on remissions at any rate in Guntur district. So far as I know these remissions were given on account of submersion of crops on swamp lands during heavy rains, and they are as likely to be necessary after the project is constructed as they now are.

2. The distribution channels so far worked out show that the area they occupy is $1\frac{1}{2}$ per cent. of the area irrigated. Including the larger branch channels which have not yet been calculated it may be assumed that $1\frac{1}{2}$ per cent. of the irrigable area will be occupied by the distribution system. This is a perfectly safe estimate as it excludes the main canal.

3. The present alignment of canal commands 630,400 acres of irrigable land. Of this about 8,000 on the right of the canal will not be irrigated and some 4,000 acres will be occupied by the canal. This leaves 618,400 acres of irrigable land on the left of the canal and after deducting $1\frac{1}{2}$ per cent. for distribution system about 610,000 acres are left for the upland canal.

4. A head sluice duty of 70 for the upland main canal requires a discharge of 8,715 cusecs or say 8,800 to allow for extra seepage in shale.

X

Letter—from Col. W. M. Ellis, R.E., Special Superintending Engineer.
To—the Chief Engineer for Irrigation.
Dated—Madras, the 21st July 1910.
No.—258 I./118.

In continuation of this office No. 232 I./118, dated 2nd July 1910, the Executive Engineer, Kistna Project, has made further enquiry regarding the causes of remissions in the Guntur Delta Tracts (Kistna Western Delta). Speaking generally the result of enquiries shew—

In *Rapalli taluk*.—That the annual remission to a small amount is given and is usually due to want of water for "parra" lands at the tail end of canal.

In *Bapatla taluk*.—The remissions generally due to untimely floods.

In *Tenali taluk*.—Generally due to want of water, but when large remissions given (as in 1313) due to floods.

2. Definite information on these points can more easily be obtained through Revenue officers.

Generally speaking, I do not think the reservoir is likely to have very great influence on remissions, and if any credit is allowable on this account, I consider one-half the average remissions would be a fair assessment of the financial benefit on this account due to it.

XI

Memorandum, R.O.C. No. 2135/10, dated 11th August 1910.

With reference to the correspondence ending with his letter No. 258 I./118, dated 21st July 1910, the Superintending Engineer on Special duty is informed that the disposal by Government of Mr. Turing's report on the revenue aspects of the Kistna Reservoir Project has been deferred for want of correct and final information as regards the areas of first and second crop irrigable under the project. Several proposals in connection with fixing the capacity of the proposed reservoir are now under consideration in consultation with the Inspector-General of Irrigation and until they are settled, it is not possible to give any final figures for the second crop and short late crop areas. But if the final figures for the area of first crop under the upland canal and in the delta can now be given, it will be sufficient to enable Government to go on with the examination of Mr. Turing's report.

2. With reference to the question as to whether deductions are to be made for extensions under the Kurnool canal it is considered that the instructions given in Memorandum Dis. No. 1049, dated 9th December 1909, should be adhered to, i.e., that the required discharge for Kurnool-Cuddapah canal should be 3,000 cusecs throughout the irrigation season whenever it is available at Sunkesala. The Velgode project is being worked out on the assumption that this discharge will be available and it is not considered desirable to alter this arrangement for the sake of an increase in second crop cultivation under the Kistna Reservoir project.

3. The Superintending Engineer on Special duty is therefore requested to report as soon as possible whether the 610,000 acres given in Executive Engineer's letter No. 428, dated 28th June 1910, which accompanied his No. 232 I./118, dated 2nd July 1910, may be now taken as the final figure of first crop areas under the upland canal for the purpose of the revenue forecasts and to give if available a villagewar statement shewing deductions to be made from Mr. Turing's figures in order to arrive at this final figure. This latter information is desirable as the revenue forecast is at present being worked out on the differential system although it is not certain whether this system will be finally approved by Government. If the villagewar particulars are not readily available, they need not be prepared as it is possible to do without them.

4. The Superintending Engineer, II Circle, is also requested to submit with the least possible delay similar statements giving final figures of extensions of first crop area in the delta, with explanations for differences, if any, between these final figures and the figures of Mr. Turing. The final figure for the maximum area of short late crop should also be given now if possible, as this figure depends upon the arrangements finally decided upon as practicable to enable the delta canals to carry the required discharge, and it is believed that these arrangements are now finally settled.

C. A. SMITH,
Chief Engineer for Irrigation.

To the Superintending Engineer on Special duty, } with a copy of Mr. Turing's report.
" " " II Circle,

To—the Special Superintending Engineer.

Dated—the 27th August 1910.

No.—645.

With reference to your No. 188 K.R./118, dated 13th August 1910, I have the honour to forward herewith statement showing villagewar particulars of irrigable areas as originally recorded by Mr. Turing's "A" registers with subsequent changes made in this office by lowering offtake level to + 189.5 for working out the revenue forecast. Attention is drawn to the notes on the abstract statement.

	ide	irt-	main	distri-	age column
Enclosures.					
Mr. Turing's A registers with subsequent changes made in this office.					
as originally recorded by Mr. Turing's A registers with subsequent changes made in this office.					

Enclosures.												
STATEMENT showing villagewar particulars of irrigable area as originally recorded by Mr. Turing's A registers with subsequent changes made in the registers.												
Name of taluk.	Number and name of the village.	Area irrigable as per Mr. Turing's A register.		Area added on account of difference found in register.	Total.	Area deducted as uncommanded by lowering of lake level to + 189.6.	Irrigable area on both sides, columns 6 & 7.	Deduct right side irrigation.	Total left side irrigation.	Deduct for main canal bed, etc.	Deduct for distributary bed, etc.	Net average column 13 - (10 + 11).
		ACS.	ACB.									
Battampallice.	16. Taduvayi	752-38	752-38	..	752-38	752-38	5,695-67	18-22	2,577-45	157-50	..	2,386-95
	16. Chinappalli	2,932-59	2,932-59	..	2,932-59	386-92	1,737-88	132-06	1,605-82	111-40	..	1,474-42
	17. Talachervu	1,384-94	1,384-94	352-94	1,737-88	386-92	3,065-72	428-91	2,636-81	147-92	..	2,439-89
	18. Chamsarra	3,196-08	3,196-08	..	3,196-08	..	77-68	58-33	2,424-76	22-35	..	2,136-67
	19. Pedapalem	2,021-25	2,021-25	..	2,021-25	..	2,459-51	34-75	1,910-88	29-15	..	1,840-02
	20. Vuyyandana	2,459-51	2,459-51	6-0	2,465-51	108-68	2,459-51	..	2,459-51	49-81	..	2,790-81
	21. Velpur	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	22. Chigurespad	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	23. Voraikallu	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	24. Kesar	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	25. Vutukur	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	26. Managoda	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	27. Didugu	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	28. Didenikola	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	29. Anaravati	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	30. Naratupad	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	31. Balatupad	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	32. Lingapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	33. Kaspad	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	34. Attalur	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	35. Bayyavaram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	36. Vippur	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	37. Koorur	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	38. Andukur	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	39. Garapad	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	40. Hamsanagaram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	41. Ramapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	42. Vallur	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	43. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	44. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	45. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	46. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
	47. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81
48. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
49. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
50. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
51. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
52. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
53. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
54. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
55. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
56. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
57. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
58. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
59. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
60. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
61. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
62. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
63. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
64. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
65. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
66. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
67. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
68. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
69. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
70. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
71. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
72. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
73. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
74. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
75. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
76. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
77. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
78. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
79. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
80. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
81. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
82. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	
83. Kallapuram	2,459-51	2,459-51	..	2,459-51	..	2,459-51	..	2,459-51	..	..	2,790-81	

**originally recorded
in this office—cont.**

Suttonspalle—cont.

• **rgtunb**

Statement showing village particulars of irrigable area as originally recorded by Mr. Turing's A registers with subsequent changes made in this office—cont.

Name of taluk.	Number and name of the village.	Area irrigable as per Mr. Turing's A register.												Net acreage, column 9—(10+11).
		1	2	3	4	5	6	7	8	9	10	11	12	
		Area irrigable as per Mr. Turing's A register.	Area added on account of differences found in register.	Total.	Area deducted as lowering of level to +189.6.	Irrigable area on both sides, columns 5-6.	Deduct right side irrigation.	Total left side irrigation.	Deduct for main canal bed, etc.	Deduct for distributary bed, etc.				
69. Lam		2,094.35		2,094.35		2,094.35		2,094.35					2,094.35	
70. Devarapally ..		2,534.03		2,534.03		2,534.03		2,534.03					2,534.03	
71. Chinapalakaloor ..		824.94		824.94		824.94		824.94					824.94	
72. Pedapalakaloor ..		3,645.94		3,645.94		3,645.94		3,645.94					3,645.94	
73. Gorintla		2,756.12		2,756.12		2,756.12		2,756.12					2,756.12	
74. Venigandla		1,054.25		1,054.25		1,054.25		1,054.25					1,054.25	
75. Pedakakani		8,804.03		8,804.03		8,804.03		8,804.03					8,804.03	
76. Uppalapad		3,420.47		3,420.47		3,420.47		3,420.47					3,420.47	
77. Nambur		6,165.75		6,165.75		6,165.75		6,165.75					6,165.75	
78. Kantamarakondur ..		2,225.99		2,225.99		2,225.99		2,225.99					2,225.99	
79. Ponnur		3,053.68		3,053.68		3,053.68		3,053.68					3,053.68	
80. Devayyabothipalem ..		626.46		626.46		626.46		626.46					626.46	
81. Tangellamudi		1,183.41		1,183.41		1,183.41		1,183.41					1,183.41	
82. Sekura		2,708.32		2,708.32		2,708.32		2,708.32					2,708.32	
83. Suddapally		1,862.42		1,862.42		1,862.42		1,862.42					1,862.42	
84. Takkellapad		3,356.31		3,356.31		3,356.31		3,356.31					3,356.31	
85. Agatavareppad		1,062.57		1,062.57		1,062.57		1,062.57					1,062.57	
86. Koritipad		6,001.16		6,001.16		6,001.16		6,001.16					6,001.16	
87. Aniruddhipalem		1,806.41		1,806.41		1,806.41		1,806.41					1,806.41	
88. Koritipad		2,619.54		2,619.54		2,619.54		2,619.54					2,619.54	
89. Mallapad		5,110.65		5,110.65		5,110.65		5,110.65					5,110.65	
90. Aniruddhipalem		2,347.31		2,347.31		2,347.31		2,347.31					2,347.31	
91. Pothur		3,734.67		3,734.67		3,734.67		3,734.67					3,734.67	
92. Kompad		2,657.42		2,657.42		2,657.42		2,657.42					2,657.42	
93. Eukur		2,120.66		2,120.66		2,120.66		2,120.66					2,120.66	
94. Veimda		2,435.27		2,435.27		2,435.27		2,435.27					2,435.27	
95. Bukampad		1,346.20		1,346.20		1,346.20		1,346.20					1,346.20	
96. Narabodur		1,708.39		1,708.39		1,708.39		1,708.39					1,708.39	
97. Godavara		2,162.03		2,162.03		2,162.03		2,162.03					2,162.03	
98. Channalamudi		610.72		610.72		610.72		610.72					610.72	
99. Lemalipada		958.06		958.06		958.06		958.06					958.06	
100. Kovelamudi		2,571.84		2,571.84		2,571.84		2,571.84					2,571.84	
101. Mullur		3,358.35		3,358.35		3,358.35		3,358.35					3,358.35	
102. Vattibobur		1,106.63		1,106.63		1,106.63		1,106.63					1,106.63	
103. Katrapad		1,445.62		1,445.62		1,445.62		1,445.62					1,445.62	
104. Yanara		1,375.79		1,375.79		1,375.79		1,375.79					1,375.79	
105. Goriapad		1,070.34		1,070.34		1,070.34		1,070.34					1,070.34	
106. Kondepad														

Guntur—cont.

111. Yanamadala ..	5,088.64	188.73	211,609.12	5,088.64	12.67	5,076.07	4.00	5,079.07	17.28	76.0	4,978.79
112. Kuruntala ..	1,118.53	..	600.61	1,118.53	..	500.61	..	1,118.63	..	17.0	1,101.53
113. Chavadvaram ..	2,518.60	..	43.73	2,518.60	..	43.73	..	2,518.60	..	37.0	2,243.88
114. Nadimpalem ..	1,407.86	..	388.97	1,407.86	..	388.97	..	1,407.86	..	16.0	875.13
115. Pratiipad ..	4,939.53	..	439.54	4,939.53	..	439.54	..	4,939.53	..	74.0	4,865.53
116. Malayapalem ..	3,299.04	..	1,079.84	3,299.04	..	1,079.84	..	3,299.04	..	50.0	3,749.04
117. Gorivolegunipalem ..	2,139.36	..	235.00	2,139.36	..	235.00	..	2,139.36	..	23.0	2,107.36
118. Gotipad ..	3,091.23	..	322.51	3,091.23	..	322.51	..	3,091.23	..	45.0	3,037.23
119. Unnava ..	2,008.02	..	650.28	2,008.02	..	650.28	..	2,008.02	..	29.0	1,892.86
Total	211,320.39	188.73	211,609.12	211,609.12	5,916.42	208,592.70	..	211,609.12	..	..	..
14. Malkapuram ..	500.61	..	600.61	500.61	..	500.61	..	500.61	..	8.0	492.61
22. Kunobanspally ..	43.73	..	43.73	43.73	..	43.73	..	43.73	..	..	43.73
23. Kolanakonda ..	388.97	..	388.97	388.97	..	388.97	..	388.97	..	6.0	382.97
24. Vaddiswaram ..	439.54	..	439.54	439.54	..	439.54	..	439.54	..	6.0	433.54
27. Ainavole ..	1,079.84	..	1,079.84	1,079.84	..	1,079.84	..	1,079.84	..	17.0	1,062.84
32. Anumalipudi ..	235.00	..	235.00	235.00	..	235.00	..	235.00	..	3.0	232.00
34. Mitragaddi-Anantavaram ..	322.51	..	322.51	322.51	..	322.51	..	322.51	..	5.0	317.51
82. Ramachandrapuram ..	650.28	..	650.28	650.28	..	650.28	..	650.28	..	10.0	640.28
91. Anantaratnapad ..	1,295.35	..	1,295.35	1,295.35	..	1,295.35	..	1,295.35	..	20.0	1,275.35
96. Karampudipad ..	1,082.69	..	1,082.69	1,082.69	..	1,082.69	..	1,082.69	..	16.0	1,066.69
106. Edulapalem ..	716.26	..	716.26	716.26	..	716.26	..	716.26	..	6.0	710.26
114. Kondsajeghanudi ..	222.62	..	222.62	222.62	..	222.62	..	222.62	..	1.0	221.62
120. Marripalem ..	288.13	..	288.13	288.13	..	288.13	..	288.13	..	3.0	285.13
Total	7,265.63	..	7,265.63	7,265.63	507.4	6,758.19	..	7,265.63	..	..	..
Grand total	218,585.92	188.73	218,774.65	218,774.65	6,423.46	212,351.19	582.61	211,768.58	942.07	3,026.0	207,800.61
9. Taavadvaram ..	511.27	..	511.27	511.27	..	511.27	..	511.27	..	..	..
10. Gorivole ..	1,653.32	..	1,653.32	1,653.32	..	1,653.32	..	1,653.32	..	3.0	1,534.7
11. Sankarantipad ..	2,148.11	..	2,148.11	2,148.11	..	2,148.11	..	2,148.11	..	29.0	1,756.26
12. Solam ..	2,630.81	..	2,630.81	2,630.81	..	2,630.81	..	2,630.81	..	..	..
13. Kondaveed ..	371.73	..	371.73	371.73	..	371.73	..	371.73	..	..	..
15. Vankayalpad ..	2,719.04	..	2,719.04	2,719.04	..	2,719.04	..	2,719.04	..	29.0	1,718.36
18. Edlapad ..	2,066.00	..	2,066.00	2,066.00	..	2,066.00	..	2,066.00	..	31.0	2,025.00
19. Karubhola ..	2,171.15	..	2,171.15	2,171.15	..	2,171.15	..	2,171.15	..	33.0	2,138.15
20. Jaladi ..	2,454.27	..	2,454.27	2,454.27	..	2,454.27	..	2,454.27	..	36.0	2,418.27
21. Kukkavallivaripalem ..	2,326.16	..	2,326.16	2,326.16	..	2,326.16	..	2,326.16	..	35.0	2,291.16
22. Vellur ..	1,720.24	..	1,720.24	1,720.24	..	1,720.24	..	1,720.24	..	26.0	1,694.24
23. Timmapuram ..	2,661.92	..	2,661.92	2,661.92	..	2,661.92	..	2,661.92	..	38.0	2,623.92
24. Mydavole ..	2,154.67	..	2,154.67	2,154.67	..	2,154.67	..	2,154.67	..	32.0	2,122.67
26. Chirumamilla ..	1,841.60	..	1,841.60	1,841.60	..	1,841.60	..	1,841.60	..	21.0	1,820.60
26. Tubad ..	2,441.71	..	2,441.71	2,441.71	..	2,441.71	..	2,441.71	..	10.0	2,431.71
27. Nadella ..	7,137.53	..	7,137.53	7,137.53	..	7,137.53	..	7,137.53	..	66.0	4,119.46
29. Kanuparu ..	277.25	..	277.25	277.25	..	277.25	..	277.25	..	..	..
30. Kesanpally ..	143.16	..	143.16	143.16	..	143.16	..	143.16	..	..	..
49. Yellamanda ..	332.12	..	332.12	332.12	..	332.12	..	332.12	..	..	..
50. Govindapuram ..	2,750.76	..	2,750.76	2,750.76	..	2,750.76	..	2,750.76	..	..	..
51. Inlapad ..	1,318.19	..	1,318.19	1,318.19	..	1,318.19	..	1,318.19	..	..	..
52. Kanur ..	3,399.39	..	3,399.39	3,399.39	..	3,399.39	..	3,399.39	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607.33	..	3,607.33	3,607.33	..	3,607.33	..	3,607.33	..	..	..
53. Ganapavaram ..	3,607										

45181.

Statement showing village particulars of irrigable area as originally recorded by Mr. Turing's A registers with subsequent changes made in this office—cont.

Name of taluk.	Number and name of the village.												Total.	Area added on account of differences found in register.	Area deducted as uncommanded by lowering of level to +188.6.	Irrigable area on both sides, columns 6-9.	Deduct right side irrigation.	Total left side irrigation.	Deduct for main canal bed, etc.	Deduct for distribution bed, etc.	Net average, column 9-(10+11).	
	1	2	3	4	5	6	7	8	9	10	11	12										
Agharams.																						
104. Inkollu	..	..	7,016-31	..	7,016-31	..	7,016-31	..	..	7,016-31	..	..	..	7,016-31	..	..	..	..	..	..	..	6,911-31
105. Somaravur	..	..	2,788-97	..	2,788-97	..	..	..	..	2,788-97	..	..	..	2,788-97	..	..	..	..	..	..	..	2,747-97
106. Kodavaviripalem	..	..	2,916-53	..	2,916-53	..	..	..	..	2,916-53	..	..	..	2,916-53	..	..	..	..	..	..	..	2,861-53
107. Swarna	..	..	4,921-54	..	4,921-54	..	..	..	..	4,921-54	..	..	..	4,921-54	..	..	..	..	..	..	..	4,867-54
116. Kundavakuduru	..	..	18-1	..	18-1	..	..	..	..	18-1	..	..	..	18-1	..	..	..	..	..	..	..	..
118. Chinnu Ganjam	..	..	1,866-41	..	1,866-41	..	..	..	..	1,866-41	..	..	..	1,866-41	..	..	..	..	..	..	..	1,792-80
119. Matlagunta	..	..	2,321-71	..	2,321-71	..	..	..	..	2,321-71	..	..	..	2,321-71	..	..	..	..	..	..	..	2,188-50
120. Peda Ganjam	..	..	2,862-66	..	2,862-66	..	..	..	..	2,862-66	..	..	..	2,862-66	..	..	..	..	..	..	..	2,307-57
121. Goussapudi	..	..	2,008-98	..	2,008-98	..	..	..	..	2,008-98	..	..	..	2,008-98	..	..	..	..	..	..	..	1,978-98
Total		..	172,815-35	..	172,815-35	..	..	..	..	172,815-35	..	..	..	172,815-35	..	..	..	..	..	..	..	..
Agharams.																						
3. Sreerangapuram	..	..	33-2	..	33-2	..	..	..	..	33-2	..	..	..	33-2	..	..	..	..	..	..	..	33-2
63. Gollapudi	..	..	873-05	..	873-05	..	..	..	..	873-05	..	..	..	873-05	..	..	..	..	..	..	..	860-06
67. Edupudi	..	..	983-38	..	983-38	..	..	..	..	983-38	..	..	..	983-38	..	..	..	..	..	..	..	968-38
70. Channurhotipalem	..	..	651-15	..	651-15	..	..	..	..	651-15	..	..	..	651-15	..	..	..	..	..	..	..	641-15
97. Keeravareppad	..	..	783-83	..	783-83	..	..	..	..	783-83	..	..	..	783-83	..	..	..	..	..	..	..	770-83
Total		..	3,313-43	..	3,313-43	..	..	..	..	3,313-43	..	..	..	3,313-43	..	..	..	..	..	..	..	..
Grand Total		..	176,128-78	..	176,128-78	..	..	..	..	176,128-78	..	..	..	176,128-78	..	..	..	..	..	..	..	..
Tonali.																						
1. Chuluvur	..	..	3,533-43	..	3,533-43	..	..	..	..	3,533-43	..	..	..	3,533-43	..	..	..	..	..	..	..	3,480-43
13. Dugginala	..	..	169-46	..	169-46	..	..	..	..	169-46	..	..	..	169-46	..	..	..	..	..	..	..	167-46
14. Kolakur	..	..	2,793-84	..	2,793-84	..	..	..	..	2,793-84	..	..	..	2,793-84	..	..	..	..	..	..	..	2,751-84
17. Gadivada	..	..	195-69	..	195-69	..	..	..	..	195-69	..	..	..	195-69	..	..	..	..	..	..	..	192-69
Tammampudi	..	..	79-52	..	79-52	..	..	..	..	79-52	..	..	..	79-52	..	..	..	..	..	..	..	79-52
Total		..	6,771-44	..	6,771-44	..	..	..	..	6,771-44	..	..	..	6,771-44	..	..	..	..	..	..	..	6,671-44
Tonali.																						
10. Addanki	..	..	5,808-1	..	5,808-1	..	..	..	..	5,808-1	..	..	..	5,808-1	..	..	..	..	..	..	..	..
11. Manikavaram	..	..	1,606-62	..	1,606-62	..	..	..	..	1,606-62	..	..	..	1,606-62	..	..	..	..	..	..	..	1,590-62
14. Bodavaripalem-Tammavaram	..	..	4,028-96	..	4,028-96	..	..	..	..	4,028-96	..	..	..	4,028-96	..	..	..	..	..	..	..	3,935-96
15. Kottakota-Takkellapad	..	..	2,224-85	..	2,224-85	..	..	..	..	2,224-85	..	..	..	2,224-85	..	..	..	..	..	..	..	2,181-85
16. Bollavaripad-Dairavaroor	..	..	3,077-0	..	3,077-0	..	..	..	..	3,077-0	..	..	..	3,077-0	..	..	..	..	..	..	..	2,999-0
18. Kottapad	..	..	1,496-08	..	1,496-08	..	..	..	..	1,496-08	..	..	..	1,496-08	..	..	..	..	..	..	..	1,466-08
Total		..	6,771-44	..	6,771-44	..	..	..	..	6,771-44	..	..	..	6,771-44	..	..	..	..	..	..	..	6,671-44
Tonali.																						
10. Addanki	..	..	5,808-1	..	5,808-1	..	..	..	..	5,808-1	..	..	..	5,808-1	..	..	..	..	..	..	..	..
11. Manikavaram	..	..	1,606-62	..	1,606-62	..	..	..	..	1,606-62	..	..	..	1,606-62	..	..	..	..	..	..	..	1,590-62
14. Bodavaripalem-Tammavaram	..	..	4,028-96	..	4,028-96	..	..	..	..	4,028-96	..	..	..	4,028-96	..	..	..	..	..	..	..	3,935-96
15. Kottakota-Takkellapad	..	..	2,224-85	..	2,224-85	..	..	..	..	2,224-85	..	..	..	2,224-85	..	..	..	..	..	..	..	2,181-85
16. Bollavaripad-Dairavaroor	..	..	3,077-0	..	3,077-0	..	..	..	..	3,077-0	..	..	..	3,077-0	..	..	..	..	..	..	..	2,999-0
18. Kottapad	..	..	1,496-08	..	1,496-08	..	..	..	..	1,496-08	..	..	..	1,496-08	..	..	..	..	..	..	..	1,466-08
Total		..	6,771-44	..	6,771-44	..	..	..	..	6,771-44	..	..	..	6,771-44	..	..	..	..	..	..	..	6,671-44
Tonali.																						
10. Addanki	..	..	5,808-1	..	5,808-1	..	..	..	..	5,808-1	..	..	..	5,808-1	..	..	..	..	..	..	..	..
11. Manikavaram	..	..	1,606-62	..	1,606-62	..	..	..	..	1,606-62	..	..	..	1,606-62	..	..	..	..	..	..	..	1,590-62
14. Bodavaripalem-Tammavaram	..	..	4,028-96	..	4,028-96	..	..	..	..	4,028-96	..	..	..	4,028-96	..	..	..	..	..	..	..	3,935-96
15. Kottakota-Takkellapad	..	..	2,224-85	..	2,224-85	..	..	..	..	2,224-85	..	..	..	2,224-85	..	..	..	..	..	..	..	2,181-85
16. Bollavaripad-Dairavaroor	..	..	3,077-0	..	3,077-0	..	..	..	..	3,077-0	..	..	..	3,077-0	..	..	..	..	..	..	..	2,999-0
18. Kottapad	..	..	1,496-08	..	1,496-08	..	..	..	..	1,496-08	..	..	..	1,496-08	..	..	..	..	..	..	..	1,466-08
Total		..	6,771-44	..	6,771-44	..	..	..	..	6,771-44	..	..	..	6,771-44	..	..	..	..	..	..	..	6,671-44
Tonali.																						
10. Addanki	..	..	5,808-1	..	5,808-1	..	..	..	..	5,808-1	..	..	..	5,808-1	..	..	..	..	..	..	..	..
11. Manikavaram	..	..	1,606-62	..	1,606-62	..	..	..	..	1,606-62	..	..	..	1,606-62	..	..	..	..	..	..	..	1,590-62
14. Bodavaripalem-Tammavaram	..	..	4,028-96	..	4,028-96	..	..	..	..	4,028-96	..	..	..	4,028-96	..	..	..	..	..	..	..	3,935-96
15. Kottakota-Takkellapad	..	..	2,224-85	..	2,224-85	..	..	..	..	2,224-85	..	..	..	2,224-85	..	..	..	..	..	..	..	2,181-85
16. Bollavaripad-Dairavaroor	..	..	3,077-0	..	3,077-0	..	..	..	..	3,077-0	..	..	..	3,077-0	..	..	..	..	..	..	..	2,999-0
18. Kottapad	..	..	1,496-08	..	1,496-08	..	..	..	..	1,496-08	..	..	..	1,496-08	..	..	..	..	..	..	..	1,466-08
Total		..	6,771-44	..	6,771-44	..	..	..	..	6,771-44	..	..	..	6,771-44	..	..	..	..	..	..	..	6,671-44
Tonali.																						
10. Addanki	..	..	5,808-1	..	5,808-1	..	..	..	..	5,808-1	..	..	..	5,808-1	..	..	..	..	..	..	..	..
11. Manikavaram	..	..	1,606-62	..	1,606-62	..	..	..	..	1,606-62	..	..	..	1,606-62	..	..	..	..	..	..	..	1,590-62
14. Bodavaripalem-Tammavaram	..	..	4,028-96	..	4,028-96	..	..	..	..	4,028-96	..	..	..	4,028-96	..	..	..	..	..	..	..	3,935-96
15. Kottakota-Takkellapad	..	..	2,224-85	..	2,224-85	..	..	..	..	2,224-85	..	..	..	2,224-85	..	..	..	..	..	..	..	2,181-85
16. Bollavaripad-Dairavaroor	..	..	3,077-0	..	3,077-0	..	..	..	..	3,077-0	..	..	..	3,077-0	..	..	..	..	..	..	..	2,999-0
18. Kottapad	..	..	1,496-08	..	1,496-08	..	..	..	..	1,496-08	..	..	..	1,496-08	..	..	..	..	..	..	..	1,466-08
Total		..	6,771-44	..	6,771-44	..	..	..	..	6,771-44	..	..	..	6,771-44	..	..	..	..	..	..	..	6,671-44
Tonali.																						
10. Addanki	..	..	5,808-1	..	5,808-1	..	..	..	..	5,808-1	..	..	..	5,808-1	..	..	..	..	..	..	..	..
11. Manikavaram	..	..	1,606-62	..	1,606-62	..	..	..	..	1,606-62	..	..	..	1,606-62	..	..	..	..	..	..	..	1,590-62
14. Bodavaripalem-Tammavaram	..	..	4,028-96	..	4,028-96	..	..	..	..	4,028-96	..	..	..	4,028-96	..	..	..	..	..	..	..	3,935-96
15. Kottakota-Takkellapad	..	..	2,224-85	..	2,224-85	..	..	..	..	2,224-85	..	..	..	2,224-85	..	..	..	..	..	..	..	2,181-85
16. Bollavaripad-Dairavaroor	..	..	3,077-0	..	3,077-0	..	..	..	..	3,077-0	..	..	..	3,077-0	..	..	..	..	..	..	..	2,999-0
18. Kottapad	..	..	1,496-08	..	1,496-08	..	..	..	..	1,496-08	..	..	..	1,496-08	..	..	..	..	..	..	..	1,466-08
Total		..	6,771-44	..	6,771-44	..	..	..	..	6,771-44	..	..	..	6,771-44	..	..	..	..	..	..	..	6,671-44
Tonali.																						
10. Addanki	..	..	5,808-1	..	5,808-1	..	..	..	..	5,808-1	..	..	..	5,808-1	..							

ABSTRACT of statement showing talukwar particulars of irrigable area as originally recorded by Mr. Turing's A Register with subsequent changes made in this office.

with subsequent changes made in this office.																					
Name of taluk.		Area irrigable as per Mr. Turing's A register.		Area added on account of differences found in register.		Total.		Area deducted as uncommanded by lowering off take level to + 189.5.		Irrigable area on both sides, columns 4-5.		Deduct for right side irrigation.		Total left side irrigation.		Deduct for main canal bed, etc.		Deduct for distributary bed, etc.		Net acreage, column 9 - (9 + 10).	
1		2		3		4		5		6		7		8		9		10		11	
Sattenapalli	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Guntur	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Narasaraopet	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Bapatla	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Onigole	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Tenali	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Grand Total	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	

Norm.—Mr. Turing's area was taken for a canal with a maximum velocity of 3 feet a section and with a diversion level of 100.

