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GOVERNMENT OF 'IRAQ
DEVELOPMENT BOARD

**Z.A.D.
IRRIGATION PROJECTS**

**SUMMARY OF REPORT
ON
NAHRWAN, ADHAIM
AND ISHAQI AREAS**

1956

**BINNIE, DEACON & GOURLEY,
CONSULTING ENGINEERS,
WESTMINSTER,
LONDON, S.W.1**

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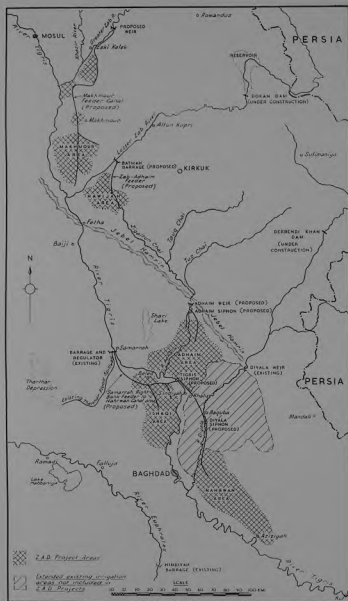
HYDRO-ELECTRIC POWER: at Samarrah Barrage and Dokan Dam.

TABLE OF MEASURES

| | |
|---|--|
| 1 square kilometre | = 100 hectares |
| | = 400 mesharas |
| 1 meshara | = 0.62 acres approximately |
| 1 cubic metre | = 35.3 cubic feet |
| | = 1,000 litres |
| 1 milliard | = 1,000,000,000 cubic metres |
| | = 1 cubic kilometre |
| | = 810,000 acre-feet |
| 1 cubic metre per second (cumec) | = 35.3 cubic feet per second (cusecs) |
| If discharge uniform throughout the year; | |
| 1 milliard per year | = 32 cumecs approximately |
| 1 cumen | = 1 cumec-month |
| | = 0.0026 milliards approximately |

Z.A.D. IRRIGATION PROJECTS

MAP SHOWING AREAS TO BE IRRIGATED



INTRODUCTION

1. This booklet contains Chapter I of Volume I of a report on irrigation development projects for the Nahrwan, Adhaim, Ishaqi and Makhmour areas, this Chapter being a summary of the report on the first three areas. The summary on the Makhmour area is included in Volume III of the report.

The whole report consists of three volumes, as follows:—

VOLUME I: Nahrwan, Adhaim and Ishaqi Areas.

Part One—Irrigation Report

Part Two—Agricultural Report

accompanied by an album of engineering drawings.

VOLUME II: Soil Survey and Land Classification Reports.

Part One—Nahrwan Area

Part Two—Adhaim Area

Part Three—Ishaqi Area

accompanied by an album of soil survey maps and an album of land classification maps.

VOLUME III: Makhmour Area.

Part One—Irrigation Report

Part Two—Soil Survey, Land Classification, and Agricultural Report

accompanied by an album of engineering drawings, soil survey maps and land classification maps.

2. The report has been prepared by Messrs. Binnie, Deacon and Gourley, Consulting Engineers, London, assisted by Sir M. MacDonald & Partners, Consulting Engineers, and Hunting Technical Services, Ltd., both of London. The latter firm carried out the agricultural, soil and land studies.

THE PROJECTS AND THEIR LANDS

Areas of Projects

3. The projects which are the subject of this summary are shown on the map at the beginning of this booklet and their areas are set forth in the table below:—

| Area covered by Land Classification (see paragraphs 9 and 10) | Adhaim 780,000 mesharas | | Nahrwan 1,520,000 mesharas | | Ishaqi 420,000 mesharas |
|---|-------------------------|-----------|----------------------------|-----------|-------------------------|
| | Right Bank | Left Bank | Nahrwan Canal | Tel Asmar | Ishaqi Branches |
| Gross Area | 160,000 | 490,000 | 590,000 | 130,000 | 640,000 |
| Classified as:— | | | | | |
| Class 2 | 67,000 | 120,000 | 104,000 | 22,000 | 38,000 |
| Class 3a | 1,000 | 2,000 | 47,000 | 23,000 | 135,000 |
| Class 3 (other) | 42,000 | 173,000 | 213,000 | 45,000 | |
| Additional land commanded and estimated as culturable .. | 110,000 | 295,000 | 364,000 | 90,000 | 173,000 |
| | — | 13,000 | 70,000 | — | 127,000 |
| TOTALS .. | 110,000 | 308,000 | 434,000 | 90,000 | 300,000 |

NOTE:—The sole limitation of Class 3a land is moderate salinity; the limitations of Class 3 (other) lands are low permeability and/or poor soil structure, either alone or in combination with moderate salinity.

