MEMORANDA

ON THE

WESTERN JUMNA CANALS,

IN THE

NORTH-WESTERN PROVINCES

OF THE

BENGAL PRESIDENCY.

BY

MAJOR W. E. BAKER,

BENGAL ENGINEERS,

LATE SUPERINTENDENT OF CANALS, N. W. PROVINCES.

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PREFACE.

THE Memoranda forming the subject of the present volume, were written at the request of the Honourable the Lieutenant-Governor North-Western Provinces, who was pleased to express a wish that before my departure from India, I should leave a record of my local knowledge of the Western Jumna Canals, with which I had been officially connected during a period of eighteen years.

During the last few months of my superintendency of the Canals in the North-Western Provinces, including the Direction of the Ganges Canal works, my attention was entirely engrossed by the current duties of my office, and it was not until I had embarked on a river voyage from Gurhmooktesir to Calcutta, that I found leisure for the task assigned me; and then under considerable disadvantage, as I had no access to detailed maps and plans, or to the records of the Western Canals Office.

With reference to the progress of Irrigation Works in the North-Western Provinces of India, the history of the Western Jumna Canals possesses much interest. These were not only the first works of the kind attempted by the British Government in this part of India, but by their eminent success in a pecuniary point of view, by their improvement of the value of land in many districts of the Delhi Territory, and by their beneficial effects in mitigating the horrors of famine in 1833 and 1837, they placed

beyond a doubt the advantages of Irrigation Canals, and forcibly attracted the attention of the Local Government to the multiplication of these useful works.

To so important a subject, I regret that circumstances have not permitted me to do more justice; but the delay which has attended the final preparation of these Memoranda has enabled me to submit them to the perusal and revision of Col. J. Colvin, C.B., by whom the restoration of the Western Jumna Canals was almost entirely effected, and who has authorized me, after some alterations made at his suggestion, to express his concurrence in the statements and opinions advanced in the following pages.

W. E. BAKER, MAJOR,
Bengal Engineers.

Gattonside House,
October 10th, 1848.

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GENERAL MAP

of the

WESTERN JUMNA CANALS,

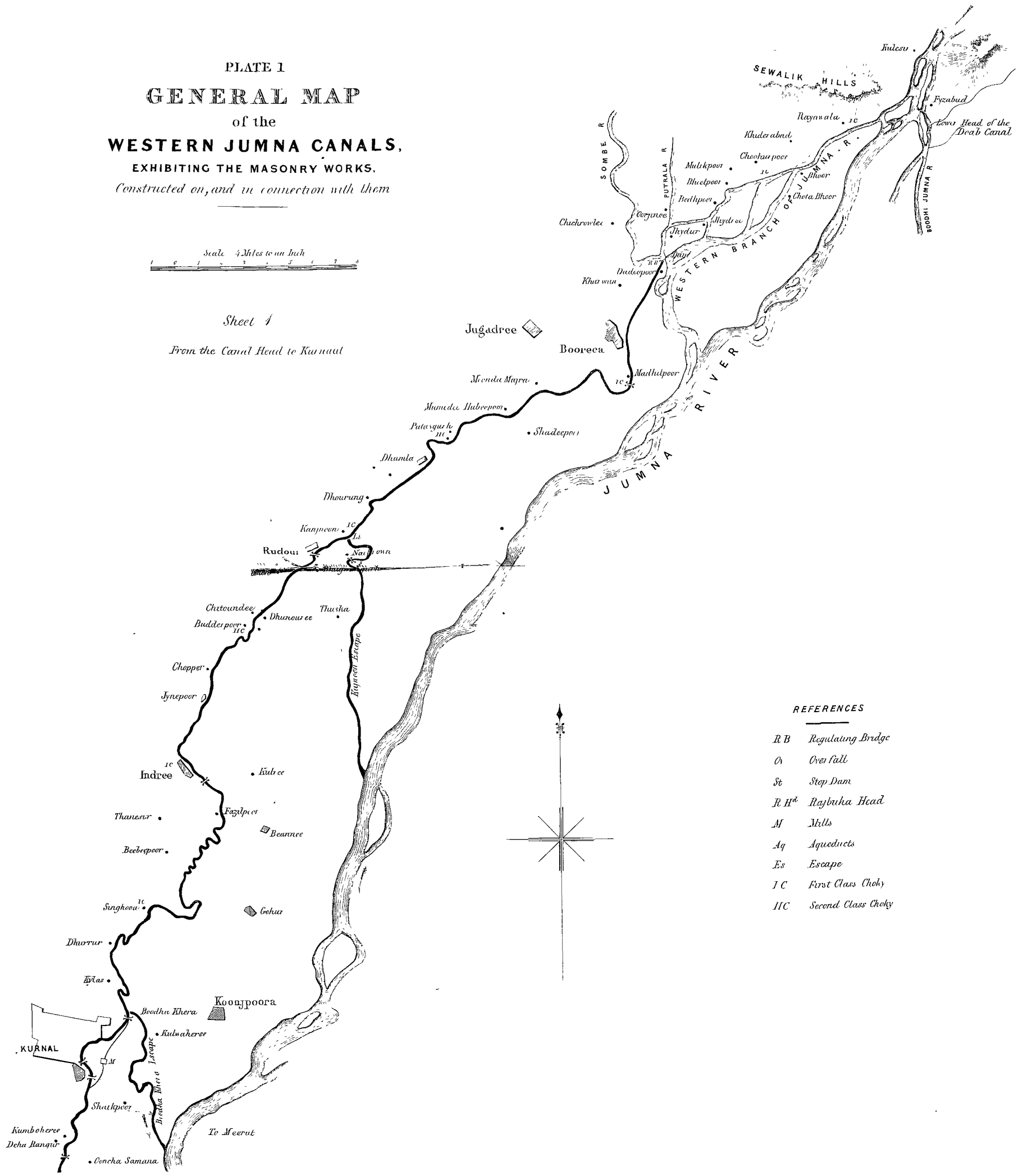
EXHIBITING THE MASONRY WORKS,

Constructed on, and in connection with them

Scale 4 Miles to an Inch

Sheet 1

From the Canal Head to Kurnaul



REFERENCES

R B	*Regulating Bridge*
Os	*Over fall*
St	*Stop Dam*
R H^d	*Rajbuha Head*
M	*Mills*
Aq	*Aqueducts*
Es	*Escape*
I C	*First Class Choky*
II C	*Second Class Choky*

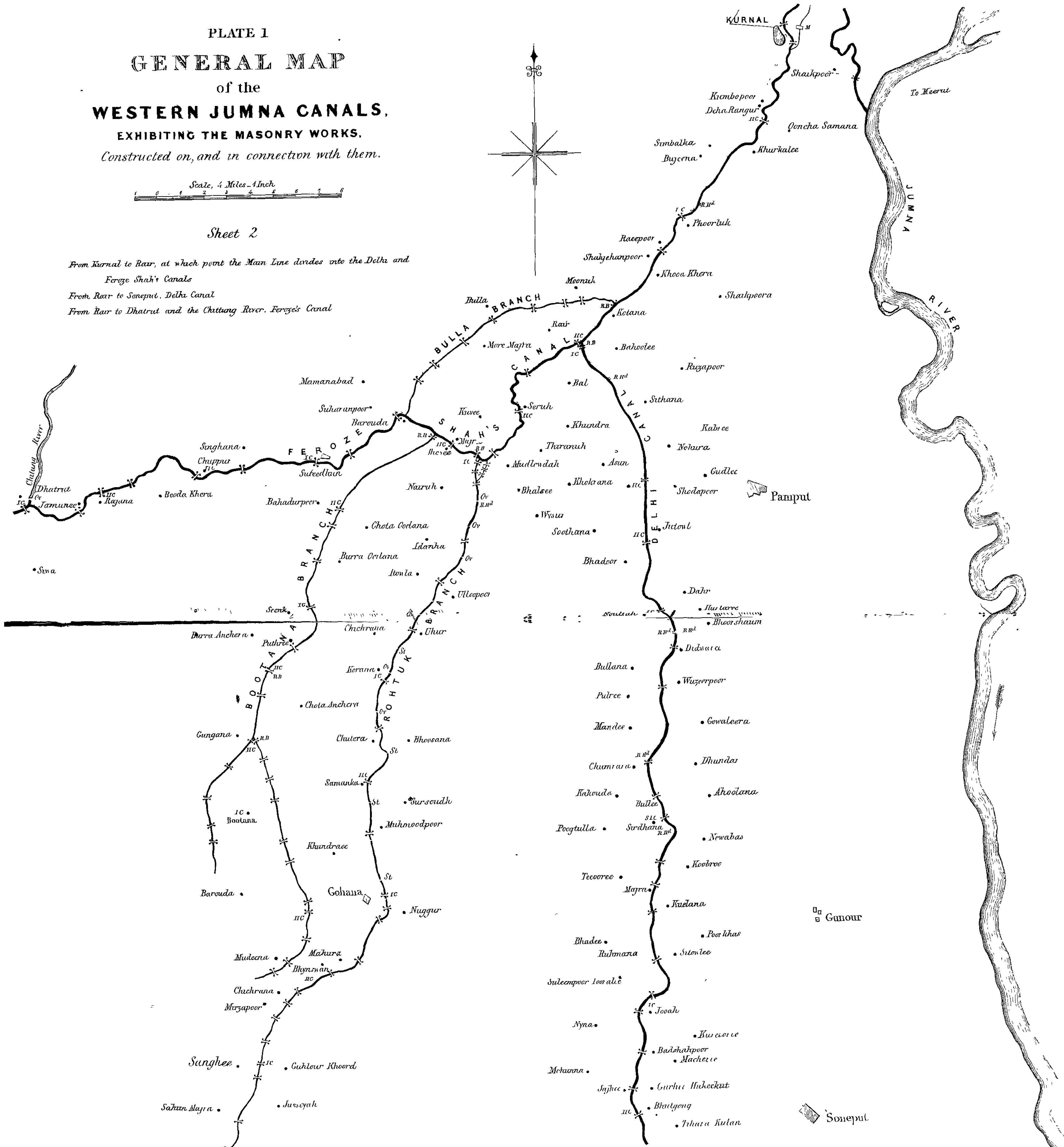


PLATE 1
GENERAL MAP
of the
WESTERN JUMNA CANALS,
EXHIBITING THE MASONRY WORKS,
Constructed on, and in connection with them.
Scale, 4 Miles = 1 Inch
Sheet 2
From Kurnal to Raar, at which point the Main Line divides into the Delhi and Feroze Shah's Canals
From Raar to Sonepat, Delhi Canal
From Raar to Dhatrut and the Chittung River, Feroze's Canal
KURNAL
Shaikpoor
Kumbopoor
Deha Rangur
Qoncha Samana
To Meerut
Simbalka
Bujeena
Khurkalee
JUMNA
RIVER
Phoorluk
Raeepoor
Shahjehanpoor
Khoon Khera
Shaikpoora
Moonuk
Bulla
BULLA BRANCH
Kotana
Raar
More Majra
CANAL
Bahoolee
Ruzapoor
Mamanabad
Bal
Sithana
Suharunpoor
Seruh
Baroude
SHAH'S
Khundra
Kabree
Singhana
FEROZE
Tharanah
Noltura
Chuppur
Suleedlaun
Mudlondah
Asun
Gudlee
Chittung River
Dhatrut
Jamunee
Rajuna
Boodu Khera
Bahadurpoor
Bhalsee
Kholoana
Shodapoor
Panput
Nauruh
DELHI
Chota Oorlana
Wisu
Soothana
Jutoul
Idanha
Burra Oorlana
Bhadoor
BRANCH
Sina
Ulleepoor
Dahr
Chichrana
Uhur
Bhoorshaum
Burra Anchera
Puthree
ROHTUK
Korana
Bidwara
Bullana
Wuzeerpoor
BOOTANA
Chota Anchera
Pulree
Mandee
Gowaleera
Gungana
Chutera
Bhoosana
Dhundas
Chumrara
Samanka
Sursoudh
Kakouda
Ahoolana
Bootana
Muhmoodpoor
Poogtulla
Sirdhana
Newabas
Khundraee
Koobroe
Tecooree
Baroude
Gohana
Majra
Kudana
Nuggur
Gunour
Bhadee
Ruhmana
Mudeena
Mahura
Bhynswan
Suleempoor
Chichrana
Mirzapoor
Joaah
Nyna
Badshahpoor
Sunghee
Guhlour Khoord
Mohunna
Jajhee
Gurhee Hukeekut
Sahun Majra
Jurscyah
Bhatgong
Jhara Kulan
Sonepat

PLATE 1.

GENERAL MAP

of the

WESTERN JUMNA CANALS,

EXHIBITING THE MASONRY WORKS,

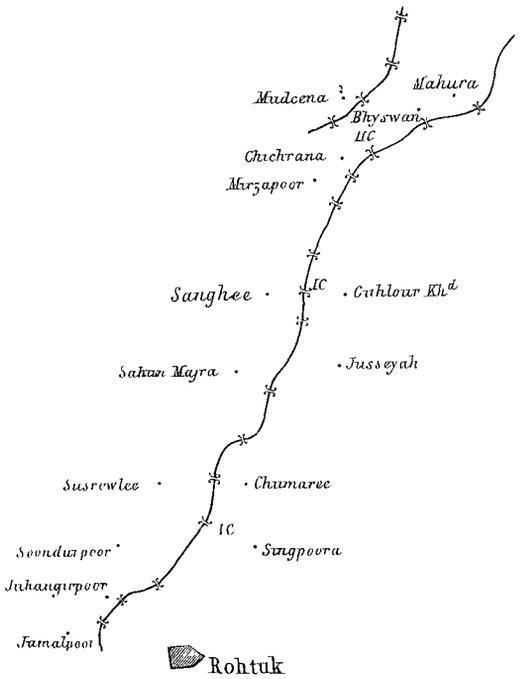
Constructed on, and in connection with them

Scale 4 Miles = 1 Inch

1 0 1 2 3 4 5 6 7 8 Miles

Sheet 3

From Soneput to the Jumna R at Delhi,
with the termination of the Rohtuk Branch



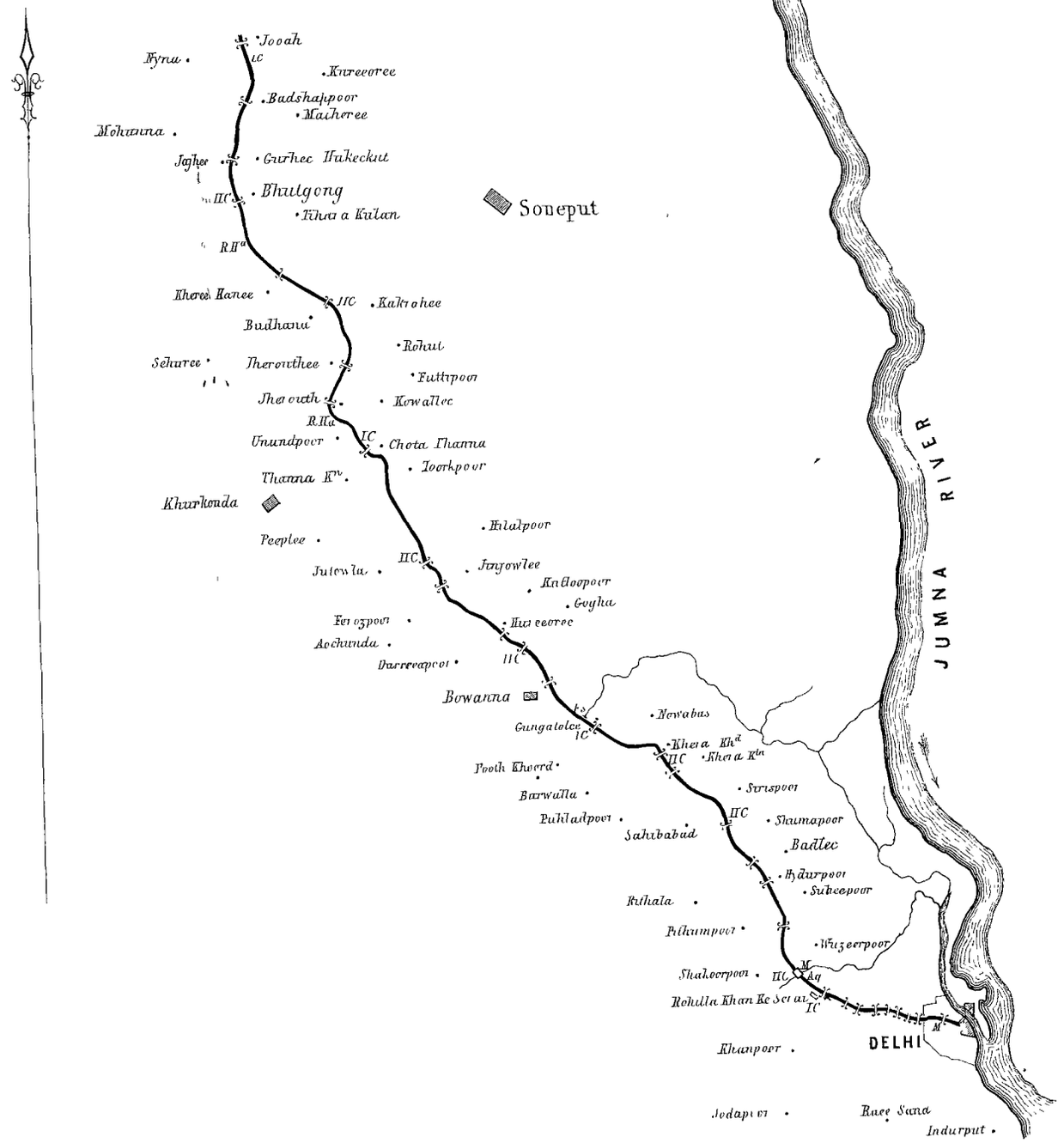


PLATE 1.

GENERAL MAP

of the

WESTERN JUMNA CANALS,

EXHIBITING THE MASONRY WORKS,

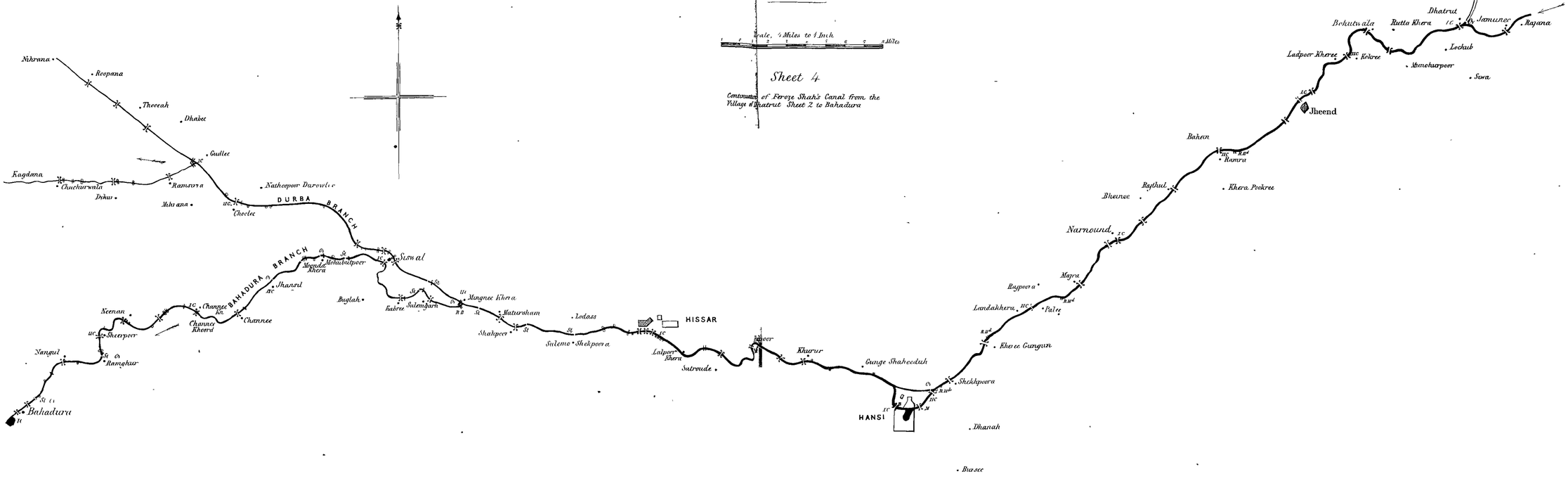
Constructed on, and in connection with them

Scale, 4 Miles to 1 Inch.

1 2 3 4 5 6 7 8 Miles

Sheet 4

Continuation of Feroze Shah's Canal from the Village of Bhatrut Sheet 2 to Bahadura



MEMORANDA

ON THE

WESTERN JUMNA CANALS.

I.—EARLY HISTORY OF THE CANALS.

Reference to Col. Colvin's Report on the early history of the Canals,

THE leading features of the early History of the Western Jumna Canals, under Native Rule, have been already detailed in a report on the Irrigation of the North-Western Provinces, written by Colonel Colvin in 1832, and published in the 15th Number of the Asiatic Society's Journal for March 1833.

And to a disquisition by Lieut. Yule on the same subject.

2. An additional, though perhaps somewhat uncertain, light has subsequently been thrown on the subject, by the discovery of a document purporting to be a Sunnud of the Emperor Akbar, a translation of which, accompanied by an ingenious commentary, was published by Lieutenant H. Yule of Engineers, in the 171st Number of the Journal of the Asiatic Society for March 1846.

These papers to be reprinted.

3. A brief summary, derived from the papers above mentioned, will form a fitting introduction to a descriptive report on the Western Jumna Canals, but particulars will be best given in the words of the authors, whose papers (or such parts of them as refer to the Western Jumna Canals), are reprinted with this report, and thus rendered more accessible than they have hitherto been, to the Officers employed in the Canal Department.

Feroze Shah's first line of Canal.

4. The first recorded public work connected with the Irrigation of the Delhi Territory, is the Canal of Feroze Shah, which was opened about the middle of the fourteenth century, and having its origin in the Jumna, and its terminus at Hissar, probably followed very nearly the course of the stream now known by the name of Feroze's Canal. The principal object of the work having been to convey water to Hissar, rather than to irrigate the intermediate country, advantage was taken of any natural hollow or channel whose slope and direction were found suitable

to the purpose. The precise position of the Head is uncertain, but from Boorreea to Kurnal, the Canal followed one or other of the natural nullas that intersect the Khadir Land of the Jumna, and was led, by a short excavation, into a line of drainage connected with the Chittung, the bed or valley of which is traceable to its junction with the Cuggur, and thence to the Sutlej. It appears to have terminated in a small masonry tank a short distance beyond Hissar,—and the absence of any traces of watercourses along its banks, seems to show that it was little used for irrigation.

Akbar Shah's operations.

5. The Sunnud translated by Lieutenant Yule, would indeed, if received as of superior authority to the History of Ferishta, lead to the belief that Feroze's Canal was not fed by the Jumna, but derived a precarious supply from the Chittung and other lines of drainage of the Sub-Himalayas; but without admitting this view of the case, I think there is good ground for believing that the Emperor Akbar, about the year 1568, restored Feroze's Canal, which had fallen into disrepair; and again, after an interval of a century, conveyed water to Hissar.

Shah Jehan's new line.

6. About the year 1626, under the immediate direction of Ali Murdan Khan, a Branch was taken off from the old line of Canal for the purpose of conveying water to supply the fountains of the Imperial Palace, and adorn the streets of the rising city, which the Emperor Shahjehan was erecting near the site of Old Delhi.

Difficulties encountered by Ali Murdan Khan.

7. To the operations of this period we are indebted for two of the existing lines of Canal, viz.: the Delhi and Rohtuk Branches. They were constructed under some natural difficulties, afforded scope for the display of considerable skill and judgment, and must have involved a large expenditure. The maintenance of the Canal supply however, then as now, required constant labour, and a greater degree of attention than was likely to be accorded to it amongst the pressing cares of a falling empire. The Canal, in fact, ceased to flow about the middle of the eighteenth century, and remained in disuse, until re-opened by the present rulers of Hindostan.

Preliminary inquiries by the British Government

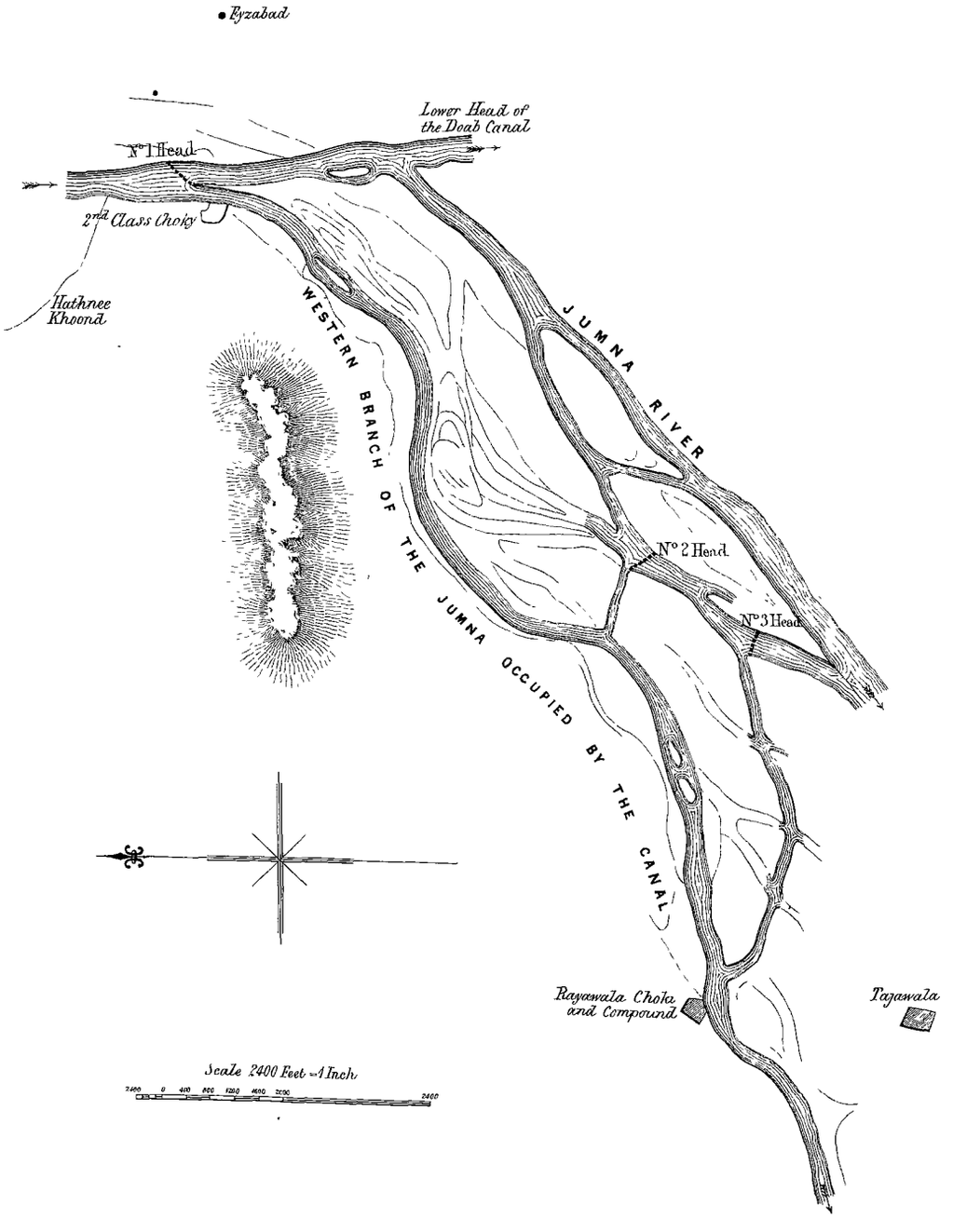
8. The restoration of these Canals by the British Government appears not to have been undertaken without due deliberation. Several Officers, afterwards distinguished in other departments, were employed in the preliminary inquiry. Amongst these were Lieutenants Todd and Macartney, parts of whose reports are on record in the Canal Office; but the great bulk of the information thus obtained lies buried in the archives of the Delhi Residency.