The present canal is taken with a velocity similar to the Puniah of 100.

Column 3 represents errors found in the original register.

Note.—Mr. Turing's area was taken for a canal with a maximum velocity of 3 feet a second and with a diversion level of +191 (column 2). The present canal is taken with a velocity similar to the Punjab original velocity and with a diversion level of +189.5 (column 6). Column 3 represents errors found by the Revenue Inspector in Mr. Turing's figures. Column 9 is not final as the whole canal is not yet worked out. Figures in column 11 are within 1 per cent. of final figures.

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No. 293-I./118, dated 30th August 1910.

Copy forwarded to the Chief Engineer for Irrigation with reference to his Memorandum, R.O.C. No. 2135/10, dated 11th August 1910.

W. M. ELLIS, Col., R.E.,
Special Superintending Engineer.

To the Chief Engineer for Irrigation.

XIII

Letter—from A. G. ROMILLY, Esq., Superintending Engineer, II Circle.
To—the Chief Engineer for Irrigation.
Dated—Bezwada, the 6th October 1910.
No.—246-I.

With reference to paragraph 4 of your Memorandum No. 2135/10, dated 11th August 1910, I have the honour to forward herewith copies of the marginally-noted letters received from the Executive Engineers, Kistna Eastern and Kistna Western Divisions, which give the information therein required.

ENCLOSURES.

(i)
Letter—from the Executive Engineer, Kistna Eastern Division.
To—the Superintending Engineer, II Circle.
Dated—the 6th September 1910.
No.—408/S.E.

With reference to paragraph 4 of the Memorandum R.O.C. No. 2135/10, dated 11th August 1910, from the Chief Engineer for Irrigation, received with your Endorsement No. 408/G1., dated 18th August 1910 thereon, I have the honour to submit herewith as noted below, the final figures of extensions of first crop area in the delta and the final figure for the maximum area of short late crop :—

(1) The first crop area in the delta still irrigable over and above the area irrigated in fasli 1317 or 1907-1908 (being the basis of the Revenue Officer's investigation) is 113,517 acres which is made up of by canalwar as shown below (the villagewar statements being not ready, not submitted) :—

Serial number.	Name of canal.	Area irrigable in the delta in acres.
1. Ellore canal	...	14,019-29
2. Ryves do.	...	7,906-33
3. Polraz do.	...	3,985-29
4. Bantumilli canal	...	8,746-89
5. Pulleru canal	...	16,006-28
6. Bandar do.	...	13,852-70
7. Bank canal	...	49,000-00
Total area	...	113,516-78

or 113,517 acres against Mr. Turing's figure of 113,949 acres (difference very small). Of 113,517 acres of area irrigable 20,249 acres have come under cultivation since 1908 and then there remain 93,268 acres the revenue of which may be credited to the Kistna Reservoir project.

(2) The short late crop area in the delta is about 81,548 acres including 72,000 acres in Kolair lake bed, against Mr. Turing's figure of 79,645 acres (villagewar statements not being ready, not submitted). Mr. Turing's figures have had to be changed somewhat and 2,078 acres of ordinary wet had to be transferred to short late crop as it did not seem to be suitable land to be classed under the former head being too low and swampy. Of the above area only 29,548 acres are practicable to be irrigated by the delta canals.

Letter—from the Executive Engineer, Kistna Western Division.
To—the Superintending Engineer, II Circle.
Dated—the 28th September 1910.
No.—358-S.E.

With reference to your No. 406-G1, dated 18th August 1910, received by me on the 9th instant from the Executive Engineer, Kistna Eastern Division, I have the honour to forward, herewith, a statement showing by blocks the final areas for which provision is made in the estimate for Kistna Delta extension submitted for sanction with this office No. 44/S, dated 22nd April 1910. Villagewar particulars as far as available have been given for a few blocks. For block Nos. 3, 7, 18, 19, 20, 21, 22, 29, 28, 32 and 33 details are not available. The areas as given in Mr. Turing's final report for ordinary crop (*vide* statement No. 1) is 40,120.50 acres for which details by blocks are not given in the report. The figures by blocks as tentatively given by Mr. Turing in his No. 298, dated 29th September 1909, to this office amount to 40,511.20 acres. As the difference between the two figures is small, the latter figure has been entered in the statement now submitted. The explanation for the excess of diminution of areas in the several blocks are noted in the remarks column of the statement. It will be seen from column 3 of the statement now submitted that estimates have finally been worked out for an extension of 57,000 acres (ordinary crop) in this delta against 40,120.5 acres fixed by Mr. Turing. The difference is due to the fact that while giving to Mr. Turing the probable area of extension to be brought under the Kistna Reservoir Project the ultimate area under Kistna anicut system in Kistna Delta was taken as 315,000 acres as suggested in this office No. 46-S, dated 14th April 1908, instead of 300,000 acres sanctioned in G.O., No. 844 I, dated 4th August 1904, and as that proposal was not accepted by the Chief Engineer, the balance 15,000 acres has been included under the Kistna Reservoir Project Delta extension. When final alignment for the several channels was made some of the lands originally thought to be unirrigable were found to be irrigable while some lands considered to be irrigable were found to be unirrigable. This accounts for most of the discrepancies between Mr. Turing's figures and the final figures as estimated for. The figures given by Mr. Turing for short late crop (1,848.54 acres) are final and no alteration has been made in the same.

STATEMENT showing the areas under each block as given by Mr. Turing and the area proposed in the estimates for Kistna Delta extension in Western division.

Block number.	Area under each block as given by Mr. Turing.	Area under each village as proposed in the Kistna Delta extension estimates.	Total area for the whole block as proposed.	Remarks.
1	ACS. 291.25	Main canal. Thunmapady Daggirala	ACS. 200	
2	239.42			
3	3,452.1	Revdandrapad side channel. Thunmapady Sringarapuram Chinnapalem Vallabhapuram Munnangi	ACS. 200	Some of the lands considered irrigable were found to be finally unirrigable.
4	624.80			
5	4,271.22			
6	624.80			
7	4,271.22	East side channel. Peddayalli Pedamatapady Amudulpalli Nizampatam Allerod Matlapady Edupalli Siripady Pittavaripalem Amirtalur Arambaka	ACS. 624	Some of the lands thought to be unirrigable were found irrigable after the alignment of channels.
8	4,271.22			
9	4,271.22			
10	4,271.22			
11	2,081.15	West side channel. Peparoo Khajipalem and Allor Moparua	ACS. 1,200	Some of the lands considered irrigable at first were found to be unirrigable.
12	189.18			
13	681.5			
14	261.85			
15	189.18		ACS. 140	Most of the lands considered to be irrigable at first were found to be unirrigable after the alignment of channels.
16	681.5		ACS. 261	
17	261.85		ACS. 261	

Statement showing the areas under each block as given by Mr. Turing and the area proposed in the estimates for Kistna Delta extension in Western division—cont.

Block number.	Area under each block as given by Mr. Turing.	Area under each village as proposed in the Kistna Delta extension estimates.	Total area for the whole block as proposed.	Remarks.
15	ACS. 1,564.65	Commamur canal Aremanda channel. Intur 150 Nidubrole 166 Isandole 724 Yazali 460 Mannava 237 Do. 270	ACS. 1,500	Some of the lands considered irrigable at first were found unirrigable.
16	198.25			
17	260.99			
18	3,588.28			
19	867.41	Anna channel and Pundla channel. Upparapalem 500 Bodipalem, Appicatta Nandur Inagarchipaud	7,210	A large extent of lands originally considered unirrigable were found to be irrigable after the final alignment of channels.
20	1,235.85			
21	625.86			
22	5,817.40			
23	2,401.16	Gopapuram, Gadipady, Nerudupalli, Veliherla and Bharthipady. Kariupalem 1,496 Ganupavaram 2,168 Perali 3,406	9,000	About 1,930 acres was originally reserved for Kistna anicut system and this has now been included under Kistna Reservoir Project extension.
24	2,845.52			
25	..			
26	6,573.5			
27	..	Bank canal, Kollipara side channel. Pedaparas 796 Kollipara 2,340 Dantalur 993 Tunulur 1,194 Chemudupad 162 Chedalavada 176 Davalur 75 Annaram 135	5,860	Some of the lands considered irrigable at first were found to be unirrigable after the final alignment of channels.
28	..			
29	..			
30	..			
31	..	Potumera channel west branch. Potumera village Singupalem Kytapalli	1,210	This block was originally reserved for extension under Kistna anicut system, but now included under Kistna Reservoir Project.
32	..			
33	..			
34	..			
35	..	Isukapalli channel. Nagarum, Pamidi Maros, Yetilipalem Muthupalli, Idupelli, Arepalli, Rajavole Kavagala, Dhulipady. Isukapalli, Singupalem Amedalupalli Alaparas, Adavuldevi and Kuehinapady, Pregnum	9,000	About 1,200 acres in these blocks were reserved for extension under Kistna anicut system, but now included under Kistna Reservoir Project.
36	..			
37	..			
38	..			
39	..	Fifth Reach, Bank canal, Kaithapalli Pallioona, Gangadipalem.	1,880	This extent was originally reserved for extension under Kistna anicut system but now included under Kistna Reservoir project.
40	..			
41	..			
42	..			
43	..		57,000	

XIV

Letter—from Col. W. M. ELLIS, R.E., Special Superintending Engineer.
To—the Chief Engineer for Irrigation.
Dated—the 22nd December 1910.
No.—439-I/127.

For purposes of the final working tables, Kistna project, I would ask what figures should be allowed for ultimate area long crop June to November under Bezwada anicut.

In the last tables the following areas were taken :—

	ACS.
Upland canal	610,000
Delta	854,000

2. In your No. 2135 of 11th August 1910 a report on this subject was called for from the Superintending Engineer, II Circle, and the figures in this report will probably give the required information.

3. As regards the second crop and short late single crop, the latest developments give a maximum combined area which can be irrigated a reservoir full on 1st February of 222,200 acres and it is for the Superintending Engineer, II Circle, to state how this should be divided between short single crop and second crop.

This will not affect the working tables but will affect the Revenue statement and cost of distribution works in the delta.

4. The latest developments entail making a full reservoir level of 224.59 feet higher than was believed a safe height six months ago and while this secures a larger late crop it will entail material extra capital cost which will probably be as much as 800 lakhs.

XV

Memorandum, R.O.C. No. 4628/10, dated 9th January 1911.

With reference to letter No. 439-I/127, dated 22nd December 1910, from the Special Superintending Engineer, the Chief Engineer for Irrigation has the honour to state that the ultimate area—long crop—June to November under Bezwada anicut as reported finally by the Superintending Engineer, II Circle, is 850,268 acres. This figure may be adopted for the preparation of the final working tables of the Kistna reservoir project.

(By Order.)

J. M. LACEY,
Asst. Chief Engineer for Irrigation.

To the Special Superintending Engineer, with copy of letter No. 246 I., dated 6th October 1910, and enclosures from the Superintending Engineer, II Circle.

XVI

Letter—from Col. W. M. ELLIS, R.E., Special Superintending Engineer.
To—the Chief Engineer for Irrigation.
Dated—Madras, the 2nd February 1911.
No.—37-I/129-A.

The new working tables of Kistna project just complete give an average area of late crops for sixteen years of 158,000 acres.

The largest area for which there is capacity in the reservoir is 222,550 acres and an area late crop exceeding 220,000 acres is realised in seven years out of sixteen.

In 1899-1900 there is no late crop.

Excepting that year the smallest area in any year is 62,700 acres.

XVII

Letter—from Col. W. M. ELLIS, R.E., Special Superintending Engineer.
To—the Chief Engineer for Irrigation.
Dated—Madras, the 25th February 1911.
No.—65-I/129-A.

Owing to a mistake in the Kistna discharge tables just discovered the average "late crop" area for sixteen years of Kistna reservoir project, which I reported as 158,000 acres in this office No. 37-I/129-A, dated 2nd February 1911, must be raised by 9,000 acres to 167,000 acres.

XVIII

Letter—from Col. W. M. ELLIS, R.E., Special Superintending Engineer.
To—the Chief Engineer for Irrigation.
Dated—Madras, the 25th February 1911.
No.—66-I/118.

In my u.o. note on the revenue investigation case, Kistna project (of which I have no copy), speaking from recollection I said that the probable year of construction when water could be given would be—

- (a) To the delta extension—seventh year;
- (b) to the upland system—eleventh year.

The further computations now made serve to show that water cannot be given to the upland till the twelfth year of construction and to the delta in the seventh year.

XIX

Memorandum, R.O.C. No. 578/11, dated 2nd March 1911.

In his letter No. 66-I/118, dated 25th February 1911, regarding the Kistna reservoir project, the Special Superintending Engineer states that "the further computations now made serve to show that water cannot be given to the upland till the twelfth year of construction and to the delta in the seventh year." As the statement that water cannot be given to the delta in the seventh year is not clear, and as some clerical error appears to have been committed, the Special Superintending Engineer is requested to report the correct year in which water can be supplied to the delta.

(By Order.)

J. M. LACEY,
Asst. Chief Engineer for Irrigation.

To the Superintending Engineer on Special duty.

XX

Letter—from Col. W. M. ELLIS, R.E., Special Superintending Engineer.
To—the Chief Engineer for Irrigation.
Dated—Madras, the 2nd March 1911.
No.—68-I/118.

[Reference—Your R.O.C. No. 579, dated 2nd March 1911.]

I have the honour to inform you that water can be given to the delta from seventh year and to the upland canal from the twelfth year.

It will be seen that, while it is possible to impound sufficient water to issue for early seedlings from the 8th year, there will not be enough water to commence second crop until the 13th year.

The water required for early seedlings is from 4,000 to 6,000 millions cubic feet. The early seedling water secures the delta "early crop" and makes the extension of the "early crop" quite safe.

2. It will be seen that while a capacity is secured for early seedlings in the 8th year that in the following four years the increasing capacity due to raising the reservoir dam is little more than sufficient to keep pace with the silt deposits and thus late crop water will not be available for these years.

This will have an unfavourable effect on revenue returns.

3. In my opinion the revenue forecast should allow for development of the irrigation to begin as noted below:—

Eighth year of construction—Extension of "early crop" in delta.

Thirteenth year of construction—"Late crop" in the delta and upland canal cultivation commences.

ENCLOSURE.

TABLE showing levels and capacities available in reservoir in February, March each year according to construction programme.

Year of construction.	Level of water in reservoir.	Gross capacity at level (column 2).	Annual and total silt deposit.	Effective capacity.	Details of new irrigation proposed.
VI	91	MILLS. C. FT. 1,000	MILLS. C. FT. Nil.	MILLS. C. FT. 1,000	
VII	104	2,500	200	1,300	
VIII	123	5,250	1,200 1,500	3,750	From this year delta canals open early for supply early seedlings— "Early crop" extension delta
IX	130	9,000	2,000 3,500	5,500	ACR. 15,000
X	138	12,200	2,750 6,250	5,950	Early crop extension delta
XI	143	14,750	3,500 9,750	5,000	Early crop extension delta
XII	150	19,750	4,000 13,750	6,000	Early crop extension delta
XIII	170	41,000	4,000 17,750	23,250	Early crop extension delta
XIV	185	66,500	4,000 21,750	44,750	Early crop extension delta Late crop delta second crop Do. single Early crop uplands
XV	200	99,000	4,000 25,750	74,250	Early crop delta Late crop delta second crop Do. single Early crop uplands Correspondingly increased areas each year till full development is obtained.

After 14th year of construction the capacity till completion of works is always more than ample.

XXIII

Letter—from C. T. MULLINGS, Esq., Executive Engineer, Kistna Reservoir Project.

To—G. F. PADDISON, Esq., I.C.S., Deputy Secretary to Government.

Dated—the 21st March 1911.

No.—1559.

I have the honour to forward herewith the index map of Kistna reservoir project for your reference. The map may be recorded in your office as it is not again required in this office.

XXIV

Letter—from Col. W. M. ELLIS, R.E., Superintending Engineer on Special duty.

To—the Chief Engineer for Irrigation.

Dated—the 4th April 1911.

No.—101 I./118.

The preliminary figures for cost of head works, Kistna project, have just been taken out and are about 100 lakhs more than I had forecasted.

They are as under:—

Direct charges	...	...	...	...	...	...	...	...	...	LAKHS.
Indirect charges	...	...	...	...	...	...	...	...	...	394
										19
Total	...	...	...	...	...	...	...	...	...	413

Roughly, the distribution of direct charges may be taken as 24 lakhs yearly and the balance in four years more.

2. The cost of the delta extension is more than I anticipated. The figures are with you; the total direct and indirect will be roughly 40 lakhs.

3. The cost of the upland system is not known, but is roughly forecasted at 425 lakhs with expenditure spread over from 5th to 24th year of construction pretty equally and indirect charges will be 15 lakhs. Total 440.

4. The total of the project including all charges will, it is feared, amount to nearly 900 lakhs. This is much more than I had anticipated and I take the earliest opportunity of informing you of it.

XXV

Letter—from the Executive Engineer, Kistna Reservoir Project.

To—the Chief Engineer for Irrigation.

Dated—the 20th April 1911.

No.—107.

[Reference.—Special Superintending Engineer's letter No. 101 I./118, dated 4th April 1911.]

In the above letter is a forecast of expenditure on the upland canal and distribution system of this project which is put at 425 lakhs.

Details of cost of major and minor distributaries which have just been compiled for 10 per cent. of the area show an average rate of 9.03 per acre for a complete system of distributaries, or about 56 lakhs in all or say 60 to provide for contingencies.

Branches may cost 10 lakhs and as the main canal costs 190 lakhs the total cost for works is 260 lakhs.

Add 20 per cent. to this for possible rise in price of labour and the total works cost is 303 lakhs. Establishment, leave and pension allowances will not increase because prices of labour rise, but assuming that they do and that their total cost together with ordinary and special tools and plant is 30 per cent. on the above the total is then raised to 394 lakhs.

From the above it appears that the forecast for the upland canal system is over-estimated by not less than 25 lakhs.

XXVI

Letter—from the Executive Engineer, Kistna Eastern division.
To—the Superintending Engineer, II Circle.
Dated—the 24th March 1911.
No.—915-S.E.

[Reference.—Your No. 577-K.E., dated 27th January 1911. Plans in connection with Kistna Reservoir Project delta extension.]

With reference to the above, I have the honour to report that the valuation of lands was based upon the information furnished by the Special Revenue Officer. These values having now been found to be far below the average values, fresh valuations were recently obtained from the Tahsildars of Divi, Gudivada and Nuzvid. These valuations are considerably in advance of the Special Revenue Officer's valuation. They are now adopted in the estimates, and revised estimates are herewith submitted for such of the estimates which required revision due to increased values of land. The alterations are as follow:—

	Original estimate. Amount. Rs.	Revised estimate. Amount. Rs.
(i) Irrigating lands under Kistna reservoir project	...	...
(ii) Excavating East Bank canal	6,75,000	7,40,000
(iii) Do. Vempad channel	7,77,000	8,29,000
	44,200	58,400

The changes in the original estimates which are at Madras can be noted by the aid of the papers now enclosed along with this report.

2. The masonry works proposed on the East Bank canal are two locks and regulators and four girder bridges. Tracings for these are now enclosed. The estimates submitted already hold good.

3. I understand that the proposals for extension of flood bank below Pedakallablocks. The sources of irrigation of the irrigable blocks were noted on the tracings of these blocks and detailed methods of irrigation were noted in tabular statements and enclosed with the tracings already submitted. The cost of the irrigation of these blocks is noted in the estimate of "irrigating lands under Kistna reservoir project in Kistna eastern delta," Rs. 7,40,000.

5. I am sorry for the delay in the disposal of this reference, but it is due to Tahsildar's delay in furnishing valuations of lands. The last of such informations was received on the 21st instant.

No. 31 I., dated 20th April 1911.

Copy forwarded to the Chief Engineer for Irrigation, with reference to his Memorandum R.O.C. No. 2947/09, dated 20th January 1911.

2. The plan of the girder bridge is similar to that sanctioned in G.O., No. 278 L., dated 11th March 1909, for constructing a girder bridge over the Bandar canal at Vallur slope.

3. The plans of the combined locks and regulators are based upon the plans of the regulator and lock across the Ryves canal, Kistna delta system, sanctioned in G.O., No. 795 I., dated 20th July 1904.

4. I have not made any alterations in these plans, as the estimates already submitted have, I understand, been prepared from them, and as there is no immediate prospect of the estimates being sanctioned for execution. I think however that certain modifications are desirable before the works are actually carried out. For example, the necessity for the screw shafts of the regulator shutters working in a narrow slot in the masonry is not apparent; the regulator shutters should close down on to cutstone sills; and the object of cutstone flooring downstream of the piers as though there were a clear overfall there is not understood. Sheet piles are shown, which were absolutely necessary in the case of the Ryves canal regulator, constructed on a foundation of pure sand, and having at times to hold up a considerable head of water; but these are quite unnecessary in

the case of the Bank canal regulators, if constructed on black cotton soil. Again, I think, it will very probably be found advisable to combine bridges of some kind with these locks and regulators. Even if bridges suitable for wheeled traffic are considered unnecessary, foot bridges will at least be desirable.

W. J. J. HOWLEY,
Superintending Engineer, II Circle.

ENCLOSURE.

Memorandum R.O.C. No. 2947/09, dated 20th January 1911.

The Chief Engineer for Irrigation has the honour to return the plans and estimates prepared by the Superintending Engineer, II Circle, for the extension of irrigation in the Kistna delta under the Kistna reservoir project, received with letter No. 424 I./114, dated 13th December 1910, from the Superintending Engineer on Special duty with the following remarks:—

(1) The Chief Engineer for Irrigation is of opinion that the Superintending Engineer on Special duty can complete the report to accompany the estimates with the aid of Mr. O'Brien, Assistant Engineer, whom he proposes to depute for the work for about a week.

(2) No drawings of the masonry work on the new East Bank canal have been furnished though the estimates appear to have been made out from the existing designs. These should now be obtained from the Superintending Engineer, II Circle.

(3) The cost of land for the distributaries does not appear to have been worked out on any accurate data. The Superintending Engineer, II Circle, should be asked to ascertain and report the actual value of land through which the East Bank canal extension will pass and also of the lands used for the Vempad channel.

(4) Proposals as to how the floods from the river and the main drains are to be excluded from the area proposed to be irrigated from new East Bank canal appear necessary. As they are said to have been worked out, they should be obtained from the Superintending Engineer, II Circle, and incorporated in the report and their cost included in the estimate.

2. It is hoped that with the above information the Special Superintending Engineer will be able to complete the project as stated in the concluding portion of his letter under reply.

3. With reference to paragraph 4 of his letter, the Special Superintending Engineer is informed that for the purposes of the estimate his proposal to provide shutters to hold up 6 feet of water in the Bezvada anicut is approved.

H. F. CLERK,
Ag. Chief Engineer for Irrigation.

To the Special Superintending Engineer.
Copy to the Superintending Engineer, II Circle.

XXVII

Letter—from C. T. MULLINGS, Esq., Executive Engineer, Kistna Reservoir Project.
To—the Chief Engineer for Irrigation.
Dated—the 29th May 1911.
No.—319.

I have the honour to report that the following are details of the complete estimates for the upland main canal, Kistna project.

	RS.
1. A. Preliminary expenses	77,575
2. B. Land	6,35,845
3. D. Regulators	54,960
4. F. Cross drainage works	36,48,870
5. G. Bridges	4,98,715
6. H. Escapes	2,76,765
7. K. Buildings	2,60,000
8. L. Earthwork	1,20,77,000
9. M. Plantations	52,000
10. O. Miscellaneous	6,05,285
11. P. Maintenance	1,00,000
Total	1,82,87,015

Item 6 includes the Buga Vagu automatic surplus escape and also three cross drainage works which have surplus works combined with them.

Item 10 includes the Buga Vagu dam (estimate now undergoing check with the Sub-Engineer); a subsidiary reservoir at mile 6 of the main canal necessary to cross a ravine.

2. To all the above items except No. 1, 20 per cent. has to be added for unforeseen expenditure and probable increased cost of labour before construction is complete and when this is done the total cost for works comes to Rs. 2,19,28,903.
3. Branch canal estimates are nearly complete and with the same allowance for probable increased cost of labour will cost perhaps 10 lakhs. The distribution system costs Rs. 64,60,000 and therefore the total cost for works is Rs. 2,93,88,903 for the whole upland canal system.
4. General abstract of cost of complete upland canal system—

Works	Rs.
Establishment at 23 per cent.	2,93,88,903
Tools and plant 1½ per cent. ordinary	65,95,361
Tools and plant special	4,30,132
Suspense	2,00,000
Receipts on Capital account	40,000
	64,305
Direct charges, total	3,67,18,701
Indirect charges—	
Abatement of land revenue	6,35,874
Leave and pension at 14 per cent. on establishment	9,23,351
Total, indirect	15,59,225
Grand total, cost of upland main canal system complete	3,82,77,926

XXVIII

Endorsement No. 174 I., dated 30th June 1911.

Telegram—from the Superintending Engineer, II Circle.
To—the Sub-Engineer, Project Branch, Chepauk, Madras.
Dated—Bezwada, the 29th June 1911.

No information available [in] my office or Kistna Eastern regarding figures abatement land revenue. Enquiries being made as to how the information is procurable but fear considerable delay.

Copy by post in confirmation.

W. J. J. HOWLEY,
Offg. Superintending Engineer, II Circle.

XXIX

STATEMENT of approximate abatement of annual land revenue for works connected with Kistna delta extension.

Number.	Particulars.	Dry land.		Wet land.		Rate of assessment.	Amount of assessment.
		Acres.	Cents.	Acres.	Cents.		
1	East Bank canal.						
2	Land for canal	35	48			Rs.	Rs.
	Land for distributaries for irrigating 49,000 acres.	612	50			3	1,888
1	For irrigating irrigable blocks						
	Land for distributaries for irrigating 3,768 acres of smaller blocks.	47	10			3	141
2	Land for irrigating 16,600 acres of bigger blocks.	206	25			3	819
3	Land for irrigating 24,000 acres of major blocks.	240				3	720
4	Land for irrigating 9,548 acres of short late crop.	119	35			3	300
	Total					3	368 †
							4,072

* The dry assessment rate varies from Rs. 2 to Rs. 4; Rs. 3 has been taken as an average rate.
† No compensation is necessary for distributaries for irrigating the remaining 20,000 acres of Collair bed, as it is Government land.

No. 175-I., dated 1st July 1911.

Forwarded to the Sub-Engineer, Project branch, Chief Engineer's office, Madras, with reference to his telegram, dated 28th June 1911.

W. J. J. HOWLEY,
Offg. Superintending Engineer, II Circle.

Order—No. 2435, Revenue, dated 8th August 1911.

Miscellaneous.

The papers read above deal with the revenue aspects of the Kistna Reservoir Project as revised by the Public Works Department in accordance with the instructions of the Government of India in their letter No. 964 I., dated 24th June 1907, to the effect that the scope as well as the cost of the project should be reduced so as to fulfil the conditions of a productive work.

2. Mr. Turing who conducted the revenue investigation estimated the net irrigable area under the project as 974,001 acres comprising the following—

	ACS.
Upland canal	725,787
Delta extension—	
Ordinary single crop	154,069
Late short-crop	9,494
Late short-crop in the Kolair lake bed	84,651

Mr. Turing also expected that there would be cultivation of second crop in the delta to the extent of 204,000 acres being 24 per cent. of the first crop cultivation which is the proportion of second crop now grown in the Gódávri delta. It has been assumed that there will be only one irrigated crop in the upland and late short-crop areas.

3. In arriving at the irrigable area, Mr. Turing has deducted from the commanded area 13,078 acres on account of grazing ground and 755 acres in the village of Lakshmipuram in the Bundar taluk on account of its unhealthiness. Regarding the latter, the Collector of Kistna states that there is a great demand for land in the village and any land brought under irrigation would be eagerly taken up. The Government agree with the Collector that there is no need to exclude this area. As regards the reservation of the assessed waste lands for grazing ground, the Government on reconsideration are of opinion that it is unnecessary to set apart of the Divi pumping system and the Cauvery Reservoir Project they hold that the deduction made on this account is unnecessary. The other deductions from the irrigable area made by Mr. Turing which are supported by the Board of Revenue are approved. The irrigable area revised in the light of the above remarks amounts to 987,834 acres of first crop and 204,000 acres of second crop. The late short-crop has in accordance with the existing practice in the district been treated as first crop.

4. But the area which the reservoir has been found by the latest calculations

	ACS.	of the Public Works Department to be actually capable of supplying is only
Upland canal	610,000	760,394 acres (or in round figures 760,000) for single crop and 141,906 acres (or in round figures 142,000) for the second crop as shown in the margin.
Delta extension (ordinary crop)	125,300	
Late short-crop	25,094	
	760,394	
Delta second crop	141,906	Following the classification of the irrigable area as estimated by Mr. Turing and

making a proportionate reduction on account of the smaller irrigating capacity of the reservoir, the irrigable area falls under the following classes :—

	Government.			
	Occupied.		Unoccupied Dry.	Zamindari and Inam lands.
	Wet.	Dry.		
Upland	ACS. 3,000	ACS. 558,000	ACS. 24,000	ACS. 80,000
Delta including Peddalanka area	Nil	42,000	24,000	64,000
Kolair lake bed	Nil	Nil	20,000	Nil
Total ..	3,000	595,000	68,000	94,000

5. In calculating the revenue to be derived from the sale-proceeds of waste lands at the disposal of Government, Mr. Turing has left out of account 7,600 acres which have been assigned on conditional patta in the uplands and also small blocks of waste lands where the total saleable extent in a village fell below 10 acres and states that the extents thus excluded would be equal to that which would be assigned free to resident ryots under Board's Standing Order No. 15 (xv). He also recommends that 20 per cent. of the land in the Peddalanka area and 5 per cent. in the Kolair lake may be assigned free to ryots in order to demonstrate to them the possibility of growing the late short-crop and stimulate the sale of adjoining land. The Collectors of Guntur and Kistna however recommend that no grant of land need be made free and the Government accept their recommendation. The Government are of opinion that all available waste land commanded by the project should be sold for the benefit of the project, and they wish to know the exact conditions on which the 7,600 acres in the upland have been conditionally assigned. Mr. Turing estimates the selling price of the waste lands at Rs. 32 per acre in the upland, Rs. 44 per acre in the delta extension (single crop area), Rs. 30 per acre in the Peddalanka area and Rs. 75 per acre in the Kolair lake area. The Collectors concerned have remarked that these prices are low but they will be adopted for the purposes of the forecast.

6. *Savings in remission.*—Mr. Turing has left this item out of account, but the Board of Revenue estimates the amount at Rs. 28,300 and has included it in its forecast. The Government of India have objected to credit being taken for savings of this character in forecasts of irrigation projects and the matter is under discussion. Pending its final settlement this item will be excluded.