4. The gross areas are defined as the areas which, regardless of whether or not they are suitable for cultivation, lie within the scope of the proposed canal systems. The additional lands commanded and estimated as culturable, which are included in the gross areas, are on the outskirts of the areas known by the names indicated, but being already generally under irrigation have not been covered by our soil and land surveys. As they could be irrigated by the proposed canal systems more conveniently than by their present means we have considered it necessary to provide for their water requirements; the probable proportion of culturable land in these areas has been assessed by comparison with adjacent classified land. In the case of the Nahrwan Canal practically all the area in question is *miri sif* land.

Adhaim Area

5. The Adhaim area is situated on both banks of the Adhaim River after its passage through the Jebel Hamrin and extends to the Tigris in the south. The culturable area on the right bank, which is within Samarrah Qadha, is severely limited on its western side by sand dunes and the Shari depression; that on the left bank, which is within Khalis Qadha, is bounded on the south-east by the Khalis Canal area and is known as the Aradhi-el-Ghurfa. The area has been irrigated at various times in the past by canals deriving from the Adhaim River whose supplies were almost certainly supplemented for this purpose from the Lesser Zab River. It is now cultivated with winter cereals grown on rainfall, and there is some pump irrigation from the Tigris on the southern fringes.

Nahrwan Area

6. By the Nahrwan area is usually meant the vast uncultivated plain, lying between the present tails of the left bank canals from Diyala Weir and the areas now irrigated by pumps on the Diyala and Tigris Rivers. It is divided between the Lewa of Baghdad, Diyala and Kut. The ancient Nahrwan Canal passes through the middle of the area but commands generally only the lands on its southern bank, together with the south-eastern quadrant; the remainder of the area, when irrigated intermittently in the past, was served by rivers and canals deriving from the Diyala River near the Jebel Hamrin. To this extent application of the name "Nahrwan" to the area leads to some confusion since the impression is conveyed that it was all served by the old Nahrwan Canal, with which in fact much of the area never had any connection.

7. With some exceptions the area between the tails of the Diyala Canals and the Nahrwan Canal is not recommended for reclamation because, although our surveys showed small areas of land to be suitable for cultivation, they are too isolated to be served economically by canals and drains. The exceptions are a block in the north-west corner, which we have called the Tel Asmar area, and a strip adjacent to the Nahrwan Canal. We recommend that the Tel Asmar area, which lies on natural extensions of the Khorassan and Mahrut canals, should be added to the area to be supplied by these canals. Revival of the old Nahrwan Canal, which we recommend, could also serve much of the *miri sif* land now irrigated by pumps on the Diyala and Tigris Rivers and we have included such areas in the Nahrwan Canal project.

Ishaqi Area

8. The Ishaqi area lies between the right bank of the Tigris River and the ancient Ishaqi Canal, extending from the present head of the Dujail Canal upstream of Beled in the north as far as the environs of Kadhaimin in the south. Although able to be commanded, our surveys showed that the land west of the old Ishaqi Canal, formed largely of gypsaceous gravel mounds, is entirely unsuitable for development and it has therefore been excluded from the gross project area. The proposed canal system would serve an area already irrigated to a large extent by pumping from the Tigris and could be extended to serve efficiently an

area north-west of Kadhaimin now somewhat poorly irrigated by the Saqlawiyah Canal. We have included in the Ishaqi project all the commanded area east of the old Ishaqi Canal; title of the culturable land is *miri sif*.