PLATE 2.

PLAN

of the **HEADS** of the

WESTERN JUMNA CANALS.



9. It was not before the year 1817, that an Officer (Lieutenant Blane of Engineers) was appointed to effect the restoration of the Delhi Canal. Such work as had been comtemplated by Government, was nearly completed by the time of Lieutenant Blane's death in 1821; but the scheme of operations was limited to the maintenance of a small supply in the Delhi Branch, and included neither Bridges nor Embankments.

Their first operations under Lieut. Blane.

10. General Tickell, who succeeded Lieutenant Blane, did much towards the improvement of the Canal; but the principal works of the Delhi, and nearly all those of the Western Branches, were constructed by Colonel Colvin, who was appointed to superintend Feroze's Canal in 1823, and assumed charge of all the irrigation works in the Delhi Territory in 1827.

The works completed by Col. Colvin.

11. Many of these works were executed under great disadvantage in having been designed, not as parts of one comprehensive plan, but to meet some pressing and immediate necessity. Both the native population and the Government (though for different reasons) were slow to appreciate the benefits of Canal Irrigation, and hence the ultimate advantage being mistrusted, temporary expedients were too generally preferred to effectual remedies. Under these circumstances, and without the light since shed by experience on the effects of such works, many of the estimates were framed on a scale that was not consistent with true economy. Nor, indeed, would Government have been likely to sanction a much larger expenditure on works which were, in a manner, experimental, and of which the advantages, however great in theory, remained to be subjected to the test of experience.

Limited sanction first accorded, and its ultimate disadvantages

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II.—FROM THE HEADS TO DADOOPOOR.

12. The Canal supply is derived from the River Jumna at the point of its debouche from the Sub-Himalayas, where the stream is rapid, the fall great, and the bed of the River consists of shingle and boulders.

Position and source of supply.

13. During the cold weather, the stream is generally confined to one or two only of the numerous channels into which the bed is subdivided, and which are all filled by the high floods of the rainy season,—but the slope being great, and hard materials for Dams

Facilities for diverting the stream.

abundant, there is seldom much difficulty in directing the stream into any one of the water-courses found between the high banks of the River. Advantage has been taken of this circumstance in both the Eastern and Western Canals, which respectively occupy ancient channels of the Jumna, during this part of their course.

Description of the first or Hathnee Khoond Head.

14. The Branch appropriated to the Western Canal leaves the Jumna at a point called the "Hathnee Khoond," nearly opposite the Old Palace of Badshah Muhul, and after a course of 25 miles returns to the main stream at Raj Ghat near Chilkana. The quantity of water naturally entering the channel varies in different years, but is never so great as to supersede the necessity of increasing it artificially, which is effected by means of deepening the channel and throwing out a Spur into the main stream. In seasons of drought the Spur is extended right across the River.

Second or Tajjawala Head.

15. To admit of this work being executed without interruption of the supply, and to prevent the inconvenience which might arise from any accident to the Bunds of the Upper Head, it has been found necessary to throw an additional supply from the main stream into the Western Branch, by two feeders. The first of these, commonly known by the name of the Second or Tajjawala Head of the Canal, was formed in 1826 by Colonel Colvin, who cut a channel across the island dividing the Central from the Western Branch, having ascertained that the difference of level was sufficient to ensure a rapid current from the former to the latter. The indraught of the Tajjawala Cut is assisted, like that of the Hathnee Khoond Head, by the formation of a Bund or Spur, thrown out into the main channel, and occasionally carried across it.

Third or Rayawala Head.

16. The Third Head is a natural channel leaving the Jumna about half a mile below the Tajjawala Head, and falling into the Canal opposite the Choky at Rayawala. This channel was formerly used to convey water for the irrigation of some of the Khadir villages, and was re-excavated by the Canal department in 1845. Its fall is somewhat deficient, and little or no water would enter it unless the main channel were dammed up.

Construction of the Dams or Gravel Bunds.

17. The material used in the Dams is chiefly boulder stones and gravel, sometimes piled up into a mound with long side slopes, but more frequently filled into large gabions of coarse basket work, in the use of which the villagers in the neighbourhood, and who are annually employed on this work, have acquired considerable skill. When the

PLATE 3

PLAN

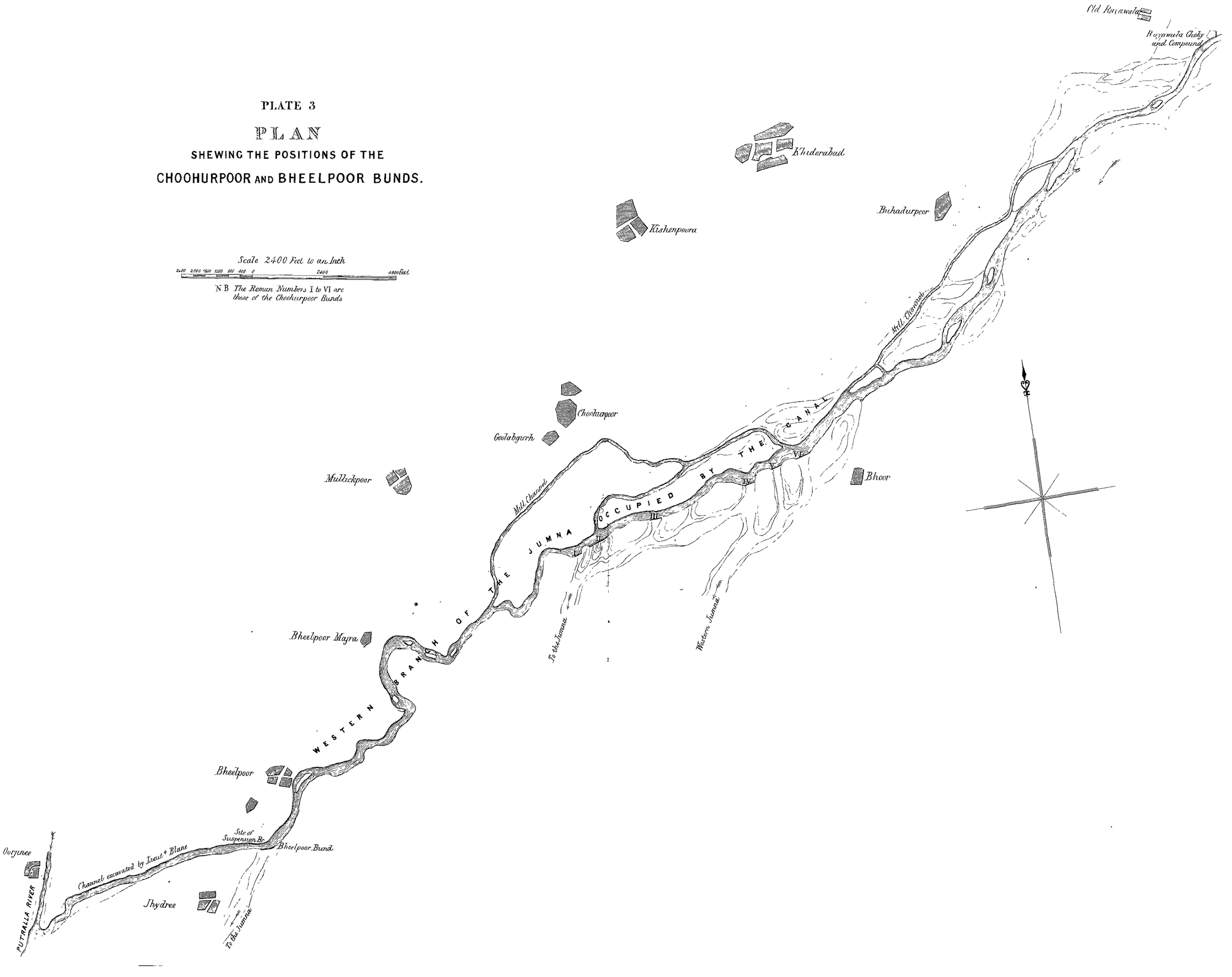
SHEWING THE POSITIONS OF THE

CHOOHURPOOR AND BHEELPOOR BUNDS.

Scale 2400 Feet to an Inch

2400 2000 1600 1200 800 400 0 2400 4800 feet

NB The Roman Numbers I to VI are those of the Choohurpoor Bunds



stream is rapid and the water requires to be much raised, the Dams consist of four rows of gabions in width, and sometimes two tiers in height. By these means the water can be held up 6 to 10 feet.

Description of the Tajjawala Bund.

18. The Tajjawala Bund, or that below Colvin's Cut, has always been more difficult of construction than any of the others, in consequence of the great depth of water in which the Dam must be formed. In some instances, indeed, it has been found necessary to turn off a portion of the water into another channel, previously to commencing the work. The plan by which it was first attempted to remedy this inconvenience, was to form a massive bank of very large stones in rear of the Dam, in the hope that it would either withstand the floods of the ensuing season, or be converted by them into a wide, stony rapid. This hope, however, was entirely disappointed, and in 1843 Captain Boileau tried the effect of forming an artificial rapid (similar to one previously made at Choohurpoor) with timber frames or cribs, packed with large stones and well imbedded in the gravel. During the succeeding rainy season, a portion of this work was carried away, and a deep channel was cut by the stream round each flank of the part that remained. Even this measure of success, however, was encouraging, and the work having been strengthened and extended on both flanks, has since stood, with the help of some annual repairs, and has certainly facilitated the construction of the Bund.

Late unfavourable changes of the Jumna.

19. The set of the current in the Jumna, which, till the last four or five years, had been very favourable for obtaining a supply from the Hathnee Khoond Head, is now gradually receding from the right bank, and setting so completely to the eastward that, in all probability, the Western Canals will soon have to depend entirely on the two lower heads; and it was partly in anticipation of this contingency that the third head was opened in 1845.

The Choohurpoor Bunds.

20. About four miles below Rayawala, or seven miles below the Hathnee Khoond, the Western Channel of the Jumna begins to throw off branches to the eastward, which again unite into one stream near the village of Bheelpoor. The Canal continues to follow the most westerly channel, Bunds or Dams being thrown across the heads of those diverging, as before mentioned, to the eastward. Six of these, which were originally constructed in the neighbourhood of Choohurpoor, have been called by the name of that village, and were consecutively numbered, but great changes have taken place since the numbers were first assigned. Many of the old channels are now entirely obliterated, and new ones have broken out.

Effects of the new measures.

21. There are at present (1848) three principal escapes, viz. (near the village of Bhoor) at the site of the old No. 6 Bund, at Nos. 4 and 5, and between Nos. 2 and 3. The Bunds were formerly made entirely of stones and gravel filled into gabions, and they were purposely given just sufficient strength to contain a full supply, with the intention that they should be carried away with the first flood. When, however, the demand for irrigation increased, it became necessary to provide more carefully against any interruption of the supply, and to insure that supply being restored at an earlier period after the rainy season. With this view a firm basis of Crib work (similar to that described in paragraph 18,) was constructed at Nos. 2 and 6 Bunds, where the greatest difficulty and delay had been experienced, and these works were subsequently extended to more than double their original length to meet the encroachments of the River.

Effects of the new measures.

22. The effects of superseding the temporary Dams by those of more solid construction, though beneficial for the intended purpose, have not been unattended with disadvantages. There is little doubt that the permanent Dams have contributed to, if not caused, the great changes above adverted to in the bed of the River; and though the level of their sills was kept below that of the Canal bottom, and the superstructure was intentionally made weak, they have not served the purpose of escapes so well as the old Bunds, and thus, by throwing a larger portion of flood-water down the Canal, they have probably accelerated the destruction of the Jhydree bridge, and have certainly contributed an additional item to the difficulties to be dealt with at Dadoopoor.

Bheelpoor Bund and junction with Putralla.

23. After passing the Choohurpoor Bunds, the Canal still follows a branch of the Jumna to Bheelpoor, from whence it is connected with the Putralla River by a channel about $1\frac{1}{2}$ mile in length, excavated originally by Lieutenant Blane, but which having been subsequently much enlarged by the action of the current, has become in appearance, as in all essential respects, a branch of the Jumna. A Bund similar to those at Choohurpoor was formerly required annually at Bheelpoor; but the channel connecting that point with the Jumna has completely filled up, and the Bund is no longer required.

The Putralla.

24. After joining the Putralla, the Canal occupies the bed of that River down to its confluence with the Sombe.

1st and 2nd class Chokies.

25. The masonry works in this part of the Canal are few, and have

all been unfortunate. The 2nd class Chokies at the Hathnee Khoond and Rayawala have both settled, and their walls have cracked. The present 1st class Choki at Rayawala is a house built many years ago by Mr. W. Dawe, and purchased by Captain Siddons on account of Government. It is a pucca, flat-roofed building, in good order, and is well suited to its present purpose. The 1st class Choki at Choohurpoor was originally built at about 100 yards from the edge of the Canal, opposite No. 2 Bund, which then afforded a free escape to the floods. The subsequent encroachments of the stream have, however, cut away the bank to such an extent, that the Choki now stands on the very verge of the Canal, and would have been cut away altogether, if preventive measures had not been resorted to. This Choki was much affected by damp to the height of three feet from the plinth, but the floor having now been raised to that height, the building is habitable, though inconveniently low. The 2nd class Choki, near Bheelpoor and Jhydree, is in good order, but the situation is unhealthy.

Jhydree Suspension Bridge its design and construction.

26. The Jhydree Suspension Bridge, erected across the Canal in 1839, is now in ruins. The bridge originally designed for this locality by Colonel Colvin, consisted of a timber platform supported on piers of masonry; and the right abutment and adjacent pier had been actually built on this plan, when, the question having been reconsidered by the Military Board, it was decided that an Iron Suspension Bridge would be more suitable to the purpose, and an estimate for such a work was called for, submitted, and sanctioned. The foundations were commenced after the rains of 1838, and the structure was completed in the following year.

Disadvantages of its site.

27. The site of the Suspension Bridge was immediately below that selected by Colonel Colvin. Being near a slight bend of the river, it was open to some objection, but, in Colonel Colvin's judgment and in my own, it was the best that could be met with,—nor, in my subsequent search for a safe position in which to reconstruct the bridge, have I seen any cause to alter my opinion. The soil, to the depth of eight or ten feet from the surface, consists of sand and shingle, with a few boulders, and is incapable of offering effectual resistance to the encroachments of the Canal, which is here in fact a branch of the Jumna, subject to the same freshes, having the same rapid fall, and being as uncontrollable in its vagaries, as the parent stream.

Description of the work.

28. The foundations of the bridge consisted of massive blocks of masonry, sunk down through the gravel to what appeared a compact bed of boulders, from $9\frac{3}{4}$ to $10\frac{1}{4}$ feet below foundation surface level.

The back chains were carefully secured in prisms of brickwork. The span of the bridge was 100 feet, and the roadway nine feet wide. The up stream flank of the right standard, against which there was a slight set of the current, was covered by the old abutment (built according to the first design), and by a barrier of crib work, which was carefully watched and repaired.

Its fall.

29. The bridge stood uninjured until the rains of 1844, when it was carried away in a flood. Not having been in charge of the work at the time of this occurrence, I cannot pronounce an opinion on its immediate cause, but there is little doubt that the waterway was too narrow, with reference to the altered circumstances of the Choohurpoor Bunds, and that the want of a connected floor between the standards permitted their foundations to be undermined.

Conditions of its reconstruction.

30. Should the Jhydree Bridge be reconstructed, there should be a space of 150 to 200 feet between the abutments, and the latter should be carefully secured with cribs and protected by a system of spurs.

Present means of communication.

31. The communication across the Canal on this line of road is now maintained by means of a decked ferry boat, and a proper landing place has been provided on each bank. The country is thinly peopled, and as the Canal is fordable in many places for cattle, the want of a bridge is chiefly felt by the Government establishment.

Trestle Bridge at Choohurpoor.

32. A rough trestle bridge, formed of bullas, and resting on piles from six to eight inches in diameter, was thrown across the Canal at Choohurpoor in 1838, but was knocked down after a few months by rafts, though a central bay of thirty feet had been left for their passage.

III.—WORKS AT AND NEAR DADOOPOOR.

Peculiar position of the Dadoopoor Dam.

33. The situation of the Dadoopoor Dam is a very peculiar one, and can hardly be understood without reference to a plan. It is built across the Sombe River immediately below its junction with the Putralla (which is here occupied by the Canal), and immediately above the junction of the united streams with the western branch of the Jumna. Thus three streams come together in one point, viz., the Sombe, Putralla, and Jumna; and two leave it, viz., the Rivers united in the Jumna on one hand, and the Canal on the other. The Canal

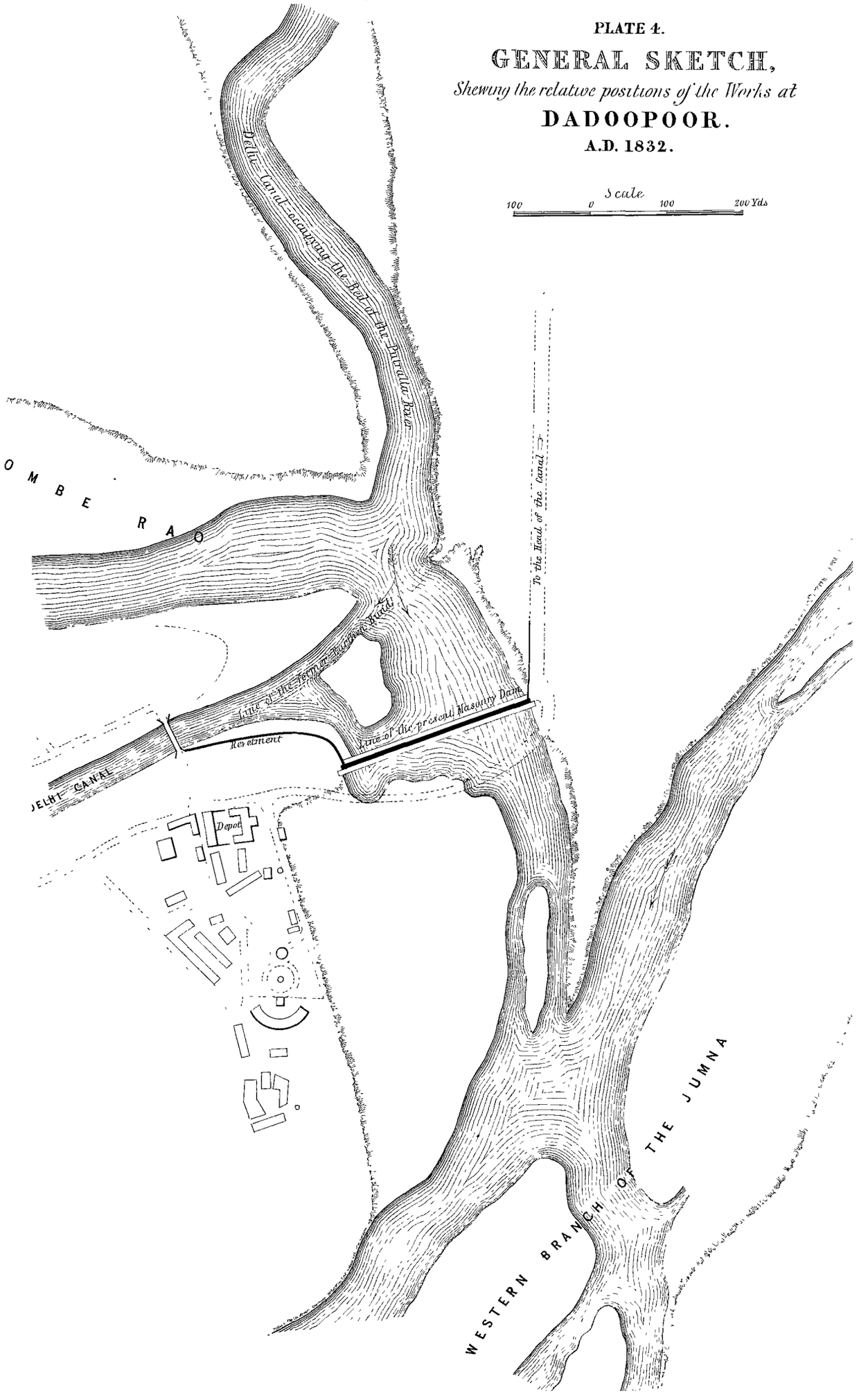
PLATE 4.

GENERAL SKETCH,

Shewing the relative positions of the Works at

DADOOPOOR.

A.D. 1832.



passes through an excavated channel parallel with the Jumna, into an old Nulla near the town of Boorreea. It was for many years carried across the Sombe by an earthen Dam annually renewed, and which was superseded by the present masonry Dam.

Inconvenience of the former earthen Bund.

34. The earthen Dam had been attended with so many inconveniences that the construction of a masonry work recommended itself at an early period to the attention of the Canal officers. The Bund being of great length was tedious in construction, and as no material but sand was available, could not be formed except across a nearly dry channel. The annual reconstruction of the work, after the periodic rains, could not be commenced before their entire cessation, and on the occasional occurrence of damage from a winter flood, repair was impossible, unless by breaking down the Bunds at the heads of the Canal, or at Choohurpoor.

Causes of delay in constructing the masonry Dam.

35. The causes of such long delay in the construction of this very necessary work were its anticipated difficulty and expense, both of which were over-rated in consequence of a mistaken idea of the nature of the soil on the proposed line of the Dam. On what information such a conclusion was formed I know not, but it was for a long time taken for granted that the bed of the Sombe consisted of pure sand to a depth of from 30 to 40 feet; and the system of masonry blocks being then unknown, it was supposed that a complicated arrangement of wells or cylinders would be required, at an expense which was either negatived by Government, or not proposed, under the idea that it would be considered greater than the expected advantage would warrant.

The difficulties overcome.

36. It was not before the year 1830 that Colonel Colvin ascertained the existence of a stratum of gravel, at a depth of 8 or 10 feet below the surface, and having remodelled his design, and formed his estimate accordingly, he seized the opportunity afforded by Lord William Bentinck's presence in the North-Western Provinces, to obtain the sanction of Government to the construction of the work.

Objections to a higher position for the Dam.

37. The selection of a site for the Dadoopoor Dam did not rest with Colonel Colvin, having been determined by the operations of his predecessors; but had an option been reserved to him it is doubtful whether he could have found a less objectionable position. Had he left the bed of the Putralla, in order to cross the Sombe higher up, a Dam would have been required for each of these rivers, and the

Sombe must have been crossed at a point where it is much wider and more rapid, and where it is surrounded by a wilderness of sand-hills.

Objections to lower position for the Dam.

38. The other alternative would have been to follow the Putralla a little further, and, having thrown the Canal into the bed of the Jumna, to have constructed the Dam across the latter River. The dimensions of such a work must not only have been proportioned to the far greater volume of water, but would, moreover, have been exposed to the risk of destruction by the main stream of the Jumna returning to its western branch.

Incidental advantages of the present position

39. On the other hand, there is one incidental advantage to compensate in some measure for the numerous evils which attend the present position of the Dam. It would seldom happen that a Sombe flood would occur, except when the Jumna also was in flood, and thus the fall through the Dam would be greatly diminished, and the tail floor of that work would be saved from much risk of injury.

Attempt to establish the Canal head at Kulsowra.

40. An attempt was indeed made by Colonel Colvin, in 1827-28, to establish the Canal Head in the Jumna at Kulsowra, about forty miles below Dadoopoor. The levels would have answered well enough, but the result of the experiment, which was abandoned after the first year's operations, was merely to shew the difficulty of establishing such a work in the Jumna or in a similar stream, after it has left the gravel and entered the wide and shifting sandy bed, so characteristic of the Himalayan Rivers.

Inquiry as to the possibility of diverting part of the Sombe drainage.

41. Amongst other expedients for mitigating the fury of the Sombe's floods, that of diverting a portion of its drainage into one of the rivers flowing towards the Sutlej, early engaged the attention of Colonel Colvin, who, soon after his appointment, satisfied himself that the main stream of the Sombe could not be diverted from its present course, and subsequently deputed Lieutenant Durand to survey the whole tract of country draining the Sombe.

Result of Lieut. Durand's survey.

42. The result of Lieutenant Durand's survey is on record in the Canal Office, in the shape of a beautiful map of the Sombe and Putralla drainage, and appeared calculated to set the question at rest—as it exhibited a bank from 40 to 100 feet high bounding the Sombe Valley from the Sub-Himalayas to near Dadoopoor—but the question was to be again renewed.

Suggestion for uniting the Sombe and Sursootie.

43. Early in the year 1843, my attention was called by the Suddur Board of Revenue to a suggestion of the late Captain W. Brown, who had been recently employed on the Revenue Survey of the Sikh States, and who supposed that the greater part of the Sombe could be diverted into the Sursootie, he himself, having in a specified locality, found the relative levels of these streams to be suitable to such an operation.

Is found to be worthless.

44. On proceeding to the spot, accompanied by Lieutenant Yule, the so-called Sursootie was certainly pointed out to us, but proved to be a Nulla easily traceable to the Sombe both in its origin and termination. On further inquiry we found that this Nulla was believed by the Hindoos to communicate with certain sacred tanks, supposed with equal probability to communicate underground with the real Sursootie, but the lowest of which was ascertained to be upwards of 40 feet above the level of the open Nulla by which it was supposed to be fed.

Description of the Dadoopoor Dam and Bridge.

45. The original work of the Dadoopoor Dam consisted of a flush floor, stretching across the bed of the Sombe, with abutments 12 feet 6 inches in height on each side, and divided into sixty openings of 10 feet each by fifty-nine piers 6 feet high, and 3 feet wide. The total width between the abutments is 777 feet. From the up-stream side of the east flank a straight revetment wall 12 feet 6 inches high and 300 feet long, enters obliquely into the left bank of the Putralla. The west flank revetment, in the form of a quarter ellipse 750 feet long, connects the Dam with a Bridge across the Canal, consisting of a timber platform supported on masonry piers, having two bays of 25 and two of 20 feet each, and front and rear curtain walls and masonry floors throughout. The height of the Bridge roadway is 12 feet 6 inches above the floor, in which also there is an ogee fall of 1 foot 6 inches.

Nature of the foundations and floors.

46. The foundations of the Dam consist of masonry blocks under the piers, connected in front and rear by lines of curtain walls. The floor is formed on flat arches abutting on the pier foundations. The depth of the blocks varies from 8 to 11 feet below foundation surface level; they all rest on a tolerably compact bed of gravel. In front and rear of the Dam there is an apron of stone and rubble masonry bounded by rows of piles 8 inches in diameter driven close together; and beyond this to the rear, there is another flooring of River stone, packed in cribs and secured by a line of tor piles about 5 inches diameter.

Overfall openings.

47. Several of the openings next to each flank are built up with ogee overfalls, diminishing in height towards the centre of the Dam. The object intended in this arrangement, and which has been effectually gained, is to keep the strength of the current in the centre of the work, and to prevent its setting along either of the abutments.

Piers.

48. The piers were originally built 6 feet high, but were subsequently raised 6 inches, and were coped with Agra stone. They are furnished with grooves to receive the sluice planks.

Present method of closing the Dam.

49. The means adopted for closing the Dam are for the most part separate planks 3 inches thick and 1 foot deep, hooped with iron, and having an eye at each end for the insertion of an iron hook with which they are lifted.

Intended arrangement of the Dam Sluices: including a Bridge.

50. It was originally intended by Colonel Colvin, that the lowest 3 feet of the bays should be closed by sluice-gates, opening in the centre, and hung vertically on hinges attached to the piers. These gates were to be closed by means of iron studs on their upper surface, fitting into sockets cut in a drop shutter, suspended on a windlass fixed on the tops of piers connected at the height of 12 feet by a roadway. This part of the design was at first postponed for the sake of economy—the piers were built only 6 feet high, with a purpose of raising them afterwards, and adding the superstructure above described. The hinge pivots for the gates were, in anticipation, built into the piers.