7. Mr. Turing calculates that in ryotwari villages the average rate of water-cess may be taken at Rs. 5 an acre for first crop and Rs. 3-8-0 an acre for second crop and proposes that these rates may be adopted for the purposes of the forecast. Mr. Turing also takes credit for a slight enhancement of revenue on a small extent of wet land in the upland area, in regard to which he has separated the water-rate into dry assessment and water-rate and has treated the difference between the water-rate thus obtained and the project water-rate of Rs. 5 an acre as an enhancement due to the project. No enhancement of revenue on the revised irrigable area worked out on the basis of these rates including the interest on the sale-proceeds of waste lands amounts to Rs. 33-9681 lakhs after deducting charges on account of maintenance, establishment and collection; and this net revenue represents a return of 4-07 per cent. on the estimated capital outlay of Rs. 833-64 lakhs of direct and indirect charges.

8. The Government are however not convinced that the above calculations correctly represent the revenue which the project will yield. Both the Kistna and Guntur districts will be due for resettlement by the time irrigation under the reservoir has been fully developed. Further, the Government have reserved in the settlement notifications of these districts power to revise during the currency of the present settlement the rates of assessment on lands the irrigation of which may be improved at the cost of the State. The Government therefore consider that the revenue forecast should be framed with reference not to the rates of assessment now in force but to the rates of assessment which may be imposed at resettlement or at such revision of settlement rates.

9. In order to ascertain what these rates will be, a comparison must be made between the average grain prices of the last ten years and those upon which the existing rates of assessment were based. The prices prevailing in the Kistna district since last settlement, excluding 1908-1909 as being years of specially high prices, give a commutation rate of Rs. 170 per garce for white paddy, Rs. 136 for black paddy and Rs. 212 for cholam, after deducting 15 per cent. for merchant's profits. Allowing the same deductions as were made at the last settlement for vicissitudes of season and unprofitable areas and allowing for an increase in the cultivation expenses in proportion to the increase in prices, the rates of assessment which on the basis of the above prices might be imposed at resettlement or at any revision of settlement rates would be as follow :—

Classification of soils.														First class.		Second class.		Third class.		Fourth class.	
I	II	III	IV	V	XII	XIII	XIV	Taram.	Rate.	Taram.	Rate.	Taram.	Rate.	Taram.	Rate.	Taram.	Rate.	Taram.	Rate.	Taram.	Rate.
1	2	3	4	5	6	7	8	1	15	2	13	3	12	4	10	5	8	6	10	7	8
2	3	4	5	6	7	8	9	2	13	3	12	4	10	5	8	6	10	7	8	9	10
3	4	5	6	7	8	9	10	3	12	4	10	5	8	6	10	7	8	9	10	11	12
4	5	6	7	8	9	10	11	4	10	5	8	6	10	7	8	9	10	11	12	13	14
5	6	7	8	9	10	11	12	5	9	6	8	7	9	8	10	9	11	10	12	11	13
6	7	8	9	10	11	12	13	6	8	7	9	8	10	9	11	10	12	11	13	12	14
7	8	9	10	11	12	13	14	7	7	8	9	8	10	9	11	10	12	11	13	12	14
8	9	10	11	12	13	14	15	8	6	8	9	8	10	9	11	10	12	11	13	12	14

Dry Scale.

Classification of soils.														First group.		Second group.		Third group.	
I	II	III	IV	V	VII	XII	XIII	XIV	Taram.	Rate.	Taram.	Rate.	Taram.	Rate.	Taram.	Rate.	Taram.	Rate.	Taram.
1	2	3	4	5	6	7	8	9	1	15	2	13	3	12	4	10	5	8	6
2	3	4	5	6	7	8	9	10	2	13	3	12	4	10	5	8	6	10	7
3	4	5	6	7	8	9	10	11	3	12	4	10	5	8	6	10	7	8	9
4	5	6	7	8	9	10	11	12	4	10	5	8	6	10	7	8	9	10	11
5	6	7	8	9	10	11	12	13	5	9	6	8	7	9	8	10	9	11	12
6	7	8	9	10	11	12	13	14	6	8	7	9	8	10	9	11	10	12	11
7	8	9	10	11	12	13	14	15	7	7	8	9	8	10	9	11	10	12	11
8	9	10	11	12	13	14	15	16	8	6	8	9	8	10	9	11	10	12	11
9	10	11	12	13	14	15	16	17	9	5	7	8	7	9	8	10	9	11	12
10	11	12	13	14	15	16	17	18	10	4	6	7	6	8	7	9	8	10	11

10. The application of these rates of assessment to the extents shown in Mr. Turing's statement VI-B gives an average differential water-rate of Rs. 7-1-0 for first wet crop and Rs. 4-12-0 for second wet crop assuming that the full enhancement justified by the rise of prices will be levied on the dry lands at the next settlement. It is accordingly proposed to adopt Rs. 7 as the average charge for the irrigation of first crop and Rs. 4-12-0 for second crop in framing the forecast in respect of the Kistna Eastern delta. The same rates will be adopted in respect of the area commanded by the project in the Guntur district. The average wet assessment in the delta area in the Guntur district is Rs. 7-11-3 per acre, and it may be assumed that this would be the average wet assessment in the upland also if that tract were now classified on the same lines as those on which the classification of the delta was carried out. As the price of paddy which is the standard wet grain for the district has risen by over 50 per cent. above that adopted at last settlement, the average wet assessment in the delta and uplands enhanced in proportion to the increase of the price of paddy would come to Rs. 11-8-10 per acre. The enhancement on the dry lands at resettlement is not likely to exceed 25 per cent. which would raise the present average dry assessment in the delta and uplands from Rs. 1-15-4 to Rs. 2-7-2. The average differential water-rate in the delta and uplands would thus be Rs. 9-1-8 for first wet crop, but for the purposes of the forecast a rate of Rs. 7 for first crop will be adopted as in the Kistna Eastern delta, as the results of the

reclassification which will be necessary in the upland tract cannot be foretold with accuracy. In view of the profits accruing to the cultivator from irrigation these rates are moderate and the Government have no doubt that they can easily be paid.

11. With these revised rates the net revenue derivable from the project amounts to Rs. 49,92,453 as shown below :—

	Extent.	Amount.
	ACS.	RS.
(1) Enhanced assessment on wet land	3,000	7,580
(2) Water-rate on dry land at Rs. 7 per acre (excluding the revenue at present derived from the bed of the Kolair lake)	757,000	52,67,317
(3) Dry assessment on unoccupied Government land at Rs. 2-7-0 per acre	68,000	1,54,303
(4) Second crop charge	142,000	6,74,500
(5) Interest on sale-proceeds of waste land	...	1,30,160
Total gross revenue	...	62,33,860

Deductions.

(1) Maintenance charges at As. 12 an acre on the total area, excluding second crop area	5,70,000
(2) Collection and establishment charges at 11 per cent. on the total revenue excluding interest on sale-proceeds of waste lands	6,71,407
Total deductions	12,41,407
Net revenue	49,92,453

This represents a return of 5.99 per cent. on the estimated capital outlay of Rs. 833.64 lakhs.

12. An estimate of the growth of net receipts and charges revised in accordance with the above forecast is appended.

13. Mr. Turing's suggestion for the formation of banks of canals and major distributaries broad enough for use by country carts will be considered in the Public Works Department.

(True Extract.)

A. G. CARDEW,
Secretary to Government.

To the Board of Revenue (Revenue Settlement).
" (Land Revenue).
" Public Works Department (Irrigation).
" Public Works Department.

APPENDIX.
FORECAST OF FINANCIAL PROSPECTS (REVISED) Kistna Reservoir Project.

PART III.—Estimate of growth of irrigation and revenue receipts and charges.

Year.	Irrigated area at the end of the year.	Gross revenue due to works.			Charges.			Net revenue due to works.		
		Direct receipts.	Enhanced land revenue due to irrigation and interest on sale-proceeds of waste lands.	Total.	Working expenses at As. 12 per acre.	Collection charge at 11 per cent. of gross receipts excluding interest on sale-proceeds.	Total.	Including enhanced land revenue and interest on sale-proceeds.	Excluding enhanced land revenue and interest on sale-proceeds.	
1	2	3	4	5	6	7	8	9	10	
8th	15,000 D.	1,05,000	8,861	1,13,861	11,280	12,116	23,396	90,495	81,634	Rs.
9th	30,000 D.	2,10,000	17,722	2,27,722	22,500	24,232	46,732	1,80,990	1,63,268	Rs.
10th	45,000 D.	3,15,000	26,583	3,41,583	33,750	36,348	69,098	2,71,485	2,45,992	Rs.
11th	60,000 D.	4,20,000	35,444	4,55,444	46,000	48,464	93,464	3,61,980	3,26,536	Rs.
12th	75,000 D.	5,25,000	44,305	5,69,305	56,250	60,580	1,16,830	4,52,476	4,08,170	Rs.
	90,000 D.	6,30,000	53,166	6,83,166	66,500	70,832	1,37,332	5,43,968	4,99,636	Rs.
14th	105,000 D.	7,35,000	62,027	7,97,027	76,750	81,083	1,57,833	6,35,801	5,91,718	Rs.
	120,000 D.	8,40,000	70,888	9,10,888	86,000	90,314	1,76,314	7,27,114	6,82,800	Rs.
16th	135,000 D.	9,45,000	79,749	10,24,749	95,187	1,08,168	1,93,355	8,16,594	7,73,426	Rs.
	150,000 D.	10,50,000	88,610	11,38,610	1,04,250	1,16,977	2,21,227	9,08,817	8,64,840	Rs.
18th	165,000 D.	11,55,000	97,471	12,52,471	1,14,375	1,27,706	2,42,081	9,99,992	9,55,286	Rs.
	180,000 D.	12,60,000	1,06,332	13,66,332	1,24,500	1,37,956	2,62,456	10,91,448	10,46,992	Rs.
20th	195,000 D.	13,65,000	1,15,193	14,80,193	1,34,625	1,48,827	2,83,452	11,82,900	11,37,448	Rs.
	210,000 D.	14,70,000	1,24,054	15,94,054	1,44,750	1,60,698	3,04,448	12,74,350	12,28,652	Rs.
22nd	225,000 D.	15,75,000	1,32,915	17,07,915	1,54,875	1,72,569	3,25,444	13,65,794	13,19,196	Rs.
	240,000 D.	16,80,000	1,41,776	18,21,776	1,65,000	1,84,430	3,46,430	14,57,224	14,11,792	Rs.
26th	270,000 D.	18,90,000	1,60,338	20,50,338	1,86,000	2,07,100	3,93,100	16,43,479	15,97,379	Rs.
	285,000 D.	20,25,000	1,69,199	22,04,199	1,96,125	2,18,956	4,15,081	17,34,905	16,88,727	Rs.
30th	300,000 D.	21,60,000	1,78,060	23,38,060	2,06,250	2,30,806	4,36,056	18,26,331	17,80,153	Rs.
	315,000 D.	22,95,000	1,86,921	24,81,921	2,16,375	2,42,657	4,57,032	19,17,753	18,71,825	Rs.
34th	330,000 D.	24,30,000	1,95,782	26,25,782	2,26,500	2,54,508	4,81,008	20,09,251	19,63,727	Rs.
	345,000 D.	25,65,000	2,04,643	27,69,643	2,36,625	2,66,364	5,02,989	21,00,776	20,55,248	Rs.
38th	360,000 D.	27,00,000	2,13,504	29,13,504	2,46,750	2,78,215	5,24,965	21,92,301	21,47,776	Rs.
	375,000 D.	28,35,000	2,22,365	30,57,365	2,56,875	2,90,071	5,46,946	22,83,826	22,39,252	Rs.
42nd	390,000 D.	29,70,000	2,31,226	32,01,226	2,67,000	3,01,922	5,68,922	23,75,351	23,30,800	Rs.
	405,000 D.	31,05,000	2,40,087	33,45,087	2,77,125	3,13,773	5,90,903	24,66,876	24,22,352	Rs.
46th	420,000 D.	32,40,000	2,48,948	34,88,948	2,87,250	3,25,624	6,12,874	25,58,301	25,13,799	Rs.
	435,000 D.	33,75,000	2,57,809	36,32,809	2,97,375	3,37,475	6,34,850	26,49,726	26,05,248	Rs.
50th	450,000 D.	35,10,000	2,66,670	37,76,670	3,07,500	3,49,326	6,56,826	27,41,151	26,96,724	Rs.
	465,000 D.	36,45,000	2,75,531	39,20,531	3,17,625	3,61,177	6,78,802	28,32,576	27,88,172	Rs.
54th	480,000 D.	37,80,000	2,84,392	40,64,392	3,27,750	3,73,028	7,00,778	29,24,001	28,79,648	Rs.
	495,000 D.	39,15,000	2,93,253	42,08,253	3,37,875	3,84,879	7,22,754	30,15,426	29,71,124	Rs.
58th	510,000 D.	40,50,000	3,02,114	43,52,114	3,48,000	3,96,730	7,44,730	31,06,851	30,62,600	Rs.
	525,000 D.	41,85,000	3,10,975	44,96,075	3,58,125	4,08,581	7,66,706	31,98,276	31,54,076	Rs.
62nd	540,000 D.	43,20,000	3,19,836	46,39,836	3,68,250	4,20,432	7,88,682	32,89,701	32,45,552	Rs.
	555,000 D.	44,55,000	3,28,697	47,83,697	3,78,375	4,32,283	8,10,658	33,81,126	33,37,028	Rs.
66th	570,000 D.	45,90,000	3,37,558	49,27,558	3,88,500	4,44,134	8,32,634	34,72,551	34,28,504	Rs.
	585,000 D.	47,25,000	3,46,419	50,71,419	3,98,625	4,56,025	8,54,650	35,64,001	35,19,976	Rs.
70th	600,000 D.	48,60,000	3,55,280	52,15,280	4,08,750	4,67,926	8,76,676	36,55,426	36,11,452	Rs.
	615,000 D.	49,95,000	3,64,141	53,59,141	4,18,875	4,79,827	8,98,702	37,46,851	37,02,928	Rs.
74th	630,000 D.	51,30,000	3,73,002	55,03,002	4,29,000	4,91,728	9,20,728	38,38,276	37,94,404	Rs.
	645,000 D.	52,65,000	3,81,863	56,46,863	4,39,125	5,03,629	9,42,754	39,29,701	38,85,880	Rs.
78th	660,000 D.	54,00,000	3,90,724	57,90,724	4,49,250	5,15,530	9,64,780	40,21,126	39,77,356	Rs.
	675,000 D.	55,35,000	3,99,585	59,34,585	4,59,375	5,27,431	9,86,806	41,12,551	40,68,832	Rs.
82nd	690,000 D.	56,70,000	4,08,446	60,78,446	4,69,500	5,39,332	10,08,832	42,03,976	41,60,308	Rs.
	705,000 D.	58,05,000	4,17,307	62,22,307	4,79,625	5,51,233	10,30,858	42,95,401	42,51,784	Rs.
86th	720,000 D.	59,40,000	4,26,168	63,66,168	4,89,750	5,63,134	10,52,884	43,86,826	43,43,260	Rs.
	735,000 D.	60,75,000	4,35,029	65,10,029	4,99,875	5,75,035	10,74,910	44,78,251	44,34,736	Rs.
90th	750,000 D.	62,10,000	4,43,890	66,53,890	5,09,000	5,86,936	10,96,936	45,69,676	45,26,212	Rs.
	765,000 D.	63,45,000	4,52,751	67,97,751	5,19,125	5,98,837	11,18,963	46,61,101	46,17,688	Rs.
100th	810,000 D.	68,10,000	4,71,412	72,81,412	5,48,250	6,26,988	11,75,238	48,37,476	48,00,240	Rs.
	825,000 D.	69,45,000	4,80,273	74,25,273	5,58,375	6,38,889	11,97,264	49,28,901	49,21,716	Rs.
110th	870,000 D.	74,10,000	4,98,934	79,08,934	5,87,500	6,67,040	12,53,540	51,04,690	50,74,272	Rs.
	885,000 D.	75,45,000	5,07,795	80,52,795	5,97,625	6,78,941	12,75,566	51,96,115	51,65,748	Rs.
120th	930,000 D.	80,10,000	5,26,456	85,36,456	6,26,750	7,07,092	13,31,842	53,71,904	53,41,704	Rs.
	945,000 D.	81,45,000	5,35,317	86,80,317	6,36,875	7,19,023	13,53,918	54,63,329	54,33,730	Rs.
130th	990,000 D.	86,10,000	5,53,978	91,63,978	6,66,000	7,47,174	14,10,174	56,39,118	56,09,784	Rs.
	1,005,000 D.	87,45,000	5,62,839	93,07,839	6,76,125	7,59,075	14,32,200	57,30,543	57,01,260	Rs.
140th	1,050,000 D.	92,10,000	5,81,500	97,91,500	7,05,250	7,87,226	14,92,476	59,06,332	58,76,816	Rs.
	1,065,000 D.	93,45,000	5,90,361	99,35,361	7,15,375	8,00,127	15,14,502	59,97,757	59,68,292	Rs.
150th	1,110,000 D.	98,10,000	6,00,000	1,04,10,000	7,44,500	8,28,278	15,72,778	61,73,546	61,44,064	Rs.
	1,125,000 D.	99,45,000	6,08,861	1,05,53,861	7,54,625	8,40,179	15,94,804	62,64,971	62,35,536	Rs.
160th	1,170,000 D.	1,04,10,000	6,28,522	1,10,38,522	7,83,750	8,68,330	16,53,080	64,40,760	64,11,432	Rs.
	1,185,000 D.	1,05,45,000	6,37,383	1,11,82,383	7,93,875	8,80,231	16,75,106	65,32,185	65,02,958	Rs.
170th	1,230,000 D.	1,09,80,000	6,48,000	1,16,28,000	8,23,000	9,08,382	17,33,382	67,07,974	66,78,594	Rs.
	1,245,000 D.	1,11,15,000	6,56,861	1,17,71,861	8,33,125	9,20,283	17,55,408	67,99,399	67,70,020	Rs.
180th	1,290,000 D.	1,16,40,000	6,67,500	1,23,07,500	8,62,250	9,48,434	18,13,684	69,75,188	69,45,776	Rs.
	1,305,000 D.	1,17,75,000	6,76,361	1,24,51,361	8,72,375	9,60,335	18,35,710	70,66,613	70,37,202	Rs.
190th	1,350,000 D.	1,22,00,000	6,87,000	1,28,87,000	9,01,500	9,88,486	18,93,986	72,42,402	72,13,872	Rs.
	1,365,000 D.	1,23,35,000	6,95,861	1,30,30,861	9,11,625	10,00,387	19,16,012	73,33,827	73,05,298	Rs.
200th	1,410,000 D.	1,28,60,000	7,08,000	1,35,68,000	9,40,750	10,28,538	19,74,288	75,09,616	74,80,864	Rs.
	1,425,000 D.	1,29,95,000	7,16,861	1,37,11,861	9,50,875	10,40,439	19,96,314	76,01,041	75,72,340	Rs.

S.—Second-crop area in the delta.

Sh.—Area irrigated in the short late crop area.

U.—Area of irrigation in upland.

Column 2—D. denotes ordinary first extension in the delta.

Column 4—

It has been assumed that the area of waste lands that will be brought under irrigation will be proportionate to the total area irrigated in the year.

Part III—Estimate of growth of irrigation and revenue receipts and charges—cont.

Year.	Irrigated area at the end of the year.	Revenue receipts and charges.									
		Gross revenue due to works.				Charges.			Net revenue due to works.		
		Direct receipts.	Enhanced land revenue due to irrigation and interest on sale-proceeds of waste lands.	Total.	Working expenses at 12 annas per acre.	Collection charge at 11 per cent. of gross receipts excluding interest on sale-proceeds.	Total.	Including enhanced land revenue and interest on sale-proceeds.	Excluding enhanced land revenue and interest on sale-proceeds.		
1	2	3	4	5	6	7	8	9	10		
		Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.		
21st	125,000 D. 324,000 U. 25,000 Sh.	38,54,287	2,49,475	40,96,772	3,55,500	4,37,918	7,93,418	33,03,354	30,60,879		
22nd	125,000 D. 324,000 U. 25,000 Sh.	41,70,897	2,47,723	44,18,620	3,82,500	4,73,122	8,55,622	35,63,998	33,15,275		
23rd	125,000 D. 324,000 U. 25,000 Sh.	44,51,397	2,52,971	47,04,368	4,09,500	5,04,356	9,13,566	37,90,512	35,37,541		
24th	125,000 D. 324,000 U. 25,000 Sh.	47,03,397	2,58,219	49,61,616	4,36,500	5,39,454	9,68,954	39,92,662	37,34,443		
25th	125,000 D. 324,000 U. 25,000 Sh.	49,55,397	2,63,467	52,18,864	4,63,500	5,60,553	10,24,053	41,94,811	39,31,344		
26th	125,000 D. 324,000 U. 25,000 Sh.	52,07,397	2,68,715	54,76,112	4,90,500	5,88,651	10,79,151	43,96,951	41,28,246		
27th	125,000 D. 324,000 U. 25,000 Sh.	54,59,397	2,73,963	57,33,360	5,17,500	6,16,750	11,34,250	45,99,110	43,95,147		
28th	125,000 D. 324,000 U. 25,000 Sh.	57,11,397	2,79,211	59,90,608	5,44,500	6,44,848	11,89,348	48,01,260	45,29,049		
29th	125,000 D. 324,000 U. 25,000 Sh.	59,49,397	2,84,463	62,33,860	5,70,000	6,71,407	12,41,407	49,92,453	47,07,990		

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Column 2. D. denotes ordinary first extension in the delta. U.—Area of irrigation in upland. Sh.—Area irrigated in the second crop area. S.—Second-crop area in the delta.
Column 4.—It has been assumed that the area of waste lands that will be brought under irrigation will be proportionate to the total area irrigated in the year.

APPENDICES.

APPENDIX I.

I

*Note on the proposed Kistna storage Irrigation Project by Mr. J. Benton, C.I.E.,
Inspector-General of Irrigation, dated 3rd April 1909.*

[Enclosure to letter No. 447 I., dated 28th April 1909, from the Government of India, Public Works Department.]

Kistna river.—The Kistna river rises in the Bombay Presidency and is largely fed by the heavy rainfall of the Western ghats. The characteristics of the greater part of the Kistna river up stream of the Bezwada weir at the head of the delta are,—lowness of the water level, narrowness of the channel which is mostly in rock, great depth in high floods, a very high maximum flood discharge of 1,010,000 cusecs, and a very low minimum cold weather discharge of 200 to 300 cusecs; these characteristics are specially true of the 89 miles of the river from Daida to Bezwada, the portion in which it has been sought in the past, and is still sought to store water for the irrigation of additional tracts under this project.

2. *Available supply in the Kistna.*—The Kistna is the third or fourth largest river in India as regards the maximum flood discharges, and it is believed that it will generally suffice for existing and contemplated works; however, this is a matter which can, and should, be put beyond all doubt, since the project now under consideration will be the last one to be served, and will only receive what is left over by the other works.

3. *Desirability of extending irrigation.*—The Irrigation Commission dealt with the question of extending irrigation in the Kistna valley in Volume II, paragraph 247, of their report; they recommended early execution of surveys, to determine whether the work would be remunerative. The principal reasons for the execution of a large storage work on the Kistna river are briefly as follows:—

(i) The ever-increasing withdrawals of water further up-stream in the Bombay-Deccan and Native States promise in course of time to materially affect the existing irrigation in the delta.

(ii) Considerable extensions of irrigation are feasible in the delta, and on the right bank, provided a work is devised which will store water for tiding over the period of short supply for the first crop at the end of the monsoon, and also for use in the cold weather for the second crop.

4. *Mr. R. N. H. Reid's project.*—This project was reviewed in my note, dated 31st March 1907, and the chief objections to it are summarised in paragraph 37 of the same; the proposed off-take was at Daida, 89 miles up-stream of Bezwada, the head of the delta, and the proposed canal would have had to be constructed for 40 miles on side-long ground largely composed of rock. I had the advantage of examining this scheme on the ground and in the project papers in concert with Mr. C. A. Smith, the Chief Engineer for Irrigation, and we were both of opinion that the difficulties, requirements and cost were all underestimated and that it was very desirable to avoid the 40 miles of unsatisfactory ground by endeavouring to find an alternative off-take 30 to 40 miles further down the river, opposite where the Bellamkonda range of hills abuts on the Kistna, that is, in the Pulichintala-Muktiala loop of the Kistna.

5. *Reconnaissance of the lower alternative site.*—The first reconnaissance in the Pulichintala-Muktiala loop was carried out by a Native Sub-Engineer who reported that no suitable site existed. The Local Government, in submitting the Sub-Engineer's report, advanced for consideration an ingenious scheme for building a lower dam at Daida, and for using the power of the water passed on to the delta to pump 6,000 cusecs up to 70 feet, for the supply of an upland canal at a lower level than proposed by Mr. Reid. This scheme did not serve to admit of the difficult 40 miles of side-long rocky ground being avoided, while it was undesirable to rely on pumping for such a large canal; this scheme was reviewed in my note, dated 10th March 1908. The report of the Sub-Engineer was held to be incomplete and inconclusive, and the appointment of a competent Engineer officer to make a more thorough investigation of the valley in the Pulichintala-Muktiala loop of the river, was considered necessary.

6. *Further examination of the lower site.*—Under the direction of Mr. C. A. Smith, the permanent Chief Engineer for Irrigation, on his return from leave, the fresh investigations were entrusted to Colonel W. M. Ellis, R. E., Superintending Engineer, II Circle, with Mr. H. L. Nicholson, Assistant Engineer, as Reconnaissance and Survey officer.

7. No less than five dam sites of more or less promise were found. Dr. W. F. Smeeth, M.A., D.Sc., the Mysore State Geologist, was called in by the Chief Engineer to advise on these sites, since it was seen that the suitability of the rock in the river bed for sustaining the great pressure of a high masonry dam, was a matter of primary importance.

8. *Report of Geologist.*—This is given at page 44 of the printed papers received with letter No. 458 I., dated 9th December 1908, of the Local Government. Dr. Smeeth's report, coupled with canal off-take requirements, served to admit of the probable sites being reduced to

- No. 1-A with No. 1 as an alternative,
- No. 2-A with No. 2 as an alternative.

These sites are all comprised in about $1\frac{1}{2}$ miles of the river channel; the Geologist's index map of scale 1 inch to 1 mile given opposite page 44 of the enclosure to the letter of the Local Government, shows sites Nos. 1 and 2 and Nos. 1-A and 2-A are about $\frac{1}{2}$ mile down-stream of these respectively. The above is briefly the history of the case up to the stage when it was reported on by the Local Government in their letter No. 458 I., dated 9th December 1908. I will now proceed to give some later results.

9. *Detailed investigation.*—The results were sufficiently promising to call for detailed surveys. The survey and project work required on the Kistna comprise the following:—

- (i) Preparation of a contoured survey of the reservoir site and of the range of hills on the right bank which will be tunnelled for the canal off-take.
- (ii) Excavation of trial pits on the alignment of the land portion of the dam and surplusings works
- (iii) Preparation of contoured map of the tract to be irrigated, with projecting and surveying of canal scheme.
- (iv) Determining of suitability of the rock in the river bed for sustaining a high dam.
- (v) Preparation of detailed maps, sections, plans of works and of estimates for the same with a report on the project.

When I was on tour in the Kistna valley from 7th to 13th March 1909, (i) and (ii) *supra* had been prepared, while (iii) was in hand and drills were about to arrive for (iv) *supra*.

10. *Results of trial pits, Left bank.*—The trial pits executed on the land ridges left bank and which would be need in conjunction with sites Nos. 2 and 2-A, go to show as follows:—

- (i) Pits dug to depths of 10 to 30 feet at various points along the ridges show shale of hardness constantly increasing with the depth.
- (ii) The quality of the rock at depths of 20 to 30 feet appears suitable for sustaining a dam, provided the intensity of pressure is kept low by spreading out the foundations.
- (iii) The shale reached in the deepest trial pits is too soft and too liable to weather on exposure to resist the severe action of great discharges of surplus water falling through a great height.

The above results in the elimination of sites Nos. 2 and 2-A and in the selection for the dam being reduced to some site about No. 1-A or No. 1. It therefore remains to select the best site for the dam in this half mile of the river channel.

11. *Napah rock.*—Fortunately at about 3,600 feet from the river margin on the left side, the geological structure of the ground is napah, lime-stone of great depth, and of a quality which can apparently be safely relied on to resist weathering and surplusings of large volume from a great height, provided a subsidiary wall is constructed to give a cushion of 20 to 30 feet in depth at the high parts.

12. *General character of site and works.*—These are as follows:—

- (i) *Right bank.*—A narrow ridge about 500 feet in height of hard shale lies parallel and close to the river bank. It is proposed for the site No. 1-A to construct the dam over the 100 to 200 feet of berm and to abut it against this ridge. The canal would be tunnelled through the ridge, the length of barrels being from 1,300 to 2,000 feet. The rock appears sound enough to answer with only roof lining, but a heading may be carried in 30 to 40 feet to clearly show what requirements will be.

- (ii) *River channel.*—This is very regular and averagely about 2,000 feet in width up to berm level. There is rock everywhere in the river bed; in parts, it projects several feet above the sand and cold weather water-supply and in other parts is covered with unknown, but apparently moderate, depths of sand. The rock is mostly of shale is apparently of better quality than on the ridges on the left bank; however, to ascertain the quality fully, it is necessary to sink trial pits or drill holes. There are some bands of quartzite crossing the river obliquely, and these are much harder than the shale. The question for investigation is the depth at which sufficiently sound rock will be found to sustain the masonry dam. It is proposed to construct a masonry dam over the river channel with the requisite number of constructional sluices at a low level and of others at a higher level, for supply of water to the delta.

- (iii) *Left bank of the river.*—The works proposed on this side consist of the following:—
- (a) A masonry dam about 3,600 feet in length—*vide* line A B C on the 8 inch to 1 mile contoured plan; this would be founded on sufficiently sound shale rock to safely resist the pressure. No surplusings would be effected in this part of the work.

- (b) A continuation of the masonry dam (iii) (a) *supra* of about 10,300 feet would be constructed on the napah rock. The line C D E F on the 8 inch to 1 mile contoured map indicates the general location of one of the lines suggested for investigation. The greater part of the river floods is proposed to be surplused over this part of the dam.

The works (i) to (iii) *supra* indicate the general proposals of the local officers and are based on the limited data available when they wrote; these proposals will be modified where additional trial pits, borings and surveys may show the need for change. I am of opinion that a feasible dam site will most probably be found in the locations mentioned, and that the conditions, as far as can be seen, warrant full investigation of a dam site generally in this location and the execution of a contoured survey for a high level to take off from the proposed dam. The chief remaining difficulty relates to measures for prevention of silting up of the reservoir, and this will be dealt with in the sequel.