Land Classification

9. Our soil and land classification surveys showed that in all three areas the soils and lands have generally similar characteristics. Where land is classified as unsuitable for irrigation development, that is lower than Class 3, the limitation is usually on account of the soil: low permeability due to fine texture, poor structure due to high exchangeable sodium, high salinity, either alone or in combination. The widespread occurrence of banks of old canals and mounds of old cities is a limiting factor in respect of topography, particularly in the Tigris and Adhaim valleys; as described in our land classification report we recommend that steps should be taken, concurrently with if not before irrigation development, to control this erosion which besides being harmful to the present rain cultivation would also be detrimental to irrigation.

10. The best land found in any of the project areas is Class 2. This is fit for cultivation without any pre-treatment; it can be settled immediately water is made available and the necessary canalisation and drainage works have been completed. The Class 3s land limited only by moderate salinity should prove readily amenable to leaching. The remaining Class 3 lands which are subject to limitations other than, or in addition to, salinity require treatment such as dressing with gypsum prior to cultivation.

Recommended Order of Development

11. In making our proposals for development we have taken into account both fitness of land for settlement and convenience of access from the proposed canal systems. Our recommendations for the first stage and our tentative forecast of development for later stages are as follows:—

| Stage of Settlement | Area in mesharas | | |
|---|------------------|-----------|---------------|
| | Adhaim | | Nahrwan Canal |
| | Right Bank | Left Bank | |
| <i>First Stage</i> , immediately water is available, land most convenient of access:— | | | |
| Class 2 land | 50,000 | 62,000 | 85,000 |
| Additional land estimated as culturable | — | 13,000 | 25,000 |
| TOTAL | 50,000 | 75,000 | 110,000 |
| <i>Second Stage</i> , land less convenient of access:— | | | |
| Class 2 land, most of remainder | 17,000 | 38,000 | 19,000 |
| Class 3s land, leached during first stage | 1,000 | 2,000 | 46,000 |
| Class 3 (other) land, treated during first stage | 42,000 | 30,000 | 50,000 |
| TOTAL | 60,000 | 70,000 | 115,000 |
| <i>Final Stages</i> | — | 163,000 | 209,000 |
| TOTAL FOR PROJECT | 110,000 | 308,000 | 434,000 |

12. The Tel Asmar and Ishaqi areas are not included in these recommendations, the former being dependent on the remodelling of the Diyala Canals, and the latter requiring decisions on policy.

Reconditioning of Class 3 Lands before Settlement

13. We recommend that all lands in need of treatment to make them fit for cultivation should be given the necessary reconditioning by Government before being settled. We consider this to be the only satisfactory method of ensuring that all settlers have an equal start in developing their farms; the alternative of making grants to settlers on Class 3 lands and expecting them to carry out the treatment required would not, in our opinion, ensure that proper measures would be taken. The cost of leaching Class 3s lands should be small, once water is available in the canal systems, but the cost of treating other Class 3 lands may be considerable.

Pilot Project

14. We consider it desirable that practical experience under conditions in Iraq should be obtained as soon as possible of the most suitable technique for improving Class 3 land where it suffers from poor soil structure and low permeability. As a full cycle of testing requires about five years, and as delays in settlement would probably occur if no experimentation were carried out until water had been made available by the completion of major works, we recommend that a pilot project should be established as soon as possible by means of a pumping scheme in the Nahrwan Canal area; a suitable site near Aziziya has been investigated. The techniques to be tested, which have proved successful in similar conditions in other countries, are described in our soil and land reports. No such pilot project, before major works are completed, is possible in the Adhaim area but the experience gained in the Nahrwan would be applicable. The pilot project would also enable early experience to be obtained in the intensive system of agriculture proposed.

AGRICULTURE AND SETTLEMENT

Cropping Pattern

15. As a suitable pattern of agriculture for all the project areas we recommend an intensive system with a rotation comprising nearly 100 per cent cropping in winter and 50 per cent cropping in summer. Essential features of the system proposed are the rotation of a cereal crop with a winter legume and the keeping by farmers of more livestock than is now customary. The benefits to the soil and other agricultural advantages resulting from this system are described in the Agricultural Report and it may be added here that it also secures substantial economies in respect of both water consumption and cost of canalisation and drainage per unit of cropped area. The water supply arrangements and canal systems have been designed on the assumption that an intensive system of agriculture will be adopted.