Reasons for abandoning the design of a Bridge.

51. During the first floods, however, after the construction of the work, it was observed that trees and brushwood, and especially rafts of timber, were brought down in great quantities, and for the most part, were washed over the Dam; but when by any chance they stuck on the piers, they were jammed against them, and collecting grass and rubbish caused a serious obstruction to the waterway. These circumstances at once pointed out to Colonel Colvin the inexpediency of carrying out his original design; as, if the piers were carried up to 12 feet and connected by a roadway, no rafts or large trees could possibly pass them, and some serious accident would probably ensue. It was therefore determined to abandon the design of a Bridge, and with it, that of vertically hung sluice-gates.

Dangers threatened to the works from various quarters.

52. The peculiar position of the Dadoopoor works in the centre of a knot of Rivers all liable to freshes and having no established beds, has exposed them to many dangers which may be described separately with reference to the several Rivers from which they arose.

53. The Putralla (or rather the collected floods which now pass down its channel) sets straight upon the Dam, and has hitherto confined its attacks to the east revetment, on which it set during the first year after its construction, and washed out the soil from the foot of the wall, causing it to bulge slightly from the pressure of the earth in the rear. The soil thus removed was replaced with a solid floor of stone packed in cribs, extending along the whole front of the Revetment, which was further backed by a wall of unburned bricks to assist in supporting the pressure of the sand. The Putralla's attack on the east flank.

54. The Putralla's next attack was an attempt to turn the east flank of the Dam, by cutting into the bank, about 300 yards above the extremity of the east revetment. The encroachment, as is usual with these Rivers, proceeded at a rapid pace, but was finally checked by a series of Spurs formed of cribs filled with stone, secured with piles, and placed in echellon, so that the head of one was protected by the tail of the other. The results of this measure, which was carried into execution in 1842, have been completely satisfactory. Its attempt to turn the Dam.

55. The Jumna has been, from first to last, a source of danger to the Dadoopoor works. Both above and below its confluence with the Sombe, it has shewn a strong tendency to cut into its right bank, between which and the Canal, the space is already so limited that any further encroachment would endanger the stability of the works. Dangers from the Jumna.

56. This danger had been foreseen by Lieutenant Blane, who either excavated or improved two channels (which still bear his name) considerably to the eastward of the present course, and which, had the River taken to them, would have saved his successors from all anxiety on that head. Foreseen by Lieut. Blane

57. Unfortunately, however, such was not the case, and in 1832, the Jumna commenced an encroachment towards the Canal about half a mile below the village of Dadoopoor, and opposite the Kharwan Ghat, and proceeded with such determination of purpose, as in a few weeks to diminish the space between the two streams to less than 100 yards. The danger was met by Colonel Colvin with characteristic energy. He commenced operations along the whole line, from the debouche of the Sombe to the point of attack. He deepened and widened all the channels having an easterly direction; obstructed those flowing to the westward with Bunds formed of gravel, of cribs and piles, of gabions, or of wattled stakes, according as greater or less strength was required; Attack on the Canal below Dadoopoor, and how repulsed.

and undiscouraged by some failures at first, he persevered in these measures, and finally succeeded in diverting the Jumna from the proximity of the Canal. The deep loop excavated by the River in 1832, is now filled up with silt to the highest flood level, and bears an annual crop of grain.

Attack upon the Dam.

58. The next serious attack of the Jumna was commenced in 1843, and was directed against the left bank, immediately above the Dadoopoor Dam.

The disastrous effects and ultimate consequences of this attack.

59. Having about this time been relieved from the charge of the Delhi Canal, I know not the detail of the measures resorted to, except that one of them was the commencement of a new cut along the left bank of the Jumna (now called Boileau's Cut).

It would appear, however, that the means used were ineffectual, and after the rains of 1845, when these Canals were again placed under my general superintendence, I found that the tongue of land which formerly extended down stream from the east abutment of the Dam, and separated the Sombe from the Jumna, had been completely carried away, and that the Jumna not only threatened to break into the Putralla above the Dam, but was in the mean time setting directly on the tail of that work. The consequence of the Jumna floods meeting those of the Sombe on the very Dam floor, had been that the level of the water had risen to an unprecedented height, and that the greater part of the Sombe had been forced down the Canal, endangering the safety of the works, and choking up the channels with silt.

Remedy proposed by Capt Boileau

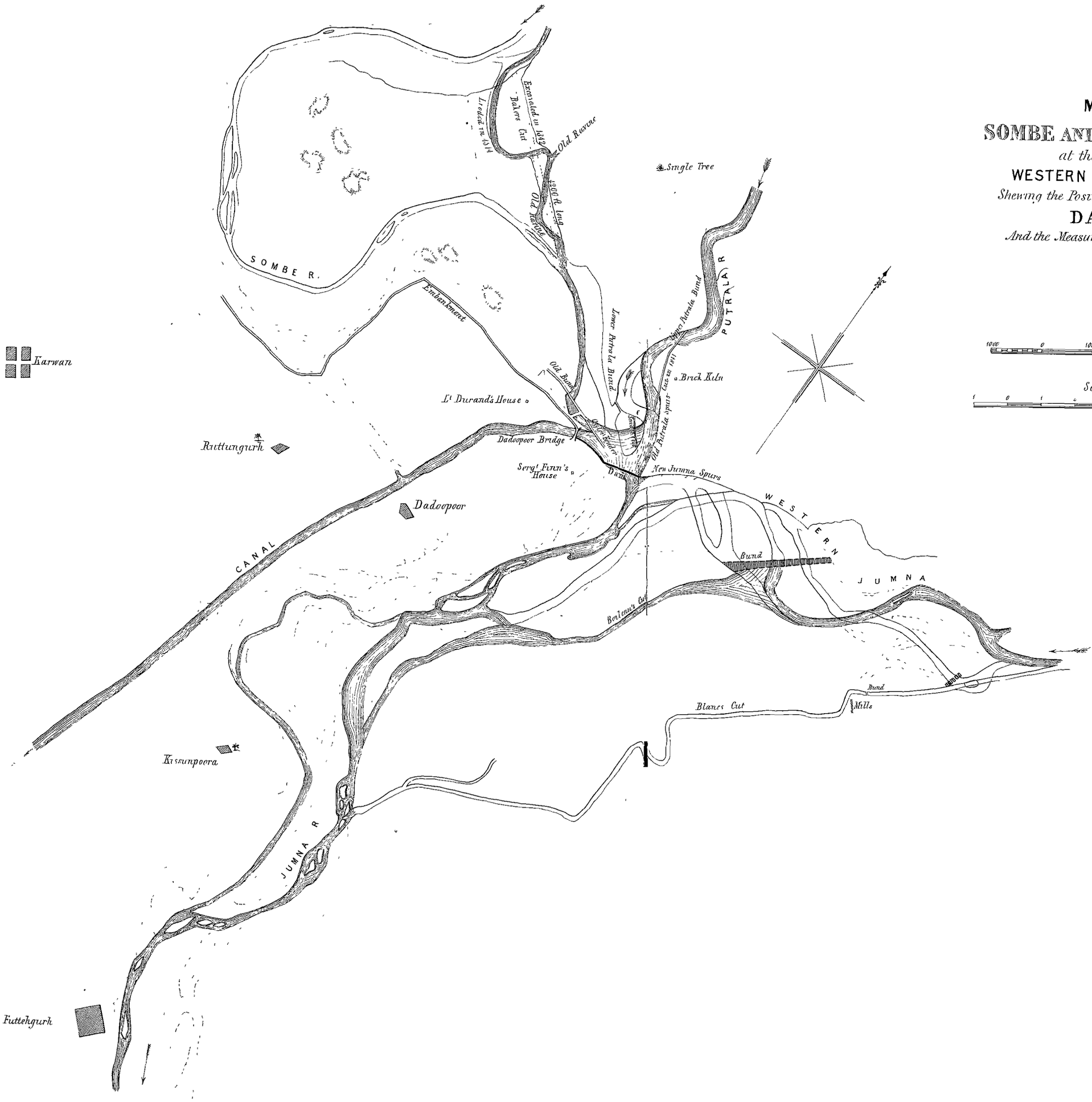
60. The remedies proposed by Captain Boileau (who had then just relinquished the charge of the Western Canals) were the completion of the cut alluded to in the foregoing paragraph, the construction of a masonry jetty 300 feet long, down stream from the west abutment of the Dam, and the protection of the banks by a series of crib-spurs in echellon, similar to those which had proved successful in the Putralla. He intended also to propose re-opening one of Blane's Cuts, the head of which is about $1\frac{1}{2}$ mile distant from the Dam.

Measures carried into operation

61. These measures have been partially carried into effect, with one important addition, viz. the construction of a substantial Bund of crib-work across the bed of the Jumna, in such a direction as to set the water into Boileau's Cut, which was deepened and widened in order to receive it. The Spurs along the bank were constructed, the block foundations of the masonry jetty were sunk to their full depth and surmounted by a superstructure of crib-work, and measures

PLATE 5

MAP OF THE
SOMBE AND PUTRALA RIVERS,
at their Junction with the
WESTERN BRANCH OF THE JUMNA,
Shewing the Position of the Dam and Works at
DADOOPOOR,
And the Measures adopted for their Protection
A.D. 1846.



Scale of Feet

1000 0 1000 2000 3000 4000 5000

Scale of Furlongs

1 0 1 2 3 4 5 6 7 8 9

were taken to throw into Blane's Cut as large a quantity of water as that channel was calculated to carry off.

62. The Bund, as I had fully anticipated, was turned on both flanks, and partially injured by the floods of 1846; but it sent a strong sweeping current down Boileau's Cut, which it much improved. So small, indeed, was the stream that flowed towards the Dam, that no displacement of the crib-work took place, and the Sombe had a free vent for its waters. Effects during the first season.

63. During the cold weather of 1846-47 the Bund was repaired, the Head of Blane's cut re-opened, and two additional channels were led into it from the Jumna at different points. Subsequent measures.

64. During the rains of 1847 the works stood admirably; but as the floods of that season were unusually light, their sufficiency was not very severely tested. Their success in the succeeding rains

65. The injuries to the Canal works, inflicted and threatened by the Sombe, have been even more serious than those already enumerated. Injuries from the Sombe.

66. There was at one time considerable ground for apprehension that the River would cut into the Canal near the village of Kharwan, and opposite the point which had been threatened by the Jumna in 1832. The Sombe, after passing Chichrowlee, made a wide sweep to the right, and after flowing under the high land of Balachore, returned into its former line, about half a mile above its junction with the Putralla. Its attempt to cut into the Canal at the Kharwan Ghat.

67. The tendency of the River to deepen this loop had been watched with much anxiety, for many years, by the successive superintendents of the Canal, and had been retarded and partially checked by the construction of Spurs and embankments. In spite of all precautions, however, the evil gained ground, and in 1841, the encroachment having now reached a natural hollow communicating directly with the Canal, it became necessary to have recourse to active measures. Ineffectual expedients tried.

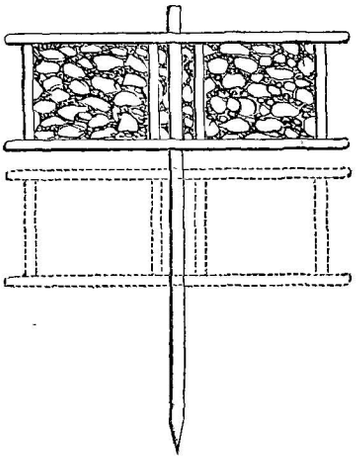
68. A new channel, now called Baker's Cut, was accordingly excavated across the neck of the loop; and though of small dimensions at first, it was speedily widened by the action of the stream, which in two years had completely deserted its former circuitous course. The Final remedy.

cutting in the new channel has been chiefly into the right bank, in the direction of the old loop, and this encroachment may hereafter require to be checked; but I see no immediate prospect of danger from this source.

Attack of the Sombe on the Dam flank.

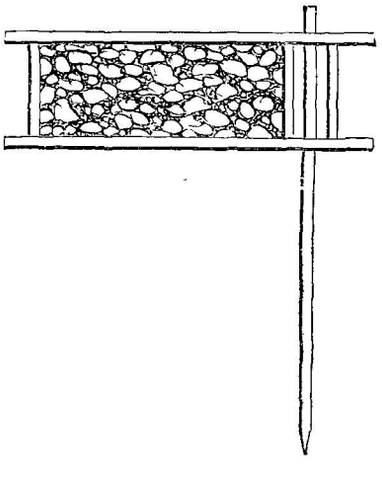
69. It was the last flood of the season of 1834 that first made an inroad on a long spit or tongue of land, by which, before the construction of the Dadoopoor Dam, and for a short time afterwards, the mouth of the Canal was protected from the rush of the Sombe floods. Immediate measures were taken to divert the River from a course by which, if persevered in, it would at once throw a much larger portion of flood-water into the Canal, and might eventually cut into the channel below the bridge.

First Breakwater in the Sombe.



70. A long line of cribs filled with stone and secured with piles driven through the centre, was first formed on the line of the Old Bank, or a very little retired behind it. The cribs were hung loosely, as it were, on the piles, so that they might, if undermined, sink freely by their own weight—and assume the position shown by the dotted lines in the annexed sketch; but this plan met with only partial success, and the stream frequently undermined one side only, causing the whole to fall forward and press out the piles. The line, too, was found to be too forward, and to offer too direct an opposition to the force of the current.

Subsequent modification of this work.



71. In the following year a new line was taken up more retired than the former one —and a new form of cribs was adopted— the piles being driven on the outer side. This work stood better than its predecessor. Some few of the cribs indeed were washed away, but the greater part sunk vertically round the piles and formed a solid foundation for future work. In the mean time, however, the Sombe had so far cut away the Bank in the direction of the Canal Bridge, that the force of the floods regularly broke upon (and in two instances over) the west revetment, and so violent was their action on one occasion during the rains of 1836,

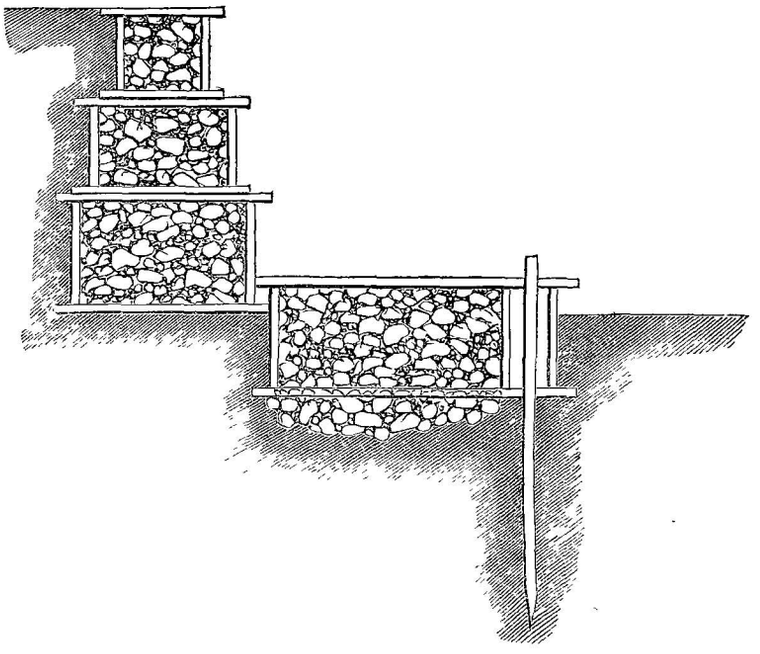
that the foundation of a large part of the revetment was laid bare, and about 100 feet of the wall fell forward into the Canal.

Permanent remedy proposed by Colonel Colvin.

72. A design was now submitted to Government by Colonel Colvin, which, had it been executed (as it might have been at that time with comparative facility) would have afforded an effectual remedy for the evil, and would have cost less in the end than the temporary expedients which were actually adopted; and which have entailed a heavy annual expense in repairs. Colonel Colvin proposed to revet with masonry the remains of the salient point between the Sombe and the Canal; and to construct, across the Canal channel, a regulating Dam, of which one abutment would rest on the salient point above mentioned, and the other on the west revetment of the Dam.

Half measures actually adopted.

73. Unfortunately, the Government, or the Military Board, preferred the apparently cheaper alternative of revetting the Sombe point with crib work, and extending and raising the "Fender" or Breakwater, the latter was formed of two, and in some places three tiers of cribs diminishing in width towards the top, and secured with piles in the manner above described. The revetment of the Sombe point consisted of three tiers of cribs also diminishing towards the top, the foot of the lowest one being protected by another crib three quarters sunk into the ground, and secured with piles in front. This outer crib, though filled with stones, was left without bottom rails, to admit of the stones falling through, and replacing the earth which might be washed out from underneath the crib.



Their imperfect success.

74. The work thus constructed stood as well as could be expected, and undoubtedly saved the salient point from further diminution, but it had little effect in keeping the Sombe floods out of the Canal, or in protecting the works. In 1845, the chief set of the Sombe current was again directed on the west flank revetment by a too great extension of

the Breakwater; and on this occasion two portions of wall were undermined and fell.

Final adoption of Col. Colvin's plan.

75. In discussing the repair of this damage, and the renewal of the wood-work of the crib revetment which had now (after eleven years) become requisite, it was again and successfully recommended to Government to sanction the construction of the work originally proposed by Colonel Colvin. The foundations were commenced in May 1847, and considerable progress was made during a temporary stoppage of the Canal. It will now be completed as opportunity may offer.*

Remarks on the present Bridge as a possible Regulator.

76. It may probably strike the reader, that the present Bridge should have been built with sluices as a regulator; or that it might now be converted into a work of that description. It might, in my opinion, have been better to have constructed a regulating Bridge as part of the original design; but the necessity of such a work was then not so apparent as it is now; the mouth of the Canal was more effectually screened from the floods, and it was feared, that had the Bridge been closed, the space in front of it would be liable to silt up in every flood.

Measures proposed and adopted for that purpose.

77. A project for fitting the Bridge with sluice gates was unsuccessfully submitted by me about the year 1841, when the space to receive silt had been greatly curtailed, and a temporary measure for that purpose was actually carried into effect in the rains of 1847, and successfully excluded the floods of that season. It is admitted, however, that the foundations of the Bridge were not originally calculated to support a great pressure of head water, and there cannot be a doubt that the measure now in progress is in every respect preferable.

Workshops, &c. at Dadoopoor.

78. Two ranges of buildings have been erected at Dadoopoor, and connected by curtain walls so as to form a quadrangle; they are occupied as workshops and godowns, and by the Canal establishment. The workshops are very efficient, and supply the greater part of the tools used in the department.

* I have since learned that the foundations of this work have been completed by Lieut. Turnbull during the current year (1848).—W. E. B.

IV.—FROM DADOOPOOR TO KURNAL.

Canal channel—Dadoopoor to Boorreea.

79. The Canal channel between Dadoopoor and Boorreea, though artificial in origin, has completely lost the character of an excavated cut. The large volume of the Canal supply, and more especially the immense body of water thrown into it during floods, have caused a great and very irregular enlargement of the channel, and their encroachments on the roads and plantations near Dadoopoor, have only been checked by a complicated system of Spurs, sometimes of crib-work, but more generally of wattled stakes. Near Boorreea, where the Canal occupies a deep natural channel, the cutting is still more serious, and is, I fear, irremediable, except by an expenditure disproportioned to the object.

Nature of channel and soil, from Boorreea to Kurnaul.

80. From Boorreea to the old Bridge about six miles south of Kurnaul, the Canal follows a nulla, which is, generally speaking, the western boundary of the Jumna Khadir. It passes in its course, through several natural jheels or swamps, and receives the drainage of a strip of bangur land to its right. The level of this nulla is, throughout, not very different from that of the Jumna, and it shares with that River the disadvantages of a surplus fall expending itself in endless windings with a consequent tendency to shift its course by cutting away one or other of its banks. The soil through which it flows is of a very yielding nature, and either naturally saturated with water or so permeable to it, that excavations made in the vicinity of the Canal and below its level are speedily filled with water.

Subsequent modifications of the natural channel

81. Though of small dimensions at first, the channel was sufficient for the wants of that period, and has subsequently widened and deepened itself in proportion to the increased volume of water, but the formation of the requisite embankments has been a source of great expense and difficulty, in consequence of the bad quality of the soil and the undermining action of the current. And even after the formation of the embankments, there was still the difficulty of providing for the country drainage, which, finding its natural outlet occupied by water at a higher level, could only stagnate, and form swamps outside the Canal bounds.

Insufficiency of the channel during the famine of 1837-38

82. During the early part of the famine of 1837-38, when the demand for water was suddenly doubled and every effort was made to complete the supply, the embankments previously formed were found insufficient, and the water overflowed them in many places, and on both sides of the Canal. Such remedies as could then be applied, were

immediately resorted to, but attention was chiefly directed to prevent the escape of water to the eastward, as its spread to the west was circumscribed by the proximity of the Bangur Land.

Method of embanking through the Jheels.

83. I subjoin a brief description of the method adopted in forming embankments through the more extensive jheels, many of which were natural, but in all cases aggravated by the presence of the Canal. A sufficiency of earth was brought at any cost, to form a slight mound of "dowl" along the line of intended bank, and formed a nucleus, round and in front of which deposits of alluvial soil were generally found to accumulate. These deposits were excavated and thrown back, as opportunity offered, until the requisite section of embankments was obtained.

Method adopted for diminishing the swamps

84. For draining the swamps which existed outside the embankments—whether naturally, by percolation, or by accumulated drainage—no other feasible method presented itself but that of lowering the Canal level, which was effected in several instances, such as at Indree, Singhooa, and Kylas, by cutting across the neck of a long loop in the Canal, and thus increasing the fall by shortening the distance. There was some risk in thus disturbing the natural regimen of the bed, but it has been attended with no ill effect, and has certainly relieved a large tract of land from the effects of inundation.

Another method alluded to—not recommended

85. It has been suggested that the swamps might be drained by machinery, turned either by a stream from the Canal, or by windmills, as is commonly practised in Holland; but, though I have little doubt that such a scheme is practicable, a rough calculation of the expenditure and means required to carry it into effect, satisfied me of its inexpediency, under existing circumstances.

Present state of Embankments, and proposed operations.

86. The embankments, in their present condition, completely prevent the escape of water by direct overflow: they were made originally, and still generally remain, 12 feet wide at top, though less in some places where they have been cut away by the current. They are not, however, very passable, being formed for the most part of soft spongy soil, and overgrown with reeds, which spring up very rapidly after being cut. It is intended that these banks shall be gradually widened and improved, and with this object it was proposed by me, and approved by the Military Board and by Government, that the Executive Superintendent should annually estimate what he could advantageously and economically spend, during the ensuing year, in perfecting the banks, and forming a continuous passable road on one side.

87. The natural disadvantages of soil and profile on the present line, though they have been obviated in some measure by the means above described, and are susceptible of still further palliation by following out the same course, are still such as can never be entirely removed; and, should it be considered advisable that these Canals, throughout their length, should be brought at any cost to the highest degree of efficiency of which they are susceptible, the most likely, if not the only, way of effecting that object, would be to abandon the old line between Dadoopoor and the Delhi Road Bridge (6 miles south of Kurnal), and to carry the Canal through the Bangur land with a uniform bottom slope of 15, or 18 inches per mile. The expense of such an undertaking would be very considerable, as, besides the excavation and bridges, it would involve two or three sets of masonry falls, to dispose of the surplus, slope, and three or four aqueducts for principal lines of drainage, which now enter the Canal at its own level, but which flow in wide and deep valleys through the Bangur land. The advantages of a better regulated channel and sound embankments, though undoubted, would still in my opinion be insufficient to justify so large an outlay, unless it could be satisfactorily shown that a great saving of water would be effected by the successful execution of the proposed measure.*

Method of overcoming the disadvantages of the present Channel.

88. The Saharunpoor and Umballa Road crosses the Canal, near the village of Madhilpoor, 2 miles below Boorreea, by a bridge consisting of a timber platform supported on piers of masonry. The estimate for this work was submitted by Colonel Colvin in 1835, and the foundations were commenced in the following year, by the close of which the bridge was completed.

Masonry work—Madhilpoor Bridge.

89. A previous examination of the soil by boring, had led to the belief that there was a stratum of firm clay at a certain depth below the sandy bottom of the Canal, and it was determined to adopt the system of block foundations, which had succeeded so well at Dadoopoor and elsewhere. The work was divided into three portions, which were successively enclosed in coffer-dams; but as it was found impossible, with a full supply in the Canal, to reduce the water in the coffer-dam below

Oversight in laying the Foundations—how remedied.

* It is by no means certain that a great saving of water would result from this expensive measure. The new course would lose one source of supply enjoyed by the present line, while it would be exposed to one cause of waste from which the latter is exempt. The Canal now occupies a natural channel, which receives the drainage of a considerable tract of moist soil, and has a stream of its own, fed by springs in its bed. The precise value of this supply has never been accurately measured; but it has frequently proved itself sufficient to maintain a stream in the Canal, when no water was passing the Dadoopoor Bridge. This resource would be lost to the new line; which moreover, being carried through higher and drier strata, would be liable to greater loss by absorption.

the level of the proposed foundation surface, it was determined to build the blocks of cemented brick work, of the precise height required for the foundations, and to add three or four feet of brick work without cement, to supersede the necessity of baling while the work was in progress. It so happened, however, that under one of the piers the stratum of clay was not met with till about 2 feet lower than had been expected, and the sinking having been inadvertently continued, the surface of the cemented masonry was found to be about 1 foot 6 inches below the level to which the water could be reduced. To meet this difficulty, cubes of masonry of 2 feet sides were built on the land, and, after the mortar was set, were lowered on to the blocks, so as to form a solid platform, on which the superstructure was raised. This incident is here mentioned, as a warning not to stint masonry under similar circumstances.

Flooring of the Madhilpoor Bridge.

90. A flooring of river stone laid without cement, and protected by rows of piles, was originally formed, but considerable cutting subsequently took place, and cribs were laid in the floors of the two bays most exposed to the current.

Accident to the East Abutment.

91. The Madhilpoor Bridge was severely tried during the period when the Sombe floods were thrown so completely into the Canal, and, in the year 1846, during a remarkable flood, the east abutment was turned and much shattered; it has since been restored, with an elongated wing wall on the up-stream flank.

Proposed water communication with the Jumna.

92. Since the period when the natural difficulties of bringing rafts of timber over the rapids of the Jumna, have been increased by the abstraction of a large portion of the water for the supply of the Canals, it has been customary for much of the timber destined to be rafted down the Jumna from Rajghat, near Chilkana, to be brought down the Canal to Madhilpoor, and thence carried overland, a distance of about 3 miles, to the river. To facilitate this transport, and thus compensate to the rafters for the inconvenience to which the Canal operations had subjected them, it appeared possible to contrive a water communication between the two streams, with a lock at either end. The levels were found suitable, but the project had not been matured at the period of my departure for Scinde, and appears to have been lost sight of by my successors. It is now recommended to the attention of the present Superintendent, in the confident anticipation that, with this addition, the Canal will afford, from the Jumna forests to Rajghat, a safer, more expeditious, and in every way more eligible passage than has ever been afforded by the Jumna.

93. At Kanjnoon there is an old escape overfall, communicating by a long circuitous nulla with the Jumna. The escape was first built about 300 yards above the present site, but sustained some injury, and the level of the Canal bed having changed, the construction of a new work was considered preferable to the repair of the old one, which was therefore abandoned. Old Escape Overfall at Kanjnoon.

94. The new overfall was built in 1819 or 1820, is founded on piles and gratings, and has subsequently been fitted with small piers of masonry to support planks. A small building was also erected on the west flank to receive the planks and stores. A portion of one of the revetments was injured in 1843, but has since I believe been restored. New Overfall at Kanjnoon.