13. *Modifications of proposals.*—Pending the collection of further data regarding character of the rock in the river bed as shown by drilling holes, quarrying trial pits,—depth at which sound shale is met with on the line A B C, as shown by trial pits,—and character of the napah rock along the line C D E F, it is impossible to hazard any definite suggestions for improvement of the proposals of the local officers regarding the works for this site; I will therefore confine my remarks to the following aspects of the case which appear to call for consideration:—

- (i) The elimination of the tunnel is desirable, if it does not result in more costly and less safe arrangements. As pointed out by Colonel Ellis in his report on the preliminary estimate of 13th October 1908, site No. 1 admits of the tunnel being dispensed with. Rough comparative estimates of the works for sites Nos. 1 and 1-A on both sides of the river, may be prepared to admit of its being seen which will be the better line. Trial pits may be sunk through the quartzite beds to show the depth at which sound rock will be found as suggested by Dr. Smeeth.

- (ii) The rough preliminary estimate shows Rs. 11,40,041 and Rs. 8,40,000 for water cushion and shutters for main dam. Colonel Ellis proposed surplusings arrangements are ingenious, but these figures go to show that they would be costly, and I hope that efficient proposals of a cheaper character can be devised. If the dam is of the solid type, as far as really required to be pierced with sluices at the minimum safe distance apart, this portion alone will require a subsidiary dam to give a cushion. The arched form of design may possibly suit the remaining part where no surplusings will ever occur except in the cold weather, when the work is under construction, and then all the surplusings could be effected in this portion before the arches are constructed; I will be obliged by the Chief Engineer having this investigated and by his sending to me direct, sections with rough estimates showing what he would propose, with reasons for and against the proposals, and comparing the cost with that of the proposals in the preliminary estimate.

- (iii) The length of 3,600 feet on the shale where surplusings cannot be effected—*vide* paragraph 11 (iii) *supra*—is costly and ineffective as regards surplusings; efforts may be made to reduce the length and cost of this portion.

- (iv) The *napah* proposed to be surplused over may have some trial pits of 20 × 20 feet sunk with the object of ascertaining to what depth it is fissured and likely to fail when great quantities of water are precipitated on it from a great height. Cushioning and lengthening of the surplusings portion are the necessary measures to compensate for possible weakness of the lime-stone.

14. *Parts remaining for examination.*—The river up-stream of Waddanapalli has been carefully examined. From Waddanapalli to Muktiala, inspection on the ground appears to show that the river bed is too deep, while lateral facilities for execution of a dam as regards high ground for terminals are lacking. Down-stream of Muktiala, the conditions which obtain have not been investigated in detail, but it is observed that the Geologist shows this portion of the channel to be in the napah belt, while a high ridge of the same formation exists to the east of Muktiala; further, according to the Survey of India maps, there are various outlying portions of high ground on both sides. The Pulichintala site, while promising to be feasible, still leaves a good many conditions which we could wish to see improved on, and I would therefore suggest the necessity of carefully investigating possibilities down-stream of Muktiala to make quite sure that the best site is adopted. A sufficient number of cross-sections should be taken of the river basins into which water would be surplused, to show whether Jaggayyapet and important villages will be submerged.

15. *Silting up of reservoir.*—The usual practice with small storage works is to construct these on affluents which give little more water than will be used annually; the result is that the storage capacity diminishes very slowly. The Kistna at Bezvada discharges on the average about eight times as much water as will be used on existing and proposed canals, and silting up will therefore proceed much more rapidly than in ordinary storage works. The Assuan dam is not a parallel case, since the Nile floods have full play for the greater part of the flood season and can greatly reduce deposits which occur during the short period when the sluices are closed.

and silt trapped. When the reservoir is completed practically, the whole of the sand rolled forward on the bed, and the fine silt and clay carried in suspension in the water will be trapped in the reservoir and the capacity of the latter will steadily diminish year by year. A time will come when the reservoir will become a high ancient capable of passing such supplies of water as there may be in the river, to either the delta or the high level canal, but there will be no storage capacity and no more second crop than there is at present.

16. *Silt carried by the Kistna.*—It is understood that some observations were made in past years on the proportion by volume of silt carried by the Kistna river, but particulars were not forthcoming when I was at Madras. The silt carried down by the river comprises—

- (i) the coarse sand rolled along the bed, and
- (ii) the finer silt and clay held in suspension by eddying motion.

The part (i) *supra* is difficult to ascertain, but the part (ii) can be readily determined. Search may be made for the records of the past observations, and it may be considered how far these can be accepted as showing the sum of (i) and (ii) *supra*.

17. In the case of the Lower Chenab canal, the aggregate of both rolled silt and that in suspension, were determined accurately on a large scale by silting up extensive depression of known contents, with a known supply of about 1,000 cusecs flowing for over two years. The proportion by volume arrived at was about 1/2284, but the amount for the Kistna may be quite different; assuming, for the present, that this proportion holds good in the case of the Kistna river, we have as follows in thousands of millions of cubic feet:—

Average discharge of Kistna—1st June to 31st October		2,521
The capacity of the reservoir is as follows:—		
At R.L. 240.0 or 10' over F.T.L.	...	183
At R.L. 230.0, that is, F.T.L.	...	151
At R.L. 187.5 or F.S.L. of upland canal	...	50
Yearly deposit of silt at the Lower Chenab canal proportion		521
millions cubic feet		2,284
We would then have as follows:—		
Thousands of millions cubic feet.		1,130

Year at end of	Silt deposited.	Balance of capacity.	Balance capacity Total capacity = Col. c. (d) 183
(a)	(b)	(c)	
0	0.0	183.0	1.00
10	11.3	171.7	0.94
20	22.6	160.4	0.88
30	33.9	149.1	0.81
40	45.2	137.8	0.75
50	56.5	126.5	0.69
60	67.8	115.2	0.63
70	79.1	103.9	0.57
80	90.4	92.6	0.51
90	101.7	81.3	0.44
100	113.0	70.0	0.38
120	135.6	47.4	0.25
140	158.2	24.8	0.13
160	180.8	2.2	0.10
162	183.0	0.0	0.00

The above shows that if the Kistna water carries as much silt as the Chenab river, the unsilted proportion of the storage capacity at the end of various periods would be as stated in column (d) of the table. The reservoir would be about half silted up in 80 years, and entirely filled up in 162 years; for reasons which I shall give below, the numbers in column (d) cannot be taken to correctly show the efficiency, but they do show for the assumed proportion of silt carried what fractional part of the original capacity would remain over for the storage of water. The above table serves to indicate that we cannot trap all the silt in the Kistna river, without rapidly silting up the reservoir.

18. *Reasons for discounting the effect of silting.*—We have the following ratios:—

(i) Capacity of upland canal at F.S.L.	=	50,000 m.c.ft.	= 1/3.
(ii) Annual irrigation of upland canal	=	150,000 m.c.ft.	
Total annual irrigation	=	610,000 acres	= 1/3.
(iii) Area of second crop upland canal	=	1,795,000 acres	
Total area second crop	=	110,000 acres	= 1/3.
		815,000 acres	

It is true that the irrigated area below Bezwada, owing to its low level, can be served, whenever the river supply suffices, and that silt accumulations below full supply level of the upland canal will not actually block water entering that work; however, neither these conditions—the high level of the upland canal off-take—nor any of the ratios arrived at above, can be taken, in my opinion, to show that one-third part of the silt laid down in the reservoir may be left out of consideration.

19. *Draw-off tables.*—The draw-off tables may be prepared so as to take cognizance of the following conditions:—

(i) The steadily diminishing capacity due to silting up of the reservoir. The observed proportions of silt in the Kistna water may be used if these include both rolled sand and silt in suspension; failing this, the proportion for the Lower Chenab canal may be assumed.

(ii) The difference of off-take levels for upland canal and irrigation below Bezwada as regards the physical possibility of passing water to these; no assumptions appear admissible as regards silt below full supply level of upland canal, not affecting the storage capacity available for the system as a whole.

In preparing the tables, it is necessary to assume that silting up has reached some particular stage; it will be advisable, in my opinion, to work out results for more than one period in the life of the reservoir, and I would suggest that three cases may be investigated with the initial capacity as follows:—

Stage.	Approximate initial capacity in thousands of millions c. ft.	Remarks.
After about 29 years	...	...
" 50 "	...	150 Full tank level.
" 70 "	...	126
" 104 "	...	104

20. *Effective life of reservoir.*—Subject to what the draw-off tables may serve to show, the figures given in the table, paragraph 16 *supra*, appear to indicate that the effective life of the reservoir of 183,000 million cubic feet capacity may be about fifty years. The project is not supposed to be fully developed until the 25th year from the commencement of construction, so that it would apparently only be efficient for about twenty-five years after full development; it would apparently be necessary to then make some other arrangements. I will be glad if the local officers can furnish good reasons for concluding that a more favourable view of the case can be safely adopted; meanwhile, I will discuss below some aspects of the case, based on the supposition that the silting difficulty is as serious as I meanwhile fear it is.

21. *Scouring out of silt through main dam.*—Periodical scouring is the only possible means of keeping the silt deposits within limits. The necessity for supplying rice irrigation on the high level canal, presents difficulty in carrying out this procedure. To scour effectively, the procedure might be as follows:—

(i) To get a sound napah rock foundation, if possible, on which surplusage could be effected safely. The action on the river bed would be moderate when scouring was in hand, and severe only in high floods; if a napah foundation cannot be got, it might be necessary to close these sluices in very high floods to obviate damage to the bed and to surplus elsewhere, but this would be costly.

(ii) To have a sufficient area of sluices in the main dam at a low level to admit of fairly large flood discharges being passed through without very much heading up.

(iii) If the ground admits of it, to add a reservoir to the upland canal, which would conserve a few days' supply for use, during scouring of the river, when the upland canal off-take draws no water from the Kistna reservoir; the former reservoir would not be of much use, if the upland canal passed through and was liable to silt it up.

In the case of the Assouan dam, scouring proceeds for the greater part of the flood season and it is only in the latter part that the vents are closed; similar procedure was proposed in the case of the Cauvery dam. In the case of the Kistna dam, the most which would be obtainable, would be from half a week to a week of scouring each year, but still, this would greatly prolong the life of the reservoir, while the narrow deep river channel at the upper end of the reservoir, lends itself for scouring rapidly.

22. *Scouring on napah at upper site.*—If the part of the napah formation nearest the river on the alignment at the upper site, is at a sufficiently low level to admit of scouring over the same with only a moderate sacrifice of the storage capacity, a sufficient area of sluices might be provided there to keep the silt deposit in the reservoir, down to a certain level, which may still leave enough storage capacity for effective working. I have not got levels, which will serve to show whether this is feasible; it may be quite impracticable, but I will be glad if it is considered by the local officers. In this case, the main portion of the flood water would be diverted to low-level sluices located on the lowest portion of the napah formation.

23. *Possibilities of sites down-stream of Muktila.*—I am unable to offer any remarks regarding these pending completion of the surveys suggested in paragraph 14 *supra*; it is hoped that some good site may be found in this locality which may serve to admit of the silt difficulty being overcome. If the river bed is already considerably scoured, this will not be wholly objectionable, since it is desirable to have a considerable depth of cushion and apart from the extra cost of the dam at the lower levels, the cushion will be more effective at a low, than at a high, level.

24. *Raising reservoir as silting proceeds.*—This is objectionable, since it deprives the delta of the silt and may ultimately result in a separate reservoir having to be constructed hereafter at Daida or somewhere up-stream of Pulichintala. The different cases which present themselves to me, are as follows:—

(i) Silting of reservoir to be accepted as unavoidable up to a certain level. The crest of the dam to be made about R. L. 240 feet as now proposed, but only to be provided with constructional low-level sluices and a minimum number of others in the main dam for the supply of water to the delta for a time. The sluices on the lowest part of the napah referred to in paragraph 22 *supra* to be constructed in the first instance as part of the surplusage arrangement. Before capacity has been reduced to an extent to lessen irrigation, the whole of the sluices in the main dam to be plugged permanently, and the creation of a silt bank behind the main dam fostered so as to make it as nearly level with F.T.L. as possible, instead of raising the main masonry dam, an earthen embankment, to be constructed about 400 to 500 feet up-stream of the reservoir. If silting up has been carried out satisfactorily, this bank may be made 30 to 40 feet in height which would give the reservoir a long fresh lease of life. The design of the other surplusage works on the napah to be made such as will admit of considerable raising at small cost. The uncertainty of this comparatively cheap procedure will be in arranging that silt will deposit just up-stream of the dam so as to make heavy currents may be difficult or impossible.

(ii) As in (i) *supra*, silting up of the reservoir to be accepted as inevitable. When it has proceeded to a certain extent, the cost of constructing a new dam further up the Kistna at a probable cost of Rs. 3,00,00,000 to be faced. We would then have as follows:—

- (a) Dam at Pulichintala merely serving as a high level anicut with no storage.
(b) Dam at Daida or elsewhere to be used solely for storage; silting to be obviated by uninterrupted flow through the body of the work at a low level during the greater part of the flood season, the dam being only closed at such time, as would be necessary to conserve water for the late part of first crop and for the whole of the second crop.

The execution of these two works would put us in a position to use the Kistna as the Egyptian Government utilizes the Nile by use of the Assouan dam.

25. With regard to the relative merits of the proposals—paragraph 24 (i) and (ii) *supra*—I am not in possession of data which will enable me to say what the cost of the first of these arrangements will be, but it is unlikely to be as costly as the second one, since with 3.75 per cent. interest, the present value of Rs. 3,00,00,000, fifty and one hundred years hence, is about Rs. 47,61,000 and Rs. 7,55,630, respectively; the hundred years' life is unattainable with the dam of the preliminary report and Rs. 47,61,000 would materially affect financial prospects, although probably not to an extent to make execution prohibitive. Since we have as follows:—

Rs. 47,61,000 at 3.75 per cent.	...	...	...	...	...	Rs.
" 7,55,630 at 3.75	"	"	"	"	"	1,78,537
						28,336

the effect on the revenues of having to provide a new reservoir, fifty and one hundred years hence, would apparently be to discount the net annual revenues by Rs. 1,78,537 and Rs. 28,336 for these cases respectively; the former amount would be a material reduction, but the latter would not materially affect the project. These results emphasize the need for selecting a site, and if possible, devising arrangements which will serve requirements, either permanently or at least for a period of about one hundred years.

26. *Further investigations regarding reservoir.*—These may be briefly summarised as follows:—

- (i) Determination of character of rock in river bed at Pulichintala sites by drilling and quarrying pits, where quartzite will not readily admit of drilling.
(ii) Determination of the best alignment at the Pulichintala sites across the river bed, and whether it will be feasible and economical to dispense with the tunnel off-take, and to arrange for an open head.
(iii) Determination of the best alignment and of sound rock level suitable for sustaining a masonry dam on the shale formation on the right and left banks.

(iv) Sinking of such quarry pits or drilling such holes, as will show the character of the napah and the level at which the rock will safely resist surplusing from a great height.

(v) Survey of sites downstream of Muktila and examination of character and level of suitable rock for the works.

(vi) Consideration of the question of silting of the reservoir and advancement of proposals for arrangements which will be either permanently effective, or if feasible, that they will be so, for at least one hundred years.

(vii) Preparation of draw-off tables for the arrangement proposed, the diminishing capacity of the reservoir due to silting and the different levels of the off-take being taken into account.

(viii) Surplusing by the following means may be considered:—

- (a) Wholly through main dam on a napah bed at various suitable sites which may be found.
(b) Partly through main dam on a napah bed, and partly at a high level on the left bank.
(c) Partly through the dam on the left bank Pulichintala site at the lower part of the napah, for, say, about half of the flood discharge, and partly at a higher level on the same formation.
(d) Mainly over the napah at a high level on the left bank, as proposed when I was on tour, with construction of another reservoir in due course.

In each of these cases, the effect in keeping down silting and probable efficient life of the reservoir, to be specially considered and the financial results of proposals reduced to effect on net revenues.

27. *Automatic surplusage gates.*—The balanced automatic gates in use in the masonry dam for the Mutha canal, Bombay Presidency, have afforded much satisfaction in use; these gates automatically surplus large floods without any action whatever, on the part of the establishment in charge of the work. The Darna pick-up weir on the Gódávri in the same Presidency, is to be provided with 68 gates 10' x 8' at an estimated cost of Rs. 88,349 or Rs. 15.3 per square foot; this rate is believed to be less than half of that for Stoney gates, which would not have the advantage of being automatic. I would venture to suggest for consideration whether automatic gates of the Bombay type could be used for the high level surplusage works of the proposed Kistna dam, in the event of the portion of the flood to be disposed of at the high level being largely reduced by surplusage a large part of the flood discharge at a low level with Stoney shutters.

28. *Survey of river channel.*—Two permanent gauges should be read in locations about one mile apart near the Pulichintala sites through next flood season; the reduced levels of these gauges should be determined very accurately. The gauges may be in sections extending from low to maximum flood level. It will be necessary for the design of subsidiary weirs and cushions below the dam, to know approximately the depth of water in the Kistna. By comparison with the Bezvada weir gauge, it will be possible to carry the gauge series back for as many years as desired, and also to ascertain the corresponding discharges.

29. *Canal surveys.*—I understand that a belt is being contoured to determine the general alignment of the main canal as far as the Gundlakamma, and that the canal will afterwards be aligned, levelled over and modified where found advisable. I would advise that all channels carrying over 300 cusecs may be set out and sectioned. From 4 to 6 typical distributaries might be aligned, sectioned and the estimates prepared in full detail so as to furnish acreage, mileage and cusec rates for use in the case of the other channels.

30. Numerous cross-sections of the canal and branches need not accompany the project, since typical ones will usually suffice.

31. *Plans of canal works.*—Plans of the principal works should be prepared, and on the whole, plans may be prepared for from one-third to one-half of the works on the main canal and branch canals of over 300 cusec capacity.

32. *Rates.*—A careful study of these should be made on comparative tabular forms and reasons given for the principal ones.

33. *Index plan.*—The index plan is the only one which is sent to the Secretary of State; I would suggest that this map may be carefully prepared in colours and be such that it can be placed in a pocket of the report. All names of places, topographical features, and works which are mentioned anywhere in the report and which come within the scope of the project, should be shown on the index map; as for other particulars which may be shown, I would invite inspection of the index map given in Volume I of the Punjab Triple Canal Project.

34. *Conclusion.*—The reconnaissances, surveys and investigations as far as carried out, have been executed in a very careful thorough manner which reflects credit on all concerned. All the circumstances connected with throwing a high masonry dam over one of the largest rivers in India, present some novel features call in for careful consideration to ensure success. A

feasible dam site has, I believe, been found, but as explained above, there are some features of the case which call for improvement, and I trust no effort will be spared in the additional surveys to be made to arrive at the best site obtainable, and to devise the best arrangement or meeting the difficulty connected with silting of the reservoir.

35. During my tour I had the advantage of being accompanied by Mr. C. A. Smith, Chief Engineer for Irrigation, Colonel W. M. Ellis, R.E., Superintending Engineer, Mr. C. T. Mullings, Executive Engineer, Messrs. H. L. Nicholson, W. I. Davies and Adams, Assistant Engineers; I wish to gratefully acknowledge the assistance afforded to me when on tour.

J. BENTON,
Inspector-General of Irrigation.

II

Note on the proposed Kistna Reservoir Project by Mr. J. Benton, C.I.E.,
Inspector-General of Irrigation, dated 3rd May 1909.

[Enclosure to letter No. 544 I., dated 18th May 1909, from the Government of India, Public Works Department.]

Previous note.—This note is supplementary to my previous one on the same subject, dated 3rd April 1909, in which I dealt with the question of silting of the reservoir in paragraphs 15 to 26. It appears to me that liability to silting up of the reservoir is a very serious matter, and I asked to be furnished with the results of observations which, I was informed, had been carried out about ten years previously by Mr. J. S. Wilson, Executive Engineer.

2. Observations of 1898—1900.—Mr. C. A. Smith, Chief Engineer for Irrigation Works, has kindly supplied me with the following:—

(i) Tabular statements showing for the six months June to November in the years 1898 to 1900 the daily discharge of river, and the amount of silt carried, as deduced by Colonel W. M. Ellis, R.E., from experiments which were carried on fairly continuously for these periods

(ii) A copy of letter No. 873-S.E., dated 31st March 1899, of Mr. J. S. Wilson, Executive Engineer, Kistna Eastern division, Bezawada, to the Superintending Engineer, II Circle, which very clearly explains how the observations were made.

(iii) A copy of a note by Colonel Ellis, R.E., dated 7th April 1909, on the probable life of the reservoir and means of prolonging the same.

3. Daily discharges and silt in suspension.—The execution of the experimental observations was under the direction of Mr. J. S. Wilson, Executive Engineer, while it is stated that the greater part of the work, after the first week or two, was done by an Engineer Subordinate student Sivaswami Aiyar who, it is stated, took a considerable interest in the matter, and later by an intelligent gumasta. The observations were made in the Kistna Eastern Main Canal, the procedure being as described in Appendix A to this note. Appendix B is an abstract of Colonel Ellis' daily discharge statement, with the silt in pounds reduced to cubic feet by dividing by 112; this appendix shows as follows:—

(i) That the proportions by volume of the silt held in suspension to the water varied greatly in different months, and also in the corresponding months of each of the three years covered by the observations.

(ii) That the proportions of silt are very large, the aggregate for each of the three years being as follows in millions of cubic feet—

Year.	Silt	Silt Water.
1898	...	...
1899	...	...
1900	...	...
Average 3,888 millions cubic feet.		
	3,464	1/611
	2,360	1/342
	4,340	1/626

* Average 3,888 millions cubic feet.

† By volume.

On fitting 1899, which was a year of unusually low supply in the river, the average for 1898 and 1900 was 3,902 millions cubic feet.

4. Since the proposed capacity of the reservoir is 151 and 188 thousand millions cubic feet up to full tank level and to 10 feet over that level respectively which the dam would suffice to store, it will be seen that the reservoir would silt up as follows:—

(i) To full tank level in 38 years.

(ii) To 10 feet over full tank level in 47 years.

Both these periods are ones of small duration in the life of a great irrigation scheme, and long before the reservoir had completely silted up, it would be very inefficient; any such short lives for the reservoir would call for rejection of the scheme.

5. Character of the observations of 1898—1900.—The observations were apparently carefully made, but for determination of the very important question now at issue, the following views may be held—

(i) Without casting any aspersion on the subordinate engineer student who made the observations, and the intelligent gumasta who succeeded him, these are not men of the class which would be deputed to determine the life of a great irrigation work; it was never contemplated that the results would be utilized for settling any question of momentous importance, such as that now at issue.

(ii) The observations were made in the Eastern Main Kistna Canal, where the proportion of silt may not be the same as the average in the river, while it is the latter which will affect a great reservoir, trapping nearly the whole of the silt held in suspension.

6. Analysis of observations.—I have prepared Appendix C to this note in the following manner. I divided the tabular statements referred to in paragraph 2 (i) *supra* into eight portions, in which the daily discharges were from 0 to 50,000—50,000 to 100,000—100,000 to 200,000—200,000 to 300,000—300,000 to 400,000—400,000 to 500,000—500,000 to 600,000—600,000 to 700,000 cusecs, and I averaged the silt in pounds per cusec foot which was held in suspension for each period; the results month by month are given in the appendix under reference, and the number of days is written under the number in each case. For flood water coming mainly from the same drainage tract, it might be expected that the early floods in June when the monsoon bursts, would carry an abnormal amount of silt and that the higher the flood, the greater would be the amount of silt swept along. It might at first sight be expected that floods of similar magnitude in corresponding months of different years would carry about the same proportion of silt; inspection of Appendix C goes to show that this is not the case, and we are left in doubts as to which of the following explanations afford reasons for the great discrepancies:—

(i) The Kistna drains numerous widespread tracts, differently circumstanced as to erodibility and quantity of soil, in which the rainfall no doubt varied greatly, while any detritus swept into the main channel would be mostly carried forward owing to the great declivity.

(ii) Operations in regulating the canal head would probably greatly affect the silt swept into the channel, while the set of the river near the off-take would also affect it.

(iii) The observations may have been faulty.

Before hazarding any opinion as to which of these explanations applies, I will briefly glance at what we know of the proportions of silt carried by some other rivers.

7. Silt carried by some other rivers.—Mr. R. B. Buckley, C.S.I., furnishes a good many particulars on this subject in his work on "Facts, Figures and Formula for Irrigation Engineers;" selecting the more important data, we have as follows:—

(a) Sirhind canal.—It is in my personal knowledge that the experiments were carried out on a very large scale, and with scrupulous attention to accuracy on the part of the Engineer officers in charge, since this canal threatened at one time to be unworkable. The river bed is sandy, and the velocity varies from 2.5 to 11 feet per second according to the volume discharged. The quantity of damp silt to one cubic foot of water were as follows from June to September—

1895	...	...	...	...	0.00165	cubic foot or 1/606
1896	...	...	...	...	0.00234	" or 1/427
1897	...	...	...	...	0.00546	" or 1/183

The particulars given by Mr. Buckley regarding the silt in the Sutlej, from which the Sirhind canal draws its supply, go to show that the proportion of silt in the former was considerably more than in the canal, as is natural.

(b) Sone canal.—The average volume of wet silt per cubic foot of water in 1898 is given as follows:—

June	...	...	...	...	0.001875	cubic foot or 1/533
July	...	...	...	...	0.003250	" or 1/308
August	...	...	...	...	0.002750	" or 1.364
September	...	...	...	...	0.000625	" or 1/1600
October	...	...	...	...	0.000062	" or 1/16129

These results go to show that there is no good reason to doubt the proportions of silt to water as exhibited in Appendix C, simply because they are much larger than expected. The Kistna experimental results go to show that the water in that river is just about as turbid as in the Sutlej, which feeds the Sirhind canal, or as in the Sone river in Bengal. It is not known what the declivity and velocities are in the Kistna, but in high conditions of the river, the depth will be from two to three times as much as in the two other rivers just mentioned.

8. Conclusion as to past experimental results.—At first sight these do not appear very consistent with themselves, while they go to show that the Kistna flood water carries very large quantities of silt; it may be found that the results of the past experiments are substantially correct—vide paragraph 7 *supra*. For present purposes, it appears to me prudent to assume that the Kistna flood waters carry as much silt as indicated by the experiments of 1898—1900, and to devise a project which will be suitable under these circumstances.

9. *Further experimental determinations.*—I understand that the Chief Engineer proposes to determine experimentally the proportion of silt carried by the Kistna river during next Kharif (June to November) and this appears advisable; I would strongly advise that the same course should be followed with regard to the Cauvery river, on which a similar storage work is proposed.

10. *Safe manner of operating.*—As already suggested in my note, dated 3rd April 1909, paragraphs 15 and 21, the safe procedure in operating a storage work on Kistna river so as to ensure it having a reasonably long period of utility, will be to arrange, if possible, for a reservoir which can be scoured out for the greater part of the flood season and that it may only be closed for a reasonably short period at the end of it, when the water is less turbid. The turbid character of the flood water as now disclosed, the practice elsewhere and logical reasoning, all appear to point clearly to this course of procedure as being necessary.

11. *Objects of Kistna project.*—In order to have a clear conception of the objects in view and of the relative importance of these, I give the various areas below as furnished by the Superintending Engineer:—

(i) Increase of irrigation in the delta comprising—		ACS.
(a) First crop	...	...
(b) Second crop	...	...
(ii) Upland canal—		
(a) First crop	...	200,000
(b) Second crop	...	205,000
		500,000
		110,000
		Total ... 1,015,000
(iii) Protection of existing irrigation in the delta comprising—		
(a) First crop	...	700,000
(b) Divi project	...	80,000
		Total ... 780,000

In the preliminary project, no credit is taken for the areas (iii) *supra*, since it is only prospective diminution of supply owing to execution of works in the Bombay Presidency or in Native States, which will affect the area of 780,000.

12. The extent of the above areas shows as follows:—

(i) That the estimated area of first crop on the upland canal is nearly half of the whole increase, and provision of irrigation for this area is apparently necessary to justify large expenditure.

(ii) That the area of second crops on the upland canal is of minor importance, being only about 11 per cent. of the whole increase, while any attempt to secure this will necessitate continuous holding up of the water to a high level, barring scour of the silt deposits in the reservoir at least in the lower part.

(iii) That protection of the existing irrigation in the delta necessitates a large amount of extra storage being provided, but immediate provision may not be necessary, since no revenue credits are claimed in the financial statements. It appears undesirable to load the present scheme with the cost of insurances for existing irrigation works which should apparently be debited to these.

13. *Scheme of works.*—With no surveys and levels to refer to, and only general recollections of the Kistna valley, it is impossible for me to formulate quite definite suggestions; however, to obviate delay in asking for and awaiting surveys and levels, I venture to hazard the following remarks:—

(i) The waters of the Kistna river will most probably be too turbid to admit of any one dam in the Pulichintala-Muktiala reach of the river, answering for all the areas detailed in paragraph 11 *supra* for a period of say 100 or 200 years; I understand this is generally admitted to be the case, at least as far as present data go to show.

(ii) Assuming that no single work on the main river will meet general storage requirements, while also raising the water sufficiently for the upland canal, it appears advisable to consider the following alternatives:—

(a) Construction of a fairly low level dam or rather pick-up-weir of limited storage capacity in the Pulichintala-Muktiala reach of the river of a suitable height and in a suitable location as regards surplusage, to meet the following conditions:—

(1) Supply of water for the following areas—vide paragraph 11 *supra*—
200,000 + 205,000 + 500,000 = 905,000

(2) Surplusage to be on sound *napak* rock by some of the means indicated in my note, dated 3rd April 1909.

(3) Annual clearing out of the reservoir down to bed level by such occasional scouring in floods as will serve to make the reservoir remain efficient for 100 to 200 years. A work which will meet these requirements, may be unattainable as regards existence of facilities for surplusage on sound rock, the levels of the surplusage portion as compared with those of the canal, or the unavoidably limited area. It would be essential that the project should be productive.

(b) Failing the work (a) above promising to meet requirements to a reasonable extent, it may be considered how it will answer financially to supplement it with a large storage work located further up stream between Daida and Pulichintala; this work would be designed to admit of scouring out, while it would be operated in the manner indicated in paragraph 10 *supra*. The cost of the pick-up-weir (a) *supra* coupled with the cost of an open dam of the Assouan type, may be too great to admit of the work promising to be productive from irrigation of the areas given in paragraph 11 (i) and (ii) *supra*; if this is the case, it may then be considered what provision should be made for existing irrigation and what debit can, and should, be made for the same.

(iii) The construction of a reservoir solely for the delta will call for consideration of the surplusage question and also for provision for scouring; it appears doubtful if a case can be made out for such a work, if no debit against existing work is warrantable.

(iv) Is it advisable to proceed with the survey of the upland canal?

14. The proposals in paragraph (i) to (iii) *supra* can be considered by the local officers when the investigations and surveys connected with possible sites are completed.