Size of Holdings

16. The cropping pattern adopted governs the economic size of farm holding, this being defined as the size which will enable the farmer to obtain a reasonable standard of living and to make a fair contribution to Government towards capital and maintenance costs of the projects. As a standard size of holding we recommend an area of 70 mesharas. Of this 56 mesharas would be under field crops, 6 mesharas garden and orchard, and the remaining 8 mesharas occupied by the farmstead and by farm channels. The area occupied by laterals and their accompanying drains is not included within the 70 mesharas. We recognize that settlers may have difficulty in following the system of agriculture proposed and that to begin with cropping may not be as intensive as recommended; we consider that during this transitional period an appropriate reduction in Government charges would enable the settler still to make a reasonable living on a holding of 70 mesharas. Details of estimated farm incomes are given in the Agricultural Report.

Number of Holdings

17. After making allowance for the area occupied by the canal and drain systems, roads and other non-agricultural uses of culturable commanded land, we estimate that the numbers of farm holdings which could be established during each of the proposed stages of development are as follows:—

| | Adhaim | | Nahrwan Canal | Total number of Holdings |
|-----------------------------------|------------|-----------|---------------|--------------------------|
| | Right Bank | Left Bank | | |
| First Stage of Development | 650 | 950 | 1,400 | 3,000 |
| Second Stage of Development | 800 | 900 | 1,500 | 3,200 |
| Final Stages of Development | — | 2,100 | 2,700 | 4,800 |
| TOTALS | 1,450 | 3,950 | 5,600 | 11,000 |

According to our estimate of income from a holding of 70 mesharas and of amount of labour required to work it, both assuming intensive cultivation, a holding would support a farm unit of about seven persons, of whom two would be adult male workers.

Forestry

18. The establishment of tree plantations on all the project areas is strongly recommended. These plantations should be considered an integral part of the development of the area, and their establishment should be put in hand from the outset. Their management should be a function of the Iraq Forest Department.

It is recommended that a small proportion of the good land (that land classified as suitable for agriculture) should be set aside for trees in addition to the areas of land unsuitable for agriculture which may prove possible for forest development. Trees are an important crop and their value in a balanced development programme is more than sufficient to justify reservation of a small percentage of arable land for them. They provide fuel, timber, shade, protection from wind, and, when established, add very greatly to the amenities of the area as a whole.

DRAINAGE AND CANALISATION

Drainage

19. Efficient drainage systems for the project areas are essential, consisting not only of main and branch drains but also of internal drainage serving the farms and fields. We have provided systems with capacities estimated to be sufficient to remove storm water and with depths great enough to take care of subsoil drainage. We recommend that for each district to be settled the drainage system should be completed before irrigation water is supplied. The construction of all drains should therefore be a responsibility of Government.

Canalisation

20. We have carried our designs and estimates of the canalisation systems generally as far as the heads of "laterals" which serve groups of farm holdings varying in number from three to twenty. Smaller branch canals serving laterals directly have been designed to operate on the "alternate" system even at times of maximum demand for water. We recommend that laterals and farm channels should be constructed as part of the project in the same way as the internal drainage systems.

Land Levelling

21. We recommend that Government should be responsible for the levelling of land to make it suitable for irrigation, since we consider that this necessary work can be carried out more efficiently and economically by machinery on a large scale.

Water Requirements

22. Irrigation requirements of the projects have been estimated by assessing the consumptive use of crops, as determined from the cropping pattern which we recommend, and by allowing for beneficial rainfall, irrigation efficiency and absorption losses on the canal systems in conveyance of water to the fields. We have allowed for 70 per cent of the average rainfall as being beneficial.

MAJOR WORKS FOR SUPPLY OF WATER TO PROJECTS

Batmah Barrage and Zab-Adhaim Feeder

23. The only practical source of water supply available for the Adhaim area is the Lesser Zab River, since the uncontrolled flow of the Adhaim River is too erratic to permit of its beneficial usage; even if controlled it would be of little value. We therefore recommend that a feeder canal should be constructed from the Lesser Zab to the Zigaitun Chai, a tributary of the Adhaim River. The feeder canal would be commanded by headworks to be constructed on the Lesser Zab at Batmah and would supply the Hawijah Canal system *en route*, provision being made in the capacity of the feeder for the Hawijah area being extended and converted to intensive cultivation.