95. The Kanjnoon Overfall has never been very efficient as an escape. The nulla into which it leads, having less fall than that of the Canal, was speedily choked with silt. It was cleared out at an expense of 8,826.13.9 rupees in 1839, but remained efficient only for a few months, and is now seldom used. Kanjnoon Escape Nulla.

96. In 1845, a bridge with piers of masonry and timber roadway was constructed by Captain Boileau, over the escape nulla near the village of Nachroun. Nachroun Bridge.

97. The Rudour Bridge, about 2 miles below the Kanjnoon Escape, was constructed in 1842. It is similar to the Madhilpoor Bridge, with exception of the parapets, which consist of horizontal rails instead of trellis work. The Rudour Bridge was the first work in which it was attempted (and with complete success) to sink the foundations of the piers and abutments in one piece, instead of separate blocks. Rudour Bridge.

98. At Indree, about 16 miles lower down the Canal, there is an iron suspension bridge with vertical drop bars. The distance between the points of suspension is 102 feet, and the width of the roadway is 9 feet. The iron work was made in Calcutta, by Captain J. Thomson, of Engineers. The standards of this bridge are founded on rectangular blocks of masonry, undersunk to a depth of 30 feet below foundation surface level. The bridge has sustained no injury since its first construction. It is not much frequented, and, from the narrowness of its roadway, and slightness of construction, is not calculated for heavy traffic. Indree Suspension Bridge.

99. The first class Chokies of the northern division below Dadoopoor, are those of Madhilpoor, Kanjnoon, Buddee-Buddurpoor, and First-class Chokies.

Indree. They are all of different patterns, and afford different degrees of accommodation. A subordinate first class Chokie at Singhooa has been sanctioned by Government, but was not commenced at the date of my last inspection.

Second-class Chokies.

100. There are second class Chokies at Moonda Majra, Putasgurh, and at the Rudour and Indree Bridges. These are rectangular flat-roofed buildings, with plank and batten doors, and containing only one room.

V.—CHANNELS AND WORKS AT OR NEAR KURNAL.

Boodha Kheera Escape Outlet.

101. The Boodha Khera Escape Outlet, about two miles above the Cantonment of Kurnal, was designed and estimated for by Colonel Colvin, and constructed by myself in 1836-7. It consists of sixteen arched openings each 5 feet wide, closed by drop shutters worked with windlasses. The sill of these openings is $2\frac{3}{4}$ feet above the tail floor, and about $7\frac{1}{2}$ feet below the full supply level of the Canal. On the right or up stream flank of the work, there is a semi-circular Chokie. The roadway is 12 feet wide between the parapets, and serves for the communication on the Kurnal and Saharunpoor Road.

Escape Nulla.

102. In consequence of the strong fall in the floor of this work, it is very efficient as an escape, and has been of the greatest use in the regulation of the Canal supply. The Nulla itself, in consequence of its windings, has less fall than could be wished, but will probably be able to keep itself clear with little assistance from artificial excavation.

Trestle Bridge over Escape Nulla.

103. A bridge was constructed in 1840, over the Escape Nulla on the Kurnal and Meerut Road, near the village of Sheikhpoora. The platform is of timber, the abutments of masonry, founded on wells, and the piers are trestles resting on piles. The work itself has stood uninjured, but it was once turned by an accidental encroachment of the Jumna, which was obviated, and has not occurred again.

Boodha Kheera Wier and head of Mill Channel.

104. About half a mile below the Escape is the Head of the Kurnal Mill Channel, connected with an overfall bridge or wier across the Canal. The primary object of this latter work, was to raise the level of the water in the Mill Channel, but it also serves as a regulator

in connection with the escape. The roadway of the Mill Outlet is of masonry; that of the bridge is of timber on masonry piers. There are three bays of 25 feet closed by sluice gates, having two extra supports between the grooves.

Accident to the Abutment Wing Wall.

105. This work and the attached head of the Mill Channel were built in 1833, and are now in good order. The down stream wing wall of the Right Abutment of the Wier was undermined by an eddy of back-water and fell down in the year 1838, but was refounded on piles, and has since stood well.

Kurnal mill Channel and Mills.

106. The Mill Channel is crossed by several small bridges. The mill buildings are calculated for twelve pairs of grinding stones, and a set of saw machinery, with the necessary godowns attached. The water returns into the Canal below the town bridge; a necessary arrangement, but one which has placed the machinery at a great disadvantage. The channel, both above and below the mills, was affected by every variation of level in the Canal. The fall, indeed (which was barely sufficient for the purpose), remained in all cases nearly the same; but not so the back water, which had a range of about 3 feet, and to this extent it was necessary to shift the level of the supply tubes, and of the overshot wheels, which cannot work below water. Should there be a prospect of the Kurnal Mills being again worked, I would recommend the substitution of turbines for the present machinery.

Experimental stoppage of the Mill Channel.

107. The mills have not been rented since the abandonment of the Kurnal Cantonment; and as the former unhealthiness of that station was by some attributed to the rice cultivation supported by the Mill Channel, that also has been experimentally stopped for the last two seasons, and will now require a considerable clearance of silt before it can be re-opened.

Kurnal Cantonment Bridge.

108. The Cantonment bridge of Kurnal has three semi-elliptical arches, built in brickwork. The spans of the centre and side arches are respectively 30 and 27 feet. The height of water-way is much too low for the present supply of the Canal, which stands 10 feet on the floor of the bridge.

Kurnal Town Bridge.

109. The Town bridge is also of masonry, and has five arches of 26 feet span; and, in consequence of the greater width allowed for its passage, the water does not rise so high on this, as on the cantonment bridge.

Workshops, &c.

110. There are a few store godowns and workshops attached to the Canal depôt at Kurnal, and a bungalow has lately been purchased to serve as a first-class Chokie.

Canal channel—Boodha Khera to Kurnal.

111. The Canal channel, from Boodha Khera to the town bridge, winds from side to side of a natural hollow much wider than itself, leaving strips of marsh on each side alternately. The sides of the hollow are securely embanked (masonry inlets being provided for the country drainage); but the water has purposely beeen allowed to spread, and has even been introduced by cuts into the side marshes, in the hope of silting them up, a hope which would have been fulfilled many years ago, had not the level of the Canal supply been raised 4 feet since the silting process was commenced. As it is, however, great progress has been made, and unless the Canal should rise still higher, there will be few or no swamps a couple of years hence.

Proposed drainage tunnels under the Canal.

112. It has been supposed that the unhealthiness of Kurnal was in a great measure occasioned by the drainage of the cantonments being intercepted by the Canal embankments, and a plan was suggested for concentrating this drainage, and conveying it under two tunnels to the Jumna. As an engineering operation such a plan is perfectly feasible, but it is doubtful how far it would improve the salubrity of the station, which is affected by many other causes.

VI.—FROM KURNAL TO THE RAIR REGULATOR.

Channel and embankments—Kurnal to Rair.

113. For about six miles below Kurnal, the Canal follows the circuitous course of a natural nulla, in which the water is held up to a higher level than that of the country, and causes a good deal of swamp on both sides. It then enters the Bangur land by a wide excavation, and continues within soil as far as the village of Phoorluk, from whence to Rair it is again slightly above the level of the country. The embankments between these points were nearly complete at the time of my last inspection, being on the west and east banks respectively 16 and 10 feet wide at top.

Masonry works—Kurnal to Rair.

114. Among the masonry works on this line is the old native bridge on the Kurnal and Delhi Road, a massive structure of three arches. The roadway is very high, and was formerly inconvenient

for wheel-carriages, on account of the blocks of kunkur with which it was paved. It has now been macadamized, and, the ramps being kept in good order, it no longer offers any obstruction to travellers. The bridges of Phoorluk and Raipoor have timber platforms on masonry piers. One abutment of the former was undermined and thrown down, during the floods of 1845, but has since been renewed. Both these bridges have been raised two feet to meet the higher level of the Canal.

Head of the Bulla Canal.

115. Two miles above the Rair Regulator is the head of a supply branch or feeder to the Hansi Canal (called also the "Bulla Branch Canal"), which will be more particularly adverted to hereafter. The work was built with reference to a lower level of the Canal, and is now nearly buried in the water.

Chokies.

116. The 1st class Chokie at Phoorluk is near the bridge of that village, with which it shared the injury caused by the flood of 1845. There are 2nd class Chokies at the Delhi Road Bridge, and at the head of the Bulla Branch; the latter is nearly uninhabitable from damp.

Irrigation outlets.

117. In this portion of the line there are numerous masonry outlets for irrigation, which is extensively practised on both sides of the Canal.

Rair Regulator and method of working it.

118. The separation of the Delhi and Hansi Branches is effected by a double bridge, connected by the up-stream wing revetments, the Delhi Branch having three, and the Hansi Branch two arches, by the capacity of which it was originally intended to regulate the supply without the aid of sluice gates, which formed no part of the first design. This simple division answered well enough, until irrigation was fully established on the Western Branch, when it became needful to stint the Delhi Canal (whose superior fall gave it an undue share of the supply), by furnishing the side arches of its bridge with drop-shutters, and partially obstructing the waterway of the centre arch with vertical spars or Pharas.

Alterations made by Capt. Boileau.

119. In the year 1844, with the hope of increasing the draught down the Hansi Branch, Captain Boileau removed the masonry arches of its bridge, and purposed to have added a third bay.

Mode of regulation to be improved.

120. The present method of regulation, though efficient for all practical purposes, has certainly a clumsy appearance, and as there can now be no doubt that some obstruction will always be required in the

centre arch of the Delhi Bridge, a neater contrivance might be adopted with advantage.

Method suggested.

121. I would not recommend the use of a common horizontal drop shutter, which would cause the water to fall, as over a Wier, on the floor of the bridge, whose foundations are not calculated to sustain the shock; but I see no objection to the use of a shutter having "stilts" or projections from its lower edge, which would secure a clear waterway under it.

Past and present condition of the work.

122. The main body of this work has stood very well, under a press of water, with which it was never intended to cope—the want of deep foundations being compensated by counter-arches under all the bays. The outworks of the bridges have, however, suffered a good deal, The down-stream wing walls and revetments of the Delhi Bridge have been undermined and partially ruined; and those of the Hansi Bridge (since Captain Boileau's alteration) have likewise cracked seriously. In the former case, the mischief is undoubtedly caused by the unchecked erosive action of the stream below the bridge by which it was dammed up, and where the natural soil has been washed out to a depth of 12 to 16 feet. This vacuity was refilled with masses of kunkur, which, however, are themselves liable to displacement, and require frequent renewal. The depths of water should be frequently sounded, and any hollow should be immediately filled up with kunkur or other heavy material kept in readiness for that purpose. As long as this practice continued, no injury occurred to the work.

Chokies at the Rair Regulator.

123. On a salient angle between the two bridges there is a small building available as a Chokie or store-room; and at a short distance, between the two canals, there is a 1st class Chokie uninhabitable from damp. The floor of this building has been raised 3 feet, but the damp has followed it, and I fear will not be evaded, unless by building a second story, or by constructing a new Chokie in a drier locality, if such can be found in the neighbourhood.

VII.—NEW SUPPLY BRANCH OR BULLA CANAL.

Objects of the Bulla Canal.

124. As connected with the regulation of the supply to the Southern and Western Branches, it may be proper to notice the Bulla

Canal, which was intended to throw a supply into the Hansi Branch below the points from whence the channels towards Rohtuk and Bootana are taken off, and the formation of which by Col. Colvin, may be received as evidence of that officer's conviction that the regulation could not be satisfactorily arranged at Rair. It is true, indeed, that the Bulla Canal has placed the advantages of Canal irrigation within the reach of a great many new villages, which have availed themselves of it to an extent, which in some measure interferes with the primary object of the work; but this subsidiary purpose might have been secured as easily by means of Rajbuhas.

Channel and embankment

125. The length of the Bulla Canal is 11 miles. The original bottom width was 10 feet, at which it has been maintained as nearly as possible by periodical clearances. The embankments are formed on each side to an upper width of 10 feet, and are kept in good repair.

Masonry works on the Bulla Canal.

Head Regulator.
Moonuk Bridge.
Hansi Road Bridge.
Bal Pybyana Bridge.
Bulla Dam Bridge.
Golee Bridge, No. 1.
Golee Bridge, No. 2.
Didwaree Bridge.
Khatela Bridge.
Inlet Overfall Bridge.

126. Including the works in the Canal embankments, through which respectively this channel leaves the main Canal and joins the Hansi Branch, it has ten Bridges, as per margin, of which those of Bulla and Didwarree are Dam Bridges, having sluice-gates to raise the water for irrigation. There is a 2nd class Chokie at Golee.

VIII.—DELHI BRANCH—RAIR TO BOWANNA.

Channel and embankments

127. From Rair to about 2 miles beyond Noulta, the Canal is within soil; the fall is considerable and the channel merely requires to be kept clear from the encroachments of weeds growing out from the sides. From Didwaree to Khoobroo it passes through a naturally swampy tract, the drainage of which (towards the Nujufgurh jheels,) is intercepted by the Canal embankments, and those of the water-courses, which, going off at right angles to the Canal, divide the swamps into so many separate ponds. A great deal of work has been done to the embankments in this part of the Canal. Since their first formation, they have been frequently raised to meet the increased height of water, and to compensate for the settlement caused by the inferior quality of the soil.

Plans for draining the Swamps.

128. In 1842-43, a series of levels was taken by Lieutenant Strachey, with a view of devising means for draining the swamps above mentioned, and clearly proved the feasibility of such an operation. Those east of the Canal might be drained into the khadir of the Jumna, and for the others, an exit might be prepared along the bottom of a natural depression, terminating, after many windings, in the Nujufgurh jheels. An essential part of both these plans would be the construction of culverts or small aqueducts under all the water-courses crossing the line of drainage. During the late frequent changes of superintendence, this subject appears to have been lost sight of, but it is one of considerable importance as regards the recovery of land for cultivation, and the improvement of the salubrity of the country.

Channel and drainage from Khoobroo to Jutowla

129. From Khoobroo to Sitaolee, the Canal is again generally within soil and requires no remark. Near Jooah it enters on another tract of low land, not so decidedly swampy as that below Noulta, but generally lower than the level of the Canal, saturated with moisture, and in many places covered with a white saline efflorescence. The drainage, naturally imperfect, has been much impeded by the Canal and its water-courses. To the eastward it is separated from the Jumna khadir, which is not distant, by a ridge sloping down towards the Canal, while but a small portion of that to the westward, with difficulty finds its way to the Nujufgurh basin. Much of this evil may be irremediable, but I have little doubt but that the lands of Jooah, Bhutgong, Khanee Kheree and Budhana, might be relieved of some portion of their surplus moisture, and it is obviously possible to maintain, in a state of efficiency, the drain cut through the high ridge, into the Jumna khadir in 1835, to carry off the inundation of Kewalee, Chota Thanna, Jutowla and Mundowree.

Winding course of the Canal

130. The very tortuous course followed by the Canal between Budhana and Chota Thanna, leads to the belief that it here occupies the bed of a natural nulla, probably the one which leaves the Canal at Bowanna, and in its lower course is used as an escape.

Embankments

131. The embankments in this part of the Canal have been carefully formed, and latterly much raised to meet the rising level of the Canal bed. The course of the Canal has, in two instances, been straightened, by cutting through the necks of small loops, and the measure has been attended with beneficial effects.

Dimmished size of the Canal.

132. The dimensions of the Canal gradually diminish as the water is taken off for irrigation. About two-thirds of the supply

which enters the Canal at Rair, is consumed before it can reach Bowanna.

133. The Masonry Bridges are those of Kokrana, Noulta, Bhutgong and Bowanna. The two former and the two latter being built severally on the same design. The Kokrana and Noulta bridges have each a centre arch of $25\frac{1}{2}$ feet, and two side arches of $18\frac{5}{6}$ feet span; their waterway is somewhat deficient for the present supply, a circumstance which, without endangering the stability of the works, causes obstruction to the passage of boats and rafts. The Bowanna Bridge was built by Lieutenant Blane; it consists of one segment arch of 22 feet span, has experienced no injury except to the plaster of the parapets, and has quite sufficient waterway for its position. The bridge at Bhutgong, a village formerly belonging to the Sirdhana Jagheer, was built by the Begum Sumroo, on the same design as the Bowanna Bridge, without any allowance being made for the greater width and volume of the Canal. Its waterway is, therefore, much too narrow; but as the arch is high, it offers little obstruction. Masonry bridges.

134. The Timber Bridges are twenty-five in number, as specified in the margin. Their waterways are of various dimensions, being gradually reduced to suit the diminished width of the Canal. From Baolee to Kuelana they have three bays each, and two bays from thence to Durriapoor, with exception of the Bridges of Kanee Kheree and Jhurouthee, which were subsequently built and have but one wide bay. The level of the roadway in all these Bridges has been raised since their first construction. The timber Bridges are inferior in appearance to those of masonry, and require more repairs; but they are more economical, more easily modified to suit the varying levels of the Canal, and for the common village traffic they are quite sufficient. Timber bridges

Baolee.
Jatowl.
Didwarree.
Pulree.
Chumrara.
Bullee.
Sirdhana
Khoobroo
Mahomedpoor Majra.
Kuelana
Sitaolee.
Jooah, No 1
do. No 2.
Machree.
Jajhee.
Kheree Kanee.
Budhana.
Jhurouthee.
Jhurouth.
Anundpoor.
Chota Thanna
Jutowla.
Ferozepoor
Hurreeoree.
Durreeapoor.

135. There are two only of these bridges which appear to me inadequate to their purpose, viz., No. 2, of Jooah and the Chota Thana Bridge, which are on great lines of traffic, and should be replaced by wide bridges of masonry. Two masonry bridges required

136. On the portion of Canal now under description, there are five 1st class Chokies, viz., at Noulta, Bullee, Jooah, Chota Thana, and Chokies.

Gungatolee, of which the Bullee Choky is uninhabitable from damp, and is to be abandoned and replaced by a new one, which will be built near the Sirdhana Bridge. The others are in serviceable order, and are all furnished with two chairs, a cot, and a table. The 2nd class Chokies are at Kokrana, Jutowl, Pulree, Muhomedpoor Majra, Bhutgong, Budhana, Jutowla, and Bowanna. Those of Bhutgong and Budhana are destroyed by damp, and must be rebuilt on a drier site.

Irrigation outlets.

137. The irrigation outlets on this line are very numerous, and are built of varying dimensions and patterns; some being calculated to supply water to one, and some to six water-courses. When more than one channel is supplied from the same head, the division is made in a cistern outside the Bank.

IX.—FROM BOWANNA TO DELHI.

Selection of the line of Canal.

138. Shortly after passing Bowanna, the Canal enters into the Khadir land of the Jumna, through which it is embanked, sometimes to a considerable height above the surface of the ground. The line has been selected with much judgment, advantage having been taken of a natural ridge, slightly but obviously raised above the surrounding country.

Bowanna Escape Nulla

139. Before entering on this difficult tract of country, the native designers of the Canal wisely provided an escape into a nulla (the course of which, as before suggested, the Canal had probably followed from Budhana), and which, after running a tortuous course through the Khadir, falls into the Jumna near the village of Booraree.

Canal channel—Bowanna to the Jumna

140. The lowest ground passed by the Canal between Bowanna and Delhi, is the valley through which the surplus water of the Nujufgurh Jheels flows to the Jumna, and over which a massive aqueduct of masonry was provided, to deliver the water at the foot of the Rocky Hills, which embrace two sides of the City of Delhi. After skirting this range for some distance, the Canal passes through it by a deep irregular excavation in the solid rock, which must have cost immense labour. It then enters the city near the Caubul Gate, and passing through several streets and gardens, reaches the Negumbode Aqueduct, from whence a

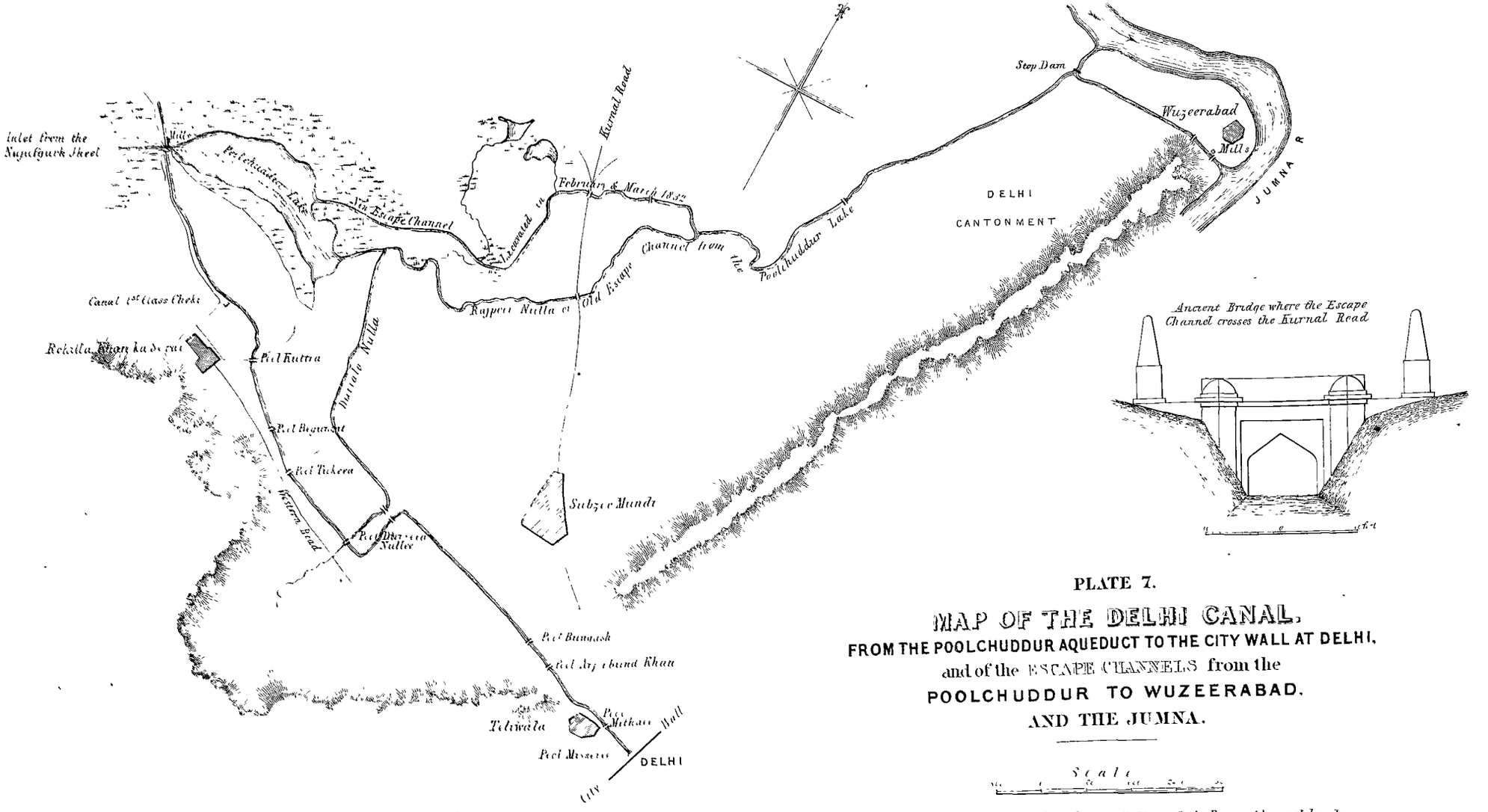


PLATE 7.

MAP OF THE DELHI CANAL,

FROM THE POOLCHUDDUR AQUEDUCT TO THE CITY WALL AT DELHI,

and of the ESCAPE CHANNELS from the POOLCHUDDUR TO WUZEERABAD, AND THE JUMNA.

Scale

NOTE Surveyed in 1834 Since this period the Rajpoor Nulla and old Escape Channel has been opened out as an Escape from the Nujufgurh Jheel into the Jumna River the dotted lines through the Pelchuddr Lake show the direction of the New Cut The effect of this measure, has been to drain the whole of the space occupied by the Pelchuddur Lake, and the adjacent marshes

portion passes through four sets of water mills to the Jumna, and the rest enters the palace of the King of Delhi.

Chandnee Choke channel.

141. An outlet which is situated in the right bank of the Canal within the city walls, supplies a small stream of water which flows through the centre of the Chandnee Choke,* in a masonry channel partly open and partly covered in.

Delhi Street channel

142. A similar channel traverses the Delhi-street, and was once supplied with water from an outlet which still exists at the Negumbode Aqueduct, but it has fallen into disrepair, and an attempt to restore it many years ago proved quite unsuccessful.

Old escape outlet at Bowanna.

143. The masonry works in this part of the Canal are very numerous, and for the most part of massive construction. The old escape at Bowanna continues very efficient, having received the addition of piers in front to retain the sluice shutters, and of an ogee overfall in continuation of the tail floor. The utility of this work as an escape, has been further enhanced by the construction of a dam bridge at Gungatowlee, by means of which, the whole supply can be shut off and turned down the outlet.

New escape outlet.

144. A smaller escape was constructed in 1831 on the left bank of the Canal, about a quarter of a mile above the old one, and though now in disuse, is in perfect order. Its chief purpose was to serve as a substitute for the old one while under repair; and in the present state of the demand for irrigation, it is not likely to be again required unless for a similar purpose.

Bridge on the escape outlet.

145. The Outlet Nulla is spanned by two bridges, one of a single masonry arch on the Delhi and Kurnal Road, the other with a timber roadway on masonry piers, near the village of Booraree.

Bridges over the Canal—Bowanna to Poolchadur

Gungatolee.
Chota Khera.
Burra Khera.
Shummapoor.
Badlee.
Hydurpoor.
Shalimar.
Pembarree.

146. The Bridges over the Canal between the Bowanna Outlet and the Poolchadur, are eight in number (as per margin), of which seven have timber roadways, and the eighth, called the Pembarree Bridge, has a single masonry arch. The Shalimar Bridge (of native construction) had four small masonry arches, which were removed by Captain Boileau in 1844 and their place supplied by a timber roadway. The Chota Khera and Badlee Bridges have been raised 3 feet. The Burra Khera,

* The principal street of Delhi.

Shummapoor, and Hydurpoor Bridges and the Gungatolee Regulator, have not yet been raised, but will be so, and their wood work will at the same time be renewed.

Poolchadur Aqueduct.

147. The Poolchadur Aqueduct, besides its primary object, was calculated to act as a self-regulating escape or waste weir, and in former years was much used for that purpose. The side walls towards the centre of the work, were merely built up to the level at which it was desired to keep the Canal water, so that a large space was left on each side for the surplus to pass over; on these spaces pillars were subsequently erected to retain planks. The water way under the aqueduct consists of five openings, of which three have been deepened in furtherance of the operations for draining the Nujufgurh Jheels.

Poolchadur Mills

148. A building containing three water mills and a godown, with a small foot bridge attached, was constructed near the Poolchadur Aqueduct in 1830, with the view of turning to profitable account the escape water of the Poolchadur, which was then always abundant; but the distance of the mills from the city and cantonment, and the difficulty of access to them, has prevented their being taken at a remunerating rent.

Bridge Aqueducts.

149. At short intervals below the Poolchadur Aqueduct, there are five old bridges with high parapets and low roadways, intended to carry across the Canal the drainage of the rocky hills on the right bank. These bridges were altered in 1831. Their water ways, which consisted of five or six low arches—the crown of which were submerged with a moderate supply in the Canal—caused a great obstruction to the passage of the water, by the accumulation of weeds and rubbish, and it was therefore considered expedient to remove the old superstructure of the Pool Kuttra, Pool Begumat, Pool Lal Tukea, and Pool Durriallia, and to rebuild it in one flat arch, retaining the old level of roadway. The fifth aqueduct, Pool Boolakee Begum, remains as it was first built.

Other bridges.