15. With regard to the question (iv) *supra*, the original proposal was a high dam in the Pulichintala-Muktiala reach which would serve for storage and supply of the upland canal; since a work which will effect both these purposes, appears at present to be unattainable, I would advise consideration of the advisability of deferring surveys of the high level canal. The offtake level could be fixed within fairly narrow limits under the previous proposals, and on this under-stand I acquiesced in the canal survey being carried out; however, if the river work in this locality is only to be a pick-up-weir, the canal offtake level may have to be a good deal lower, and surveys for a canal at a considerably higher level might be of very little use. The surveys already executed may suffice for revenue survey purposes. It would appear desirable to carry out detailed alignment and sectioning on the line which the canal will occupy, and this will apparently depend on the work to be built in the river. For these reasons, it appears to me that the alignment and levelling of the canal should be deferred, so that labour may not be lost. I presume there is abundance of work for the establishment in the survey of sites for works on the river, or on the Cauvery project under the same Superintending Engineer.

16. *Storage reservoir.*—In the event of it being found that the works must comprise (i) a storage reservoir and (ii) a separate pick-up-weir, the latter should be sufficiently removed from the former, not to back water up on the storage dam; this appears to preclude any of the five sites opposite the Pulichintala answering for a storage site. The site at Daida, surveyed for the Tungabhadra project, was not found to be very favourable as regards probable cost and facility for securing land; it is very desirable to procure a site which will be freer from objections. In selecting a site, canal offtake requirements have not to be considered which may be carried out on such of these as appear to call for it. This will unavoidably involve considerable extra labour, but it appears essential for success to devise a scheme which will be free from the very serious objection of being short-lived.

J. BENTON,
Inspector-General of Irrigation.

APPENDIX A.

Extract from a note by Colonel W. M. Ellis, R.E., on the manner of executing the Kistna silt observations of 1898—1900.

2. The measurements of silt in suspension were practically confined to the water after entering the canals (Eastern delta) and a series of regular observations were made for the years 1898, 1899, 1900 and for June and July 1901, when the observations were unfortunately discontinued. The nature of the observations taken in 1898 is clearly described in a note, dated 31st March 1899, by Mr. J. S. Wilson, a copy of which is attached.

3. Briefly the method of observations in 1898 was as under:—
A site in the centre of the main canal some 200 feet below the bridge which used to stand in the site of the present head sluice, was selected. Here samples of silt were taken at different depths by lowering a bamboo to the bottom with five corked bottles (quart bottles of capacity about 1½ pints) attached at intervals, the top of the lowest bottle being 1 foot above canal bed. On

reaching the bottom, the corks were withdrawn from the bottles by strings and the silty water at various depths filled the bottles. The bottles were raised and corked up. Each bottle was then shaken and any excess water drawn off to a mark indicating a certain known capacity (Twenty ounces Apothecaries' weight, each ounce being 480 grains). About 1 grain of alum was added to each bottle which was left 24 hours to stand. The clear water was then syphoned off. The wet silt was poured into a copper pan and evaporated to dryness and weighed. The sum of all the weights gave the number of grains of silt in five bottles capacity and from this the number of lbs. per cubic foot of silt was computed.

Observations were taken every three or four days and the exact dates and results are all noted in the silt register which has been examined by me.

4. Similar observations were taken in subsequent years with the following minor deviations:—

- Observations were taken daily during the silt carrying period.
- A small chemical balance was used in place of the medicine scales used the first year.
- The contents of the bottles of silt, taken at various depths were mixed before separating out and weighing the silt, so that the silt carried at different depths was not measured separately after 1898.

(d) Certain further observations of quantities of heavy (muddy settling) sands in the silt were made and recorded, but these do not affect the total quantities of silt now being reported on.

5. Inaccuracies in the results may have occurred from the primitive character of the apparatus and in the first year (1898), through taking observations at intervals of three or four days.

Also the measurements of the quantity of water in each bottle might be 3 or 4 per cent. in error, as the file marks on the bottles were in the big part of the bottle.

An ascertained error was in counting 44 bottles to the cubic foot, whereas by actual measurement 45 bottles filled up to the mark were required to fill a cubic foot measure. By calculation foot is 45.41 bottles. This introduces an error of about 2½ per cent. and to eliminate this 2½ per cent. should be added to the total quantity of silt given in the attached tables. I have not altered the registers, as our errors of observation will probably be much more than this and all that is put forward is that these observations give valuable and reliable results and the limit of error probably does not exceed 12 per cent.

APPENDIX B.

Month.	1898.				1899.				1900.			
	Discharge in cusecs. From To		Discharge in millions cubic feet.		Discharge in cusecs. From To		Discharge in millions cubic feet.		Discharge in cusecs. From To		Discharge in millions cubic feet.	
June	94,312	310,805	151,078	591	57,034	148,941	77,754	281	14,758	120,940	59,977	469
July	34,931	516,191	519,336	736	50,676	292,048	264,096	228	48,680	78,912	752,026	2,150
August	17,308	446,888	569,366	241	21,707	74,344	119,823	34	640,632	568,441	1,049,417	1,293
September	46,877	344,920	456,273	856	39,156	398,865	308,281	1,828	54,286	227,044	241,354	275
October	29,042	282,539	360,310	1,016	6,577	20,313	32,122	9	15,034	226,683	160,928	161
November	..	..	82,155	24	7,157	5,287	5,287	(0.2)	7,302	15,005	17,508	2
Total	..	..	2,119,418	3,464	..	807,362	2,360	..	..	..	2,281,210	4,340
				1/611			1/342					1/525
				1/266			1/297					1/130
				1/704			1/1154					1/347
				1/2838			1/3600					1/812
				1/533			1/169					1/882
				1/346			1/3293					1/1000
				1/3394			1/3111					1/9338

APPENDIX C.

APPENDIX C.

Month.

Discharge in 1,000 cusecs.

From
To

00
50

50
100

100
200

200
300

300
400

400
500

500
600

600
700

Silt in pounds per cubic foot of water.

Month	From To	00 50	50 100	100 200	200 300	300 400	400 500	500 600	600 700
June	1898 ..	..	..	694	180	..	..	..	..
	1899 ..	027	161	431	..	..	..	..	..
	1900 ..	326	720	1070	..	..	132	..	..
July	1898 ..	034	051	076	083	161	..	..	..
	1899 ..	097	037	037	084	3	132	191	..
	1900 ..	..	560	480	340	170	130	410	..
August	1898 ..	..	015	023	161	028	080	..	..
	1899 ..	011	018	048	12	027	..	..	..
	1900 ..	..	027	190	038	062	..	..	..
September	1898 ..	..	059	084	038	228	320	..	..
	1899 ..	020	030	050	41	062	1059	..	..
	1900 ..	..	028	093	198	8	3	..	..
October	1898 ..	035	091	258	188	420	..	..	..
	1899 ..	023	10	8	1	11	..	..	..
	1900 ..	044	140	104	2	..	..	..	..
November	1898 ..	018	025	050	..	..	..	..	..
	1899 ..	14	11	..	..	..	..	..	..
	1900 ..	004	9	..	..	..	..	..	..
	1900 ..	010	9	..	..	..	..	..	..

Note on 12

III
Note on the Kistna River Storage Scheme, Madras Presidency, by Mr. J. Benton,
C.I.E., Inspector-General of Irrigation, dated 15th January 1910.
 [Enclosure to the letter from the Government of India, dated 3rd February 1910, No. 82 I.]

Previous notes.—Appendix A to this note serves to show the further investigations which were suggested in my notes of 3rd April and 3rd May 1909.
 2. *Investigations.*—With regard to the head works dam on the Kistna river, the general condition of the investigations was as follows at the time of my visiting Madras :—
 (i) The character of the rock in a part of the river bed has been determined; but in a considerable portion of the deepest bed it remains to be ascertained during the present cold weather.
 (ii) Some borings have been made in the *napah* on the left bank, and a survey has been prepared showing the disposal of the different rock formations as they appear on the surface. The soft shale rock extends into the *napah* rock area and additional borings are required to determine whether the former is shallow in depth and if an adequate length for surplusing purposes is procurable on the *napah*; until this is decided the dam alignment left bank cannot be decided on, nor can a definite form of design be advanced.

(iii) Investigations go to show that a better site than Pulichintala is not procurable downstream of Mukhtiala.

(iv) The silt determinations fully support the results arrived at by Mr. J. S. Wilson in 1898—1900.

(v) A good contoured map of the ayacut has been prepared.

3. *Proposals of local officers.*—These are as follows :—

(i) To eliminate the tunnel for the canal by carrying the alignment round Pulichintala ridge with a head bed level of R.L. 175, and full supply level of R.L. 190.

(ii) To have no double cropping on the upland canal, to divert the river water into the canal by using the high level dam, to keep water level up to R.L. 192 from June to about 16th September; about the latter date the water would be impounded up to a level of R.L. 210.

Since floods of over 200,000 cusecs carry large quantities of silt, it is proposed to pass these floods down the river as far as admissible, so as to obviate silting up of the reservoir. Between R.L. 192 and R.L. 210 is designated the impounding height, and the capacity of this part is 43,000 and 6,000 below R.L. 192 or a total of 49,000 mills. c. ft. In this proposal the impossibility of preventing silting up of the deep channel to R.L. 180, and of the remaining part of the reservoir to about R.L. 190 is accepted, and it is sought to operate the dam sluices above this level so as to procure the required storage capacity.

(iii) Forty sluices of 7' x 30' are proposed in the body of the main dam with sill at R.L. 145, and the balance at a higher level in the upper portions of the dam on the left bank; as already stated neither dam site nor design of these latter sluices can be determined until more borings through the shale are carried out.

4. The abandoning of the small area of double crop on the upland canal involves a small sacrifice of irrigation, while it makes the satisfactory working of the reservoir more assured. Surplusing sluices in the main dam are more costly for the discharge passed than in the case of the high-level ones on the left flank; also the fact cannot be blinked that surplusing on to the bed of soft shale carrying the dam is undesirable, even when a subsidiary dam with a good water cushion is provided. A certain number of sluices are required to keep the mouth of the high-level canal clear of silt, but apparently the number should be limited to what is required for this purpose; these sluices should be close to the canal off-take for scouring purposes, but this is difficult to arrange, because the shale below cannot be cushioned except by the costly operation of making 900 feet of the dam on the right hand end about 50' deeper than would be necessary to get a good foundation for a non-surplusing work. I would suggest that the right-hand group of sluices may be located where shown, but that they may be reduced in height, and probably also in number, so as to only retain enough to quite safely effect the necessary scouring. It will eventually be necessary to construct an advanced regulator on the silt with face as near to the end sluice as will be safe. The advantages of procuring extra surplusing capacity should not be given undue weight; numerous deep sluices would produce a strong heavily silt-laden current from which to draw off canal supply, and this is very undesirable. When the reservoir silts up to R.L. 180 to R.L. 192, there will be little to gain in supply by placing these sluices low down. Low deep sluices will be fed from top, left side, bottom and (d) right side, and it is only the latter which will cause the desired scour; for these reasons it appears advisable to raise the level of these sluices and to diminish their number and their depth.

5. *Construction sluices.*—It is proposed to have four construction sluices of 25' x 7' at a low level in the dam; but these will be buried in silt at a rather early stage in the life of the work, when it is proposed to build up the vents. The number of these sluices should be reduced to what can be shown to be necessary, since they will be costly and ultimately of no use when the dam is finished.

6. *Character of work.*—This will be seen from the following proposed levels :—

(i) Crest level of dam	..	..	..	..	..	..	..	..	..	R.L. 213.0
(ii) Maximum height of impounded water	..	..	..	..	..	..	..	..	..	210.0
(iii) Ordinary height during non-impounding season	..	..	..	..	..	..	..	..	..	190 to 192
(iv) Cill level of surplusing sluices, left flank	..	..	..	..	..	..	..	..	..	180
(v) Full supply in level upland canal	..	..	..	..	..	..	..	..	..	190
(vi) Cill level of canal regulator	..	..	..	..	..	..	..	..	..	175
(vii) Lowest bed level of river on present surface	..	..	..	..	..	..	..	..	..	82.6
(viii) Probable lowest foundation level on hard shale	..	..	..	..	..	..	..	..	..	56.0

The deep channel of the river which will be maintained towards the high level under-sluices will tend to silt up to about R.L. 180.0 at the dam, while the remaining part of the reservoir will silt to the ordinary non-impounding level of about R.L. 191.0; the storage capacity of the river trough is put at 6,000 mills. c. ft., and of the remaining storage at 43,000 mills. c. ft. or a total of 49,000 mills. c. ft., a small amount to derive from such a large dam, and which it appears desirable to increase. These figures go to show that the impounding height will only be 210—191=19 feet and on this the effective life of the reservoir depends; if we can considerably increase this height, we will increase the storage capacity for second crop in the delta, make greater provision for

silt, and thus increase the effective life of the reservoir. I would suggest as follows for consideration: (i) decrease of depth of canal supply from 15' to about 11' which will add 4' to the impounding height; (ii) the feasibility of lowering canal bed level from R.L. 175 to R.L. 170.0 or even lower which will add 5' or more to the impounding height; and (iii) feasibility of lowering the sill of the surplus sluices from R.L. 180 to R.L. 175.0 or even lower. Each foot of lowering of canal supply level means a decrease of 2,240 acres in the commanded area or, say, 1,300 acres of irrigation, but on the other hand it adds over 2,000 mills. c.ft. to the effective storage which would suffice for about 9,000 acres in the area of second crop possible in the delta, or seven times as much as would be lost in the higher-rated first crop on the upland canal, while it would add to the life of the reservoir. The area of second crop which may be had better provide a large margin over 200,000 acres since there may be no data to show what the maximum area is really possible. We require a nearly free fall for the surplus sluices on the left flank. In the absence of the plans I am at a disadvantage in dealing with this question, and I can only urge that the Chief and Superintending Engineers will carefully consider what relative levels will give the most advantageous results as regards present and future possible requirements for irrigation in the delta, the area of second crop which is possible there, and the effective life of the reservoir after silting up to diverting level has occurred; if it is feasible the impounding level about the height proposed. The canal will be a non-silting one, and the loss of level in passing water through the head will not exceed about 1'. In what follows I will deal with the levels as proposed by the local officers, but I would specially request that the proposals made above may be considered with the least possible delay, since the alignment of canal being laid out at a higher level than I now propose should not be allowed to lead to the whole of the 140 miles being laid out at a higher level than may be desirable. On roughing out the results for the different cases the Chief Engineer may select the system of levels which appears most advantageous and proceed with the project accordingly; the reasons for the levels adopted should be given fully in the preliminary report on the dam.

7. *Operating the dam.*—The irrigation on the upland canal, which will all be first crop, will require that the water should be held up to at least R.L. 191 throughout the crop and for storage at the end of it to R.L. 210, that is, from the time the reservoir fills up, say, about 15th June to 15th December, when requirements for first crop will cease; after this latter date water will be drawn off for the second crop in the delta on to about March, when the water will subside to the level of the sill of the scouring sluices in front of the canal regulator. There will be two distinct stages in the operating of the dam—

(i) Until the reservoir silts up the supply available will be that above the silt level down to sill of the scouring sluices in front of the canal offtake. This period will be one of rapid silting up and its duration may be calculated.

(ii) When silting up has occurred to R.L. 191, the supply available will be that from R.L. 191 to R.L. 210, and this will be considerably less than (i) *supra*. This period will be one of very slow silting up, and the rate of deterioration should be investigated.

Even with Superintending Engineer's proposal to pass on floods over 200,000 cusecs above R.L. 191 will continue, but deterioration will be very slow. The time will come when it will be warrantable to increase the height of impounding by construction of an earthen dam on the silt about 1,000 feet up-stream of the dam; it would then be possible to give the work a greatly extended life with the possibility of repeating it. In designing the high level under-sluices the certainty of having to raise the impounding level may be borne in mind, as it is essential not only to see the way to raising, but also to provide for the future execution of the same in the profiles of the work as proposed to be now carried out.

8. It is insufficient to design a work which will answer for 30 to 50 years with no definite practicable proposals for extending the life of the work; I would suggest that we should see our way to adapting the work to serve for several hundreds of years under the most unfavourable conditions. When the reservoir has silted up in 25 to 35 years, the work will be a high level ancient capable of storing 49,000 mills. c.ft. of water at that stage, but that quantity will decrease very gradually year by year, and it is essential to show that additions can be made to the works which will serve to admit of the further life of the reservoir being prolonged practically for ever, or at all events for some hundreds of years; this question may be dealt with in the preliminary design and report. By constructing in the remote future an entirely new dam at Dhaida—to be used for storing water from some date in September and to be scoured out from June to September in the following year—the permanency of the storage would be perfectly assured; in this case the Pulichintala dam would ultimately be chiefly used as pick-up weir.

9. *Conclusion as to storage works.*—The dam now proposed will answer for 25 to 35 years by which time silting up will have reached nearly to the sill of the high level sluices in the deep channel and to R.L. 191 elsewhere. The next stage will be a very slow reduction of the impounding capacity by continued silting from holding up all the river supply from some date

in September on to the end of the season. When the diminished capacity begins to tell on the extent of second crop irrigable in the delta it will be possible at a moderate cost to add works giving a greatly increased storage capacity, and this process can apparently be repeated so as to make the work quite efficient for some centuries; however this period calls for determination. After the lapse of a very long period it may be necessary to fall back on the permanent arrangement of constructing a new dam further up-stream at Dhaida, and of simply using the Pulichintala one as a pick-up weir. The Dhaida reservoir could be scoured out every year, and would not be liable to deteriorate. The river supply far exceeds any possible requirements, and it is only necessary to arrange for sufficient storage, and to operate the works so as to commence storing the water at the proper time.

10. *Land to be submerged.*—The reservoir is the valley of the Kistna, the right side being in British territory, and the left side in Hyderabad State. The land to be submerged in this Native State is much less valuable than the irrigated jagir of the late Sir Salar Jang which the Tungabhadra dam affected, and the difficulties to be encountered in procuring the land will not be so serious; however, since all negotiations of this character are liable to occupy a considerable time, I would recommend that they may be commenced as early as possible.

11. *Revenue estimate.*—It is understood that the Revenue officer's report is expected shortly; I would recommend that this side of the case may be advanced as far as is feasible before the cost of the works is known, so that the project may not be delayed.

12. *Submission of project estimate.*—The Chief and Superintending Engineers are of opinion that the project estimate can be submitted to the Local Government in a perfectly complete state by the end of December 1910; and presumably it would reach Government of India a couple of months later. In my opinion there should be no difficulty in working well within these dates if good arrangements are made which will obviate loss of time at any stage of the operations.

13. *Pulichintala dam.*—On determination of the best alignment, the design may be submitted with a preliminary report and estimate to Government of India for approval before it is incorporated in the project estimate.

II.—TECHNICAL.

14. *Dam to be mainly of rubble masonry.*—In the high dams of the Bombay Presidency close jointed rubble masonry is used in the following parts of the work.—

- (i) Throughout all the deeper parts.
- (ii) On the front and rear faces for a certain thickness.
- (iii) In the upper part.

I understand that concrete is only used where the stress does not exceed a certain safe limit of intensity, which as far as I recollect is 60 lb. per sq. inch. In the rubble masonry the stones are carefully fitted, the mortar only amounting to about 24 c.ft. per 100 c.ft. masonry as far as I recollect, while the jointing is so close that water used in dampening the work will remain in pools for days on the unfinished work. I recommend this procedure for consideration, and would suggest inspection of the Bombay works on the Godavari. Since there were no plans of the masonry works when I visited the site I am unable to offer further remarks.

15. *High level canal.*—This has only been set out for a few miles, but its location can be seen from the contoured map when the bed slope is assumed. The line will follow a falling contour, and will be tortuous to an extent depending on the minimum radius.

16. *Formula for discharge.*—Kutters' formula with $N=0.020$ may be used for the larger channels and 0.0225 for those discharging under 1,000 cusecs. With regard to erosion the water will carry very little silt for probably quarter of a century, but when the reservoir silts up to sill level the proportion of silt may be nearly the same as carried by the canals in the delta; it is understood that the critical velocity in the delta varies from 0.8 to 1.0 of that given by Mr. Kennedy. When I visited Madras Presidency the alignment had not been set out on the ground, and there were no geological sections showing what the sub-soil in the channel of the canal will consist of, so that it is difficult to say what the critical velocity will be. I was informed that black cotton soil similar in colour to what is obtained on some of the delta canals is prevalent; however the delta was laid down by the Kistna river which carries large quantities of fine silt of a dark colour, while the black soil of the uplands presumably resulted from the decay of rock and the wash down of ground at higher levels; and these agencies promise to give coarser and less erodable soil than the fine product reaching the delta of a long river. The ruling considerations are not the velocity suitable to the Kistna soil in the delta but that which will not erode the soil of the upland will give a canal section of an economical practical form adapted for curves of small radii, and which will be safe in high embankments, while not too expensive where in deep cuttings.

17. *Field work and designing.*—As the various reaches are set out it is hoped that designing of canal and of masonry works can proceed apace without waiting for the completion of the survey of the whole of the main canal.

18. There are insufficient data for guidance, and it behoves us to adopt a safe course without involving unwarrantable initial cost or formidable expenditure in future re-modelling, if the latter is ever required.

19. I would suggest the adoption of the following:—

- (i) Kutters' $N = .020$ where discharge is over 1,000 cusecs.
- (ii) " $N = .0225$ " " under 1,000 "
- (iii) Mr. Kennedy's critical velocity V throughout; this depends on the depth.
- (iv) A surface slope of 0.125 per 1,000 in the head reach beyond the rock cutting: this may be increased to 0.150 further down; and to still steeper slopes not exceeding 0.175 in the tail part.
- (v) The following are some ordinary proportions between bed width and depth for ordinary surface slopes:—

Bed. FEET.	Depth. FEET.
250	12 to 11
200	11 to 10
150	8.5 to 7.5
100	7.5 to 6.5
50	6.5 to 5.5
40	5.5 to 5
20	5 to 4.5
15	4.5 to 4
10	4 to 3
5	3 to 2.5

The surface slopes and critical velocities would have to be considered in the deciding on the exact dimensions, since a compromise will be necessary.

20. *Radii of curves.*—For a canal of 250' to 200' bed width it is the practice in open country to give radii of $1\frac{1}{2}$ to 2 miles, while 20 times the bed width may be regarded as the least radius which would ordinarily be used for a canal of this size. For a given high velocity and great depth, the greater the bed width, the greater the requisite radius. In this case it is desirable, in order to lessen earthwork, to use sharper curves than indicated by the empirical rule just quoted, and to prevent erosion by protecting the slope on the concave side. It will probably suffice where the soil is not rock, gravel, or kunker, to make the slopes in such parts $1\frac{1}{2}$ to 1 and to lay down on these from $\frac{1}{2}$ to $\frac{1}{4}$ this of a foot of stone, modular kunker, or gravel with a horizontal toe of 10' in width. The trial pits may serve to show where the material will be procurable for carrying out this protection.

21. *Cross section of canal.*—For a canal of the size of the Kistna upland one in ordinary alluvial soil the leading particulars may apparently be generally as follows:—

Particulars.	Head with about 10,000 cusecs capacity.	Where discharge under 500 cusecs.
Bed width	As stated above (will depend on area).	As stated above.
Depth	Do.	Do.
Slopes in cutting (d)	1 to 1	1 to 1.
Do. of banks	1.5 to 1	1.5 to 1.
Berm width	8' to 5' + $\frac{d}{2}$	8' + $\frac{d}{2}$
Free-board	8'	8'.
Crest width, left bank	20' to 25'	20'.
Do. right bank	30'	15.
Top width of dows on inner side	1.5	1.5.
Height width of dows on inner side of top of banks	1.0	1.0.
Slopes width of dows on inner side of top of banks	1.5 to 1	1.5 to 1.
Depth of dry earth over toe of 4 to 1 hydraulic gradient	4'	8'.

It may be considered in the light of experience what departures should be made in dealing with black cotton soil. In all typical cross sections the hydraulic gradients should be drawn in high banks the outer slope may have to be flattened or berms added, so as to have a sufficient depth of dry earth over the hydraulic gradient at the toe. In support of proposals particular may be given of successful high banks of black cotton soil in the delta where the margin of safety has proved adequate, while not excessive.

22. *Typical cross sections.*—The typical cross-sections should be sufficiently numerous to comprise all cases which can occur.

23. *Longitudinal sections.*—Levels at 500' intervals would suffice in flat country, but very little of the tract is of that character, and they will apparently be usually needed at 100 feet intervals and even closer at drainage crossings. A vertical scale of 1/100 would show depths adequately, and the horizontal scale may be such as will give space for the figures. Miles of 5,280 with furlongs have been discarded with great advantages in several provinces in India, and I would suggest that the longitudinal sections and tables of works may only show miles of 5,000 and feet. In this case the reduced distances at the foot of the sections would give, the miles of 5,000 in firm figures, and other intermediate distances would be in small figures and may start from zero for each mile. I have indicated in Appendix B to this note the information which in my opinion is required on the longitudinal section. I would express a hope that these plans are not to be converted into a species of irregular estimate forms for either earthwork or land, since all such details should be given in proper estimate forms. This will save the time of draftsmen who are said to be far from plentiful, and it will also be an advantage for administrative officers who do not require estimate details before them when examining longitudinal sections.

24. *Plan.*—I understand that it is proposed to give a tracing of part of the plan on the same sheet as the section; this plan may show mileage sites of works in red and indicate the thousand feet points without figuring them.

25. My reason for entering into so much detail regarding surveys is my desire to have the information which is required advanced in a form which will obviate loss of time and labour on the part of those who prepare or who have no scrutinized plans.

26. *Deep cutting in hard material.*—In rock, laterite or other hard material if it will result in saving to make the bed below normal level, this may be carried out; the extra depth should not in my opinion exceed about 30 per cent. of the normal depth of water in the canal. The contraction, expansion and sloping down and up of bed may be at the rate of 1 in 10 to 1 in 20.

27. *Reserving best material.*—If there is considerable difference in the material got from the canal excavation, the best of it should be used on the canal roads and bank slopes.

28. *Borrow pits.*—Pits dug inside the canal and below bed level do not silt up fully; they give rise to wide silt berms and are undesirable.

29. *Canal roads.*—These usually comprise, the outer boundary roads for use during construction and for country traffic, one road on crest of left bank solely for inspection purposes, and one on the crest of the right bank for country traffic, more especially as the canal bank may make the lower road unsuitable for traffic in rainy weather.

30. *Design of masonry works.*—I hoped that typical plans of bridges and drainage culverts might be available for discussion, but this has not been possible. I wish to remark as follows:—

(i) Elsewhere bridges are usually provided at an average rate of one cart bridge and one foot bridge per 5 miles of large canal; the works are located where they can be of most use to the public in serving existing roads, towns, and villages. Wide cart bridges are considered unwarrantable when the traffic is light. Circumstances in this tract may call for departures from the practice as just explained.

(ii) With regard to culverts hydraulic gradients should be drawn for the terminals, and if possible 4' of dry earth given over the toe. The liability of overhead arches and of flat floors (if any) to blow up must be guarded against. Masonry floors should be adopted until the velocity is reduced below about 6 feet per second. Weep holes may be provided in side walls, and floors, and blowing up may be guarded against. The protection up and down stream may be on a liberal scale, and should cover all parts of the bed exposed to higher velocities than the bed. All bed and slope protection is required to a greater extent than for the ment. At least 3 feet of the barrels should be above bed level downstream so that silting up by small floods may not occur to a dangerous extent. Longitudinal sections of drainages for some distance on each side of the crossing are required, and these should show M.F.L. and cutting down of outfall if proposed. It will often be desirable to lay puddle over the works so as to lessen percolation and risk of floors blowing up. Dr. Unwin's formula may be used in calculating the discharging capacity of syphons; in all works where the arches are liable to blow up the hydraulic gradients should be drawn.

(iii) The canal is aligned across the drainages; and it is advisable to prepare a general map of drainage catchment areas, and then to decide on how the run-off from each part is to be provided for.

(iv) Arrangements should be made for ascertaining the maximum floods which pass down the principal drainages from now until the masonry works are put in hand. Levels of the flood water are required at suitable distances apart for the discharge to be calculated by Kutters' formula. Attempts to gauge floods by velocity observations are not likely to be successful, because the floods usually last for a very short time and may occur at night.

(v) Liberal assumptions as to run-offs should be made as the general tendency elsewhere is to underestimate these.

31. *Plans of masonry works.*—It will probably suffice to prepare plans for about 30 per cent. to 50 per cent. of the works. The bridges and cross drainage works may be tabulated separately along with the leading particulars on which the design will depend as regards number of bays, depth of foundations, extent of protection, height of waterway and ramps; the works drawn out in detail should be the least favourable ones as regards cost of construction per unit of length. It may be possible to adopt the detailed estimate for one work for similar ones elsewhere without any additions or deductions of entire bays. In other cases it may be possible to adapt the estimate by adding or deducting the quantities for one or more bays, but these quantities should be taken out in full detail. Rates per lineal foot of masonry works are liable to be very inaccurate, and in my opinion should not be adopted as the bases of any part of the estimates. Each plan should show the works for which it is applicable, with or without deductions.

32. *Foundations.*—Since black cotton soil is generally unsuitable for foundations it appears advisable to sink trial pits at the sites of all works of any importance, and to show on sections the character and reduced levels of the different strata and also spring level.

33. *Sections of drainage lines.*—Cross drainage works may require lowering of the outfalls, and levels for the requisite distance up and downstream may be given; the levels of canal bed, full supply level, soffit of arch, and floor may be shown for the crossing. Reputed and calculated maximum flood levels may also be shown for the crossings both on these sections, and also on the longitudinal section of the canal.

34. *Catchment area map.*—A tracing to a suitable scale may be incorporated in the project showing the area in square miles and the estimated run-off of each catchment area. The location of canal with mileage and character of works and location of the same should also be shown. The intercepted drainage areas near the canal require to be considered where the right hand bank would block the run-off.

35. *Classes of channels.*—The various channels may be as follows:—

- (i) Main canal from head to the point where its capacity is about 300 cusecs, beyond which point it would be a distributary.
- (ii) Branch canals from (i), being channels which usually carry over 300 cusecs.
- (iii) Major distributaries carrying from 300 to about 25 cusecs.
- (iv) Minor distributaries carrying from 25 to 2 or 3 cusecs.
- (v) Water-courses which may carry up to about 5 cusecs.

The works (i) and (ii) will be aligned on the ground and estimated in full detail. The works (iii) and (iv) will not be aligned on the ground for project purposes. I would recommend that these channels may be estimated at acreage, mileage and head cusec rates; since the expenditure involved is very large no pain should be spared to get at a perfectly reliable estimate of cost. The rates may be compared with those of executed works, and with those of other projects. The location of the point where the minor will end; and the water-courses begin depends on the village boundaries: as a rule when Government has carried the water to a commanding point on the boundary of a village they have done their part, and the small channels beyond are water-courses—*vide* item (v) *supra*. The water-courses are channels owned and maintained by the people, although the Irrigation officers should see to their location in the proper positions, and in some cases may by arrangement construct them at the cost of the people. Cases will arise in which departures have to be made from the above procedure, in the case of channels which are burdened with initial cost or expenditure on subsequent maintenance of channels which are water-courses. Rapid development is very desirable, but usually this will not warrant saddling the project with charges debitable to others which will tend to bar its ever being sanctioned, while maintenance which follows construction would be a drain on the finances of the project for ever. With a suitable Canal Act it should be possible to arrange for the cultivators doing what is required of them elsewhere, and for rapid development being possible without any costly departure from this customary practice.