Adhaim River Works

24. For diverting supplies from the Adhaim River to the Adhaim canal systems we find the most suitable site for a weir to be two kilometres downstream of the old Bund-i-Adhaim. The project areas on both sides of the river commence nine kilometres downstream of the proposed headworks. On account of difficult terrain on the left bank we find it more satisfactory and economical to construct for the first nine kilometres from the proposed weir a combined head reach canal on the right bank. On reaching the commanded areas the head reach canal would bifurcate into two main canals, one serving the right bank and the other the left bank after crossing the Adhaim River in a siphon.

25. We recommend that some addition should be made to the capacities required in this feeder system for supplying the Adhaim area, in order that it could be extended when desired to supplement the Diyala River. We consider that this extension will probably be required at some time in the future and the cost of providing the extra capacities is small.

Supply to Nahrwan Canal

26. For the Nahrwan Canal the most accessible source of supply is the Diyala River, but we find that even after the completion of Derbend-i-Khan Dam the resources of that river must all be allocated to the Diyala Canals if the latter are to be provided with water sufficient for a fully developed fallow system of agriculture. It is therefore necessary to obtain supplies from another source; these could be drawn solely from the Lesser Zab by means of a Zab-Adhaim-Diyala feeder system or from the Tigris supplemented at times of low river flow from Dokan or any other future storage reservoir on the upper Tigris or Greater Zab.

Zab-Adhaim Route to Nahrwan Canal

27. We have exhaustively examined the possibilities of the Zab-Adhaim-Diyala route and find that its net cost is somewhat less than that of any route from the Tigris. As compared,

however, with a route from the Tigris it makes a substantially greater call upon the resources of Dokan Reservoir. We consider that storage works on the tributaries of the Tigris should be assigned primarily for the service of areas which they alone can supply and which are inaccessible to the Tigris; looking to the future the storage at Dokan should be as far as practicable reserved for possible subsequent developments on the Lesser Zab, Adhaim and Diyala Rivers. Furthermore we consider that technical and administrative problems would inevitably arise if the Nahrwan Canal had to rely upon supplies integrated with those of the Diyala Weir canals; such integration is unavoidable because of engineering reasons.

28. During the course of our investigations into the Zab-Adhaim-Diyala feeder system we carried out surveys to examine the possibility of connecting the Adhaim to the Diyala by a canal on the north side of the Jebel Hamrin. We found that this scheme is not a practicable proposition.

Diversion Barrage on Tigris

29. Having studied the Zab-Adhaim-Diyala route we conclude that the Nahrwan Canal should preferably be supplied by a feeder canal diverted from the Tigris. This diversion could be effected either by constructing a new barrage on the Tigris or by utilising Samarra Barrage. We consider that not only would a new barrage present serious problems in maintenance but also we estimate that the cost of this method would be substantially higher than the cost of constructing a feeder canal from Samarra; a new barrage would have to hold a head of eleven metres for which the river conditions at the most suitable site are not favourable.

Routes from Samarra Barrage

30. Of the two possible routes from Samarra Barrage the route on the right bank is the better. The head regulator constructed for supplying the Ishaqi Canal has adequate capacity for serving also the feeder canal, whereas the incorporation of new headworks on the left bank would involve considerable complications; the left bank route has other engineering difficulties greater than those on the right bank. A combined head reach for the Ishaqi Project and the feeder to the Nahrwan Canal leads to economy in the capital costs of both projects, but even without this asset the right bank route is estimated to cost less than that on the left bank.

Tigris Siphon

31. We do not consider that the construction of a siphon under the Tigris for a right bank feeder from Samarra presents any great problem either in construction or maintenance. It is interesting to recall that Sir William Willcocks, in an early report dated 1905 on the Irrigation of Mesopotamia, proposed a Tigris Barrage at Beled and a feeder canal on the right bank crossing the river in a siphon near Dokhela to serve lands on the lower Diyala and Tigris left bank.