150. Beyond the last named aqueduct, there are three old bridges, and one recently built by a native, opposite Trevelyan Gunge. There is also a wide bridge under the city wall, built about twenty-five years ago by the garrison engineer.

Masonry Revetments in the city.

151. On the Canal bank within the city there are many Ghats and lines of steps, both ancient and recently built by private individuals; and at the suggestion of Captain Boileau, Government has lately determined to connect these detached portions of masonry by a stone wall, with steps in front for the convenience of bathers. The work is

PLATE 9.

POOLCHADUR AQUEDUCT,

ON THE CANALS WEST OF THE JUMNA, NEAR DELHI.

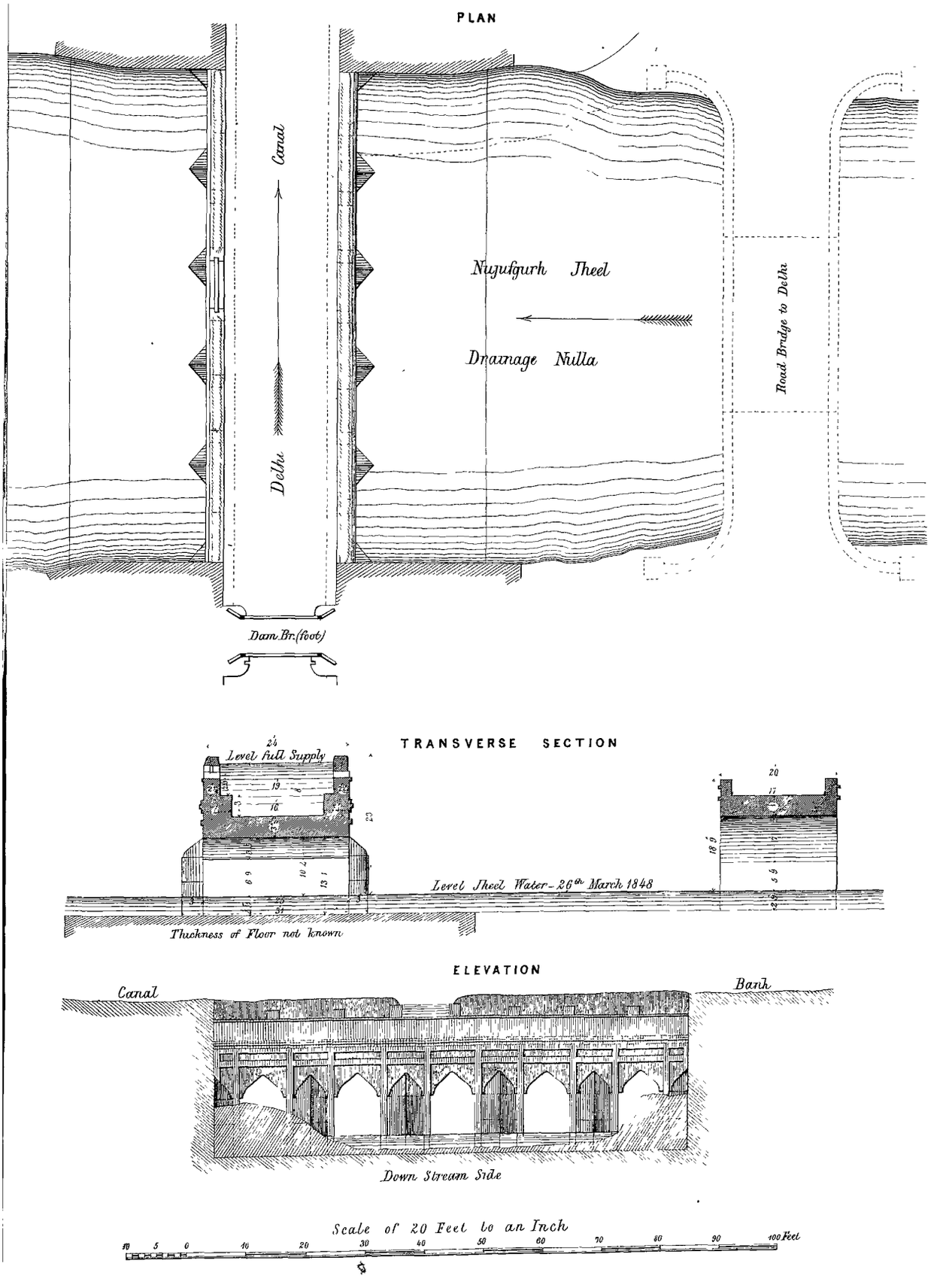


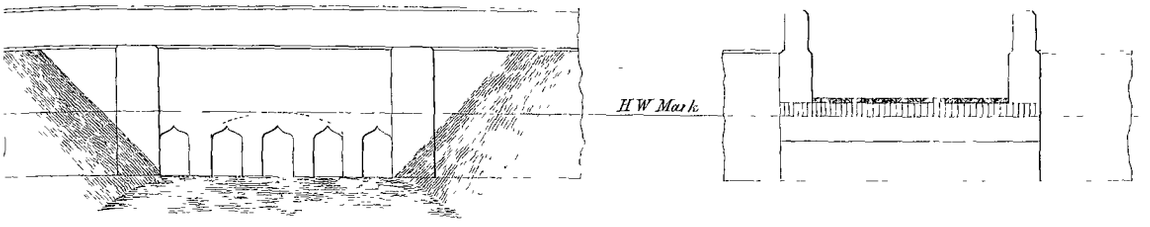
PLATE 6.

ANGIENT AQUEDUCT BRIDGES NEAR DELHI.

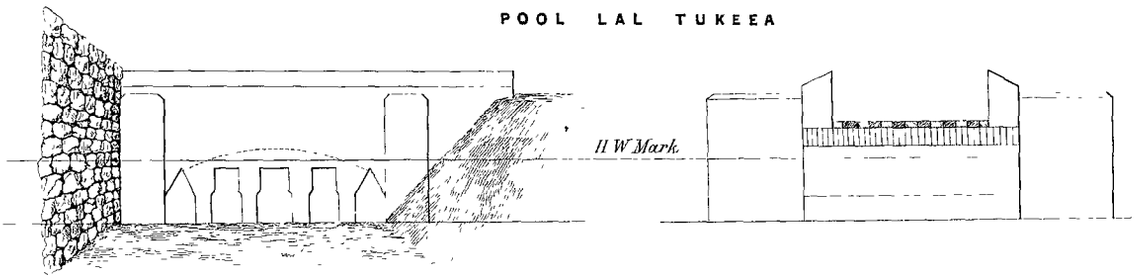
Altered to facilitate the Passage of Water towards the City

NB The dotted Lines shew the Alterations

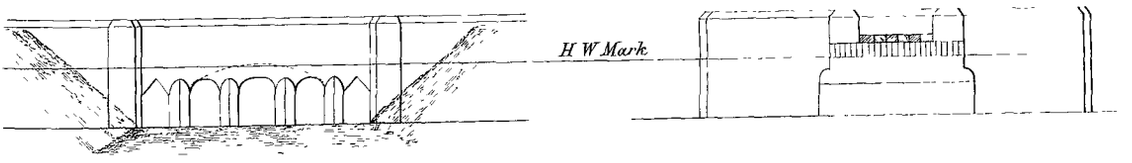
POOL DURREEA NULLEE



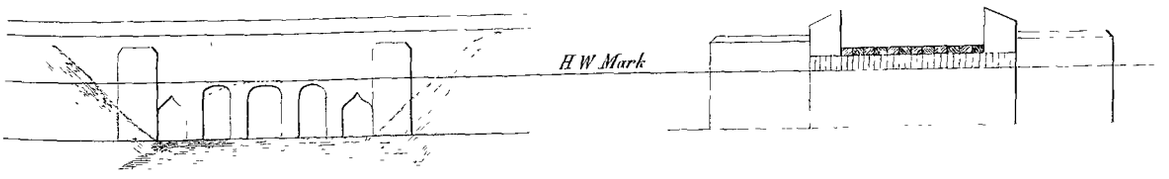
POOL LAL TUKEEA



POOL BEGUMAT



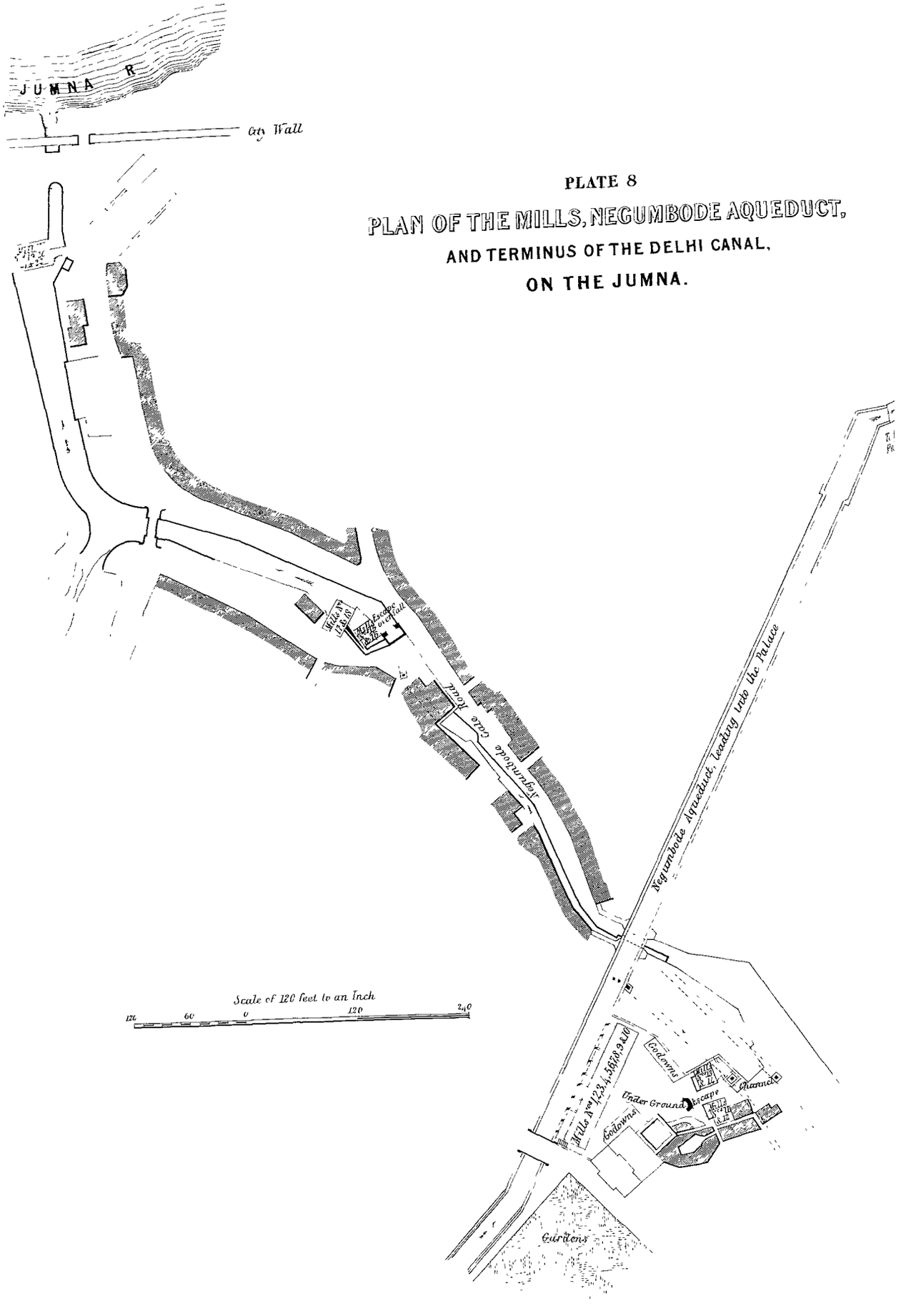
POOL KUTTRA



Scale of 16 Feet to One Inch

PLATE 8

PLAN OF THE MILLS, NEGUMBODE AQUEDUCT, AND TERMINUS OF THE DELHI CANAL, ON THE JUMNA.



now in progress, and when completed will be a great improvement to the appearance of the Canal.

152. The Negumbode Aqueduct is an immense mass of masonry, highly raised above the level of the ground, and, in fact, carrying the Canal above the level of the house tops in the Negumbode-street, into the Palace. Negumbode Aqueduct.

153. Parallel to this aqueduct on the Right Bank, a building has been erected, containing ten water-mills, turned by overshot wheels. The fall of the water in these mills is very great, and each pair of stones is calculated to grind eighty maunds* of wheat in the twenty-four hours, and pays a rent of upwards of five rupees per diem. Upper Negumbode Mills

154. From the ten upper mills above described, the water passes to the second set of four mills contained in two separate buildings, and which are also very powerful, and rent for five rupees per diem; the greater quantity of water compensating for the lesser fall. Lower Negumbode Mills.

155. From this point the water passes under the Negumbode Aqueduct, along a small masonry channel on one side of the Negumbode street. It then supplies two more successive sets of four mills each, the lower of which is built near the Negumbode Gate, and is so near the flood level of the Jumna that the mills are frequently impeded by back water during the rains. Negumbode Gate Mills

156. The Poolchadur escape nulla formerly belonged exclusively to the Delhi Canal, but has lately been taken possession of by the Executive department of the Nujufgurh Jheel drainage. It still, however, occasionally supplies four water mills, built by Colonel Colvin, at Wuzeerabad, near the cantonment of Delhi; and these are still in the hands of the Canal officers. Wuzeerabad Mills.

157. There is a 1st class Chokie built of stone masonry at Rohilla Khan ke Serai, between the Poolchadur and Delhi, and another has been commenced near the Negumbode Aqueduct, in the vicinity of which there is a range of stone buildings, containing the mill-treasury, guard, and store-rooms. The 2nd class Chokies are at Chota Khera, Sirispoor, and Shalimar. Chokies and Guard Room.

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* 80 maunds is 6,400 lbs.; or 2 tons, 16 cwt. 1 qr.

X.—HANSI BRANCH—RAIR TO JOSHEE.

Channel and embankments.

158. The Canal channel, from Rair to the Joshee Regulator, follows an exceedingly tortuous course, the rectification of which, had it been effected at first, would have given a better fall in this direction, and might have saved the necessity of damming up the Delhi side of the Rair Bridge. The full supply in this part of the Canal stands generally 2 to 3 feet above the level of the country, and is confined between strong embankments, of which one is 16 feet wide throughout, and both are so sound as to prevent the slightest leakage. The increased height of water within the last ten years, is, I believe, accounted for by its increased volume, and is not in any measure attributable to deposits of silt which do not here occur in the Canal bottom, but are found at all the sharp bends of the channel, and are periodically removed.

Masonry bridges.

159. Between Rair and Joshee are three bridges, each consisting of two semi-elliptical arches in brickwork, of 16 feet span, and respectively opposite the villages of Dhurmgurh, Shera, and Mudlowda. These bridges are, under present circumstances, deficient in waterway, and (especially that of Mudlowda) have too little height above the surface of the Canal.

Joshee Regulator

160. The work at the head of the Rohtuk Branch, known by the name of the Joshee Regulator, consists of an overfall bridge across the Hansi Canal, with an attached lock, the whole being connected by a revetment wall, with the Rohtuk Branch Regulator or Dam Bridge. The overfall or weir forms, in plan, an arc of about 60 degrees; it consists of a bar of masonry, of which the up-stream face is perpendicular, and the rear slope, over which the water falls, is cut into small steps, instead of being disposed in the more usual form of an ogee.

Subsequent additions to the original work

161. The overfall alone was first constructed, and the bridge and attached lock, with a bascal drawbridge over the latter, were subsequently added, to provide a communication across the Canal, and to obviate the inconvenience experienced by those rafting timbers to Hansi, who were at this point obliged to take their rafts out of the water, and re-form them below the overfall.

Recent alteration.

162. At the period when the above additions were made to the work, there was a clear fall of 3 feet at the weir, and a space of 1 foot,

or 1 foot 6 inches, between the bridge beams and the upper surface of the water, but the levels have since altered considerably, particularly below the fall, which has almost disappeared. The water above the weir has risen so much as to submerge the bridge beams, and rafts have for some time habitually passed through the lock as an open channel, without using the gates. The wood-work of the bascal drawbridge having also fallen into disrepair, it has been determined to remove it and the present road bridge, to raise the piers of the latter considerably, and to substitute for the drawbridge across the lock chamber, a fixed platform of timber, at such height above the water as will admit of the free passage of boats.

Rohtuk Branch Regulating Bridge.

163. The regulating bridge at the head of the Rohtuk Branch has required no alteration, but, being retired from the line of the main Canal, the space in front is liable to be choked up with deposits of silt, which, having been frequently removed, now lie in large heaps on the adjacent banks. An irrigation outlet for the supply of the village of Naira and two or three others, is attached to this regulator.

Feeder to the Rohtuk Branch.

164. On the left bank, about half a mile above the regulator, there is an outlet supplying a channel, which acts as a second feeder to the Rohtuk Canal, and falls into it below the Naira Bridge. This little cut has a strong fall; it is not used for irrigation, and has three masonry bridges over it.

Chokies, &c.

165. There is a 2nd class Chokie near the village of Shera, and one of the 1st class at the Joshee Regulator. The plinth of this Chokie was once well raised above the surrounding ground, over which the sand, taken out of the Canal and the Naira water-course, has since been spread to such an extent that it is now higher than the floor of the Chokie, which however continues dry.

XI.—HANSI BRANCH—FROM JOSHEE REGULATOR TO HANSI OVERFALL.

Disadvantages of the line.

166. From the Joshee Overfall to the bridge opposite to the village of that name, the direction of the Canal is nearly straight, and was I believe selected by Colonel Colvin; but, from that point to Hissar,

it follows the line adopted by the engineer of Feroze Shah—obviously that of a natural nulla, as it cannot be supposed that a line freely selected would have followed so tortuous a course, attended as it is with the disadvantages of increasing the length of channel and embankments to be kept in order, and of diminishing the fall to a degree far below what would be desirable for a Canal of this size and volume.

Section of channel as first adopted.

167. The section adopted in the first instance for the Canal was a central channel, with wide terrepleins on each side, bounded externally by 10-feet embankments. The object was to provide a sufficient central waterway for ordinary occasions, and at the same time to afford an ample section for floods, to which, from its connection with the Chittung and other natural nullas, it was supposed to be subject.

Section subsequently found inadequate

168. While the channel retained its original depth and width, and while the demand for water was moderate, the section above described was found to answer very well, but silt deposits soon clogged the bottom, while the growth of weeds and rushes contracted the width, and a few seasons of drought having taught the Zemindars the true value of the Canal, it became necessary to increase the supply beyond what the central channel could carry, and the terrepleins having become almost universally flooded, were soon covered with a thick growth of reeds and bulrushes.

Modification of the Section

169. During the cold season of 1837-38, when this evil grew to a head, the water was too much required to admit of the Canal being stopped for clearance; but in the following spring, after the wheat crops had been reaped, an effectual clearance was made, the Canal having been turned off for that purpose. The earth excavated from the channel was thrown up on the edges in continuous mounds, so as to form, in most places, an effectual barrier to the spread of the water. These have been strengthened and extended during subsequent clearances, and having now attained sufficient dimensions, the earth obtained from the channel will in future be applied in reforming the east embankment, which is out of repair, and increasing that on the west to a width of 16 feet.

Relative levels of the Canal and the country.

170. The Canal, to within a short distance of Hansi, is generally within soil, *i. e.* it is lower than the ground outside the embankments; but this is not found to interfere materially with irrigation. The slope of the country is greater than that of the Canal, the fall of the latter being diffused over a great length by means of the windings of the channel, as described in paragraph 166. Under these, circumstances

a straight cut led from the Canal in the direction of the natural slope of the country, but having a slightly less declivity, brings the water after a short distance to the surface of the ground.

171. From Joshee to Narnound the silt deposits are not of very rapid growth, and may be kept down by a good clearance every four or five years; but from Narnound westwards, where the natural fall is less, and where it has been still further reduced by the construction of the Palee weir and Hansi overfall, the accumulations of sand are very rapid, and require annual removal. The Canal is embanked for some distance above the Hansi overfall, the object of which is to hold up the water to supply the mills. Silt deposits.

172. Between the villages of Joshee and Suffeedhun, the Canal gives off on its left bank the supply of the Bootana Branch, and receives on its right that of the Bulla Canal, described in paragraphs 124 to 126. The Bootana Canal will be adverted to hereafter. Bootana Branch and Bulla Canal

173. From Joshee to the Hansi Overfall there are twenty-seven Bridges (as per margin), including the one attached to the last-named work. They are all of masonry, but of various designs. The Bridge of Joshee, the second Bridge of Suffeedhum, the Bridges of Singhana, Boodha Khera, Rujana, Jamunee, Dhatrut, Munohurpoor, Bohutwala, Kokhree, Narnound (No. 1), Majra, Palee, and Kheree, have a horizontal roadway 10 feet wide between the parapets, on two semi-elliptical arches. Their water-way is not deficient in width, but the arches are generally too low to admit of the convenient passage of boats. The first Bridge of Narnound is particularly faulty in this respect, the water sometimes rising up to the crown of the arch. The Bridges of Kuvee, Choppur, Jheend, Ramra, and Rajthul, have a convex roadway $17\frac{1}{2}$ feet wide between the parapets, and are, with exception to No. 2 of Jheend, built at the several points where the straighter line of the Kurnal and Hansi Road intersects the more circuitous one formed by the Canal. They have each three arches, slightly flatter than a semicircle, the centre arch having a span of $15\frac{1}{4}$ feet, the side arches of 10 feet each. The waterway of these bridges appears to be ample, and the height of the centre arch admits easily of the passage of boats. The Baroude and Bheinee Bridges and the second Bridge of Narnound have a convex roadway 10 Masonry bridges.

Joshee.
Kuvee.
Baroude.
Suffeedhun, No. 1.
do. No. 2.
Singhana.
Choppur.
Boodakhera.
Rujana
Jamunee.
Dhatrut.
Munohurpoor.
Bohutwala.
Kokhree.
Jheend, No. 1.
do No. 2.
do. No. 3.
Ramra.
Rajthul.
Bheinee.
Narnound, No. 1.
do. No. 2.
Majra.
Palee
Kheree.
Shekpoora.
Hansi Overfall.

feet wide between the parapets, and a single elliptical arch of 32 feet span. Their waterway is perfectly adequate, and the height of the arch sufficient for any purpose. The old Bridge of Suffeedhun has three high arches, on massive piers; its roadway is inconveniently raised. The width and height of waterway are quite sufficient, but the excessive width of the piers, unnecessarily extends the length of the bridge, and has an awkward appearance. The Sheikpoora Bridge has but one arch, of 25 feet span, and has a roadway 10 feet between the parapets. Though the waterway is smaller than those of the Bheinee and Narnound Bridges, it is sufficient for the diminished volume of the Canal.

Hansi Overfall and Bridge.

174. The Hansi Overfall Bridge has three semicircular arches of 12 feet; its floor serves as a tail to the weir which is built immediately above it, and is similar in design to that of Joshee, having the form of a circular arc, and its rear face being cut into small steps. An apron or tail floor extends to a width of 20 feet below the bridge. The fall over this bridge is perfectly free, no deposit of silt having taken place in the channel below it.

Chittung Bridge near Dhatrut.

175. Near Dhatrut there is a bridge over the Chittung, which here falls into the Canal. Shortly after the construction of the bridge some part of the foundation appears to have settled, causing cracks in the wing walls, and a separation of the parapets from the crown of the arch. As, however, it has continued in the same condition for eighteen years, no further sinking need now be expected. The Chittung contributes no water to the Canal, except occasionally after heavy rain, and even these occasions are annually becoming more unfrequent, in consequence of the silting up of the bed, and the greater spread of the waters.

1st and 2nd class Chokies

176. In this portion of the Canal, there are four 1st class and six 2nd class chokies. The former are at Suffeedhun, Dhatrut, Jheend, and Narnound. The latter are at the Bootana Canal Head, at Choppur, Kokhree, Ramra, Landakhera, and at the Hansi overfall.

Irrigation Outlets.

177. Throughout the Jheend district, *i. e.* from Baroude to Ramra there are no masonry outlets for irrigation, their construction having been deferred with a view of remodelling the irrigation of this territory, and substituting a well-organized system of Rajbuhas,* for the imperfect and irregular native cuts now in use. The Superintendent

* For further details of this system, see paragraphs 240 and 241.

of the Western Jumna Canals is now in correspondence with the Jheend Raja on this subject, and there is every prospect of a speedy and satisfactory settlement of the question. In the Hansi District, the outlets are all of masonry, of the same general pattern as those already described on the Delhi Branch. There is, however, in this district a greater proportion of single large outlets, which are the heads of Rajbuhas.

178. The Palee weir, between the Majra and Palee Bridges, was constructed by Colonel Colvin in 1831, and was intended to raise the level of the water at the head of a large Rajbuha, for the irrigation of the late Colonel Skinner's indigo plantations. It consists of a bar of masonry across the Canal, having a clear waterway of 32 feet, flanked by abutments, whose wing walls enter the bank. The sill of the weir is 2 feet above the true bottom of the Canal; but the surface fall over the work is not more than 6 inches. Palee Weir.

XII.—FROM HANSI TO THE MINGNEE KHERA REGULATOR.

179. From the Hansi Overfall, the Canal divides into two branches, which, passing on either side of the city and fort, are reunited about half a mile to the westward of the latter. The right or more direct channel, conveying the water that passes over the weir, has a strong fall, and is not liable to deposits of silt or the growth of weeds. Western channel at Hansi.

180. The eastern or mill channel is confined between high embankments down to the mill-dam, a distance of about 1¼ mile. The width of the channel is very great, and the current so slack as to be scarcely perceptible. As might be expected under such circumstances, the silt is rapidly deposited, and weeds grow with such rapidity as to require a party of labourers constantly employed in removing them. Eastern channel.

181. After passing the mills, the Canal enters a series of natural tanks, through which, and through sundry portions of connecting channel, it flows to its junction with the western branch. The object for which these tanks were connected with the Canal, was to insure to them a constant supply of fresh water, and there can be no doubt that Hansi Tanks.

such an arrangement was very conducive to the comfort and convenience of the inhabitants, and (as far as a supply of pure water is concerned) to their salubrity, and, while the tanks remained deep, it was unobjectionable in every respect. In the course of years, however, from the accumulation of such silt as passed the mill-dam, and from the growth and decay of weeds, &c., many parts round the margin of the tanks became shallow, and covered with reeds and rushes. The first tank thus affected to any remarkable extent, was one near the Sepahis Hospital, and to it was partly attributed the sickness which then prevailed in the cantonment. The remedy proposed, and which, being sanctioned by Government, was executed by the barrack department, was to deepen the part of the tank most remote from the hospital, and to employ the earth so obtained in raising the shallower half of the space, to a level about 1 foot 6 inches higher than that of high water in the Canal. A similar process has since been continued in the other tanks, except that the part deepened is a central strip along the course of the Canal, and the excavated earth has been disposed round the margin, so as to confine the spread of water.

Tank at the Gate.

182. From this description must be excepted the tank opposite the Bursee Gate of the town, through which the Canal was embanked by Lieutenant Spens, in pursuance of arrangements made by his predecessor, Captain Boileau. The tank is thus divided into three portions, of which the central one is occupied by the Canal, and the two sides receive respectively the drainage of the town and cantonments, but would have no means of passing it off, or purifying it by the admission of fresh water. It was therefore recommended by me on the occasion of my late inspection (and approved by Government), that the water should be again admitted into the side portions, and that in them the same process should be adopted as in the other tanks, for deepening the centre and limiting the spread of water.