36. *Rates.*—Past, present and probable future rates for the more important classes of work should be made the subject of very careful study: it has to be borne in mind that the execution of extensive works is liable to cause an enhancement of the local rates for small works, and that it is very unsafe to draw any conclusions from the latter. It may be advisable to have two sets of abstracts of cost as follows:—

First set.—Based on rates in excess of the current ones and which ought to see the works through to the extent of 60 or 70 per cent. These rates would appear in the detailed estimates amounts arrived at above under the different account heads enhanced by appropriate percentages far each class of work, so as to cover the unforeseen. The amounts of this enhanced estimate are those which would be used in the Financial forms, and for which sanction would be procured. Project estimates are prepared for Government and their officers, and I would venture to suggest that reference, by contractors to rates quoted therein, should not be tolerated.

37. *Form project will assume.*—Hitherto it has been usual for each important project to be an improvement on those previously submitted in the same or in other parts of India, and I fully trust this will be true of the great Kistna project. Conditions are different in storage and non-storage projects, but there are certain parallel subjects in the case of both classes of works. Inspection of other project estimates will show what form these have taken and what subjects were dealt with. The report including the more important statements regarding supply, tables of works, general abstract of estimate, Financial forms, abstract of estimates for works under the several account heads with general abstract of the same, revenue report, and correspondence regarding the same, should all be printed along with a suitable statement of contents. I would suggest that the project as submitted should be complete in itself, when papers which are not printed are referred to the gist of these may be given, or extracts may be given as appendices the principle being to anticipate the requirements of the reader, to save him from unnecessary labour, and to advance a report which will be sound, convincing and attractive, without being so voluminous as to detract from these possibilities.

38. With regard to the plans I would suggest that a convenient size may be decided on for all plans, and that these may be bound in large books, all of the same size with stiff covers made in a way which will not result in warping. A list of the contents of each book would appear in the report on the estimate, and at the commencement of each book, survey sheets may have to be folded to some extent, but it is generally advisable to bind them even when they are folded.

39. The index map is the only drawing forwarded to the Secretary of State, and it is desirable that a useful and attractive one should be prepared which will convey a great deal, while being to such scale and of such material as will admit of it being folded and put in the board pocket of the report on the estimate. I would suggest that this map should include the delta, that it should show all names of places in the project area or near to it which are mentioned anywhere in the report and appendices, and that it should show hills, rivers, drainage lines, sea, railways, roads, district and tahsil boundaries, existing and proposed canals and irrigation works in distinctive colours, as well as other topographical features of interests; suitable toned colours may be used. The index map put up with different projects may be compared and a course of procedure adopted which will ensure that for the Kistna project being better or equal to the best of these. The preparation of a map such as is required occupies a considerable time, and it should be put in hand early so as to be ready before it is likely to be required.

40. *Concluding remarks.*—I had the advantage of discussing the Kistna project in all its bearings with Mr. C. A. Smith, Chief Engineer, Colonel W. M. Ellis, R.E., Superintending Engineer, and Mr. C. T. Mullings, Executive Engineer, when on tour in the Madras Presidency, and I wish to acknowledge the assistance which I received from these officers, and the zeal and ability which they are displaying in carrying the preliminary investigations to a conclusion. The stage has now been reached when a detailed project estimate can be prepared for the consideration of Government. The scheme is a large and very important one, and I fully trust that no efforts will be spared to evolve a very complete and satisfactory project in record time. The works are feasible, and it remains to be seen if the revenues are to be such as to warrant execution as a Productive Work.

J. BENTON,
Inspector-General of Irrigation.

APPENDIX A.

Extract from a note on the Kistna Storage Project by the Inspector-General of Irrigation, dated 3rd April 1909.

26. *Further investigations regarding reservoir.*—These may be briefly summarised as follows:—

- (i) Determination of character of rock in river-bed at Pulichintala sites by drilling and quarrying pits where quartzite will not readily admit of drilling.
- (ii) Determination of the best alignment at the Pulichintala sites across the river-bed, and where it will be feasible and economical to dispense with the tunnel offtake, and to arrange for an open head.
- (iii) Determination of the best alignment, and of sound rock level suitable for sustaining a masonry dam on the shale formation on the right and left banks.
- (iv) Sinking of such quarry pits or drilling such holes as will show the character of the napah and the level at which the rock will safely resist surplusing from a great height.
- (v) Survey of sites down stream of Mukhtala and examination of character and level of suitable rock for the works.
- (vi) Consideration of the question of silting of the reservoir, and advancement of proposals for arrangements which will be either permanently effective or, if feasible, that they will be so far at least 100 yards.

(vii) Preparation of draw-off tables for the arrangement proposed, the diminishing capacity of the reservoir due to silting, and the different levels of the offake being taken into account.

(viii) Surplusage by the following means may be considered :—

- (a) Wholly through main dam on a *napah* bed at various suitable sites which may be found.
- (b) Partly through main dam on a *napah* bed and partly at a high level on the left bank.
- (c) Partly through the dam on the left bank Pulichintala site at the lower part of the *napah* for, say, about half of the flood discharge and partly at a higher level on the same formation.
- (d) Mainly over the *napah* at a high level on the left bank, as proposed when I was on tour, with construction of another reservoir in the due course. In each of these cases the effect in keeping down silting, and probable efficient life of the reservoir to be specially considered, and the financial results of proposals reduced to effect on net revenues.

Extract from a note on the Kistna Storage Project by the Inspector-General of Irrigation, dated 3rd May 1909.

13. *Scheme of works*—With no surveys and levels to refer to and only general recollections of the Kistna valley, it is impossible for me to formulate quite definite suggestions; however to obviate delay in asking for and awaiting surveys and levels I venture to hazard the following remarks :—

(i) The waters of the Kistna river will most probably be too turbid to admit of any one dam in the Pulichintala-Muktiala reach of the river answering for all the area detailed in paragraph 11 *supra* for a period of, say, 100 or 200 years; I understand this is generally admitted to be the case, at least, as far as present data go to show.

(ii) Assuming that no single work on the main river will meet general storage requirements while also raising the water sufficiently for the upland canal, it appears advisable to consider the following alternatives :—

(a) Construction of a fairly low level dam or rather pick-up weir of limited storage capacity in the Pulichintala-Muktiala reach of the river of a suitable height and in a suitable location as regards surplusage, to meet the following conditions :—

(1) Supply of water for the following areas—vide paragraph 11 *supra* :—
200,000 + 205,000 + 500,000 = 905,000.

(2) Surplusage to be on sound *napah* rock by some of the means indicated in note, dated 3rd April 1909.

(3) Annual clearing out of the reservoir down to bed level by such occasional scouring in floods as will serve to make the reservoir remain efficient for 100 to 200 years. A work which will meet these requirements may be unattainable as regards existence of facilities for surplusage on sound rock, the levels of the surplusage portion as compared with those of the canal, or the unavoidably limited area. It would be essential that the project should be productive.

(b) Failing the work (a) above promising to meet requirements to a reasonable extent, it may be considered how it will answer financially to supplement it with a large storage work located further upstream between Dhaida and Pulichintala; this work would be designed to admit of scouring out while it would be operated in the manner indicated in paragraph 10 *supra*. The cost of the pick-up weir (a) *supra* coupled with the cost of an open dam of the Assowan type may be too great to admit of the work promising to be productive from irrigation of the areas given in paragraph 11 (i) and (ii) *supra*; if this is the case it may then be considered what provision should be made for existing irrigation and what debit can and should be made for the same.

(iii) The construction of a reservoir solely for the delta will call for consideration of the surplusage question and also for provision for scouring; it appears doubtful if a case can be made out for such a work if no debit against existing works is warrantable.

(iv) Is it advisable to proceed with the survey of the upland canal?

14. The proposals, paragraph (i) to (ii) *supra*, can be considered by the local officers when the investigations and surveys connected with possible sites are completed.

APPENDIX B.

Particulars suggested to be given on longitudinal section of canal works.

- (i) Heading, scales, number of sheet.
- (ii) To be written over (iii) below. Roads—from—to and class. Names, if any, of drainages crossed. Names of railways crossed and mileage on the same. Any other item of information calling for special notice. All the foregoing to be in black and R.D. to be given in 5,000 miles and put thus R.D. 50/2500 which would serve to show location of a work at reduced distance 50 miles 2,500 feet. All proposed masonry works to be noted in red along with the reduced distances.
- (iii) To be drawn to scale. Profiles of ground. Crest of banks. Full supply. Bed of canal. Geological sections. Spring level at sites of works where known. M.F.L. in drainages where determined.
- (iv) Radii of curves in feet to be given on a line below (iii) *supra*.
- (v) Lines from end to end of each sheet may be set apart for the following which may be given once only on each sheet in this order from the top :—
Protected side slopes (it will suffice to give length only in feet).
Width berms. (This will take form of an entry such as $0.5d + c$ where d = depth digging and c = a stated constant for each part.)
Crest width of bands.
Free-board.
Critical velocity v_c .
Velocity. (For discharge allowed.)
Cutters N.
Depth. (For discharge allowed.)
Bed width. (Do.)
Discharge allowed.
Do. required.
Bed slope.
- (vi) Below (v) *supra* the usual columns of figures for the following :—
Height embankment. } (In different colours.)
Depth digging. }
Reduced level of bed.
" " ground.
Reduced distances. { Feet. (The feet to run for each mile separately; in flat country with only hundreds of feet these might be rendered in hundreds to save writing. The miles to be only given for mile points and to run continuously from head to tail.)
" " Miles.
- (vii) Datum [to be given where convenient in the columns (vi) but below the last entry is usually convenient.]
A great deal more information could be added, but it is believed that the above will suffice while it is undesirable to add particulars which can be dispensed with as far as design of channel is concerned.

IV

Note on the Pulichintala-Kistna Reservoir Irrigation Project, Madras Presidency,
by Mr. J. Benton, C.I.E., Inspector-General of Irrigation,
dated 30th November 1910.

[Enclosure to letter from the Government of India, No. 1292.I., dated
23rd December 1910.]

1.—TECHNICAL.

General Condition of Project.

In the following table the first column contains remarks on the condition of various works, investigations which have been made, conclusions which have been arrived at by the officers engaged on the project, or proposals which have been made by these; for the sake of convenience I have given such remarks as I have to offer in column 2 of the table:—

Project operations and proposals.	Remarks on the entries—column 1.
1.	2.
2. <i>Surveys.</i> —Contour surveys of reservoir site and of commanded area completed.	The surveys are excellent.
3. <i>Alignments.</i> —Canal alignments completed for the full length of the canal.	This is quite suitable for project purposes. The assumptions as to levels are as follows for the offtake:— Canal full supply ... R.L. 189.5 Canal bed level ... R.L. 174.5 Bed slope ... 1/6600 At R.D. 7.25 miles there is a rise of 4 feet in the bed, the depth for some distance beyond that being 11 feet.
4. <i>Borings.</i> —Borings on the proposed site of the dam are completed and show a gullet about 300 feet in width and 61 feet below normal bed. The extent up and down stream of this gullet has not been ascertained, as boring through 61 feet of sand and shingle is difficult and tedious. I understand it was proposed to make no more borings at the present stage and to prepare the estimate for the alignment already selected.	This gullet in the bed will involve an extra expenditure of about 8 lakhs of rupees, and this should not be faced without knowing for certain that it is unavoidable. It is impossible to have reasonable assurances as to the suitability of the rock at the bottom of the gullet and of the further depth at which it may be necessary to found the work. The estimate will be unreliable, and such as could not be advanced with the requisite assurances of the provisions being adequate. The Government of India has had several cases of very serious excess to deal with, resulting from such procedure as is proposed in this case and I would suggest that it is essential to determine whether this gullet can be avoided.
5. <i>Location of dam.</i> —The dam alignment is too far up-stream to admit of the cheap and easy expedient of constructing an earthen embankment on the silt to extend the life of the reservoir for any desired period.	It is very desirable to be able to give confident assurances of the possibility of infinite prolongation of the life of the reservoir by the cheap expedient here indicated, since this would effectually cover all possible mistakes in the assumptions made regarding silting up of the reservoir.
6. <i>Alternative sites.</i> —The character of the river bed about 250 feet up-stream of the quartzite bar has not been determined, and this is an alternative site for the dam; also it has not been investigated opposite the bar and this is required for the subsidiary dam.	If this site admitted of the gullet in the river bed being avoided, there would be the further advantage of the alternative alignments for the dam—vide the line I to VI and VII to VIII shown on the 8-inch to 1 mile contoured map on the right and left sides of the river probably serving to admit of omission of the first two difficult miles of canal channel round Pulichintala ridge.

Project operations and proposals.	Remarks on the entries—column 1.																
1.	2.																
7. <i>Slope of Kistna river surface.</i> —Examination of the Kistna river between the proposed dam site and Bezwada has shown that the surface slope varies from 1/3900 to 1/5000 for a discharge of 300,000 to 400,000 cusecs, with a bed width of over 2 miles where unobstructed, and a critical velocity of 1.15 V _c .	These investigations have furnished instructive results.																
8. <i>Channel in silted reservoir.</i> —For the channel to be formed through the silt above the dam, it has been shown by the Special Superintending Engineer that we will have as follows:— <table> <tr> <th>Distance above dam.</th><th>Mean width of new river.</th></tr> <tr> <td>0 to 1.5 miles ...</td><td>5 furlongs.</td></tr> <tr> <td>1.5 to 3 " ...</td><td>6 "</td></tr> <tr> <td>3 to 4 " ...</td><td>8 "</td></tr> <tr> <td>4 to 15.5 " ...</td><td>14 "</td></tr> <tr> <td>15.5 to 20 " ...</td><td>10 "</td></tr> <tr> <td>20 to 25 " ...</td><td>8 "</td></tr> <tr> <td>Above 25 " ...</td><td>3 "</td></tr> </table> Bed and surface slope for 400,000 cusecs discharge 1 in 4,000 Kutter's N. for discharges of 250,000 to 500,000 cusecs 0.0225.	Distance above dam.	Mean width of new river.	0 to 1.5 miles ...	5 furlongs.	1.5 to 3 " ...	6 "	3 to 4 " ...	8 "	4 to 15.5 " ...	14 "	15.5 to 20 " ...	10 "	20 to 25 " ...	8 "	Above 25 " ...	3 "	The assumptions appear to be generally on the safe side.
Distance above dam.	Mean width of new river.																
0 to 1.5 miles ...	5 furlongs.																
1.5 to 3 " ...	6 "																
3 to 4 " ...	8 "																
4 to 15.5 " ...	14 "																
15.5 to 20 " ...	10 "																
20 to 25 " ...	8 "																
Above 25 " ...	3 "																
Critical velocity 1.2 V _c .	Do. do.																
9. <i>Initial stage.</i> —Contents of silt up to the permanent silted bed is estimated to be 99,173 m. c.ft. The average quantity of silt carried annually by the river is estimated at 4,155 m. c.ft. and the time of completing the initial stage at $99,173 \div 4,155 = 23.8$ years.	This appears to be very safe.																
	The Special Superintending Engineer has worked out this and the following two stages with great care and skill and on the bases of the following assumptions, the results would be as calculated:— First.—Completion up to permanent bed level. Secondly.—Formation of side silt berms up to the 650,000 cusecs berm line. Thirdly.—Raising of 650,000 cusecs berm line from reservoir capacity of 42,100 to 36,500 m. c.ft. This procedure appears to be both natural and reasonable, and I have already acquiesced in its general correctness. The questions which now presents itself to me are as follows:— Will the stages (1) to (2) above apply to the whole of the reservoir throughout its length, or will there be a general progression of these stages from the upper to the lower end, each following the other closely, while the part beyond would be of great depth throughout its width and would only receive the finer silt not deposited in the upper parts where the velocity is rapid? If the latter supposition is correct, would silting up to the final stage occur earlier than under the end-to-end stages assumed in column 1 of this table? In silting up a belt of low land, 7 miles in length, 200 feet in width, and 7 feet to 10 feet in depth, I observed that the procedure was for bed and berms to closely follow each other, and for the tail deep part to receive very little silt.																

Project operations and proposals.

Remarks on the entries—column

1

2

10. *Intermediate stage.*—This relates to the formation of side berms after silting up to the bed level—paragraph 9 above—has occurred. Examination of existing conditions elsewhere goes to show that the side berms get flooded by discharges of 400,000 to 500,000 cusecs, and that no further silting occurs; however, to be on the safe side the discharge corresponding to equilibrium of the side berms has been taken by the Special Superintending Engineer as 650,000 cusecs, the maximum discharge of the river being taken as about 1,010,000 cusecs.

During the diversion period it has been assumed that no accretion will occur on the marginal berms. The intermediate stage is estimated by the Special Superintending Engineer to last for 44.5 years. The effective capacity at the end of this stage is put at 42,100 m. c.ft.

11. *Final stage.*—This relates to the period which will elapse between completion of the silting of the side berms up to the 650,000 cusecs level, when the capacity is 42,100 m. c.ft. and the time when the capacity will be reduced to 36,500 m. c.ft. which represents requirements to effect the proposed irrigation. Silting has been assumed in this case as for the intermediate stage—to be proportional to the flow over the 650,000 cusecs berm level, and the conclusion arrived at is that the quantity deposited annually will on the average be 55.59 m. c.ft. so that the period would be 42,100—36,500—100.8 years.

12. *Total silting for the three periods.*—The average annual discharge of silt by the Kistna river being 4,155 m. c.ft. the results may be summarised as follows:—

Period in years.	Quantity of silt in m. c.ft.		
	Total.	Deposited.	Carried away.
i. Initial ... 23.8	98,889	98,889	Nil.
ii. Intermediate, years ... 44.5	184,898	14,356	170,542
iii. Final ... 100.8	418,824	113,245	305,579
Total ... 169.1	692,611	126,490	566,121

13. The final stage rests on a different footing and it is urged that this is the important one. The capacity per foot of extra height is silting of 47.4 m. c.ft. in the mean rate of stage this would give an extra 68.2 years per foot of extra height; hence raising impounding level from R.L. 221.5 to R.L. 224.5 would give an extra life of 204.6 years.

14. *Surplusage.*—Vents in the dam for disposing of 500,000 cusecs of the flood waters are proposed, in order to keep the canal head clear of silt, and because damage to the river-bed can

It is assumed that the silt deposited on the side berms will bear the same proportion to the total amount of silt carried, as the quantity of water flowing over these berms bears to the whole discharge of the river.

With reference to the marginal table the periods (i) and (ii) will proceed together, and the 170,542 m. c.ft. cannot be carried over the dam, because in a length of 2,000 feet with a low velocity of under 0.5 foot per second, the water will deposit all its silt, while there will be many times this length above the dam. It would be absolutely safe to put the initial and intermediate period at $\frac{113,245}{4,155} = 27.2$ years.

The time for the three stages may, in my opinion, be taken to be as follows:—

	(i)	(ii)	(iii)	YEARS.
	...	...	...	23.8
	...	...	...	3.4
	...	...	...	100.8
Total	...	...	...	128.0

The contentions urged here are reasonable, and I can see no flaw in the careful calculations of the rate of silting in the impounding or final period. A dam with impounding height at R.L. 224.5 may, in my opinion, have a life of 128 + 204.6 = 332.6 years. This is a long period, but it would be well to arrange that even if it is incorrect, the life of the work will be practically infinite.

The objections to events in the dam are that they are liable to throw extra wear on the rock on the river bed which is soft shale. The wear can be minimised by cushioning, but we have

Project operations and proposals.

Remarks on the entries—column 1.

1

2

be prevented by cushioning. A further reason is that if these vents are transferred to the high level portions of the dam the drop from crest to the *napah* rock will be too great.

very little to show what amount of cushioning is required to obviate any wear, and we might be compelled to protect the bed of the river hereafter, a very costly work. To have surplus sluices in the dam will bar the possibility of constructing an earthen embankment on the silt up-stream hereafter to prolong the life of the work almost infinitely with very little expenditure. For keeping the canal head clear of silt, 5,000 to 10,000 cusecs passed through the dam close to the canal offtake will suffice but the sluices must be near, and as surplusage on to the berm will require cushioning, the number of sluices in my opinion should be a minimum. The cost of surplusage at the high level will be about the same as through vents in the dam, and as the former is safer, I would urge that the estimate may be made complete in every respect for this arrangement, and also the financial statements, as I will be under the necessity of urging the safest course for acceptance. Any alternatives desired may be estimated and advanced for consideration in a complete form. Protection of the *napah* will be less costly than protection of the river bed.

A depth of 15 feet is unusually great and has apparently been adopted to economise in passing through shale, and to adapt the canal to short radii which are 20 times the bed width. Pending settlement of the site of the dam—*vide* paragraphs 4 to 6 above—I would advise as follows:—

(a) Acceptance of the proposed grading from R.D. 7.25 miles to the tail so that drawing of plans of works and estimating of cost may at once proceed.

(b) On determination of site of dam that the upper 7.25 miles and crest level of dam may be made to suit the lower portion—*vide* (a) above.

(c) If there is not a substantial advantage in the 15 feet depth for the head reach, the depth and bed width might be made the same as for the part beyond R.D. 7.25 miles.

This part of the project can now be advanced rapidly in the manner indicated in the remarks opposite paragraph 15 above.

I would advise these being based on the supposition that the plans of masonry works will be as shown in the typical drawings made over to the Chief Engineer in connection with the Cauvery Reservoir Project; if the cost by using these plans exceeds that arrived at by using the new and untried types, this is a reason for adopting those which have already been shown to answer. The average rate per cusec per mile may be considered, as it is elsewhere found to be a more reliable rate than the acre rate, but both may be calculated for channels of different sizes as the rate varies with size and declivity.

15. *Canal offtake, level and grading.*—This has been conditionally projected on the sections as follows:

At head.

Full supply level R.L.	... 174.5 feet
Bed of canal	... 189.5 "
Bed width	... 118 "
Depth	... 15 "
Slope of bed	... 1 in 6,600
Velocity feet per second	... 4.75 per sec.

At R.D. 7.25 miles.

Rise of bed at 1/50	... 4 feet
Bed width	... 201 "
Depth	... 11 "
Slope	... 1 in 8,000
Velocity	... 4.00 per sec.

16. *Masonry works.*—No plans of masonry works have been prepared.

17. *Rating for distributaries.*—Distributaries have been schemed for an area of 70,000 acres to arrive at a rate per acre.

Project operations and proposals.	Remarks on the entries—column 1.								
18. <i>Hyderabad State.</i> —Preliminary enquiries are understood to have been addressed to Hyderabad regarding the terms on which submergence of land by the reservoir will be agreed to.	Questions of this character are liable to occupy much time in settlement, and I would venture to suggest that measures may be taken which will ensure a general agreement being arrived at in time to obviate the project being delayed. Under Codal rules the project could not be submitted to the Secretary of State for sanction until the general terms of the agreement are decided on. The orders of the Local Government may be procured in time to obviate the project estimate being delayed.								
19. <i>Revenue prospects.</i> —It is understood that the revenue prospects of the project have been investigated and reported on by a Revenue officer, but the Madras Government have not yet pronounced on the case.	In my opinion there is no need whatever for any additional preliminary reports of the character indicated here, while a project which is admittedly a good productive one, as far as at present known, and on which so much money has already been expended should, in my opinion, be made perfectly complete. It will be seen from volume I, paragraph 139, of the Irrigation Commission's Report, that they advised an expenditure in 20 years as follows:—								
20. It was suggested to me when on tour that the project to be prepared might not be a detailed finished one suitable for submission for sanction, but an additional preliminary scheme, the reasons for this course being that the Cauvery Reservoir Project costing 885 lakhs will occupy about 18 years and should first be disposed of, and that it appeared unnecessary to spend time and money on a project which would not be undertaken for 18 years to come.	<table> <tr> <td>(a) Productive works...</td><td>265</td></tr> <tr> <td>(b) Intermediate ...</td><td>675</td></tr> <tr> <td>(c) Unproductive ...</td><td>600</td></tr> <tr> <td>Total</td><td>1,540</td></tr> </table> This gives an average expenditure on classes (a) and (b) of 47 lakhs for 20 years and on the three classes of 77 lakhs. With regard to the above sums, 600 lakhs were provided for the Tungabhadra, which has been virtually abandoned, and 600 lakhs for the Kistna. To remain contented with an expenditure of 30 lakhs on the average <i>per annum</i> on the Cauvery would not be in any sense attainment of the programme of the Irrigation Commission. If the Commission were about right in supposing that an expenditure of 77 lakhs <i>per annum</i> could be arranged for with advantage, it is not understood why there should now be expenditure to embark on a greater average than 30 lakhs <i>per annum</i>. This is viewing the case solely from the establishment and labour point of view; the question of funds is not one on which I can hazard any remarks. If the Cauvery work had a few years' start of the Kistna dam, work on the latter could apparently proceed without any material effect on the former, while all water stored would have a market in the delta.	(a) Productive works...	265	(b) Intermediate ...	675	(c) Unproductive ...	600	Total	1,540
(a) Productive works...	265								
(b) Intermediate ...	675								
(c) Unproductive ...	600								
Total	1,540								
21. <i>General remarks.</i> —I would express a hope that it may be found possible to submit the Kistna Reservoir Project in a complete state in March next.									
22. I wish to acknowledge the able manner in which the investigations regarding this difficult project have been made under the directions of the Hon'ble Mr. C. A. Smith, Chief Engineer, Irrigation Works, the very thorough manner in which the investigations, more especially those regarding silting of the reservoir, have been carried out by Colonel W. M. Ellis, R.E., Special Superintending Engineer, and the excellent surveys of Mr. C. T. Mullings, Executive Engineer. It remains to complete and crystallize these labours in the form of a finished project for the greatest work remaining to be executed in the Madras Presidency.									

30th November 1910.

J. BENTON,
Inspector-General

APPENDIX II.

I

Mr. Nicholson's Preliminary Geological Report.

Letter—from Lieut.-Col. W. M. ELLIS, R.E., Superintending Engineer, II Circle.
To—the Chief Engineer for Irrigation.
Dated—Bezwada, the 11th May 1908.
No.—54-I.

I forward a report by Mr. Nicholson on his work on the Kistna Investigation during April 1908 with a sketch plan and sections in original to which reference is made in the report.

2. It will be noted that a site which appears promising as a dam site is two miles above Muktiaba (Moogetala). The capacities obtainable by a dam here are being roughly investigated and a sample of the shale in the river bed will be forwarded in due course. As regards the shale I cannot give any opinion as to whether this work is likely to be found suitable for the foundation of a big dam at reasonable depth below its present surface, but fear this may prove the weak point of this site.

3. The opinion of Mr. Bruce-Foote on this point would be very valuable as he knows this locality well and has given special study to its Geology.

4. I have increased Mr. Nicholson's staff by two Surveyors who will join him by 15th May making in all one Upper Subordinate and three Surveyors and further details may be expected in three weeks. Meanwhile, no steps will be taken in investigating the Daida to Bellamkonda country for a suitable alignment for a channel.

ENCLOSURE.

Preliminary Report of Kistna Reservoir Project Investigation Party, April 1908.

The object of the present investigation is to survey the river Kistna, from Chintapalli up to Tadutla by means of cross sections, and thereby find, if possible, a site for a dam more suitable than the one at Daida.

If such a site were found, the savings would probably be considerable on the construction of the main canal, as the difficult ground in the first 39 miles of Mr. Reid's main canal would be avoided. Moreover, it might be possible to take the canal at such a level that pumping would be unnecessary, while sufficient ayacut could be commanded to make such a canal pay.

2. *Description of river between Chintapalli and Madapad.*—The river bed is about half a mile wide and contained between banks 40—50 feet high. The right half of the bed is covered with sand of unknown depth, while the water occupies the left side. From Vedatri to Chintapalli there is practically no surface fall during the hot weather, as the water forms a lake about ten miles long and 1,000 feet wide with a depth at centre varying from 10 feet at Vedatri to 65 feet at the gorge, $1\frac{1}{2}$ miles north of Chintapalli. Rocks appear in the river bed near Vedatri, but from this point southwards there appears to be a considerable depth of sand before the rock bed is reached.

On each side of the river, low hills of 200 to 600 feet height are separated from the river by a strip of alluvial black soil. This soil is not deep and the rocks, quartzite, shale and lime stone occasionally appear above its surface.

At Chintapalli, Challagarigi and Vedatri the hills send out spurs towards the river forming possible dam sites. A brief description of each of these follows.

3. *Chintapalli.*—The river is only 800 feet wide during summer, with a depth of 65 feet. Hills rising steeply on each side would form good abutments for a dam. There is, however, no suitable saddle for the byewash, the rock is very much contorted and the depth so great as to make construction difficult and the dam too high. The foot of the Mondibodu ridge of hills is about level + 170. This gives a limiting bed level for the canal, as a greater elevation might involve heavy cutting along the side of the hill, while at a lower level the canal might not command sufficient ayacut to make it pay. The F.T.L. of the reservoir would probably be not less than + 210 to obtain sufficient capacity, top of dam about + 225 and sill of byewash about + 200.

4. *Challagarigi site.*—The hills on each bank would form suitable abutments, and a byewash could be made on the left flank of the dam. The depth to rock foundations is unknown, but it is likely to be considerable, and a dam at this place would be both long and expensive.

Both the above sites were examined by the Superintending Engineer who considered that they were not worth further investigation.

5. *Vedatri sites.*—There are two sites—at C.S. 6 and 8 respectively. Suitable abutments are formed by the hills in each case, and the depth of the river is small, rocks appearing above W.L. in the former. The hills form a chain on each side and a suitable byewash can probably be obtained. A site survey of this is considered desirable, and will be made during May.

Between C.S. 6 and 7, the present water section converges to a width of 100 feet and depth of 1 foot. This stream was gauged and found to have a discharge of 160 cusecs. There is a considerable depth of sand, however, through which there may be a sub-soil flow.

From C.S. 7 to a point 2 miles south of Mukhtala, the river forms another pool, having a maximum depth of 45 feet at Mukhtala. There is no suitable site owing to the depth to rock foundations, and to the distance between the hills at either side.

A very promising site is found where the river leaves the Pulichintala ridge, a continuation of the Bellamkonda hills. A rough survey with various cross sections was made here and the results are shown on plan 2.

The Pulichintala ridge rises steeply to an elevation of about + 600 and forms a good abutment on the right bank. Low hills on the left flank provide two alternative sites for dam and surplus. Cross sections of both sites are shown.

Of the two, that marked D, E, F appears the more suitable, owing to the excellent provision for a byewash. The saddle between E and F could be cut down to a level of say + 200, and form good foundations for surplusing sluices. These might have a total width of 3,000 feet and a depth of, say, 15 feet. A subsidiary dam might have to be constructed between B and E so as to force the surplus water between B and C and thence round the quartzite ridge to the river.