Diyala Barrage

32. We considered the construction of a barrage on the Diyala River in order to divert to the Nahrwan Canal supplies brought to the Diyala from the Tigris. To this proposal there is the objection that sedimentation of the Diyala would result, largely because the character of that river will be changed by the construction of Derbend-i-Khan Dam, and its flood carrying capacity impaired. Furthermore we estimate that the cost of a barrage would be substantially more than that of a siphon and extra length of feeder canal. We recommend that the latter method should be adopted.

Recommended Route to Nahrwan Canal

33. Finally we recommend a supply route to the Nahrwan Canal, by means of a feeder canal from Samarra Barrage crossing the Tigris and Diyala Rivers in siphons. This method of supply is in our estimation the most satisfactory in respect of conservation of storage water, operation and maintenance. Moreover, it is the least costly route from the Tigris.

Supply to Ishaqi Project

34. With the adoption of our recommended method of supply to the Nahrwan Canal the Ishaqi Project would consist of branches from the Nahrwan Feeder Canal.

Constructing Feeder Canals initially to Half-capacity

35. We have considered the possible economy in first cost which might result if the feeder canals were constructed initially to half-capacity. The savings on earthwork would amount to about six per cent of the estimated cost of the Zab-Adhaim feeder canal and about 14 per cent of that of the Samarra feeder canal if made to half-capacity; enlargement later would probably cost at least double the amount of these savings. Structures should be built initially to full capacity since the cost of enlargement later far exceeds any initial economy. We recommend that the two feeders should be constructed to full capacity from the beginning.

WATER BALANCE ACCOUNT FOR DOKAN RESERVOIR

36. In drawing up an account of abstractions from Dokan storage for service of the Nahrwan Canal and Ishaqi projects it is not necessary with our recommended supply route to include the requirements of these two projects during the first half of the year; they would then be drawing Tigris water which is in excess of other irrigation demands and can thus be abstracted without detriment to other users. For the Nahrwan Canal and the Ishaqi the water account therefore only shows abstractions during the second half of the year.

37. It is necessary to allow for supplying to the Tigris the average contribution now made to that river by the Lesser Zab during the second half of the year when irrigation demands are heavy.

38. The water balance account below is prepared for average conditions of rainfall since Dokan Reservoir provides long term storage, and it can be assumed that heavier demands during years of poor rainfall will be balanced by smaller demands during years of good rainfall.

| <i>Estimated supply available</i> | <i>Milliards</i> |
|--|------------------|
| Dokan Reservoir, annual firm yield | 5.37 |
| <i>Estimated abstractions required</i> | |
| For whole of year: Adhaim projects | 1.41 |
| Hawijah area | 0.56 |
| For second half of year: Ishaqi project | 0.33 |
| Nahrwan Canal project | 0.80 |
| Compensation water to Tigris | 0.88 |
| Total abstractions | 3.98 |
| Estimated balance available for other usages | 1.39 |
| | 5.37 |

Estimated losses on feeder canals are included in the above abstractions. No credit is taken for inflow to the Lesser Zab River below Dokan, a part of which might sometimes be put to beneficial usage.

39. The significant fact emerging from the above table is that Dokan Reservoir can meet the estimated water requirements of the Adhaim, Nahrwan Canal and Ishaqi projects; ensure that the lower Tigris does not suffer a loss of irrigation water as a result of the Lesser Zab being controlled; and still provide about 1.4 milliards of water annually for other usages.

ESTIMATED COSTS OF CONSTRUCTION FOR RECOMMENDED PROPOSALS

Basis of Estimates

40. The unit rates used in preparing our estimates are based on those in contracts in force in Iraq during the last three years. To the costs arrived at from the quantities and rates we have added 15 per cent for contingencies and a further 10 per cent for engineering and administration of contracts.