Channel from Hansi to Hissar

183. From Hansi to Hissar the Canal continues to follow a very winding course, and the fall is still further reduced, being not more than 6 inches per mile. The section is of the same form as that described in paragraph 167, viz., a central channel with a side berm on each side, bounded by embankments. The deposits of silt are inconsiderable, and derived chiefly from the degradation of the side slopes of the channel. The earthy matter brought down by the Canal is, for the most part, deposited in the slack water east of the Hansi Overfall, in the mill-pond, and in the Hansi Tanks. The growth of weeds, however, is very luxuriant, and causes great obstruction to the passage of the water. Of these weeds some grow from the Canal bottom, and these, when removed

by dredging, are reproduced within a fortnight. Of the weeds that grow on the Terreplein and shallow edges of the Canal, throwing out long shoots into the Channel, the most persevering is a species of guinea grass, introduced experimentally by Colonel Colvin as likely to be useful to the Hissar stud. The roots of this grass have not only established themselves on the edges of the Canal and on the Terrepleins—wherever the latter are submerged—but its branches spread out in a thick tangle, and unless constantly removed, cover the entire surface of the water; the plant appears, moreover, to have degenerated in quality as fodder, as it is said to be of no use to the stud, and is rejected by the villagers unless in seasons of scarcity.

Khurrur and Satroude Tanks.

184. In the vicinity of the villages of Khurrur and Satroude, respectively, the Canal was originally taken through the village tanks, with the same object as at Hansi; but the depth of water being much less, the growth of reeds, &c., was more abundant. In both these localities, embankments have been formed through the tanks, in my opinion injudiciously, as they have isolated portions of swamp, which are maintained in that condition by percolation, and by the drainage of the country.

Channel east of Hissar.

185. Before reaching Hissar, the Canal is conducted in a wide channel between two embankments, across a natural hollow, and though from 2 to 5 feet deep throughout its width, was much choked by weeds. It was, by the stud officers, considered to be a source of malaria; and on representation being made to Government, authority was given to contract the dimensions of the channel, by filling up a broad strip, inside each embankment, a measure which has been partially carried into effect, the earth being obtained from external excavations, in which water was lodging at the period of my last inspection. The exchange of a stagnant pool outside the banks, for an equal area of reedy vegetation within them, and constantly supplied with fresh water, appears to me to be of questionable advantage.

Hissar Tanks

186. In passing round the city of Hissar, the Canal flows through two tanks, both deep, and one of them of considerable size. They are but little infested with weeds, and though hereafter there may be occasion to contract them by the process followed at Hansi, they will require much less work to maintain them in a wholesome condition.

Channel from Hissar to Mingnee Khera Regulator

187. After leaving the large tank west of Hissar, the Canal follows a straight course for $1\frac{1}{2}$ mile to a square pucca tank, in which it formerly terminated, but which is now choked up, with the exception of

a central channel which passes through it diagonally. From this point another short excavation conducts the Canal again to the regular bed of the Chittung, which it follows to the Mingnee Khera Regulator.

Embankments

188. The embankments between Hansi and the Mingnee Khera Regulator, were originally formed 10 feet wide, on each side of the Canal, except in some places round the town of Hissar, where the ground would not admit of the formation of regular banks. From Hansi to Khurrur, the left bank has lately been widened to 16 feet, and from Hissar to the Mingnee Khera Regulator, the right bank has received a similar addition to its width. In the intermediate space both banks are maintained in good order to the original width of 10 feet. The Terrepleins are in many places submerged, but more generally above the level of the water.

Hansi Mill Dam and buildings.

189. The Hansi mill-dam and attached buildings, containing 8 pairs of grinding stones, turned by horizontal overshot wheels, are situated about $1\frac{1}{4}$ mile below the overfall. The dam is of masonry, having a waste weir at the top, and a central scouring sluice at the level of the Canal bottom, and opening out into a masonry channel, which also receives the water which has turned the mills. The scouring sluice has not been in use for many years, but arrangements for working it were made by Captain Siddons, and there is little doubt that its occasional use would not only assist in keeping clear the mill-pond, but would materially facilitate the regulation of the Canal supply. In front of the mill buildings, there is a road bridge on two masonry arches, and a range of godowns. The mills were well rented as long as the cantonments of Hansi was occupied by regular troops, but of late years the rate has fallen considerably, and it is seldom that more than two or three pairs of stones can now be kept at work.

Bridges and Stop Dams.

190. Between the mills and the junction of the east and west branches, there are three masonry bridges of two arches, and on the west branch there is one such bridge; they require no particular remark. The old road from Hansi to Hissar crosses the Canal three times, namely, twice near the village of Khurrur, and once at Raipoor. The second bridge of Khurrur and that of Raipoor have been fitted up with sluice shutters worked with windlasses, the object of which was to hold up the water for "tor" irrigation; that is to say, to enable it to flow freely over the surface of the fields, but the supply of water reaching these points having of late years become scanty, and the demand for the stud lands at Hissar urgent, the sluice shutters are now seldom if ever used, and the irrigation of the fields is effected by means of dauls

or chumbuls. There is a masonry bridge of two arches opposite the village of Satroude. The first bridge of Hissar, called the Juhaz Bridge, from a building to be more particularly alluded to hereafter, is partly of ancient construction. Its massive piers and pointed arches are of native origin; the parapets and wing-walls were added by Colonel Colvin. There are two bridges over the Canal, severally opposite gates of the walled town of Hissar; each of these consists of two masonry arches at a considerable height above the water, as the Canal is at this point in deep cuttings. West of the pucca tank alluded to in paragraph 187, there are two Stop Dams, of which one was lately required by the stud officers, to hold up the water for the oat-lands, and the second was constructed by Colonel Colvin for the irrigation of several villages. These works consist simply of a masonry floor across the Canal bed, bounded on each side by blocks of masonry, having grooves to receive sluice planking, and a windlass to raise it. At Shahpoor there is a bridge of a single masonry arch, and another at Matursham, with two narrow side openings, and a central arch in which there is an arrangement for the occasional use of sluice planks; beyond this, there is another Stop Dam similar to those already described, and about a mile beyond the village of Mingnee Khera, there is a double bridge forming a regulator, at the division of the Canal into two branches.

Mingnee Khera Regulator.

191. This work, besides the bridge, consists of a masonry weir by which the water is held up to supply the Durba Canal, and over which it falls into the Buhadera Branch. The Overfall is of the same form as that of Hansi, but on a much smaller scale. It has posts for the reception of two feet of planking, calculated to give that additional height to the weir. The two bridges have each one arch, and that of the Durba Branch has a sluice shutter by which it may be entirely closed when need requires.

Chokies.

192. There are 1st class Chokies at Hansi and Hissar, lately constructed; and to the 2nd class Chokies at Raipoor and Shahpoor a second room has recently been added, so as to render them available for officers or overseers on inspection duty. There is also a 2nd class Chokie at the Mingnee Khera Regulator.

"Juhaz" at Hissar

193. At Hissar the Canal Department have taken possession of an old building called the "Juhaz"* and supposed to have been built by a travelled courtier of Ferozeshah, with a view of giving his master a proper idea of a ship. The resemblance of this building to any ship of

* *Anglice*, "Ship"

the present day is not very striking, though near enough perhaps to support the authority of the tradition. It is now used as a godown for Canal stores, for which purpose its ample "hold" renders it very suitable.

XIII.—BUHADERA BRANCH FROM HEAD REGULATOR TO THE END.

Channel and Embankments.

194. This Canal occupies the old bed of the Chittung, which flows through a well marked valley bounded by sand hills, but having a considerable area of culturable ground on both sides of the Canal. The soil through which the Canal is cut is hard and retentive, and the fall of the Canal, though deficient, is greater than it is between Hansi and Hissar. The section is, as before described, a central channel with berms and embankments on each side. The embankments were originally made 10 feet wide at top, but have not been very rigorously maintained at that width in the lower part of the Canal. From Mingnee Khera to a little beyond Siswal, the right bank has lately been formed to 16 feet, but it does not appear advisable to extend this expensive work further. The irrigation from this channel is confined to the valley of the Chittung.

Bridges and Stop Dams.

195. The Bridges on this line are few and far between, the country being very thinly peopled. They are all of masonry, and are provided with sluice-shutters, to enable them to act as Stop Dams. They are thirteen in number (as per margin); and at Kabrere there is a Stop Dam like that of Shahpoor, and intended for a similar purpose.

Sulemgurh.
Siswal.
Mohubutpoor.
Moonda Khera.
Jhassil
Baire.
Channee, No 1.
do. No. 2.
Neenhan
Sherpoor.
Nangul.
Buhadera, No. 1
do. No. 2.

Chokies.

196. There are 1st class Chokies at Channee and Buhadera, built by Colonel Colvin, and one is under construction, or has just been completed, at Siswal. The 2nd class Chokies are at Jhassil and Sherpoor.

XIV.—DURBA BRANCH—HEAD REGULATOR TO THE END.

Channels, &c.

197. The Durba Canal is entirely an artificial excavation, designed and executed by Colonel Colvin, at a time when there was abundant surplus water in the Canal, after supplying the limited demand for irrigation east of Hissar. It follows a course nearly parallel with that of the old channel, as far as the village of Siswal, from whence it turns off to the north-west, to near the village of Ramsirra, where it again divides into two minor branches, one going to the left, passing by Ramsirra, and having formerly extended by a small cut to Kagdana, the other, to the right, passing by Muhrana, and intended by Colonel Colvin to have reached the town of Durba, had the supply of water been sufficient. The extension of the left branch to Kagdana, though twice cleared out, is nearly obliterated, being covered up by the sand which drifts across the face of this part of the country, during many months of the year.

Nature of soil and sand drifts.

198. The soil through which the Durba Branch has been cut is very sandy, and the excavation, which is deep in some places, is very liable to choke up, from the sand washed down from the side slopes, or drifted into the channel by the wind.

Masonry works.

199. Between the Mingnee Khera and Ramsirra Regulators, there are on this line five Bridges, viz., three at Siswal, one at Adumpoor, and one opposite the village of Choolee. The Ramsirra Regulator is a double Bridge, and like all the rest is furnished with sluice shutters. The minor branches have three bridges, at Ramsirra, Duhir, and Chuchurwala. There is also a Stop Dam between the Head and Siswal.

Scanty supply of water.

200. There is a good deal of land fit for irrigation near the extremities of this branch, but the water seldom passes beyond Siswal in quantity sufficient for any purpose but the highly beneficial one of filling the village tanks.

XV.—ROHTUK BRANCH—JOSHEE TO GOHANNA.

Former use of the channel.

201. As far as the town of Gohanna, the Rohtuk Branch follows a natural hollow, which, as mentioned in Colonel Colvin's report, was the line first selected by Ali Murdan Khan, in his attempt to carry water to Delhi. From Gohanna, he attempted to turn off the water by another channel towards Jutowla, when his bund broke, and a catastrophe ensued.

When restored under British rule.

202. This line was first re-opened, or rather the water was allowed to flow in it, by Lieutenant Blane in 1821, and at that time the Zemindars were, I believe, permitted to throw earthen dams across the channel, to hold up the water for their fields. The construction of masonry works and formation of embankments was commenced by Col. Colvin in 1825.

Interference with the natural slope remedied by nature.

203. From Joshee to Gohanna, the natural fall of the country is sufficient to maintain a good current in a canal, but not so great as would be admissible, and even advisable, in one of small dimensions. This fall was, however, very much reduced by the establishment of masonry weirs or overfalls, at short intervals, of which the object was to hold up the water for irrigation. It was, I believe, an error of design to check the fall of the Canal by the erection of permanent dams, instead of such as can be closed or opened at pleasure, by means of sluice gates, but nature has been silently and effectually working to counteract it, and to restore the proper regimen of the bed. Deposits of silt have been formed at the tails of all the overfalls, to such an extent that (with one exception) the fall at the weirs has been nearly obliterated, and a mere ripple in the water now marks the spots where there was once a direct fall of from two to four feet. To keep pace with this partial rise of the bed, it was necessary to form higher embankments, and the material for that purpose, though not of the best quality, was supplied by the Canal itself.

Channel.

204. The channel is now in good working condition, it has sufficient capacity, a good current throughout, and is confined between sufficient embankments; it still, however, deposits its silt rapidly, and requires annual clearance. The original cross section was like that of the Hansi branch, viz., a central channel, with berms and embankments on each side; but the berms are now generally filled up con

siderably above the supply level, and do not, except in a few localities, admit of the spread of the water under any circumstances.

Embankments.

205. The right or west embankment, which is generally used as a road, is for the most part 16 feet wide, but is considerably reduced where it crosses the irrigation outlets, whose roadway has a width of 10 feet between parapets of $1\frac{1}{2}$ foot each. As a road it is very heavy for wheeled carriages, on account of the sand of which it is chiefly composed. The east bank is only 10 feet wide, except where the superabundance of silt has given it additional width. Notwithstanding the rising of the bed, the water is not raised more than 1 to 2 feet above the level of the country, except where it crosses a hollow near the village of Muhmoodpoor, and here, during the rains of 1846, considerable leakage had taken place, and had caused much inconvenience to the inhabitants of the village. Advantage was taken of the stoppage of the Canal in May 1847, to strengthen this weak point, to consolidate the interior slope of the embankments, and to give them additional width. The tract of country through which this Canal passes, is the best irrigated and most flourishing of any on the Western Jumna Canals.

Masonry works

206. Between Joshee and Gohanna there are six permanent Overfalls, and four stop dams similar to those already described on the Hansi Canal. There are also twelve Bridges, some of which are provided with sluice shutters, so as to act as Stop Dams.

Permanent Overfalls.

Naira.
Idanha.
Waisser.
Uhur.
Korana.
Bhoossana.

207. The Overfalls are as per margin, of which the Naira, Idanha, Uhur, and Korana have no longer any perceptible effect on the level of the water. The Bhoossana Overfall has been kept tolerably clear of tail deposits by the effects of a scouring sluice in the centre of the weir. There are Foot-Bridges on most of the Overfalls.

Stop Dams

Korana.
Moondlana.
Muhmoodpoor.
Gohanna.

208. The Stop Dams are enumerated in the margin. This form of work was adopted by Colonel Colvin, with a view of assisting the irrigation, without incurring the inconvenience entailed by permanent bars; but it has the additional advantage of being an efficient instrument in the regulation and distribution of the water, as the simple removal of the planks from any Stop Dam is sufficient to shut off the supply of the water-courses dependent on it.

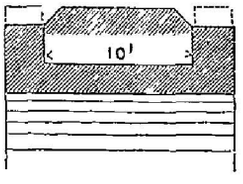
Bridges.

Naira.
Idanha.
Itowla.
Uhur.
Korana.
Chutera.
Muhmoodpoor, No. 1.
do. No. 2.
do. No. 3.
Gohanna, No. 1.
do. No. 2.
Sumanka.

209. The Bridges are twelve in number, as per margin, of which five, viz., those of Idanha, Itowla, Uhur, Korana, and Chutera, have timber roadways, resting on masonry abutments. The rest are of masonry. At Naira there is a plain Road-Bridge, having one arch of 21 feet span. The Sumanka Bridge, which has also one masonry arch of 12 feet waterway, has a sluice-shutter worked by a windlass, and acts as a Stop Dam. The three Bridges of Muhmoodpoor were originally built when the Canal terminated at Gohanna, and the height and width of their waterway were calculated for such small volume of water as might be expected to reach so far. It is, perhaps, to be regretted that these three Bridges were not removed when the extension of the Rohtuk Branch was determined upon; for they are certainly disproportioned to the present volume of its water, which frequently stands higher than the roadway of the Bridges, and has been known to wash over the parapets. The expense of removing the arches, and turning them again on raised piers, would be inconsiderable, and attended with great advantage. The Gohanna Bridge was also built before the extension, and its waterway is too narrow; it is much higher, however, than those of Muhmoodpoor, and does not urgently require modification. Opposite Nuggur there is a Dam Bridge similar to that of Sumanka.

Irrigation Outlets.

210. The irrigation outlets on this line are numerous, they are all of masonry, and with few exceptions situated in clusters above the Overfalls and Stop-Dams. The fall of the watercourses being less than that of the Canal, their heads soon get choked up with silt, the constant removal of which has formed inconvenient accumulations of sand near all these works, the irrigation outlets also, having been built before it became necessary to raise the banks, the parapets are all too low, and the earth being heaped up to the requisite height has inconveniently contracted the roadway. Arrangements have now been made and sanctioned for raising the parapets.



Chokies.

211. At Koranna and Gohanna there are 1st class Chokies, both of which are dry and in good order. There are 2nd class Chokies at Uhur and Sumanka.

XVI.—ROHTUK BRANCH FROM GOHANNA TO ROHTUK.

Channel.

212. A few miles west of Gohanna the Canal leaves the natural hollow in which it has flowed from Joshee, and follows a direction generally parallel with it for fifteen miles, entering it again near the village of Singpoora. The new line was selected after careful examination by Colonel Colvin, and although unavoidably partaking of the unequal distribution of slope which characterizes the country, is well suited to supply irrigation to the villages for which it is intended. On first leaving the old line the Canal is embanked above the level of the country, which, however, it approaches gradually until it enters into deep cuttings at Bhynswan, from whence it flows alternately above and below the level of the country, until it falls into the natural hollow at Singpoora, near the ruins of Lalpoor, the city which is said to have been destroyed in the inundation caused by the first unsuccessful operations of Shah Jehan's engineers. In this story there appears to be a considerable disproportion between the effect and the supposed cause; but it is certain that Lalpoor is built in a valley, from which there is no exit for the drainage, until it shall have accumulated to the depth of 4 or 5 feet in the basin.

Disposal of the tail water.

213. After entering the hollow above mentioned the Canal crosses the Delhi and Hansi Road, beyond which it was not intended that excavation should be carried, except what might be necessary to pass off the surplus water, and carry it into the more sandy parts of the flat valley in which it is finally absorbed. The accumulation of this water has on one or two occasions caused inconvenience; but the length of the Canal, and the demands upon its waters which have been admitted, are so well proportioned to the head supply, that the amount of surplus to be disposed of is generally inconsiderable.

Embankments.

214. The embankments throughout this line have been formed with great care, and that on the right or west bank has in many places been widened out to 16 feet, and this operation will be continued as earth may be obtained from the channel.

Bridges.

215. From Gohanna to the end of the Branch there are sixteen Bridges, besides one built over the tail escape, on a new line of road, by the Ferry Fund Committee. Of those constructed by the Canal Department, three have

Rubruha.
Mahura.
Mudeena.
Bhynswan.
Chichrana
Mirzapoor Kheree.
Sanghee, No. 1.

Sanghee, No. 2.
do. No. 3.
Sahun Majra.
Khireewala.
Chumaree.
Nasirpoor.
Soondurpoor.
Juhangeerpoor.
Hansi Road.

timber roadways, supported on piers of masonry. These are narrow; and, not being on a high road, are intended merely for the convenience of the village population. The remaining thirteen Bridges are of masonry, and are all calculated to act as Dam Bridges, being fitted with sluice-gates and windlasses. They have all got masonry drains attached to their up-stream fronts. These deliver the water through the bank into cisterns having separate outlets at the heads of the several water-courses. By these Dam Bridges the distribution of the water is equably regulated, their sluices being closed and opened respectively, according to a fixed and regular routine. The silt which reaches this part of the Canal is inconsiderable in quantity, and is not found to choke the heads of the water-courses.

Chokies.

216. The 1st class Chokies on this line are at Sanghee and Singpoora, near Rohtuk. The former is rather damp; the latter, which is on a high mound at some distance from the Canal, is in good order. The 2nd class Chokies are at Bhynswan and Chumaree, of which the latter has been very recently built. The Bhynswan Chokie, though 30 yards from the Canal bank is very damp, and much affected with saltpetre.

XVII.—BOOTANA BRANCH CANAL.

Direction of the main line and minor branches.

217. The Bootana Branch Canal was excavated in 1835, with a view to bringing under irrigation a cluster of fine villages, near the Jheend Boundary, to which water could not be supplied from the Rohtuk Canal. Its direction, for the first twenty miles, is regulated chiefly by that of the lands to be irrigated, and crosses some tracts of low ground where the Canal is embanked to a considerable height. Near the village of Gungana the channel is divided into two forks, one minor branch passing on each side of the fertile valley in which the extensive lands of Bootana are situated, and from which there is no natural exit for the drainage. Both these forks are capable of extension, as far as regards levels, but the supply of water is deficient, even for some of those villages to which the Canal already extends.

Design for a western branch abandoned for want of water.

218. Another branch of this Canal was originally intended to leave the main trunk at Anchura. The levels were found to be

peculiarly favourable to such a design, and the lands through which it would pass were precisely those best suited for, and most requiring, irrigation. The difficulties, however, of satisfying the existing demands for water, precluded the entertainment of any design for incurring new ones.

Channel and silt deposits.

219. The fall of the Bootana branch, after leaving the main Canal (being sixteen inches per mile) is as great as the levels of that part of the country would admit; but is not sufficient to keep the channel clear of silt deposits, or to prevent the encroachments of reeds and rushes growing on the sides. Previous to the clearance which was effected in 1847, and by which it is supposed that the Canal bottom has been restored to its original level, the deposits had grown to a considerable extent, and the levels of the Canal were much raised. When the Canal was first opened, the indraught at the head was such that it was necessary to keep the regulating sluice partly lowered, in order to prevent the abstraction of too much water from the Hansi Canal. But so much was the state of affairs changed by the silt deposits, that in 1844 Captain Boileau deemed it necessary to adapt temporary sluices to the Kuvee Bridge, and to throw out a Spur in the Hansi Branch, in order to force a supply down the Bootana Canal. These measures are now abandoned, and it is hoped that by attention to the channel they will not again need to be resorted to.

Embankments.

220. The embankments were originally formed to 10 feet at top, as far as the Anchura Regulator. From thence to Gungana they were at first made 6 feet wide; but now will be increased to 10 feet. The embankments of the minor branches, which are in fact little more than watercourses, are 4 feet only, being merely formed from the earth obtained in excavating the channel.

Bridges to Gungana

Hath.
Chota Oorlana.
Burra Oorlana.
Seenk.
Pathiee
Anchura.
Jagsee.
Gungana.

221. The Bridges are all of masonry, and most of them are fitted with sluice-gates, so as to act as Stop Dams. From the Head to the Gungana Regulator, including the latter, there are eight Bridges, as per margin. The Anchura Bridge is a double one, having been so built as a Regulator at the head of the intended Western Branch alluded to in the 218th paragraph.

Bridges on the minor branches.

222. On the east fork there are ten, and on the west five Bridges, all of small dimensions. They are fitted with sluice shutters, and regulate the distribution of water for irrigation.

Irrigation Outlets.

223. The irrigation outlets are all of masonry, some attached to the Dam Bridges, and others separate, but all in connection with these works, and dependent on them for their supply of water.

Chokies.

224. A subordinate first-class Chokie has lately been built at Seenk, and another will be constructed at Bootana. The second-class Chokies are at the Head, at Chota Oorlana, at Anchura, and at Gungana.

XVIII.—PLANTATIONS.

Planting by the original designers of the Canals.

225. It would appear from the Sunnud of the Emperor Akbar, which was translated by Lieutenant Yule, that the subject of planting the Canal banks with trees met with some attention from the original designers of the work; but the Canal avenues appear to have shared the fate of those which adorned the Royal road from Agra to Lahore, and it is only in the immediate vicinity of Delhi, that any trees having an appearance of intentional planting, remained to recent times.

First planting operations under our rule.

226. Some commencement of planting was made by Colonel Colvin's predecessors, but it remained for that officer to work on a regular plan, and to obtain the sanction of Government to a fixed annual expenditure for that purpose. His first care was to establish nurseries, and plant out young trees at intervals of 30 feet in rows, on the outside of the formed embankments, on those branches of the Canals on which navigation was possible (leaving a clear space for tracking between the water and the bank), and on both sides of the embankments of minor Canals. He also planted many pieces of waste land adjoining the Canals, being strips of reclaimed marsh, or deserted loops of the channel.

Method of procedure.

227. After a few years' experience, it was found that trees, planted originally at such intervals as would be eventually necessary when they should attain their full growth, had a tendency to spend their strength in throwing out lateral branches, to the detriment of the main trunk, which remained short and almost unfit for economical purposes, whereas, when planted close together, the young trees shot up with long and straight stems.

It was therefore determined to diminish the intervals where trees had been planted out separately, by putting in one or two intermediate ones, and in many places to which planting had not yet extended, to rear continuous belts of young trees, which it was intended to thin gradually, as they should grow up, by removing the less promising and leaving only the strongest and straightest plants. But it would appear that this intention was not well understood by succeeding Superintendents, who inadvertently brought on the dead stock valuation list of Canal property a number of trees which were in much closer order than would admit of their ultimate development, and then scrupled, without special authority, to diminish the nominal value of the dead stock, by removing such of the trees as interfere with the healthy growth of the others. An explanation of these circumstances, however, and of the real merits of the case, has lately been made to the Military Board, and full sanction has been obtained for whatever degree of thinning, may, in the Superintendent's opinion, be most conducive to the improvement of the plantations, and consequently to the enhancement of their real value.

Present state of the plantations.

228. Excepting in some parts of the northern division, of which the soil, like that of most Khadir land, is unfavourable to the growth of trees; and excepting, also, the extremity of the western branches, to which the water does not reach with sufficient regularity, the Canal embankments have been once planted with continuous rows of trees; but owing to accident, neglect, or other causes, many vacancies still occur and afford scope for future operations, especially on the Hansi and Bootana branches. The enlargement of the Canal embankments from the original width of 10 feet to 16 feet, was attended with the unavoidable sacrifice of many thousands of the trees first planted out, and which had attained a considerable size.

Remarks on the Sissoo

229. The most prevalent, because the hardiest, description of tree on the Canal banks is the Sissoo (*Dalbergia sissoo*). Its timber, when full grown, is valuable for agricultural as well as architectural purposes; but it is slow in attaining maturity, and when young the wood is of little use except for fuel. The bole of the sissoo is seldom straight, and unless the trees have been planted close together when young the main trunk is short, and the branches are seldom thick enough to afford planks. The sissoo grows best in clayey soils, is not affected by frost, and can stand occasional though not permanent inundation of its roots. It should be planted in rows, with intervals of 10 or 12 feet between the stems.

On the Babool and Keekur.

235. The Babool or Keekur (*Mimosa Arabica*) is, perhaps, the most remunerative of all the trees grown on the Canal banks. It attains maturity in about thirty years, and is then worth from 8 to 12 rupees per tree. The wood is preferred to all others in the construction of ploughs, carts, Persian wheels, and other agricultural implements. The smaller branches are useful for fourah helves, tent-pins, and conversion into charcoal, and the bark is used in tanning hides. It will not grow in all parts of the Canal, being sensitive to cold, not affecting a moist soil, and being quickly destroyed, if the ground about its roots is inundated.

Remarks on the Toon.

231. The Toon (*Cedrela toona*), though extensively planted, has not yet been very successful. It is long in reaching maturity, and appears to be liable to many diseases at all stages of its progress. A beautiful avenue of these trees, near the Rair Regulator, when about twenty years of age, suddenly and unaccountably withered in the course of a few months. The Toon requires a moist soil, not only when young, but throughout its existence. Those in the Hansi Cantonment, planted while the Station Gardens were watered by a stream from the Canal, died, without exception, when the supply of water was cut off, though some of them had attained the height of 30 feet.

On the Teak.

232. The Teak (*Tectona grandis*) has been cultivated on the western Canals, but not with much success. It is particularly liable to injury from frost, which frequently blights all above ground, leaving vitality only in the roots, which throw out new shoots in the following spring. Many teak trees on the Canal banks are thus not larger now than they were ten years ago. Some advantage has been found in planting teak under the shelter of "sirris," and other fast growing trees, which act as nurses during the infancy of the plant, and are subsequently thinned, or entirely removed, to admit of its healthy growth.

On the Saul and Fir.

233. In the Northern Division an experimental plantation has been formed of Saul (*Shorea robusta*) and Cheer (*Pinus longifolia*), which appear to thrive well, but require protection from frost for some years. The saul has not succeeded south of Kurnal.