6. The foundations of the main dam would have to rest on a grey-black rock which takes up one-third of the river bed, and will probably be found a few feet below the sand of the rest of the bed. The probable geological section is shown from A to C. This, if correct, reveals a curious condition of affairs. The quartzite and shale belonging to the Kadapa series apparently overlie the limestone of the Kurnool series reversing the correct order in which the limestone strata was well known to Geologists as shown by the following extract from paragraph 234 of the Kistna District Manual (1888). "If we examine the strata east of Karempudi, we find the sequence reversed for the Kurnool lime stone is undermost and the quartzites of the Kistna group above it. Further north of this the limestone is overlaid by an immense thickness of slates with several bands of quartzites forming the Pulichintala ridge." The slates are undoubtedly the shaley rock found at the dam site, and it is necessary to ascertain whether this formation will provide a suitable foundation. Further experiments will be made during May, and specimens of the rock sent for examination.

7. *Alignment of main canal.*—There are two methods by which the water might be drawn from a reservoir at this place (1) through a head sluice in the right flank of the dam, the water might be conducted round the end of the ridge and along a depression caused by a stream which falls into the Kistna near Taduvayi; (2) by cutting a tunnel through the ridge at a saddle about 2 miles south of the dam. A tunnel at level + 170 would have to be, at most, 1,000 feet long. The suggested line for main canal is shown dotted in plan 1.

8. *Materials.*—Excellent sand, limestone and quartzite exist at site. Granite and gneiss are found near Jaggayyapet. Wood for burning abounds in the neighbourhood. There is a good metalled road from Bonakul station on the Nizam's Railway to Mukhtala. Further investigation of this site and the higher reaches of the river are now being carried on.

6th May 1908.

H. L. NICHOLSON,
Asst. Engr., Kistna Reservoir Project Investigation.

Letter—from Lieut.-Col. W. M. ELLIS, R.E., Superintending Engineer, II Circle.
To—the Chief Engineer for Irrigation.
Dated—Bezwada, the 25th June 1908.
No.—126 I.

In forwarding with a note of my own on Mr. Nicholson's second report on his examination of the Kistna between Chintapalli and Tadutla, I venture to submit for your consideration a few remarks as to the line of investigations which, it appears to me, should be adopted with a view to deciding whether detailed investigations for a revised "Kistna Reservoir Project" with the great expense attendant on such are to be undertaken.

2. I have personally formed a very favourable opinion of the suitability of the site above Wadanapalli and in my mind there will be clear and sufficient case for full investigation and drawing up a complete project, if we find that the character of the rock in the river bed and under the alluvial deposit on the left side, is such as to be suitable foundation for a high masonry dam. If, after your inspection of the ground, you accept this view, it is clear that, while the comparatively cheap although slow process of taking sufficient levels to enable the best line of canals to be located may be proceeded with, there is no use in making any final recommendation or appointing highly paid establishment until the point as regards suitability of foundation is settled.

This is the crux of the whole question.

3. While the operations necessary for arriving at a decision regarding the suitability of foundations, viz., trenching and boring in the rock across the river bed and under the alluvium on the margin, will entail considerable expenditure; this is not a process requiring the highest engineering skill and experience.

I would therefore suggest that only such establishment should be appointed from, say, October 1908 as is considered necessary—

(a) for carrying out trenching and boring in the river bed and on the margin or on sites of surplus works,

(b) to superintend taking of levels by survey establishment, and that no further expenditure be incurred in appointing a special Superintending Engineer and full staff until it is proved that the suitable foundations can be got.

4. I think a junior Executive Engineer with an Assistant and two or three experienced subordinates with a staff of surveyors could carry out all the work required and that the final examination of the borings, trenches, etc., should be made by senior officers as assisted by a professional Geologist, when a decision regarding the suitability of the site would be come to. A good deal of expenditure must no doubt be incurred even in carrying out the above programme, probably Rs. 30,000 to Rs. 40,000; but the appointment of a highly paid staff should in my opinion follow, and not precede, the carrying out of such work.

5. The first thing to do and which must be done at once is to obtain permission from the Government of His Highness the Nizam to make the necessary excavations, borings, etc., in his territory. The left side of the river from the drainage outfalling just above Mukhtala belongs to Hyderabad State. It is generally a matter entailing much delay to settle compensation or obtain permission to carry out works in a foreign territory, and the sooner this matter is put in train, the better, as we cannot start any serious work other than survey without it.

ENCLOSURES.

Note by the Superintending Engineer, II Circle, on 2nd Report of Mr. Nicholson, Assistant Engineer on his inspection of the River Kistna between Chintapalli and Tadutla and on the No. 2 Dam site, Wadanapalli.

The first report which was submitted with this office No. 54 I., dated 4th May 1908, dealt with the river from Chintapalli to Wadanapalli and this report continues the description from Wadanapalli to Tadutla.

No copies of the plans sent with the first report were retained by Mr. Nicholson and as I was not aware of this, I had no copies made in this office and thus the plan showing the whole length of river now submitted does not show all detail between Chintapalli and Challagarigi, but this can be inserted in it from the information available from the plans already sent in original to the Chief Engineer for Irrigation.

2. The survey of a possible dam site above Vedatri referred to in the first report has not been made and it will, I think, be advisable, when opportunity offers, to make a plane table survey and examine the country on the left of the river here, so as to record in definite terms the advantages and disadvantages attached to this locality as a dam site. From general inspection I think it might be found a feasible site, but it does not, I believe, compare as regards natural features with the site in the vicinity of Wadanapalli. The time available to date has thus been expended on the Wadanapalli site and the survey of this locality has been postponed.

As regards the foundations, the rocks here are schists similar in structure to those in the riverbed at Wadanapalli.

3. Mr. Nicholson's present report describes with the aid of a rough plan (2 inches = 1 mile) the characteristics of the river and possible dam sites which are four in number. Cross sections of these sites accompany and levels are further plotted on the plan and make the general situation clear.

4. One of the principal points to be considered in locating a dam is the facilities for offtake of a canal to irrigate the uplands of Guntur district on the east of the line of high ground stretching from south of Bellamkonda to the north loop of the Kistna at Mukhtala (Moogetalah on $\frac{1}{4}$ " Atlas sheet). The levels shown on the plan now submitted, some of which have been taken by Mr. Reid's party and some by Mr. Nicholson's party, show—

(a) That there is an opening through the hills at the north end of the Pulichintala ridge opposite Wadanapalli by which a canal could be led through practicable country round the north end of the Mondibodu hill and so attain the east of the high ground above mentioned.

(b) That approximately the highest level at which such a canal could be carried round the north end of Mondibodu hill would be with bed level here between 175 and 180 having in view the character of the country.

This fixes roughly the level of the canal attaining the east of the high ground by this route.

(c) The next lowest possible route for a canal is by cutting through the saddle east of Papayapalem.

A large scale sketch of this is shown on sheet No. 4 and it is also shown in the 1" scale tracing (sheet No. 5). It will be seen that the lowest summit is + 320 and the ground for over two miles is at level over 300. As any dam in this section of river considered must be founded on a river bed below level 100, it is clear that this route for taking out a canal is impracticable, while a tunnel by this route would be of such length as to be also out of the question.

The investigations therefore show that from any dam between Chintapalli and Tadutla we must take our canal round the north of Mondibodu hill, and as this fixes roughly the level of the canal, we assume a bed level at this point between 175 and 180.

5. It will be seen that for facilities of offtake any dam would preferably be placed at or below Wadanapalli, but it will also be seen from the plan that between C.S. 16 and C.S. 13 the ground gives facilities for an offtake by tunnelling through the Pulichintala ridge.

For an offtake at bed level + 180 a tunnel between 4,000 feet and 5,000 feet long would take a canal out at suitable level.

6. I have personally inspected the river between Chintapalli and Ketavaram and agree with the view expressed by Mr. Nicholson that dam-site No. 2 gives by far the best promise of proving suitable.

Site No. 1 has advantages as regards facilities of offtake, but the natural features do not lend themselves to so efficient a surplus work, which work would be confined between the small hill above Wadanapalli and the limestone outcrop, while the level of the saddle + 157.22 is too low for conveniently surplus. Altogether as a preliminary expression of opinion, site No. 2 is considered decidedly the best and as regards natural features most promising.

7. Mr. Nicholson has submitted a special report regarding site No. 2 with a contour survey of the sites for the surplus works (sheet No. 3). This plan needs to be extended to Mukhtala where it is believed it can be arranged that the surplus will outfall into the present river bed; but for the present time has not allowed of this. The natural advantages of the site as regards surplus will readily be seen from the plan.

The hills consist of quartzite overlying slaty schist and reasonably good foundations for surplus works will probably be obtained within a few feet of the surface, while it is believed borings and pits will show that the hearting of the hills is of such solid rock as to secure surplus works from any danger by erosion or cutting back. As regards the character of the rock in the river bed and elsewhere to carry the masonry structure with which it is proposed to dam the Kistna, this can only be ascertained definitely by excavation of trenches and examination of the rock exposed and by supplementing such examination by boring. The site has, however, been examined by Dr. W. F. Smeeth, Mysore State Geologist, and that officer's report is awaited.

It is understood that he is of opinion that there is good prospect of suitable foundations for a dam being obtained by excavation to a moderate depth (between 10 and 20 feet say) below the existing rock surface.

As regards the offtake from such a dam, I think it likely that tunnelling will be found to be the best method of leading water into the basin to the east of Pulichintala ridge.

As suggested by Dr. Smeeth during his examination, it would probably be desirable to make a number of separate tunnels to carry the water rather than one large tunnel. This would save large interest charges, while the actual cost of works could probably not be materially more satisfactory in other ways, while the irrigation was being developed as well as being greater, the total cross-sectional area of tunnels being the same.

8. As regards the canal between the outfall of the tunnel and the north end of Mondibodu hill, the levels shown on plan No. 1 along the Taduvovagu and the roughly-dotted line showing roughly the course of a contour canal from the suggested dam site at "X", makes it clear that while some difficult rocky ground must be traversed, the works required to carry the canal round to the east of Mondibodu hill present no real difficulties.

9. By examination of the levels taken by Mr. Reid's party along spurs and channel alignments, Mr. Nicholson has been able roughly to outline the course of a contour canal taking 4" per mile and starting with a bed level + 178 at the north end of Mondibodu hill.

Such a canal would outfall into the Gundlakamma with a bed level 149 and thus the water carried would command the land on the right of the Gundlakamma under the anicut which, it is understood, has a crest of + 120.

The alignment is shown in blue on the sketch map 8 miles = 1 inch of Kistna Reservoir Project enclosed.

The gross area commanded including that on the right of the Gundlakamma under the anicut, has been taken out as 600,000 acres by Mr. Nicholson as he has verbally informed me and this would mean a net irrigable area of about 450,000 or at least 400,000 acres. This alignment is through a country of the same general character as Mr. Reid's main canal east of Bellamkonda and presents no special engineering difficulties. The line being far lower than Mr. Reid's main canal will probably be running in deeper and easier soil and there is no doubt of the economic feasibility of constructing such a canal.

10. At No. 2 dam site we are well off for materials. The quartzite which forms the upper layers of Pulichintala ridge will make excellent stone for rubble masonry or concrete. There is a widespread limestone outcrop within a mile.

The river-bed sand is of good quality, clean and sharp.

Fuel is not very plentiful, but could be obtained in large quantities by floating down from the denser growths higher up, while Singareni coal fields are not far from the site. I have not seen good earth for surki near the site, but everything else is at hand.

There is a metalled road within 3 miles leading to the nearest railway station, Bonakalu (23 miles).

11. The reports now submitted place you in possession of the facts as far as they are known and I proceed to report what further investigations are now being carried out.

12. As already reported and with your approval, I have granted Mr. Nileholson leave for six weeks from 20th June and have left the survey operations under the immediate charge of the overseer (T. R. Narsimhaiahari). Under these conditions, I have thought it best to undertake survey operations to determine roughly the capacity of a reservoir with a dam at site 2.

I do not think even for a rough computation Mr. Nicholson's computation of capacity by comparison with that of the Daida site gives information of any value. A party of eight surveyors are therefore employed.

(a) Running a contour at level + 180.

(b) Taking sections up each spur and valley and intermediate lines not exceeding 4 furlongs apart and roughly at right angles to the river line from the river margin to level + 280.

(c) Interpolating contours on the plans showing these levels and from this computing capacities. It is computed that this work will take six weeks by which time Mr. Nicholson will return.

The work then to be done should be—

(1) Running such levels as will enable the best alignment of canal up to north end of Mondibodu to be located.

(2) Contour survey of left side of river of surplus sites to be extended up to Mukhtala.

(3) Plane table survey of the site near Vedatri.

Before this is done, the Chief Engineer will himself have inspected and it is useless at present to forecast what should next be undertaken.

W. M. ELLIS, Lt.-Col., R.E.,
Superintending Engineer, II Circle.

Report on the dam site near Wadanapalli, called on the plan site No. 2.

Dam.—The river at this place is about 1,300' wide between banks 40' high above summer water level. On the right flank the Pulichintala hills are separated from the river only by a narrow strip of alluvium; they rise steeply with a slope of less than 3 to 1 to a height of 500' above water level. A layer of quartzite debris hides the true character of the rocks which consist of quartzite and slates in alternating strata—vide geological section No. 1 which was taken by Mr. Bruce-Foote at a point 2 miles upstream—vide volume VIII, part 1, Memoir of Geological Survey of India. The Pulichintala ridge forms a fine abutment for the right flank of the dam.

The river bed in summer is divided roughly into three parts; on the right is a shelving sandy bed. Experiments made with a Norton's tube well showed that the rock at site No. 1 is nowhere more than 5' below low water level. It is not likely to be much more than this at site No. 2 where the conditions are very similar. The rocks which appear on the left edge are slates and quartzites, dipping towards the south-east, so that the strike runs nearly parallel to the river axis. At the surface the slates are weathered and partially disintegrated, but it is hoped that at a small depth they become compact and homogeneous. That they are hard and resist the action of water is shown by the fact that the river has been unable to cut into them to any depth. Not even at Daida itself can bed rock be met with at so small a depth across the whole width of the river.

The left flank of the dam would rest on a hill whose crest is about 127' above low water level. It is separated from the river by a lower ridge which curves round in a westerly direction behind the byewash. The hill marks the termination of the dam and the beginning of the first byewash.

2. **Byewash.**—Nature has provided splendid facilities for dealing with the surplus water, and it is pretty certain that an effective cheap byewash can easily be built. The byewash consists of two separate parts: (1) The left end of the dam is joined by a ridge having an average height of + 215 (or 125' above low water level) to the end of a chain of hills named Narlaghattu.

This ridge is about 4,000' long, and of a surprisingly constant height and width throughout. Its top could be cut down where necessary to coincide with the sill level of the surplus sluices, and the surplus water would then run smoothly over and down the hill side without any sudden drop. (2) Between Narlaghattu and the plain which slopes up towards the west, there is a low, but broad, saddle, whose height coincides almost exactly with that of the above-mentioned ridge. By a moderate amount of cutting, a width of 2,200' could be obtained, thus giving a total effective length of byewash of 6,200 feet. It is to be noted that the foundations would be on solid rock a few feet below the surface.

Quartzite or slate will be the nature of the foundation. It will probably be much fissured.

W. M. ELLIS,
Supg. Engineer.

The surplus water would find its way into a basin separated from the river by a ridge which runs from the left flank of the dam to Wadanapalli. There is one low saddle and one break in this ridge. Low walls constructed where necessary would confine the surplus to the basin, and prevent it reaching the river until past Wadanapalli, 2 miles below the dam. A saddle between the Wadanapalli hill and the limestone outcrop on the west would convert the basin into an artificial lake, affording the surplus water two separate steps—(1) from the reservoir at, say + 220 to the lake at + 180, (2) thence to the river at + 130 (high flood level). This would make the immense volume of surplus water easier to control than if it were to run down to the river without a break.

3. *Capacity.*—At present no contours have been run to determine the capacity, but rough calculations and readings with an aneroid barometer seem to indicate that a large capacity would be obtained at reasonable depths. The ground on the left slopes up gradually for many miles and on the right there are numerous valleys and low basins between the hills and the river. The waterspread is likely then to be wide. As to the length it may be seen from the levels that at a depth of 130' at Wadanapalli = + 220, the water will back up far beyond Daida where the bed level is + 155, a distance of at least 40 miles.

The banks are 40' above low water level, and the ground slopes gradually back: the depth is likely therefore to be considerable, over a wide area.

The country covered by this reservoir resembles in appearance that covered by the Daida reservoir, and an inspection indicated that the capacities were likely to be about equal for given depths. For comparison, therefore, the accompanying curve was prepared from Mr. Reid's data, and a rough approximation may be obtained with its help:—

Levels—	Above maximum supply level.	Capacity: m.c. ft.
Maximum tank level		
Full		
Sill of byewashes	+ 225	48,000
Sill of head sluice	+ 220	44,000
Sill of vents in dam	+ 210	36,000
Bed level	+ 180	20,000
Maximum depth of water cushion	+ 165	14,000
Top of dam	+ 90	
	+ 130	
	+ 235	

These levels are quite arbitrary and for purposes of comparison. At maximum supply level of + 235, the capacity would be 58,000 millions of cubic feet.

4. *Offtake of Main Canal.*—The Pulichintala ridge is so steep and rocky that a contour canal round its end would be expensive both in prime cost and upkeep. Probably the best way to draw off water for the upland canal would be by means of a series of 2 or 3 parallel tunnels driven through the ridge at about 1½ miles from its end. One tunnel would suffice at first, but as irrigation developed and the project began to pay, the remainder would be driven as required.

5. *Main canal.*—Between the Pulichintala ridge and the eastern arm of the great Kistna bend lies a complicated mass of low hills covered for the most part with dense jungle, and intersected by two or three rocky streams running from west to east. The largest of these streams has its source at the east mouth of the tunnel and indicates the direction in which the main canal would have to be taken. The accompanying plan of the first 2½ miles of the stream shows that at its head the bed level is 287 and that after 2½ miles its bed corresponds with that of the main canal. Referring now to the sketch, it will be seen that in the middle distance a ridge, called the Pilligundla ridge, cuts off the drainage of the east side of the Pulichintala hills except at one gap; it is through this gap that our stream, reinforced by several tributaries, finds its way. The gap corresponds with the "x" on the plan. A low masonry dam would collect the water and a contour canal, whose position is indicated in the sketch, would conduct it round the Mondibodu ridge. The levels taken so far merely show that the canal can be run as far as the gap without any great difficulty. No doubt the rock cutting will be heavy in the first mile (partly through granite) both to excavate to channel bed level and to straighten the line. Between the gap and Mondibodu ridge no levels have as yet been taken, but I have carefully examined the country and do not hesitate to assert that there are no big engineering difficulties: there is no high saddle to cut through or deep valley to cross, and only one stream which can

be passed under the canal by means of an undertunnel. The main difficulty is likely to be in making the banks water-tight, as there is very little earth in this area, except on the banks of the streams. The only earth in this area occurs in the banks of the Vagus. At about ¼ mile distance east of the Pulichintala ridge, occurs an outcrop of granite shown on sketch plan which would come in useful. There is also an outcrop near Tadurayi.

The main canal commands a gross area of about 6 lakhs of acres including the ayacut under the Gundlakamma anicut. Of this total it is possible that 75 per cent. may be brought under irrigation.

6. *Conclusion.*—The question of the foundations of the main dam is still "sub judice", but as regards the other links in the chain, i.e., capacity, surplus facilities, materials, ease of construction, capital cost and revenue, there is everything to indicate a sound project.

H. L. NICHOLSON,
Asst. Engineer, Kistna Reservoir Project.

Report on Survey of Kistna upstream of Wadanapalli.

The Narlaghattu range of hills which forms the surplus of No. 2 site curves round to meet the left bank again at Nevilpur, enclosing a low basin of alluvial soil between it and the river about 3 miles long by 1½ wide. On the other bank the Pulichintala hills turn in a southerly direction a mile north of Pulichintala, and opposite the village are about ½ mile from the river bank, affording the possibility of site No. 3.

From Nevilpur upstream to Uddalur the country on the left slopes gradually up towards W. by N., without any prominent hills or deep cut valleys. Seen from a distance, it looks like a flat monotonous jungle. A rough contour at + 200 made with a barometer shows, however, that low spurs approach the river at Vellatur, Repalle and Tadutla; otherwise the contour keeps well inland.

2. On the right side the Pulichintala hills run parallel to the river until at Ketavaram, opposite Repalle a spur projects to within ½ mile. This gives a possible site No. 4. The only other point where the hills approach each other is at Tadutla. Those on the right bank, however, are too low for a dam unless produced to an undue length. From Tadutla a good view is obtained upstream and it is at once apparent that the country on each side is flat and gives no chance of a site. From Tadutla to Wadanapalli the river in the hot weather consists of a chain of long pools connected by short rapids. The depth of water is small except at the bends. A shelf of rock can be seen at the base of each bank for most of the distance, but there are no outcrops in midstream except at Pulichintala. The greater part of the bed consists of long banks of sand and shingle of unknown depth. The rocks consist of limestone, quartzite, and slates. The limestone forms a wide outcrop stretching from near Jaggayapotta on the north to Bodanam on the south; it also appears at the Tadutla bend. It is cut through by the river at Vellatur, and follows the right margin thence, with a width of about a mile.

The top edges of the banks are about 40 feet above low water level in this reach.

3. *Nevilpur, Site No. 3.*—A hill + 237 feet high, separated from the main ridge by a narrow valley, forms the left abutment, the right being the Pulichintala hills. A short escape 2,200 wide could be formed in the saddle between the Narlaghattu hills and the limestone outcrop (this is byewash 2 of site No. 2). Two alternative lines have been shown on the plan. They have been re-inspected and found to have little to recommend them in comparison with site No. 2. The main dam would be far longer, with deep foundations; arrangements for conducting water to an upland canal would be difficult, for a tunnel would be too long and a contour canal round the end of the ridge most difficult and expensive to construct, owing to the steepness of the hill side and its rocky structure.

4. *Ketavaram, Site No. 4.*—The only real point of interest about this site is that the foundations consist of limestone, instead of slate or slate and quartzite as in all the other places. A fair byewash could be obtained on the left bank, but the formation of rocks on which it would be founded is a confused series of shales and quartzites. The surplus water would fall into the river too near the foot of the dam from which it is separated only by a low ridge of kankar overlying the usual rocks.

The limestone when compared with that of the Kothapalle site at Daida is found to be somewhat similar in structure, but not so clear in colour, more laminated and the vertical cleavage is more pronounced. The surface rock on the right bank is hard and brittle; that on the opposite side, softer and shaley. Apart from the question of foundations the main disadvantage in this site is that there is no satisfactory means of taking an upland canal to the Sattenapalle side of the Bellamkonda ranges. The objection to a contour canal round the Pulichintala ridge is the same as at the Nevilpur site, only accentuated by the increased length of such a canal.

5. With a view to determining whether a tunnel of moderate length could be driven through the hills or a cutting of reasonable depth excavated, a short visit was made to Papayapalem where occurs the only gap in the double chain of hills. It may be seen from the taluk map that the two lines of hills enclose a valley

• Or sheet No. 1 of Mr. Reid's Survey, or sheet No. 5 now sent.

along which levels were taken under Mr. Reid. The valley widens out near Manisultanpuram and is separated by a low ridge into two parts. That on the west is a basin having a minimum height of + 220, that on the left forming an elevated plateau which falls very gradually to the east. The whole of this valley from Bellamkonda to Mondibodu hill consists of granite underlying a surface layer of earth—*vide* the accompanying section No. 2 also taken from Volume VIII, Part I of the Memoirs of the Geological Survey of India. Judging from the numerous outcrops of granite through the surface soil, one would say that the latter is not deep. It is evident from the levels which have been taken that a tunnel running west to east at an elevation of, say, + 180 to + 200 would have to be of enormous length and, cut through granite for a great part of the way, + 260 would have to be the minimum elevation for a canal to be run in cutting. The country slopes so gradually towards the east (*vide* the longitudinal section of Mr. Reid's Guntur canal or any of its left-side distributaries) that the + 180 contour is not reached for several miles from the foot of the hills, except north of Chintapalli where it runs along the foot of the hills. The point it is desired to make clear then is: that for any dam of reasonable height built downstream of Tadutla, the only feasible outlet to the main canal must be at some point north of the Chintapalli-Nevilpur line. For this reason alone it is desirable to have the dam north of this line, and of the sites thus left to choose from, I venture to put forward that near Wadanapalli, called No. 2 site, as being in every way the best that I have inspected. A special report on it is enclosed herewith.

Referring to the note by the Inspector-General of Irrigation, dated 16th * March 1908,

* Printed in G.O., No. 270 I., dated 20th July 1908.

paragraph 7, in which he recommends that lines of levels may be run through all the saddles: which may probably be adopted for alignment, the most southern saddle is that at Papayapalem, and it has been shown from my own levels that it will only suit a high-level canal. The next saddle is opposite Kollur, for this, levels had already been taken—*vide* sheet No. 8 of portfolio 1 on which my levels are also plotted in pencil. As regards the saddle west of Chintapalli, the valley between the main ranges is high through; no levels have actually been taken yet, and standing at a place near Mondibodu hill having an elevation of + 250, I was unable to see over the top of the saddle. It is probably over + 280.

H. L. NICHOLSON,
Asst. Engr., Kistna Reservoir Project Investigation.

Memorandum No. 113/0., dated 6th July 1908.

[Reference—Letter No. 126 I., dated 25th June 1908, from the Superintending Engineer, II Circle.]

The Chief Engineer for Irrigation has the honour to approve generally of his proposals regarding the investigation to be undertaken, pending the inspection of the Chief Engineer for Irrigation, after which a definite programme will be drawn up in consultation with the Superintending Engineer.

The Chief Engineer for Irrigation would, however, be glad if a few trial pits could be excavated on the right bank of the river before the Chief Engineer for Irrigation's inspection if practicable, and if the Superintending Engineer, who has seen the site, considers that any further information of value as regards the nature of the road could be obtained by so doing. Nothing in this direction should be attempted on the Hyderabad side until formal permission to do so has been obtained, as to which the Resident at Hyderabad is being addressed.

The index map of the Kistna Reservoir Project which accompanied the Superintending Engineer's letter under reply is returned herewith.

To the Superintending Engineer, II Circle, with a map.

C. A. SMITH,
Chief Engineer for Irrigation.

II

Geological report on sites for a reservoir dam on the Kistna river.

In the early part of June 1908 I visited the Kistna river at a point above 50 miles west of Bezvada in company with Colonel William Ellis, R.E., Superintending Engineer. The object of the visit was to examine the geological character of the river bed and adjacent banks for the purpose of ascertaining whether a suitable site for a dam existed and whether the rock foundations at such site would be likely to prove satisfactory.

The portion of the river examined lies between Mukhtala and Ketavaram, a distance of about 15 miles. Between these points, the river flows in a north-north-east direction between banks which are some 1,200 to 1,500 feet apart. The river bed was for the most part covered with shallow water, sand and shingle and with comparatively few exposures of rock. The banks of the river are for the most part steep, some 20 to 30 feet in height, and composed

largely of alluvial silt which forms a high-level terrace for some distance from the river bed. On the left bank of the river this terrace rises into a series of low rocky ridges or hillocks which for the most part do not exceed from 130 to 150 feet above the river bed. On the right bank the ground is higher rising to some 300 feet or so above the river bed in a series of ridges. At Ketavaram, the high ground on the right bank is about a mile from the river; it then recedes considerably as the river is followed northwards and returns again close to the river bank, a little to the north of Pulichintala forming the Pulichintala ridge.

Plate No. 1 is a sketch map showing the reach of the river between Ketavaram and Muktiala with the hills on either bank indicated by rough contours and with the geological distribution of the rock shown in colours. The alluvium and soil which cover much of the ground on either side of the river are not shown on the map. All the rocks in the tract examined belong to the Kurnool formation (palaeozoic) and consist of limestones, slaty shales and quartzites.

The limestone occupies the western side of the area examined. It is the lowest rock of the series and dips at gentle angles underneath the slates and quartzites. The angle of dip varies for the most part from 10° to 25° and its general direction is about east-south-east. The boundary line of the limestone crosses the river a little south of Muktiala and runs southwards some distance west of the river which it again crosses near Vellatur. From this point to above Ketavaram, the whole of the river channel is excavated in limestone.

The limestone is a bedded deposit, the various layers of which vary from greenish white to grey and purple in colour and consist almost entirely of carbonate of lime with variable small amounts of fine sand and argillaceous material. There are also thinner layers separating the foregoing and containing much more argillaceous material which has been altered largely into secondary minerals, giving these layers the character of calcareous schists. These latter frequently contain a good deal of pyrites which, under the influence of surface water action, has decomposed with the formation of soluble sulphates and sulphuric acid which no doubt largely account for the presence of numerous solution cavities in the limestone.

The beds as a whole show numerous small faults and where the rock is much exposed, it can be seen to be traversed by numerous vertical joint fissures.

It is improbable that either the solution cavities or the joint fissures will extend for any appreciable depth below the river bed, but where the rock outcrops boldly on the banks, it would require to be excavated to a very considerable depth before sound foundations could be obtained.

2. *Slaty shales and quartzite.*—These overlie the limestone and form the bed of the river and the adjoining banks from a little south of Muktiala up nearly to Vellatur. The major portion of the visible outcrops consists of quartzite, although by far the greater portion of the area is composed of the slaty shales. This is due to the superior hardness of the quartzite which ~~causes it to resist~~ denudation much better than the slaty beds and also to the fact that the beds are dipping at low angles which enables comparatively thin beds of quartzite to make a very considerable surface show. The slaty shales are on the whole much more of the character of slates than of shales, and hereafter I shall call them slates. They were originally mud stones containing a large, though variable, proportion of fine sand. Subsequent pressure has consolidated them and re-crystallised the argillaceous components to a very large extent with the production of chlorite, mica and allied minerals. In some layers small amounts of carbonate of lime have been formed and in places a little pyrites. A few of the beds approach argillaceous limestones in character and some containing coarse sand grains might be described as grits.

Although the beds are dipping at low angles, they have evidently been subjected to considerable pressure resulting not only in the crystallisation above referred to, but also in the development of an imperfect slaty cleavage which is frequently distinctly oblique to the original bedding planes of the rocks. This pressure has been a favourable and important factor from the point of view of the suitability of these rocks to serve as foundations for a large dam. Not only has the original material been strongly compacted, but much of it which once existed as fine sediment has been converted into crystalline material forming a cement for the larger sand grains, thereby rendering the rock as a whole little pervious to water.

3. *Resistance to deformation.*—The slates are on the whole fairly soft rocks, that is to say, they have not much power of resisting abrasion. This fortunately is a factor which does not affect the problem of the proposed dam very much. In dealing with the very large volume of surplus water which comes down the Kistna, it will of course be necessary to construct the waste weir of solid masonry with a well-built apron and to guard against any lateral scour along the toe of the dam, if the site finally chosen tends to produce such scour, but there is, I should say, no difficulty in providing for this by suitable construction.