Cost of Feeder Canals

41. The costs of the recommended supply routes to the project areas are estimated as follows:—

For Adhaim projects

| | <i>Estimated Cost in million I.D.</i> |
|---|---------------------------------------|
| Batmah Barrage on Lesser Zab and Head Regulator | 1.35 |
| Feeder canal from Batmah to Zigaitun Chai:— | |
| Earthwork, 6,150,000 cubic metres | 0.78 |
| Falls, three | 0.26 |
| Cross-drainages, five | 0.64 |
| Bridges and minor works | 0.07 |
| Zigaitun Chai, anti-erosion works | 1.75 |
| Adhaim Weir and Head Regulator | 0.05 |
| Head Reach of Adhaim Canals:— | 0.95 |
| Earthwork, 3,200,000 cubic metres | 0.35 |
| Adhaim Siphon | 0.65 |
| TOTAL | 5.10 |

For Nahrwan Canal and Ishaqi projects

| | |
|---|-------------|
| Feeder canal from Samarra to Beled Railway Station (head of main offtake to Ishaqi project):— | |
| Earthwork, 5,900,000 cubic metres | 0.60 |
| Falls, four | 0.24 |
| Bridges and other works | 0.12 |
| | 0.96 |
| Feeder canal from Beled Railway Station to head of Nahrwan Canal:— | |
| Earthwork, 18,100,000 cubic metres | 1.83 |
| Tigris Siphon | 1.28 |
| Diyala Siphon | 0.45 |
| Escape to river at Diyala Siphon | 0.19 |
| Bridges and other works | 0.39 |
| | 4.14 |
| TOTAL | 5.10 |

Cost of Canalisation and Drainage

42. From the estimated costs of canalisation and drainage, including land levelling and all minor channels except field drains, the following rates emerge per meshara of commanded culturable area in the respective projects:—

| Item of Work | Cost per meshara in dinars | | | |
|--|----------------------------|-----------|---------------|----------------|
| | Adhaim | | Nahrwan Canal | Ishaqi project |
| | Right Bank | Left Bank | | |
| Main and branch canals | 5.5 | 5.8 | 3.9 | 2.9 |
| Main and branch drains | 5.8 | 6.3 | 3.1 | 4.7 |
| Laterals, farm and field channels, collector and farm drains | 9.6 | 9.6 | 8.2 | 9.6 |
| Land levelling | 1.3 | 1.2 | 0.4 | 1.2 |
| TOTALS | 22.2 | 22.9 | 15.6 | 18.4 |

Total Cost of Projects

43. The total engineering costs of each project are then as follows:—

| Project | Culturable Commanded Area mesharas | Engineering Development Charges Cost per meshara I.D. | Cost in million I.D. |
|--|------------------------------------|---|----------------------|
| <i>Adhaim projects</i> | | | |
| Cost of major works and feeder | | | 5.1 |
| Canalisation and drainage: | | | |
| right bank project | 110,000 | 22,200 | 2.45 |
| left bank project | 308,000 | 22,900 | 7.05 |
| TOTALS | 418,000 | | 14.6 |
| Overall cost per meshara I.D. 35/000 | | | |
| <i>Nahrwan Canal project</i> | | | |
| Proportionate cost of feeder | | | 4.7 |
| Canalisation and drainage | 434,000 | 15,600 | 6.8 |
| Overall cost per meshara I.D. 26/500 | | | 11.5 |
| <i>Ishaqi project</i> | | | |
| Proportionate cost of feeder | | | 0.4 |
| Canalisation and drainage | 300,000 | 18,400 | 5.5 |
| Overall cost per meshara I.D. 19/500 | | | 5.9 |

GRAND TOTAL I.D. 32 MILLION

Engineering development charges do not include reconditioning of Class 3 lands nor field drains, both of which are regarded as part of agricultural development charges.

HYDRO-ELECTRIC POWER

At Samarra Barrage

44. The firm power potential at Samarra Barrage would be reduced as a result of diverting water to the Nahrwan Canal at the barrage instead of constructing a new diversion barrage downstream. We estimate that the comparative loss of firm power would be 8,000 kilowatts.

At Dokan Dam

45. During the early and intermediate stages of irrigation development there can be no conflict between hydro-electric and irrigation interests. By the time that the irrigation demands have grown sufficiently to take precedence over power development other means, such as the linking of the Lesser Zab and Diyala Rivers in the first stage and the construction of a re-regulating reservoir (probably on the Adhaim River) in the second stage, would be secure that power was not adversely affected.

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