Fruit trees on the banks

234. In the neighbourhood of Delhi the Canal banks are planted with fruit-trees, (such as the Goolur, Mulberry, Jamun, Bēr, &c.) the produce of which is the source of a small annual revenue. The plantations of Bombay mangoes, which have succeeded so well on the Doab Canal, have not yet been introduced west of the Jumna.

235. The value of the plantations depends much on their situation relative to a market. The wood produced on the Delhi branch, and on the main trunk above the Rair Regulator, obtained a ready sale at Delhi, to which it is rafted down the Canal channel; and in the Western Districts, which are naturally bare of trees, there is a considerable demand for the Babool grown on the Canal banks; but even here, firewood is not in much request, as the use of cow-dung for fuel is very general, and wood in any quantity can be cut in the Jheend jungles, and floated at small cost down the Canal. On the other branches the Canal wood is nearly unsaleable. Babool and sissoo, self-sown from seed scattered by the Canal trees, spring up naturally along the lines of village watercourses, and supply the wants of the people. In such localities the value of the Canal plantations is nearly confined to their ornamental appearance, to the shade they afford to those frequenting the Canal Bank, and to their use in suppressing the redundant growth of grass and weeds. Value of plantations

236. The annexed Tabular Statement (see Appendix D), will show that the amount realized by the sale of grass and wood within the Canal bounds, has hitherto been considerably in excess of the expenditure on plantations, which for many years was 2,000 Rupees per annum, but has been lately fixed at the yearly sum of 3,000 Rupees. Returns from sale of wood, &c

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XIX.—WATERCOURSES AND RAJBUHAS.

237. The Delhi and Rohtuk Branches of the Canals appear to have afforded extensive irrigation to the country during the time of the Emperors; and the watercourses excavated at that period were the first availed of, when the Canals were reopened under our rule. The proprietary right to each of these watercourses appeared to be well understood throughout the country, and was seldom the subject of disagreement; a circumstance which was so far fortunate, as it obviated many disputes which would doubtless have arisen, when the water had to be taken through the lands of one village for the irrigation of another; but it had also its disadvantages. The old watercourses were often raised above the level of the country, probably owing to former accumulations of silt, and thus the labour of excavation was Ancient watercourses.

in the first instance enhanced, and less room was left for the disposal of earth removed from the channel in subsequent clearances.

New water courses.

238. When the benefits of Canal irrigation were better known and understood, they became the object of desire to many villages which had no ancient watercourses, and as these were for the most part at some distance from the Canal, a necessity arose for arranging, authoritatively, and once for all, the terms on which watercourses might be cut through the lands of other villages than those for whose use they were intended. Under the arrangement proposed by Colonel Colvin, and sanctioned by Government, it was made compulsory on all villages, bordering on the Canal, to permit the excavation through their lands of such watercourses as should be approved and considered necessary by the Superintendent; and any village so intersected by a watercourse, was entitled to as much water from it as it could raise with one "daul" worked by two men. No remission of the Land Revenue was, I believe, made at the time on account of land occupied as above described (at least no report on the subject was made by the Canal officer to the Collector), but it was duly considered in the present settlement, in which only cultivated and culturable lands were assessed.

Conditions of the excavation of private watercourses.

239. All expenses connected with the restoration of old, or formation of new watercourses (except that of the masonry outlets through the Canal banks), were borne by the Zemindars, who were required to provide sufficient embankments, where the water was above the level of the country, and to construct bridges (formerly of wood, but latterly of masonry) on all established roads crossing the line of their cuts. A new line of road carried across an existing watercourse has always been considered chargeable with the expense of its own bridge. The Zemindars at first were occasionally assisted with loans, proportioned in amount to the extent of the proposed watercourse, and repayable by two or more half-yearly instalments, but this practice has ceased since the introduction of the Rajbuha system.

Rajbuhas, their first introduction

240. Rajbuhas are joint stock watercourses designed and executed by the Canal officers for the use of two or more villages. The original cost of construction, as well as the annual expenditure incurred in clearing the channel and maintaining its efficiency, are defrayed in the first instance by Government, and ultimately recovered from the villages, in shares proportionate to the benefit received by each. This system was first tried on the Hansi Canal, and with so much success as to lead to its general adoption east of the Jumna. On the Delhi and Rohtuk branches, where irrigation had been practised from the com-

mencement, the existence of long-established private watercourses prevented the rapid introduction of a new system, involving additional expense to the cultivators, and though, during the drought of 1833 and 1837, many new clusters of villages were brought under irrigation by means of Rajbuhas, yet in the case of a great proportion of the new claimants for water, the demand was too sudden and too urgent to admit of the delay involved in the examination and selection of a line, and more especially as the time and attention of the Canal officers was then engrossed by the care of maintaining, and equally distributing, such supply of water as could be obtained from the Jumna.

Gradual supercession of private watercourses.

241. The accumulation of silt at the heads of watercourses, especially where several are supplied from the same cistern, has been already adverted to, and the annually increasing inconvenience arising from this circumstance, though on many accounts to be regretted, is beginning to have one beneficial result, in inducing many villages to come forward voluntarily, with a proposal to relinquish their private imperfect means of irrigation in exchange for Rajbuhas, formed and maintained under the supervision of Government officers. It is certainly a desirable object, and one which the Superintendent of the Western Jumna Canals should lose no opportunity of promoting, to absorb as many private watercourses as possible in a well-arranged system of Rajbuhas. The chief difficulty will probably be found in the existence, in many instances, of contracts for irrigation, agreed to between the Superintendent and the cultivators, and which are dependent on the areas of existing irrigation outlets, but I have little doubt that the supply of the new Rajbuhas can be so adjusted as to satisfy the fair claims of all parties.

XX.—ESTABLISHMENTS.

European Establishments.

242. The European Establishment of the Western Jumna Canals consists of—

An Executive Superintendent.
3 Assistant do.
9 Overseers.

Superintendent's Salary and Duties.

243. The Superintendent, who draws a staff salary of 600 Rupees per mensem, has lately, by an Act of the Supreme Government, been

vested with the powers of a Deputy-Collector and Joint Magistrate, in all matters connected with his public office. His duties are sufficiently multifarious, involving the direction and control of a large establishment in the Executive, Revenue, and Police departments. It is hardly necessary to remark that on the judgment of this officer, on his impartiality and patient attention to business, the prosperity of the Canal, and of the various important interests connected with it, in a great measure depend. A local acquaintance with the works, and some previous training in the Canal department, are important, if not essential qualifications, and these may probably be secured for the future should Government determine to hold out inducements to young officers to remain on the Canals beyond the period at which their standing would entitle them to one of the smaller executive charges in the Barrack department.

Salary and Duties of First Assistant.

244. The First Assistant at present receives a staff allowance of 300 rupees per mensem, a salary which was first accorded during the incumbency of Lieutenant H. Yule, but which is secured by the orders of the Governor-General in Council, dated 30th April 1838, to any one of the Canal Assistants whose services it is desirable to retain on the Canals, and who would, by his standing, receive a similar salary in the Barrack department. The First Assistant has subordinate charge of the Executive and Revenue duties of the Delhi and Rohtuk Branch Canals, with such discretionary powers as the Superintendent may think fit to entrust to him. He and the other Assistants are, by the resolution of the Lieutenant-Governor, North-Western Provinces, dated 31st May 1845, declared competent to exercise the powers of Deputy-Collector and Joint Magistrate, under the direction and on the responsibility of the Superintendent.

Salary and Duties of Second Assistant.

245. The Second Assistant, at present drawing a staff salary of 200 rupees per mensem, is either placed in subordinate charge of the Hansi and Bootana Branches, or, when quite inexperienced, as must frequently be the case, he is kept with the office of the Superintendent, or employed in field work.

Salary and Duties of Third Assistant.

246. The Third Assistant, Mr. Conductor W. Dawe, drawing a consolidated allowance of 325 rupees per mensem, was raised to his present appointment as a reward for long and faithful service in the capacity of an overseer on the Canals. He has subordinate charge of the Northern Division, from the Heads to near Kurnal, including the complicated works at and near Dadoopoor.

247. The European overseers are the executive agents employed by the Superintendent, in all expenditure on original works, or in annual repairs. They transmit their accounts monthly, either direct, or through the Assistants, to the Superintendent's office. They have the registry of the water-gauges, and meteorological observations, and are occasionally employed to patrol the banks during the days and nights when the watercourses of their districts are ordered to be closed, but they have nothing to do with the collection of revenue, and exercise no control over the Zilladars, or other establishments whose duties lie exclusively in that department. General Duties of European Overseers

248. The number of overseers at present attached to the Western Jumna Canals is nine, and the situation and extent of the divisions of works to which they are severally posted are detailed below. Divisions of Works assigned to Overseers

Northern Division.	Sergeant Willcocks. From the Heads to Madhilpoor. 24 miles. Sergeant A. Bremner. From Madhilpoor to Dhurrur. 70⅜ miles.
Kurnaul Division.	Sergeant Fitzpatrick. From Dhurrur to Kokrana. 56⅜ miles.
Soneput Division.	Sergeant Buttress. From Kokrana to Chota Thanna. 48 miles.
Southern Division.	Conductor Symms. From Chota Thanna to Delhi. 34⅛ miles.
Rohtuk Division.	Sergeant Webster. From Rair to Rohtuk. 57⅞ miles.
Jheend Division.	Sergeant Martin. From Joshee down the Bootana Branch and Feroze's Canal, to Rajthul. 72⅝ miles.
Hansi and Western Division.	Conductor Johnson. From Rajthul to Raipoor. 35⅛ miles. Sergeant Dixie. From Raipoor Bridge to the end of the Canals. 76 miles.

249. The Native Establishment may be divided into three sections :— Native Establishment.

I.—The Superintendent's Office.

II.—The Establishment for Works and attached to Overseers.

III.—The Establishment employed on the collection of Revenue, distribution of Water, &c.

Superintendent's Office Establishment, and their Duties.

250. The Superintendent's Office, part of which is always detached with assistants, is constituted as follows:—

6 English Clerks.
1 Persian Moonshee.
5 Accountants or Mootsuddies.
1 Treasurer.
1 Duftree.
1 Duffadar of Sowars.
10 Suwars.
6 Chuprassies.
9 Classies.
2 Duffadars of Burkundauzes.
8 Burkundauzes.
1 Sweeper.
1 Bheestie.

The monthly accounts and progress reports of works are received from the Overseers and their Mootsuddies separately, in English and Oordoo. After examination by the Superintendent, they are checked and abstracted in the Office, and entered into the General Ledger, in order to the ultimate preparation of Bills. The Collection Accounts, or more properly the materials for preparing them, are received in Oordoo from the Daroghas and Zilladars; and are examined, abstracted, and entered in the Office Books, both in English and Oordoo. From the documents above alluded to are prepared the Accounts Current for Works and Collections required by the Military Board or by Government. The correspondence between the Superintendent and the Native officials is carried on entirely in the Oordoo language. The Sowars, Chuprassies, and Classies, are for carrying orders and messages, for the conveyance of treasure, and for orderly and surveying duties. They are proportionably divided between the Superintendent and his three Assistants.

Establishment for Works

251. The Native Establishment attached to each Overseer consists of one or more Mootsuddies, according to the extent of his charge:—

3 Chuprassies.
2 Classies.
3 Chokidars.

1 Mate Bricklayer.
1 Mate Carpenter.
1 Mate Blacksmith.

And a Burkundauze Guard sufficient for the protection of his treasure-chest, tools, &c.

252. The Establishment for conducting the Revenue and Police duties consists of— Establishment for Revenue and Police Duties.

2 Daroghas.
10 Zilladars.
4 Accountants for measuring Crops.
8 Mirdahs for ditto.
32 Sowars.
61 Chuprassies.
124 Chokidars.

253. The Daroghas superintend the half-yearly measurement of the crops, and report specially to the Superintendent any circumstance which may appear to call for remission of Water Rent on land measured or on contracts. It is also the duty of the Darogha to examine the Zilladar's accounts, to acquaint himself thoroughly with his mode of performing his duties, and to report to his superior any irregularity, oppressive conduct, or inefficiency on his part or that of his subordinates. The office of Darogha is a very important one; and there is much reason to regret the decease of the two individuals formerly holding it, and who discharged its duties to the entire satisfaction of their superiors for many years. The limit of salary allowed to Daroghas has lately been extended to 100 rupees per mensem; but neither of the present incumbents is entitled to the full amount. Duties of the Daroghas

254. The duties of the Zilladar are to collect the Revenue and pay it into the Government treasuries, to carry out the Superintendent's orders for the management and distribution of the water, and to inquire into and report all cases of trespass, waste of water, or other infringement of the Canal regulations. He accompanies the Darogha while engaged on his half-yearly measurements, and points out the land irrigated. It is his business, in communication with the village Mukuddums and Putwarees, to arrange the share of Water Rent, &c., payable by each individual, and he is bound to enter, in a village receipt book kept for that purpose, an acknowledgment for every sum of money that he may collect. The Zumindars are previously warned against paying money, except on warrants bearing the signature and office-seal Zilladar's duties

of the Superintendent, and of which the receipt is not duly acknowledged in the village books. The Zilladar is assisted in the general discharge of his duties by the subordinate establishment above detailed. The salaries of the Zilladars vary from 20 to 50 rupees, and the amount of security required from them ranges from 2,000 to 5,000 rupees.

XXI.—WATER GAUGE REPORTS AND METEOROLOGICAL REGISTER.

Object and use of Water Reports.

255. In so extensive a tract of country as that which is dependent for irrigation on the various Branches of the Western Jumna Canals, it will be readily supposed that the fall of rain is by no means uniform, and that the demand for irrigation, dependent on that and other circumstances, frequently varies considerably in the different districts. To enable the Superintendent to regulate the distribution of water in the several branches, with reference to the probable demand, he receives daily or weekly, as it may be, a report of the height of water on fixed gauges established at certain points (chiefly above and below the Canal regulators); and from each division a statement of the daily temperature, as shown by a thermometer at sunrise, and of the amount of rain-fall, measured by pluviometers of uniform size and pattern. These registers are kept by the European overseers, and entered in neat lithographed forms, in which also a column is provided for remarks, relative to wind, weather, &c.

Meteorological observations at Dadoopoor.

256. At Dadoopoor, from 1832 till within the last few months, a barometer, and attached, detached, and wet bulb thermometers, were registered four times a day, with the primary intention of affording to the officer stationed at Dadoopoor some guidance in opening the great dam in anticipation of Sombe floods, which come very suddenly, and sometimes without the previous occurrence of local rain; but besides this particular use, the observations, which were accurately and faithfully made, possessed much general interest, and it is to be regretted that they have been interrupted by some accident having occurred to the barometer during the last rainy season. The instruments are the private property of Colonel Colvin.

Remarks on Water-Gauges.

257. The value of a water-gauge register, as a means of comparing the quantity of water at different times, obviously depends on

the permanency and identity of the standard by which its depth is measured, and great pains have therefore been bestowed in selecting for the "punsauls," or water-gauges, a position as little as possible liable to change, and when it has become necessary to replace one destroyed by decay or accident, the greatest care has been taken to preserve the original zero of graduation. No precaution, however, will prevent the fidelity of these returns being affected by local silt deposits, or by a general rise of the level of the Canal bed. Several of the gauges on the Western Canals have, by these causes, been rendered useless for affording the means of comparing the present with the supply of former years, though they still show with sufficient accuracy the fluctuations in one season. A few only, as for instance those at Dadoopoor, above and below the Rair Regulator, at the Negumbode Aqueduct, and at the Hansi overfall, are still, I believe, unaffected by these causes, and their returns may be relied upon as indicating now, the same ratio as in former years, between the discharge and the recorded height of water.

XXII.—REGULATION OF THE SUPPLY, AND ADEQUACY OF THE JUMNA TO MAINTAIN IT.

Frequent necessity for a regulated distribution of water

258. In some years of abundant rain, and during eight or nine months of every year, the supply of water procurable from the Jumna is sufficient to satisfy all the existing demands on the Western Jumna Canals; but the extension of the gravel bunds at the Heads during the cold weather, so as to intercept the whole volume of the river, after deduction of the Doab Canals claims, is now an event of almost annual occurrence, and even this measure has often been found insufficient to maintain a full supply in the Western Canals. When, from this or other circumstances, the demand for water exceeds the supply, it becomes the duty of the Superintendent to provide for the deficiency being felt by all alike, and not exclusively by the villages situated near the extremities of the several branches.

Means by which it is effected.

259. On the Rohtuk and Bootana Canals where irrigation is dependent, as above mentioned, on the use of sluice gates, the regulation of these, by a fixed routine, is sufficient to insure an equable distribution of the water; but on the Delhi and Hansi Branches it is usual, in times of scarcity, to stop the irrigation of all the divisions of

the Canal, in their respective turns, for three days out of every seven; and as the prohibition to open watercourses between certain points, and during certain days, is absolute, the duty of enforcing its observance, by the European and Native officials appointed to patrol the banks, is greatly facilitated. The Superintendent has a further check by means of the water-gauge registers, the fluctuations in which clearly mark the degree in which the restrictions have been observed.

Partition of the Jumna between the Eastern and Western Canals.

260. A question regarding the fair partition, between the Eastern and Western Canals, of the Jumna's supply, at times when it should be inadequate to satisfy the full demands of both, was first brought forward after the great drought of 1837-38, when the Jumna had fallen lower than had been known before, or has since occurred. The loss on this occasion fell entirely on the Western Canals, that on the opposite bank having, by its local position, a command of the water, and naturally having made the most of its advantage.

The question referred to the Military Board, and the results of the reference

261. The question was taken up in a liberal spirit by the Military Board, who ordered the superintending Engineer, in concert with the Executive Superintendents of both Canals, to measure the discharge of the river when nearly at its lowest, and, in consultation with those officers, to submit to Government some plan for the settlement of the question, in which all parties could concur. In pursuance of these instructions, the discharge of the Jumna, and of the two Canals near their heads, was measured by Captains Abbott, Cautley, and Baker, in February 1842, with the following results:—

Discharge of the Jumna . . .	3488·82	cubic feet	per second.
„ of the Western Canals	2276·96	„	„
„ of the Eastern Canals	537·98	„	„
Surplus at that time	673·88	„	„

A scheme, founded on these results, was privately submitted by me to Captain Abbott; but having found that officer under orders to join General Pollock's division of the army in the Khybur Pass, was mislaid and forgotten.

The question now in the hands of Government, North-Western Provinces.

262. Amidst the frequent changes of management which subsequently took place, the subject appears to have been lost sight of, until it was again pressed on the notice of the officers interested in the Western Canals, by the submission and approval of a project for a considerable extension of the Doab Canal irrigation by means of Rajbuhas. The question is now in the hands of Government, North-

Western Provinces, and will, I trust, be definitively settled in such time as will admit of the rules laid down for the equitable division of the water, being added as an appendix to this report.*

XXIII.—CANAL REVENUES.

Progressive increase of Revenue.

263. The Canal revenues were at first of slow growth, and it was not till the year 1833-34 that they exceeded the annual cost of establishment and current repairs. For ten years from that date the surplus revenue continued steadily to increase, until, in 1842-43, it exceeded two lacs of rupees; the gross amount being 311,265 rupees, and the expenses 110,834 rupees. A statement of the annual revenue and current expenses from 1831-32 to 1846-47, will be found in Appendix E.

Items of Revenue.

264. The principal source of revenue is water rent on irrigation. The other items are rent on water-mills and watering cattle, transit duties on rafts, amounts realized by sale of grass and wood, and fines.

Rates of Water Rent first established.

265. When the Canal was re-opened in 1819, and its waters began to be used for irrigation, the rates of assessment first adopted would appear to have been experimental, and to have varied considerably, at the discretion of the Superintendent. They were, for the most part, very low, as an inducement, probably, to the Zumindars to adopt a

* The hope here expressed has not been realized; and I may, therefore, be allowed to place on record the views I have taken on this question, and to state what I consider to be the basis on which alone it can be equitably settled. The Western Canal, from priority of construction, and other causes which need not here be enumerated, extended its irrigation to very near the limits of its capabilities (with reference to the available supply of water) many years before the Eastern Canal was in a condition to follow its example. By these means it obtained the *right of possession* to the proportion of the Jumna for which it had already found profitable employment. This claim of possession is now of ten years' standing, and is further strengthened by the facts that contracts or leases of most of the Canal outlets, for twenty years, have been given, under the sanction of Government, to villages on the Western Canals; and that the assessments of their Land Revenue, for periods of twenty to thirty years, have been fixed with especial reference to the facilities of irrigation in each village Nor does the inexpediency of diminishing the resources of the Western Canals, in order to extend irrigation in the Doab, appear to me less obvious than its injustice. Such a measure would involve a revision of the Canal contracts, as well as of the Revenue settlements, of many villages, and entail a considerable loss to the State; while it would tend to shake the confidence of the people in the stability of engagements entered into with them on the part of Government.—W. E. B, Oct 1848.

new mode of irrigation. In 1827 the regulations now in force with regard to contract and measured irrigation, having been framed by Colonel Colvin on the experience acquired during the intermediate period, were submitted to the Supreme Government, and obtained their sanction under date the 30th August 1827. They have since received additional confirmation from a resolution by the Honourable the Lieutenant-Governor, North-West Provinces, dated 31st May 1845, for giving effect to Act VII. of 1845, regarding Canals.

Specification of present rates on measured irrigation.

266. The rates of water-rent on measured irrigation are discriminating, with reference both to the nature of the crop and the method of irrigation employed. 1st. Garden ground, met with almost exclusively in the neighbourhood of large towns, and requiring very frequent irrigation, is assessed at the half-yearly rate of $2\frac{1}{2}$ or 2 rupees per acre, according as the irrigation may be "tor" (*i. e.*, when the Canal water is higher than the natural surface of the soil) or "daul" (*i. e.*, when the water requires to be raised by labour to the level of the ground). 2nd. Sugar-cane, which requires water for ten months in the year, indigo, and a few other products, requiring very frequent irrigation during their respective seasons, are assessed at 2 rupees "tor," and $1\frac{1}{2}$ rupee "daul," per acre. 3rd. Rice, cotton, wheat, &c., occupying the ground for five months, and requiring four or five waterings to bring them to maturity, pay 1 rupee "tor," and 10 as. 8 p. "daul," per acre. 4th. Gram, barley, jowar, bajra, &c., not commonly watered, except in failure of the usual rains, and then not more than once or twice, are assessed at 10 as. 8 p. "tor," and 8 as. "daul," per acre.

Former rates of contract.

267. The rates of contract on outlets was fixed at 2 rupees per annum, per square inch of area for "tor," and half that rate for "daul" lands; but the Superintendent was allowed a discretion in modifying these rates, according to the favourable or unfavourable circumstances of the watercourse, or of the land to be irrigated. The half-yearly rent on the machines for raising water, varied also with their capabilities, but were calculated to afford irrigation at the rate of about 8 as. per acre. No period was prescribed for the term of contract, but those for outlets were seldom given for more than three years, while the machines were generally rented half-yearly.

Abuse of contracts by Zumindars

268. The system of contracts above described obtained very generally until the year 1833, when it was deemed advisable, for the following reasons, temporarily to suspend its operation. 1st. It was found that several villages having agreed for one or more outlets, for a specified number of years, and having derived great advantage from

them during drought, refused to pay water rent for the seasons during which they chose to cultivate crops not requiring irrigation, or more frequently when, to carry some point with the Collector, they thought proper to throw their lands out of cultivation. On such occasions the contract rent was invariably claimed by the Canal authorities, and the accumulation from this source of outstanding arrears at one time became considerable. 2nd. The rents being fixed with almost exclusive reference to the area of the outlet, it was found, not only that water courses paying the same rent had different capabilities of irrigation, but that the capabilities of all the outlets were subject to a progressive improvement, in consequence of the annual increase of the Canal supply giving them a higher head water.

Contract system suspended for a time, and resumed when

269. For the above reasons it was determined not to renew the contracts for outlets after expiry of the terms for which they had been respectively given, but to measure all irrigated crops until, 1st. The Canal supply should have approached its maximum. 2nd. The revenue affairs of Canal villages should be finally settled; and, lastly, until we could discover some simple and satisfactory method of estimating the actual and practical value of each outlet.

Canal supply had reached its maximum since 1837-38.

270. The first of these conditions was fulfilled in 1837-38, in which, and the following years, the available supply of the Jumna was exhausted. The value of the outlets in some localities, has, indeed, been since affected by a cause not then anticipated, viz., the rising of the level of the Canal bed by silt deposits; but this change is in a measure counteracted by the accumulation of sand at the heads of the watercourses.

Revenue settlement had been completed,

271. The second condition has been fully met by the late Revenue Settlement, on leases of 20 to 30 years, which have left the cultivator no wish or object but that of making the most of their lands.

And the difficulty of determining the value of outlets had been met

272. The third condition, viz., the discovery of a simple rule for estimating the practical value of a given outlet, might have been fulfilled by the adoption of some of the methods long practised in Italy, had there been any surplus fall to work upon. The water in the cisterns of supply might then have been maintained at a uniform level above the sill of the outlets, without reference to the fluctuations of the Canal; and this would have ensured a uniform discharge, provided also that the slope of the watercourse, or channel of derivation, were such as to admit of a free current. The circumstances of the case, however, with which we had to deal were very different; a few only of the watercourses on the

Western Jumna Canals have any surplus fall, and to have reduced them to the level of the rest would have been to inflict upon them a positive injury. Equalization could only have been effected by reducing all to the level of those that had the least fall; and this being inexpedient, it remained only to ascertain the value of each head of irrigation separately; nor, even in this inquiry, was much aid derived from science. An attempt was made to get the discharge of outlets by measuring the velocity of their channels, but this was found to vary so much with reference to the inconstant height of the Canal, the state of the water-course, and the level of the land to be irrigated (which may vary considerably in the same watercourse), that no satisfactory result was obtained; and it was finally determined to assess the outlets with few exceptions, on the average of their irrigation for three or more years; taking also into account in some cases, the maximum cultivation of any one fussul. On this plan was assessed the water rent of the greater number of the villages irrigating from the Western Jumna Canals.

Villages excepted from contracts

273. The villages situated near the extremities of Branch Canals, or otherwise liable to occasional interruption of the supply of water, were entirely left out of this arrangement. The frequent claims for remission in such cases, would, in their investigation, have led to as much trouble, and would have been liable to the same objections, as the half-yearly measurements.

Terms and period of contract.

274. The terms of the contract will be found in Appendix H., they are calculated to leave as much as possible at the discretion of the Superintendent, the occasions and extent of remission claimable on account of short supply of water; but with the full intention that all such claims should meet with liberal consideration. The term or period of contract was fixed at 20 years, and has been confirmed to that extent by the Sudder Board of Revenue and the Government of the North-West Provinces.

Advantages derived by the Zumindars from the new arrangement

275. Though some trouble was experienced at first in inducing the Zumindars to enter into the new arrangement, they are now, generally speaking, well satisfied with it, and fully able to appreciate its advantages, which may be thus enumerated. 1st. The contract villages are first supplied with water in times of scarcity. 2ndly. They are freed from the minute interference on the part of the Canal Establishment, which is inseparable from a half-yearly measurement of their crops, and which, doubtless, affords opportunity for extortion on the part of the subordinates, on whose reports the measurements must in many cases be made. 3rdly. They may irrigate superior crops at the

same rate as inferior ones, and will frequently save the latter, or render them more productive by one timely watering, which would be withheld were it to be paid for directly. 4thly. They are allowed to fill the village tanks without extra payment: and, lastly, if they choose to extend their cultivation to the utmost limit of the capabilities of their outlets, they will obtain the water at little more than half price.

Advantages derived by Government

276. The benefits accruing to the state from this arrangement, are a steady revenue, less liable to fluctuate with the varying seasons, and a reduction in the measuring establishment which must otherwise have been considerably increased. The revenue, indeed, will still fluctuate to some extent, but its relation to the seasons is reversed. On the former system the driest years were those in which the Canal Revenues were greatest; but now the best returns will be obtained in those seasons when there may have been rain enough to fill the Jumna, and when there is most water over and above the consumption of the contract outlets.