As to resistance to crushing due to forces acting on the masonry of the dam, it may be admitted that the average crushing strength of these slates is not very high as rocks go, that is to say, the rock would not give very high results if crushed in a testing machine. Good slate will give a crushing strain of 10,000 lbs. per square inch and upwards, but I should doubt if the rock in the Kistna river would stand more than about one-third of that amount. This is

only a rough guess and as none of the rocks which are exposed in the river are really sound and unweathered, no useful tests have been possible. Sound rock will be met with in excavating for foundations, and I should be glad to have some tests made subsequently.

Supposing, however, the rock can stand only a strain of 3,000 lbs. per square inch, this will still amount to about 190 tons per square foot and as the strain on the foundations is not to exceed 10 tons per square foot, there appears to be an ample margin of safety even if my estimate was found to be somewhat too high.

Further, it must be remembered that the crushing of a block in a testing machine by no means represents the sort of work which the rock is called upon to perform in practice. In the foundation the rock is confined and supported on all sides and cannot yield unless it is compressible or unless the pressure is sufficient to set up a flow, and there can be no question that the compressibility of the rock will be negligible—probably not exceeding that of the masonry of the dam itself—and that the pressure which could produce flow will never be approached. In my opinion, therefore, there is no question as to the rock being amply strong enough to bear any weight which may be placed upon it without sensible deformation.

4. *The quartzites.*—These are interbedded with the slates. A thick bed of quartzite forms the crest of the Pulichintala ridge and lies on the eastern slope of the same. In the bed of the river there are a few comparatively thin beds of quartzite and three or four beds of quartzite form the chief outcrops on the ridges south of Wadanapalli which sweep away westwards and return and cross the river near Pulichintala. South of Pulichintala I did not see any outcrops of quartzite though the beds no doubt extend under the capping of alluvium and soil.

From the point of view of foundations we have to consider a number of thin beds of quartzite intercalated with the slates. These quartzites are composed essentially of sand grains from fine to coarse in texture and cemented together by a little altered argillaceous material. In several cases the quartzite beds have been penetrated by veins of quartz and the original sandy grains have been largely connected by infiltrations of silica rendering the material rather vitreous in character and making it very compact and impervious. This appears to have been largely the case with the big bed forming the crest of the Pulichintala ridge and with portions of the beds intercalated with the slates in the river bed.

Taken as a whole, these quartzite beds will have a considerably higher resistance to crushing than the enclosing slates. On the other hand, although the material of the quartzite beds will be *per se* more impervious than the slates, the amount of jointing and fissuring which they have suffered renders them more permeable in their superficial parts. I am of opinion that this jointing and fissuring will not be found to extend to any considerable depth below the bed of the river and that whatever percolation may occur at first will not prove deleterious to the strength and stability of the rock material and will probably be reduced to a comparatively insignificant amount by the filling up of the cracks with fine sediment.

5. The foregoing remarks may be regarded as covering the various classes of rock which occur along the reach of the river from Mukhtala to Ketavaram and in my opinion there is nothing in the composition and character of any of these rocks to militate against a large and high dam being founded on them.

It remains now to discuss the various sections across the river at points which have been selected as possible sites for the dam in order to indicate any local advantages or disadvantages which may exist. In doing so, it must be remembered that the exposures of rock in the river bed and on the banks are comparatively few and the geological sections which I give must be regarded as diagrammatic rather than as close representations of the actual strata.

The outlines of the sections (plate II) are copied from those furnished by Colonel Ellis, and they have been given corresponding numbers. As the vertical scale is six times the horizontal scale, the dips of the beds are correspondingly increased and the beds appear on the sections to be steeply inclined, but in reality they have dips varying between 10° and 30° with local variations up to about 45° .

6. *Dam site—No. 1 (C.S. No. 12).*—This is half a mile above Wadanapalli. The river bed is shallow, being only 2 to 3 feet below low water level. There are several quartzite beds in the river channel which cross the line of the dam obliquely and both the slates and quartzites. Without excavation I am unable to say whether this would prove a fatal objection to the building of a high pressure dam, but it is quite certain that the western side of the channel level—before satisfactory foundations could be expected. This, to my mind, forms a serious objection to this site and there is the further objection that the ground to the west of the section is somewhat low for the purpose of forming a waste weir and is formed of soil and decomposed slaty rock, which would necessitate considerable excavation and the building of a subsidiary dam out as far as the limestone over which to pass the surplus water.

I do not therefore recommend this site although, if no other site were available, there would be no insuperable difficulty in securing good foundations, though the cost would be considerable.

7. *Dam site No. 2 (C.S. No. 13)*—Situated about 6,000 feet above Wadanapalli. This is undoubtedly the most favourable site of all those which I have examined and I have extended the section so as to include the Pulichintala ridge on the east side and the rising ground extending for a mile or so in a westerly direction on the western side, for the purpose of including some remarks on the outlet channel and on the surplus weir.

The general lie of the rocks is sufficiently clear from the section given. It will be seen that there are fewer quartzite beds in the river channel—where the maximum strain will be produced—than at No. 1 site, and what is of much greater importance the beds of quartzite and slate are running here nearly at right angles to the line of the dam and have not been broken and contorted by earth movements.

The following points give this site an advantage over all of the others:—

- (a) The length of the dam (about 4,000 feet) is less than for any other site.
- (b) The river bed is shallow and the depth to which the base of the dam will have to be carried, is less than in any other case.
- (c) The high ridge between the points A and B forms, so far as I can tell from the levels already taken, a suitable site for the construction of a waste weir nearly a mile in length flanked at the points A and B by higher ground. In no other case have I seen so suitable a site for a waste weir.

I will discuss some further details as to construction after referring to the remaining sites.

8. *Dam site No. 3 (C.S. No. 18) at Pulichintala*.—A dam at this point would have a length of some 9,000 feet and from the depth of water in the river, the foundations would be considerably deeper than in the case of site No. 2. Moreover, the large number of quartzite beds which here cross the river obliquely and which are superficially much fractured, would involve much excavation possibly to a depth of 30 feet or so below the bed of the river. The fact that there is an island in the middle of the river is scarcely an appreciable advantage if it is an advantage at all. The island is composed of quartzite beds with some beds of decomposed slate which cross the river obliquely dipping at low angles, all of which would have to be removed to some distance below water level, before satisfactory foundations could be expected.

The left bank which contains numerous quartzite beds would have to be excavated for, I should say, 30 to 40 feet and the long stretch on the right bank which is largely composed of slates covered with alluvium would probably require to be excavated for an average of at least 30 feet deeper near the river and shallower inland. The construction of a dam on this site is chiefly a question of expense which would obviously be large, and apart from the greater length and depth of the dam would involve more difficulty in securing satisfactory foundations beneath the bed of the river than would be the case at No. 2 site.

9. *Dam site No. 4 (C.S. No. 18-A) at Pulichintala, alternative site*.—Omitting the remarks about the island, the opinion which I have given about site No. 3 holds good in the case of this site also, so far as one can judge from the very meagre exposures of rock which are to be seen. Of the two sites Nos. 3 and 4, I should give No. 4 a decided preference.

10. *Dam site No. 5 (C.S. No. 19), situated 500 feet above Ketavaram*.—The section given on plate II shows that a dam at this point would be of great length roughly about 11,000 feet, but it was hoped that this disadvantage would be compensated for by obtaining very much better foundations than at the sites already referred to, on account of the fact that the dam would rest on limestone for the greater portion of its length. The limestone itself is certainly a harder rock than the slates which occupy the river-bed further to the north and would stand a considerably greater crushing strain in a testing machine than the slates. On the other hand we have to consider not the limestone alone, but the rock mass as a whole, and we find that the beds of limestone are intercalated with thinner beds of softer calcareous schist which will probably possess a resistance to crushing, not much, if anything, superior to that of the slates. The rocks are but little exposed along the line of the proposed dam (C.S. No. 19), but a little to the north of it close to the village of Ketavaram, there is a very good exposure on the right bank of the river where the beds form a steep cliff about 40 feet in height. At this point the beds are seen to be jointed and fissured from top to bottom, many of the fissures being several inches wide. The fissures are due partly to a series of small faults and partly to temperature cracks and they have been widened by solution of the limestone by the action of surface water containing carbonic acid and by sulphuric acids and sulphates formed during the decomposition of iron pyrites, of which there is a fair amount in the more schistose layers.

Most of these defects will tend to disappear in depth, but they will probably involve the excavation of the limestone for a depth of at least 50 or 60 feet for a considerable distance inland from either bank of the river.

The bed of the river itself is fairly deep—in places some 15 or 16 feet below low water level—and the rock below the bed of the river would, I think, require to be excavated for perhaps 15 or 20 feet before a sound foundation would be reached. This is, however, merely an opinion on general considerations which could easily be checked by a series of borings. There are very few exposures on which to base an accurate forecast, but I noticed that the rocks on the left bank opposite the village of Ketavaram were chiefly of the soft schistose

variety and these will probably extend under the river-bed in the neighbourhood of the foundation line. Where exposed, the schistose layers are quite soft owing to decomposition and could be removed with pick and shovel, but it is quite likely that they would be found to be comparatively firm and sound at a small depth below the existing river-bed and I would by no means condemn the site on this point alone, especially as the actual extent and character of the beds can be so easily tested by a series of boreholes. There are one or two other points which deserve consideration.

The beds are dipping across the stream from the left to the right bank at gentle angles—probably not more than 10° to 15° on the average. The hard, and transversely somewhat brittle, limestone layers alternate with softer and more tenacious layers of calcareous schist (where the latter are undecomposed), and it is all a question of the relative disposition of these layers as to how satisfactory the foundations would prove and this can be discovered only by boring or excavation.

11. On the whole I am of opinion that examination of the rock below the river-bed would show that foundations which would satisfy an Engineer could be secured within a depth of about 20 feet below the bed itself; but, taking into consideration the depth of the water, the amount of excavation necessary on either bank and the great length of the dam, it is probable that the structure would cost at least two or three times as much as a dam at site No. 2.

The limestone rock of which abundance could be quarried close to the site could be used for the construction of the dam and would prove a satisfactory building material.

12. *Further notes on site No. 2.*—From the foregoing remarks it will be obvious that in my opinion the most favourable site of all those which I have examined is site No. 2. On purely geological grounds relating to the strength, stability and freedom from percolation of the rocks, the advantages possessed by site No. 2 over the other sites are not very great; but they are in my opinion quite appreciable, and when to these are added the fact that the length of the dam will be shorter and the depth of foundation below low water level, less than in any other case, the arguments in favour of site No. 2 become more substantial, and there can be no question that this is the site which should be selected unless some very material defects are found on the engineering side of the question, such as insufficient storage capacity, want of height or other difficulties connected with the supply channel or difficulties connected with the disposal of surplus water. So far as I could see from a general inspection, I do not think that any great difficulties will be encountered in respect of these matters and I therefore add some notes on the assumption that the selection of site No. 2 is probable.

13. *Strength and stability of foundation.*—Apart from the question of site No. 2 being more favourable than other sites, there is the essential question of whether it is sufficiently good for the purpose required. Colonel Ellis who accompanied me during my inspection will probably agree with me that the few exposures of rock to be found near the site of the dam are not very encouraging from an engineering point of view. Where the slates are exposed, they are soft and can be removed by a pick and shovel, and the quartzites which form the greater number of the exposures are much fissured and fractured. But these defects are purely superficial and will be found to disappear at a comparatively shallow depth where rock will be found which will, I have no doubt, satisfy an Engineer who is content to accept material which will be amply good enough for the purposes required of it, without demanding that it should be absolutely first class. By first-class material I mean rock foundations composed of solid masses of granite or gneiss, limestone or hard slates or schist. Such foundations are sometimes met with, but not frequently, and many dams have been constructed on foundations less satisfactory than those which may be accepted at site No. 2. As I have already pointed out, the rock (slates), though not very hard and not having a very high crushing strength, will, in my opinion, be amply strong enough to support a high dam without yielding or deformation, and I have no hesitation whatever in making this opinion most emphatic.

14. *Percolation.*—Practically every rock foundation as well as the masonry of every dam permits of a certain amount of percolation. In many cases drains are provided to carry off the percolating water and in several cases of dams which have stood well, the amount of percolation through the foundations is quite considerable. In the present case I am satisfied that the amount of sub-foundation leakage will be satisfactorily small, especially if care is taken in dealing with the quartzite beds which I shall refer to presently.

In considering the question of percolation, the essential point is the action of percolating water on the rock material. This action may be mechanical or chemical and may in some cases tend to soften and disintegrate the rock and to remove appreciable amounts of material in solution. From my examination of numerous specimens I am satisfied that no such action is to be feared in the present case. The slates are decomposed and softened only where exposed to the action of surface waters combined with atmospheric oxidation, and this will not be the case below the foundations of the dam when filled with water. Many even of the specimens taken from surface show little decomposition, the small amounts of calcite which they contain and which is the most soluble component being practically untouched. Some of the ferruginous components which exist in small quantities have been altered, but this will not be so at a little depth below the bed of the river and is nothing more than would be the case with almost any kind of rock exposed in the same way.

The rock will, I am satisfied, remain permanently sound and what little percolation may take place will be without mechanical or chemical influence to any appreciable or injurious degree.

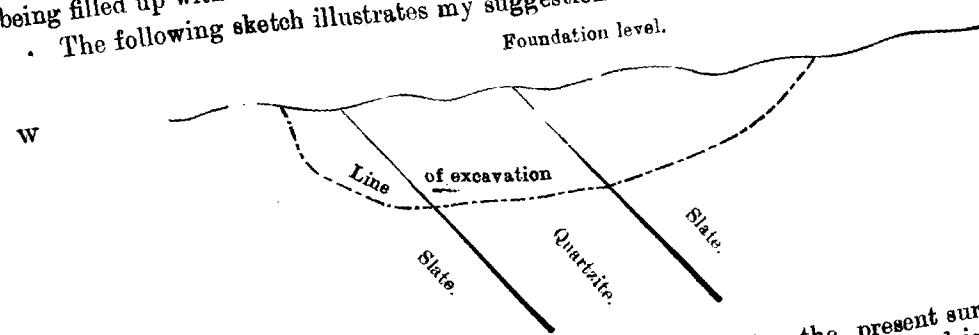
15. *Upward pressure of water.*—It is usual to take this into consideration, although it can be of moment only in exceptional cases or where there has been faulty workmanship during construction. If the rock or foundation material is of such a nature as to become more or less saturated with water, and as a consequence more or less mobile, there would no doubt be a partial upward pressure due to the head of water. No such effects will occur in the present case.

Again, if there should be any discontinuity between the material of the dam and the underlying rock, there would also be an upward pressure tending to reduce stability. This is purely a matter for the Engineers during construction, and if the rock surface is thoroughly cleaned with water and grouted with good cement, there is no reason why a perfectly good contact should not be secured. Given that this is secured, the effect of water under pressure in minute joints or cracks of the rock, such as are likely to exist in almost any rock foundation, will be so small in total amount as to be negligible.

16. *Depth of foundation.*—One of the points upon which I have been asked to express an opinion is whether a good foundation can be secured at a reasonable depth. I have already expressed the opinion that a good foundation can be secured, and as to the depth at which it may be expected, I should say that in the bed of the river itself, the amount of excavation which will be required will most probably be between 5 and 10 feet below the rock surface and this means within 12 or 13 feet of the level of low water in the river. As this is the place where the masonry will be deepest and where every foot in depth tells heavily, the above estimates will, I think, be regarded as exceptionally reasonable.

It is possible that in some places this depth may require to be exceeded and particularly so in the case of the comparatively thin beds and layers of quartzite. These beds are dipping to the east at angles of about 25° to 30° , and, as they are likely to be somewhat fissured, even when the adjoining slates are compact, I would suggest that all of the layers of quartzite be excavated to depth of several feet below the level of the adjoining slates. This will tend not only to reduce percolation, but will afford a more comfortable bed for the masonry, the excavations being filled up with concrete.

The following sketch illustrates my suggestion:—



On the banks of the river the amount of excavation below the present surface level will, I have no doubt, be much greater than below the bed of the river itself and is not likely to be less than 20 or 25 feet, and will probably in some parts amount to 60 or 70 feet. The excavation will, for the most part, be easy work and, as the surface is at a considerable elevation, the masonry required will not amount to anything out of the way.

17. *Waste weir.*—It looks as though the fairly high ridge between the points A and B on Plate I would form a very suitable site for the construction of a waste weir. It will be noticed that the outcrops of the beds run more or less parallel to this ridge and they are dipping at low angles towards the south and south-east. The ridge is capped by beds of quartzite with beds of slate in between, though the latter are not apparent at surface. The slates will be found to be soft for a considerable depth and the quartzites are much broken up at surface, so that the rock forming the ridge will not itself prove suitable for passing a heavy surplus discharge. It will be necessary to construct a curtain wall in the ridge and to carry it down to a good foundation which should preferably be on slate. It will also be necessary to construct a long and substantial apron of masonry, from the wall down the north slope of the ridge and possibly also to put in a wall at the toe of the apron so as to avoid under-scouring. For the purpose of building this masonry, the quartzite excavated on the ridge itself will prove a suitable material for rubble work and, if it is thought desirable to give the apron a smooth surface, large flat slabs of limestone can be obtained from the beds a little to the west.

I am not quite certain whether some of the surplus water will tend to pass back to the river immediately north of the ridge on which the dam is to be built; but if it is so, it will be necessary to prevent any scour near the downstream face of the dam on account of the softness of the rock and its low resistance to abrasion. This can be effected by groin walls or by blocking the channel leading to the river so that all the surplus will have to pass west of Wadanapalli and get into the river a little south of Muktiala.

I understand that the dam will have a number of sluices for passing water down the river and it will be necessary to prevent this water having any scouring action on the rock immediately below the dam by means of a water cushion or otherwise.

MISCELLANEOUS.

18. *Main channel.*—The channel leading the water from the reservoir must, I understand, be on the right bank of the river and there are only two ways in which it can be made, viz., either as a surface canal along the face and round the north end of the Pulichintala ridge, or as a tunnel through the ridge.

I think that the surface channel would give rise to difficulties on account of the fairly steep slope and the soft nature of the surface rock, and it would be liable to blocking or injury from the possible fall of material from the crest of the ridge.

Without venturing to express a decided opinion, I should think that a tunnel through the ridge would prove to be the best and most satisfactory means of exit for the water. As will be seen from the sketch section of site No. 2 given in Plate II, the tunnel (which will no doubt be made at a point further south than that shown in the section) will cut through the slates for a considerable distance and afterwards through the thick series of quartzites lying on the eastern slope. As a whole, the excavation for the tunnel should prove fairly easy and cheap. It will, in my opinion, be found necessary to line the tunnel at any rate for the greater portion of its length, on account of the nature of the rock and the direction of its bedding and cleavage planes; otherwise the roof, even though fairly sound at first, would gradually fall in. The lining would be a comparatively light one as heavy pressures need not be anticipated, but will, of course, depend on the diameter of the tunnel. Colonel Ellis in discussing this point suggested that a tunnel some 30 feet in diameter might be required. If this capacity is required, I would certainly suggest the building of two tunnels of about 20 feet in diameter, rather one of 30 feet diameter, on several grounds. The smaller tunnels would be easier to construct, safer, and require less lining and possess the advantage that one could be closed for repairs without stopping the whole supply of water.

As to the cost, the two tunnels would no doubt prove cheaper than one large tunnel, as the scheme of irrigation will take a long time to complete and the construction of the second tunnel can be deferred for many years during which the amount saved in interest on capital charges will doubtless much more than cover the increased total cost.

19. *Building material.*—The large bed of quartzite which crests the Pulichintala ridge will yield abundant material for rubble work, but will not be very suitable for dressed stone work. For the latter large slabs of limestone could be employed. As the quartzite bed on the crest of the Pulichintala ridge forms an abrupt scarp, which rises very steeply above the end of the dam, I would recommend that the greater portion of the quartzite immediately over the end of the dam should be quarried away to avoid heavy falls of rock which might possibly injure the masonry.

A good deal of the limestone which occurs to the west of the river looks as though it would yield a good lime for making surki, but I did not see any clay suitable for making the bricks to be mixed with it. Most of the alluvium in the river basin appears to be too sandy, but no doubt a good clay can be obtained at no great distance.

20. *Conclusion.*—The questions upon which I have been asked to give an opinion, viz whether suitable foundations for a large dam can be obtained, and if so, whether they will be within a reasonable depth from surface—must both be answered in the affirmative.

Of the various sites examined, that known as No. 2 site possesses unquestionable advantages over all the others, and I have no hesitation in recommending its adoption if the topographical and engineering features are satisfactory. I have discussed the characters of the rocks at this site at perhaps an unnecessary length and have not hesitated to point out the disadvantages which they possess. I have done so, because it is probable that many Engineers would be very dissatisfied with what can be seen of the rocks at surface and it is with a full knowledge of the an ideal site from the point of view of the foundation rock, but as one which is amply good enough and capable of performing all the functions that may be required of it. I have no doubt that when the foundations have been stripped to about the depths, which I have already indicated, the rocks disclosed will satisfy an unprejudiced Engineer.

BANGALORE,
4th July 1908.

W. F. SMEETH, M.A., D.Sc.,
State Geologist in Mysore.

Letter—from Lieut.-Col. W. M. Ellis, R.E., Superintending Engineer, II Circle.
To—the Chief Engineer for Irrigation.
Dated—Bewada, the 18th July 1908.
No.—167-I.

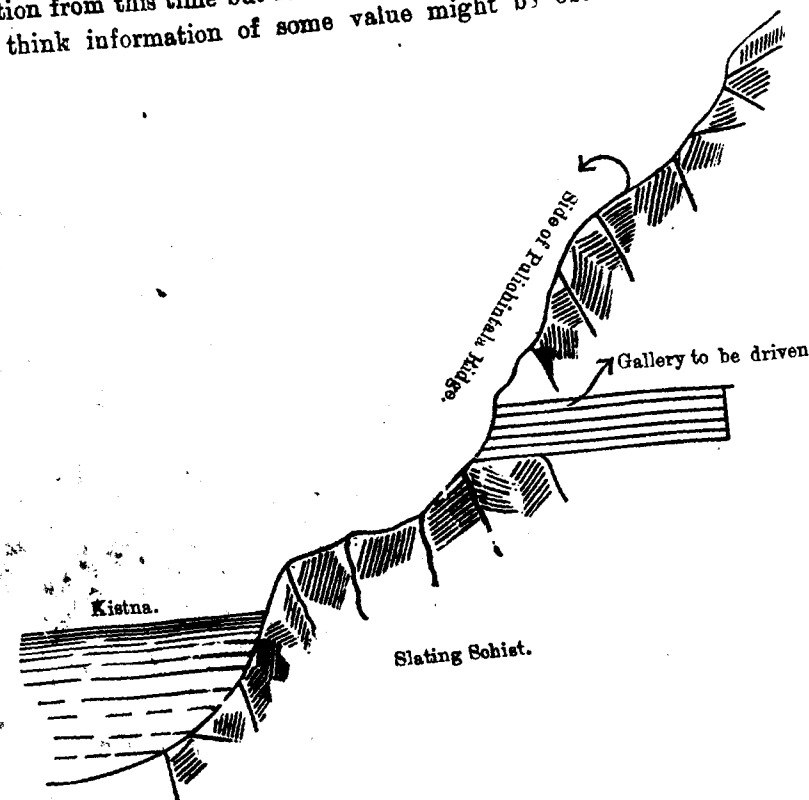
[Your No. 118-O, dated 6th July 1908.]

I fear it will be difficult to get trial pits at No. 2 Dam site (Wadanapalli) on the right of the Kistna excavated before your visit. On this side all the margin is rock in various stages of

decomposition, and excavation down to sound rock is a considerable task and requires supervision, which will not be available till Mr. Nicholson's return from leave. I will endeavour to start excavation from this time but fear no material progress will have been made before your visit.

I think information of some value might be obtained by sinking a shaft or better still driving a gallery with the hill face of Pulichintala ridge as per sketch on the margin, but until such gallery is 30 to 40 feet long, it is unlikely that rock typical of the foundation available will be reached and this will take time.

Arrangements to start work will, however, be made.



III

Inspection Notes of the Chief Engineer for Irrigation on the new Kistna Reservoir Project.

My inspection was confined to the river between Muktiala and about two miles above Wadanapalli which includes the proposed dam site Nos. 1 and 2.

The reports of Colonel Ellis, Dr. Smeeth and Mr. Nicholson so clearly indicate the superiority of No. 2 site over all the other possible sites, that it is intended for the present to confine further investigation to this site.

The river was in high flood which prevented me from seeing anything of the rock exposed in its bed. This, however, was unavoidable at this time of the year and the high level of water in the river was to some extent advantageous, as it had backed up the drainage vagues and clearly indicated the lie of the country through which the surplus water from the reservoir will have to pass.

2. *Dam site No. 1.*—This was inspected, but I agree with the Superintending Engineer's conclusion that it is inferior to No. 2 and Dr. Smeeth has also given clear indication that, although practicable, it is likely to be geologically inferior.

It is, therefore, unnecessary to make any further remarks upon it at present. The contour surveys relating to No. 2 site will include No. 1 site also and will therefore be available, should it be necessary hereafter to make any further detailed investigation as to the latter.

As sites 1, 2 and 3 are all on the same slate formation, it may be remarked here that if further investigation proves that this formation is for any reason unsuitable for the dam foundation, such reasons are likely to be applicable to all three sites.

3. *No. 2 site.*—The site is very apparent from both banks of the river from a long distance below and could hardly fail to be noticed by any one looking for possible dam sites as one which is clearly deserving of consideration. At the same time it is clear from Mr. Nicholson's report on the river that he had a clear grasp of his subject before he started his investigation, and he has carried out the important duty entrusted to him in a manner which is very creditable to such a young officer and which is in striking contrast to the manner in which the question was dealt with by the experienced Sub-Engineer who preceded him.

4. Both flanks were inspected and also both the saddles over which it is proposed to pass surplus water and which are about 4,000 ft. long and 2,000 ft. long, respectively.

The nature of the rock in these saddles has been clearly explained by Dr. Smeeth as well as the necessity for protecting the rock in rear from scour.

There should be no difficulty in making a safe escape although the cost may be heavy.

5. The length available is none too great, as it is desirable to keep the height of the escape shutter as low as possible, but with a certain number of vents in the main dam, there should be no difficulty in making adequate provision for surplus water with a reasonable height of shutter. If the lower alternative line for No. 2 dam is adopted, it will give an extra 1,000 ft. of escape which will also be available during construction, the saddle being on lower level. It is unlikely that there will be any very material difference in the foundations at the two sites, as they are only about 2,000 ft. apart, but the two alternatives will have to be worked out hereafter from all points of view and the best arrangement adopted.

6. The river being in flood, I was only able to inspect the numerous outcrops of slate rock on the banks and these being weathered, give no indication whatever to an Engineer as to the quality below the surface.

On this point, however, we have Dr. Smeeth's definite opinion that the rock will be found to be good enough for our purpose at a reasonable depth.

7. It may be here stated that the whole question as to the practicability of the present project is likely to rest upon the suitability of the slate rock for the foundation and it is quite possible that there may be considerable difference of opinion among Engineers on this point.

8. To decide this question definitely it is obviously necessary to excavate trial pits and trenches and take borings which will involve considerable expenditure and which will require the previous sanction of the Government of India. For the present, therefore, it is proposed to confine the further investigation of No. 2 site to the following:—

(a) To complete the contour survey of the reservoir water-spread and of the river between the dam site and Muktiala to enable the surplus arrangements to be worked out.

(b) To prepare a contour survey of the area on right bank of river between the Pulichintala ridge and the Mandibodu spur to enable the best position of the proposed tunnel and the line of main canal to be selected.

(c) After (b) is completed and the line selected, a trial line for main canal on a falling contour to be run up to the point of offtake of the Gunjur branch.

(d) A trial pit to be started as soon as possible on right bank of river to verify Dr. Smeeth's opinion as to the quality of the slate below the surface and to enable samples to be sent to him as well as to the Madras Engineering College for testing, etc.

The hand-power diamond drill now available in the Public Works Workshops to be sent for and some borings taken on right bank with a view to collecting further information as to the subsoil strata.

9. It is understood that it will take Mr. Nicholson's present staff consisting of 1 overseer and 8 surveyors about 6 weeks to complete, and in the meantime the Chief Engineer for Irrigation proposes to make a semi-official reference to the Inspector-General of Irrigation and ascertain his views after which an official reference can be made to the Government of India for sanction to whatever further investigations are then found to be necessary. The Superintending Engineer considers that Mr. Nicholson requires another Upper Subordinate and the Chief Engineer for Irrigation agrees and an application will be made to the Chief Engineer.

10. The area between Pulichintala and Mandibodu referred to above at (b) was inspected, and while it is impossible without the contour survey to locate either the tunnel or the channel line with any accuracy, there is no doubt that this means of taking off the upland canal from the reservoir is possible and the channel is not likely to present any engineering difficulties.

11. The contours of reservoir being still incomplete, the capacity of the reservoir is not yet worked out, but from the work already done it seems probable that the capacity between + 180 and + 230 will not be less than 100,000 millions cubic feet and the capacity at + 220 will be about 80,000 millions cubic feet, which will probably be sufficient for all requirements and will necessitate a dam 130 feet high above river-bed. This level of + 220 will probably also be suitable for the level of the escape saddle with shutters about 15 feet high.

12. The level which will be suitable for sill of upland channel head sluice has been tentatively assumed at + 180, but if this can be reduced to + 170, it may be profitable as giving more capacity above the offtake and less below it. With a view to ascertaining what capacity is actually sufficient for the requirements of the project, it is advisable to get a set of tables worked out as soon as practicable making due allowance for proposed projects above and also reducing the available surpluses at Bezawada in the manner indicated in paragraphs 88 and 89 of Mr. Benton's notes, dated 31st March 1907.

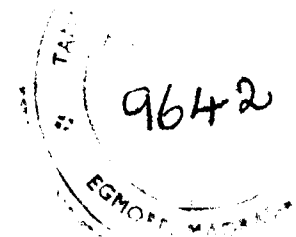
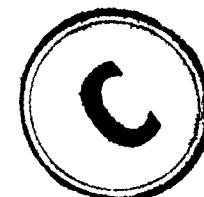
13. The Bezawada anicut discharges will probably have to be recalculated after comparison with the results of the velocity observations now in progress, but for the present they may, for the purpose of calculating approximately the reservoir capacity, be assumed to be correct.

14. The exact method to be adopted for the calculation will be settled with the Superintending Engineer.

15. In conclusion, I agree with the Superintending Engineer that the scheme as sketched out is distinctly promising, and if the dam foundation which, as explained above, is the crucial point proves to be satisfactory, there is every prospect of being able to work out a project, which will be thoroughly sound both as regards engineering and financial grounds.

C. A. SMITH,
Chief Engineer for Irrigation.

25th August 1908.



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