Arrangements with villages near the head of the Canal

277. Under the head of "Water Rent" must be included a contribution of labour to the annual restoration of the Canal Heads, by certain villages in their vicinity, and which receive in exchange a supply of water for their irrigation, and for working their "Girats" (a rude species of corn-mill). The arrangement is one of long standing, and was entered into by Colonel Colvin when he took possession of the channels of the Jumna, by which these villages had been in the habit of bringing their own supply. Under such circumstances, it would not have been just to charge them with the full water rent, but there was no reason why they should not contribute to the Canal Works a portion of the labour which they would have had to bestow on their own. The money value of the labour thus obtained is small, but in a thinly peopled country, it is of great advantage to secure the attendance of a small body of able-bodied men, many of whom are well practised in making gabions, and constructing the gravel-bunds.

Rent on watering cattle.

278. The rent on watering cattle is contributed chiefly by the Hissar District, and is levied only on those villages which pay less than 100 rupees per annum for irrigation. It is now inconsiderable in amount, having been gradually diminished with the extension of irrigation. Many villages which formerly paid rent for watering their cattle have now obtained exemption, and of those situated near the extremities of the Western Branches, the supply is too precarious to admit of any rent being charged.

Rent on Water-Mills.

279. The rent on water-mills for grinding corn, though still a considerable item of revenue, has considerably diminished within the last few years. The mills were situated at Kurnal, Delhi, and Hansi, of which the Kurnal and Hansi mills have been thrown out of work, in consequence of the abandonment of those cantonments as stations for regular troops. The Delhi mills being situated at the extremity of a branch, frequently suffer from the consumption of the entire supply of water in irrigation, an object which is always considered as of superior importance to that of working mills.

Transit Duties on Rafts.

280. The revenue derived from transit duties on rafts of timber passing down the Canal, reached its maximum some years ago, and is now sharing the deterioration of the forests in the valley of the Jumna, in which no timber of any size, or of the first quality, is now to be found. The quantity of small timber, such as Pharas, Kurries, Tors, and Bullees rafted down the Canal, is still considerable, and has been increased by the annual diminution and frequent stoppage of the water of the Jumna, by the Canal bunds; and even when there may be sufficient water on the rapids of that river for the passage of rafts, the more safe route by the Canal is frequently preferred. The successful execution of the project referred to in paragraph 92, for establishing a navigable communication between the Canal and the Jumna at Madhilpoor, would probably lead to some increase of revenue from transit duties.

Navigation by boats.

281. The navigation of the Western Jumna Canals by boats, has been unsuccessfully attempted, but, perhaps, has never had a fair trial. With the present levels of the water, some of the bridges on the Hansi Canal, and nearly all of those on the Delhi Branch, would interfere with the passage of boats, and even were these impediments removed, the fluctuations of the Canal supply, dependent on irrigation, would be a frequent and serious impediment to any regular plan of boat navigation.

Sale of Embankment produce

282. The revenue derived from the sale of embankment produce, though inconsiderable in amount, is more than sufficient, as has been before observed, to cover the annual expenditure on plantations. The value of grass, &c., is not likely to exceed its present limit; but it is hoped that considerable sums will be realized hereafter by the sale of timber, grown on the Delhi and Hansi branches.

Fines

283. The infliction of fines for the breach of Canal regulations, is a necessary evil, and is the most appropriate mode of punishment for the generality of cases with which the Superintendent of a Canal

has to deal. The amount of fines must be expected to increase with the extension of irrigation; but the general introduction of the contract system, has removed many occasions of fraud on the part of the Zumindars; and it is, on the whole, a matter of congratulation that the revenue from fines at the present time bears a less ratio to the water rent than it did in former years.

Per-centage on Water Rent allowed to village Mukuddums

284. In the year 1831, the sanction of Government was accorded to a proposal by Colonel Colvin, to give to the Lumberdars or Mukuddums an allowance of five per cent. on the water rent of their respective villages, on condition of all arrears being settled within three months of the date of the warrants for collection of the half-yearly revenue. The objects of this measure were twofold. It was intended to promote the extension of irrigation, by giving the influential heads of villages a direct interest in the cause; and to assist the collection of revenue, by acting as a discount on its prompt payment. Both of the contemplated objects were attained, though how far the Mukuddum's allowance contributed to the extension of irrigation can never be known, as more powerful stimulants soon came into operation. As a discount on prompt payment and as an aid in collection, the value of this allowance is undoubted; and to it may be attributed that the Canal officers are seldom or never obliged to resort to stringent measures for the realization of the revenue.

Discussion regarding the continuance of this allowance

285. It has always been fully explained to, and understood by the Zumindars, that the Mukuddumee allowance was a matter of favour and not of right; and the question of its discontinuance was brought before Government in 1838, when it was obviously no longer required as a stimulus to irrigation. It was then proposed by the Sudder Board of Revenue that the allowance should be confirmed to the Lumberdars, on condition of their taking upon themselves the responsibility of collecting the Canal revenue; but they declined receiving it on such terms, though professing their willingness to assist the Canal Establishment, as they had hitherto done, by every means in their power. The final result of this discussion was the continuance, though not the confirmation, of the allowance.

Per-cen age on Mill Rent allowed to European Overseers

286. At the same time that a per-centage on water rent was allowed to the Zumindars, and with a similar object, an allowance of five per cent. on mill revenue was granted by Government, to be divided between the European overseers in charge of the mills and those on whose vigilance and activity the supply of the water depended. By this it was intended to give the overseers a personal interest in renting

the mills advantageously, and at the same time to afford an opportunity of rewarding men who, by a long course of good service, had established a claim to such an indulgence.

XXIV.—PROJECTS FOR FURTHER EXTENSION OF IRRIGATION.

Limited nature of admissible projects.

287. Under the circumstances discussed in paragraphs 258 to 262, it is evident that no project could be entertained for extending the irrigation of the Western Jumna Canals, except such as might have for their object to turn to account the waste water occasionally discharged by the Canal escapes, or whose demands on the Jumna were limited to those seasons of the year when they could be abundantly satisfied. It should also be remembered that a Canal flowing only during the rainy season would necessarily be attended with two obvious disadvantages. It would supply irrigation at a time when it would seem to be least required; and, secondly, the water with which it must be supplied must, in the nature of things, be loaded with silt, which would speedily choke up the Channel, and might impoverish the soil over which it was spread. On the other hand, it is notorious that, in many of the districts between the Jumna and the Sutlej, the rains are very precarious, and frequently quite insufficient for the cultivation of the Khurreef crop; while in other localities, the Rubbee or spring crop is dependent on the saturation which the land may have received, naturally or artificially, during the autumn.

Project for supplying the Nujufgurh Jheels with escape water from the Delhi Canals.

288. In 1837-8 it was proposed by Lieutenant H. M. Durand, in connection with other measures for the improvement of the Nujufgurh Jheels, that an Escape should be established on the right or west bank of the Delhi Canal, immediately opposite the Bowanna outlet (described in paragraph 143), with a view of throwing into the Nujufgurh basin, a portion of the water which now escapes eastward to the Jumna. The principal objections by which the suggestion was met were as follows: The new Escape could not be taken off at so low a level as the old one, and therefore would not act so efficiently as a scour to the Canal; and, secondly, that this reinforcement to the Jheel would be seldom available except during those seasons when its natural sources of supply were abundant, and would certainly fail in time of drought. Under the system

of management now coming into operation on the Nujufgurh Jheels, and of which Rubbee irrigation forms a part, it may be found advisable to make use of the waste water of the Delhi Canal, but as the expense of the New Escape would be considerable, an accurate estimate of its advantages would be a proper preliminary.

Project for the irrigation of Kythul from the Delhi Canal

289. In the year 1843, at the suggestion of his Excellency G. R. Clerk, Esq., and on the requisition of Government North-West Provinces, I submitted a rough estimate for a cut from the Delhi Canal to feed the Chittung nulla, and for continuing the same (for the irrigation of the Kythul district) to a point south of the village of Kuttiana.

Description of the Chittung

290. The Chittung above Dhatrut, where it is occupied by the Hansi Canal, has no permanent supply, nor any connection with the hills. It is fed solely by the drainage of the high Bangur lands, which are divided by the Sombe River from the Sub-Himalayas. It first assumes a defined shape near the town of Belaspoor, from whence to near Leela Kheree it flows in two channels (one of which is called Raksee) in a south-westerly direction, nearly parallel with the Sursootee on the west, and the Delhi Canal on the east. The strip of country which it drains is not more than 8 miles wide. From Leela Kheree the Chittung still follows a South Easterly direction, by an exceedingly tortuous course, as far as Dhatrut in Jheend, where it joins another drainage channel, now occupied as the bed of Feroze's Canal. The Chittung differs considerably in the nature of its channel from the other nullas that intersect the protected Sikh States. Instead of the usual wide sandy bed, it has one or more well-defined channels, cut for the most part in stiff clay, and winding, with multiplied sinuosities, through a wide shallow valley. The slope and velocity of the channel are much reduced by its tortuosity; and this, joined to the contracted section of the central channel, causes the flood water to spread out laterally over the whole valley, through which it flows with a scarcely perceptible current.

Levels of the country favourable to the design.

291. The relative levels of this channel and of the Delhi Canal are not unfavourable to the design of throwing a supply of water from the latter into the former; and the most favourable position for the head would be the vicinity of Indree, from whence to Burass, a channel of 18 miles in length would have a fall of 28 feet; from thence to Kuttiana, the Canal would follow a south westerly direction, which is that of the natural slope of the country.

Principal masonry works required.

292. The execution of this project would involve the construction of two principal masonry works, viz., a Regulating Double Bridge at Indree, and an Escape in Ferozeshah's Canal, below the point where the Chittung enters it, to provide against the consequences of a large body of water being occasionally thrown into the Canal when a heavy fall of rain might cause a temporary suspension of irrigation in the Kythul district, and when the Canal would probably be full from the same cause. The Escape Channel might with advantage be led off into the dry Pergunnas of Mehim and Bewanny, the fall of country being favourable for such a purpose, and the aridity of the soil in those districts being such as to ensure at all times a welcome reception to the stream.

Estimated cost and returns

293. The cost of executing the project above adverted to was roughly calculated at 160,000 rupees, and the returns from Khureef cultivation (for which alone the supply would be available) was calculated at 54,000 rupees per annum, from which the annual expenses must be deducted.

Idea of supplying the Chittung from the Sombe

294. Another proposal for feeding the Chittung originated with Lieut. Strachey, who suggested that a Canal, leaving the right bank of the Sombe about two miles above the Dadoopoor Dam, might be taken under the village of Kharwan, and thence, by a cut through the ridge of the Bangur, which at that point has little elevation, might be thrown into the Raksee nulla. There are many objections to this scheme, as, indeed, to all which have been brought forward having for their object the diversion of any part of the drainage of the Jumna into the Valley of the Cuggur. Considering, however, the circumstances of the last-named river and its tributaries, the annually diminishing volume of water which reaches their termination, and the consequent gradual advance of the desert on the once-cultivated lands, the inquiry is one of too great importance to be lightly relinquished, and may well engage the attention of future Superintendents of the Western Jumna Canals, when not engrossed by objects of more pressing necessity.

APPENDIX.

APPENDIX A.

ON THE RESTORATION OF THE ANCIENT CANALS IN THE DELHI TERRITORY.

By Major Colvin, Engineers.

[*Extracted from that Officer's Report to Government as Superintendent of Canals.*]

I. THE CANAL OF FEROZ SHAH.

The original branch of the canals lately re-opened, to the west of the Jamna, was excavated under Feroz Shah, about the middle of the fourteenth century. The neighbourhood of Hissar was his favourite hunting ground, where he evidently must have passed much time, attended by his court, if we may judge from the extensive ruins of buildings and tombs still existing, and occupying a space of several square miles, all attributed to that period; the advantages of an abundance of good water for so large an assemblage, in a country of such extreme aridity, where the wells are 130 feet deep, and the springs often salt, may have been the principal incentive to this great undertaking.

Probability and tradition point out the head of the original canal to have been where it now is, immediately at the point where the Jamna issues from the lower range of hills, and nearly opposite to another hunting seat of the same emperor, marked in the maps as Bádsháh Mahal; from whence it was apparently conducted along one of the many old water-courses of the Jamna, till it fell into what was then the mouth of the Sombe river.* This channel, under the operation of time and floods now become the western branch of the Jamna, was then probably of more moderate dimensions, and, to turn the water into the cross-cuts formed, must have been closed below Fattehgarh, probably by an earthen dam renewed annually, no remains whatsoever of any permanent work remaining in that vicinity. By one or other, or all of the channels, the remains of which now exist, the water was conveyed across a tongue of land into what is clearly another old channel of the Jamna under Búrya, being a wide hollow, skirting the high ground to its north and west, which is continuous, though with numerous and deep indentations, from the hills along the right bank of the Sombe river, and then following this water-course as far as Karnál; towards the hills rising little short of 100 feet, thick,‡ of most excellent quality; buildings erected of such materials could not

* A mountain-torrent nearly dry, except in the rains, when it receives the drainage of the mountains south-east of Nahun, and of the plains east of its course, nearly to the Jamna, from which and a strong fall, its floods are most violent and sudden in their effects.

and sinking south of Karnál, near Uncha Sumáná (where the canal enters on the high land, and diverges from the Jamna), to about fifteen feet. Above this point the land on the left bank is uniformly low, extending to and forming the Kádir land of the Jamna, a most fertile tract, almost entirely under cultivation, and from its composition, and the closeness of water to the surface, almost independent of irrigation.

From Uncha Samáná, a canal must have been excavated, at first of great depth, but gradually diminishing as it approached Suffídon, near which it opened into a branch of the Chítang river, said to come from near Teraûrí by Barôd, a few miles east of Suffídon,* along which the canal was led with partial excavations, of which the remains exist, in some places more in others less (as would be the case in clearing out a river bed), until it rejoined the other branch of the Chítang, at Dhátrat. From Dhátrat the marks are more apparent of its having been an ancient river bed, simply cleared out to pass on a stream of water to Hissár, and a few miles beyond the latter, apparently with a view to provide an escape for the surplus water of the canal into the old bed of the river; as within a few miles of Hissár all trace of former excavation ceases, whilst the river bed is continuous; latterly, winding among the sand hills of Bhikanír, or more properly speaking, along the northern bounds of the sandy desert,† until the bed unites with that of the Ghaghar river, near Badhopal, and about twenty-two miles south-east of Bhatnír, whence it has been traced by Mr. W. Fraser, to open on the valley of the Satlej, north-east of, and about twenty miles from Baháwalpúr; thus securing an outlet for the waters, should such ever be needful; but as the Ghaghar river, which receives the drainage of the hills from Náhan to Plassía, and generally of the country between the Jamna and the Satlej, does not in the heaviest season pass in force beyond Bhatnír, no stream by the Chítang is likely to effect the junction, and the period when this river ceased to flow as one is far beyond record, and belongs to the fabulous periods of which even tradition is scanty.

It may not be out of place here to advert to the causes which are even now operating to destroy the utility of the Ghaghar and such rivers, and tending to extend the limits of the desert, which forms our north-western boundary in this quarter. What the country about and west of Ráneah, now inhabited by the Bhattís, has been, may be inferred from the numerous sites of towns and villages scattered over a tract, where now fixed habitations are hardly to be met with. I allude only to the vicinity of the bed of the Ghaghar, with which I am personally acquainted;—when the depopulation took place, I am not prepared to say; it must have been long since, as none of the village sites present one brick standing on another, above ground,—though, in digging beneath it, very frequent specimens of an old brick are met with, about sixteen inches by ten inches, and three inches

* Of this branch all I am aware of is, that in heavy seasons of rain great floods pour into the canal near Barôd, said to be consequent on the destruction of the earthen dams of the Chítang.

† The grounds of this remark are, that south of the bed of the Chítang the country is merely a succession of hills, and swells of sand, in some parts rising 200 feet, whilst to the north the sand is chiefly in detached ridges and patches, the sub-soil, when it gets clear of the drift sand, being a hard flat, covered with low tree jungle, totally different from the sandy desert of Bhikanír.

‡ Such bricks were all found marked thus  , evidently by a revolution of the fingers extended with the thumb as a centre, and gradually drawn round and up to the thumb. Similar bricks, of an age anterior to the Mahomedan conquest, have been excavated at Hansí.

have passed away in any short period. The evident cause of this depopulation of the country is the absolute absence of water, most probably the effect of the system now in use in the Sikh states, through which all these rivers pass from the mountains ;—namely, the erection of dams of earth across the streams at all favourable points, to raise the water so high as to flow over the face of the country and irrigate it, the surplus escaping by the sides till stopped by other dams, and so on, it might almost be said, *ad infinitum*.

It will easily be conceived, that in forming this string of lakes the consumption of water by absorption and evaporation disposes of the greater portion, whilst the irrigation takes a very small share, which could be equally well, though more expensively, drawn off by small canals from the main stream, leaving the latter open to proceed onward as far as it would go, and such an unencumbered stream would, by being in constant action, prevent the accumulation of impediments in the river bed, which, under the system of damming, have eight months of each year to accumulate, and in a country liable to drift sand, any vegetation in the bed is sufficient to collect and stop it, and form banks, which from the effect of the next rains is spread and deposited in hollows, gradually raising the bottom, and thereby widening the water way, and diminishing its power of sweeping clean the channel —an operation which with an open river would have been constantly going on, as no particle of water passes onwards without moving somewhat nearer to its final receptacle some portion of the river silt. In the Ghaghar, the outlet no longer existing, the operation is that of a gradual filling up from the tail of the river upwards, and the consequent shortening of the point to which water reaches from its source. At present the stream in the dry weather reaches to Dúndhal, and it is only in the rains that any portion of water reaches our provinces, when heavy floods sweep along the bed of the Ghaghar, sometimes as far as Bhatnìr, and convert all the hollows into lakes, which are gradually shoaling, by the amount of silt in the water filled into them. The bed of the river, thus saturated and aided by irrigation from the patches of water, yields the most splendid crops of wheat in the neighbourhood of Ráneah (a space several miles wide)—a benefit our landholders must lose as the river retrogrades, but which might be much extended, as was shown in the year we occupied the Bhattí country, when, a number of the lower dams being cut, the floods of the rains reached and passed Ráneah in abundance, where they had hardly been for years previously. The most beneficial effect of insisting on a right to a share of the waters which do not rise in, but only pass through, the Sikh states, would be in affording a sufficient supply of water for the nala or canal from the Ghaghar, at Múnok, into it again near Ráneah. The general line of it is shown on the map passing by Fattehábád, and being in a great measure within our frontier, it would be an extension of the benefits of irrigation from the Ghaghar to our own subjects, who now derive so little from the vicinity of what the acts of our neighbours make but a nominal river nearly. This old watercourse is well defined at its head, and so far open that, in the rains, the freshes send down a supply of water for the rice cultivation near Fattehábád. Feroz Shah is said to have made a canal from the Ghaghar, and it is possible that this is the channel alluded to. The advantages of its being re-opened (only, however, after the Ghaghar river shall have been cleared of dams, for at least 100 miles up) should not be lost sight of. The only thing further I have to say on the canal of Feroz Shah is, that as no marks of irrigation channels exist along its

banks, it is natural to suppose no system of extensive irrigation had time to take root, and that, with the decease of its founder, it fell into neglect, and discontinued flowing; had it flowed long enough to get up any system of irrigation, the remains of watercourses would not have been utterly obliterated, whereas there are no traces of them west of Suffídon.

ALI MARDAN KHAN'S, OR, THE DELHI CANAL.

Whether the above canal continued to have a stream in any part of its course or not, at the time the Delhi branch was thought of, early in the seventeenth century, does not seem very clearly known; though the expression of Ali Mardán Khán "having brought his canal from Karnál to Delhi" would imply that the original canal still flowed as far as Karnál, and thence probably into the Jamna, from the choking up and neglect of the excavated portion between Karnál and Suffídon. Anxiety to take advantage of the ancient canal of Feroz Shah, so far as suitable in direction, probably induced Ali Mardán Khán to follow it as far as Madloda, whence turning south he would fall in with a natural hollow near Korána, which is in fact the head of a great drain of the country ending in the Farkhnagar Jhíl, about fifteen miles S. W. of Delhi, and this he unfortunately followed to Gohána. Thence diverging south-east, he appears to have pursued a line, the traces of which are most prominent from Gohána to Jatola; and thence on or nearly on the present line, he made his way to Delhi. A terrible catastrophe is recorded to have happened on the first trial of the works, when the water having got into the deep hollow at Gohána, could not escape thence by the channel formed, and accumulating, until it overtopped the embankments across this hollow way, destroyed the town of Lálpúr, of which the extensive ruins still exist in a hollow west of the present town of Rhotak. The correction* of this error appears to have been made with much judgment, passing closely to the natural ridge of the country, where the land falls off on each side. From Jatola, the departures from his old course are of less moment; although, to account for the remains of bits of canal here and there, he must have made another detour near Bhowána, where, entering on the low ground between that and the rise on which the city stands, he had his most difficult task. He appears to have secured himself, by an outlet, at the upper end of this dangerous spot, sufficient to reduce the level of canal materially in case of accident. Ahead of this point, to maintain the level required in the city and palace, the canal, instead of being sunk in the ground, is carried along an elevated mound, in many parts of which the bottom rises much higher than the surrounding country. The lowest portion of this hollow was crossed on an aqueduct of masonry, under which escapes the surplus water of the Farkhnagar Jhíl into the Jamna. The canal shortly after entering on and skirting the base of the range of hills west of Delhi (the drainage from which crosses over the canal by ancient aqueducts) is finally led directly across the ridge by a channel cut out in the rock, to the depth of about sixty feet at the crest. It then enters the city, and passing through it by an open channel, traverses along another extensive aqueduct into the palace, throughout the whole of which it ramifies in open or covered watercourses, having outlets to the Jamna, thus per-

* By excavating anew from near Rair to Jatola.

mitting the passage of constant streams of fresh water. Similar to these, in the space between the range of hills and the palace, numerous underground channels were led off to the various residences of the nobles, and the divisions of the city, yielding to the whole city and its suburbs a supply of good water, from the open well shafts connected with these underground watercourses, and necessary to admit of their being cleared out.

On a review of the ancient works in Delhi, connected with the canal, money must have been expended with a most lavish hand to effect what is known; and much is yet hidden in the ruins of the neighbourhood. The branch thus successfully opened appears to have been maintained in a state of efficiency until the year 1760, including a supply down the Gohána branch, and another down a portion of Feroz's canal, in which latter the water ceased to flow at Suffídon about 1740. The decay of the canal was probably gradual; and final only, when the power of the emperor was too much circumscribed, and his attention too much engaged by the perilous circumstances of his reign, to attend to such matters: to which may be added the gradual increase in size and depth of what was then the western branch of the Jamna, rendering the annual formation of the earthen dam across it in time for the irrigation of the crops, a work of more difficulty and labour than was compensated by the advantages derived. During the long period that it did flow, the system of irrigation from its waters appears to have been most extensively diffused, judging from the multitudes of watercourses which intersect the country on both banks from below Karnál to Delhi: the amounts of the revenue derived from it must, however, be deemed fabulous, or must be misunderstood;—villages, which have from 12,000 to 15,000 bigas of land, being stated to have paid a lakh of rupees a year—a sum about equivalent to the gross produce of the land, supposing every part of it yielded one first-rate crop annually, and that the whole of the lands were under irrigation, a matter for which the capacity of the canal was perfectly inadequate. Either the price of produce must have been much higher then, or the village bounds much more extensive; or, what is more probable, districts were designated by the names of the principal towns or villages, and thus the rents stated include the total revenues. Certainly no such results are now witnessed in villages of the first magnitude, where irrigation is used to the extent of 1500 rupees per annum for the use of the water. One such village, Bhatgaon, yields the Begum Sumroo 20,000 rupees a year, I believe; and another, Sissana, pays, I think, to our Government 16,000 rupees. Another, Korána, pays about 14,000 rupees, and is one of our finest villages on the canals, though not so large as others: these villages irrigate extensively.*

Restoration of the Canals in the Delhi Territory.

The attention of Government seems to have been drawn to the canals shortly after these provinces came under our dominion. I have understood the first suggestion was the offer of a gentleman (Mr. Mercer) to re-open the Delhi canal at his own expense, under the engagement of having secured to him the whole benefits resulting for a period of twenty years, which was not accepted; and under orders of government, a survey and design for the work was completed and submitted for

* In these sums I do not pretend to perfect accuracy they are noted from recollection. Bhatgaon and Korána are two of those stated to have yielded a lakh of rupees a year.

consideration by Lieut. Macartney, of the Cavalry, in the year 1810; this was further followed up, if not preceded, by several reports from other officers on the subjects (Lieut. White of the infantry and Lieut. Fordyce of the engineers, amongst the number), whose reports are lodged in the Chief Secretary's Office: and the whole subject seems to have elicited such a variety of opinion from Colonels Kyd, Garstin, and Colebrooke, either as Surveyors General or Chief Engineers, that the matter seems to have fallen into abeyance, until revived during the government of the Marquis of Hastings. In the same year, a survey of the Doab canal was made by Lieut. Tod, followed up by a notice from Lieut. Hodgson, from which nothing resulted. The canal of Feroz Shah is merely incidentally noticed, and appears not to have engaged any attention until the period of Captain Blane's appointment to the canals. I am unable to give any special notice of what may be called the preliminary measures, from the want of records in my office, where nothing further than the original reports by Lieuts. Macartney and Tod exist.

Restoration of the Delhi Canal, from the Hills to Delhi, 185 miles in length.

This subject appears to have early engaged the attention of the Marquis of Hastings, although it was not till the beginning of 1817 that Lieut. Blane of the engineers was appointed to conduct the work; his estimate was framed on the report of Lieut. Macartney: although in the progress of the work it was found necessary to depart considerably from the ideas of that officer, in consequence of the changes effected by the river in this interval. The work was carried on by Lieut. Blane, with great zeal and in the face of numerous difficulties, and the water being partially brought down as the work progressed, irrigation commenced from it in 1819, and by the end of May 1820, the water was brought to the city of Delhi, and passing through the main conduits in the palace, rejoined the parent stream.

Lieut. Blane, instead of drawing his supply of water from the river by any of the old heads near Búrya, or, as pointed out by Lieut. Macartney, from near Dadúpúr (either of which, in the then state of the case, would have entailed the closing up of what had become the western branch of the Jamna, either by a permanent work eminently liable to destruction, or by an earthen dam renewed annually, at a great expense and loss of time, besides the almost certainty of its destruction, from the floods of the cold weather), wisely selected the vicinity of Chúharpúr, to draw the supply from, although it entailed the passage of two rivers, one the Patralla, of no great moment, the other the Sombe, of considerable difficulty, from its being the sole drain of the mountains south-east of Náhan nearly down to the Jamna: these two rivers between them drain also the whole country nearly between the Sombe and the Jamna, and as their streams united before reaching the Jamna, one crossing would be saved. He unfortunately drew his new line of canal from the junction to Búrya, too close to the Jamna, instead of leading it under Balachor and Kharwán, which, though much more expensive in the onset, would have proved less so hereafter; it would at least have been much safer, as it has now become necessary to take measures against the encroachments of the Jamna,* which this

* The effects of this, supposing the Jamna to cut into the canal, may be here noticed the present bed of the canal is above the low-water surface level of the Jamna: the fall of the Jamna is more

season have been to a formidable extent, and may this year require expensive means to prevent its continuance, which can only be decided on after the rains. The water led from the Jamna near Chúharpúr is conducted along a natural channel to Jhydarí, thence by a new cut into the Patrálla, which it follows to its junction with the Sombe, where Lieutenant Blane projected a dam of masonry, but was deterred from its execution by the heavy floods of 1820 the earthen dam then required was in extent 500 feet, now it has extended to a serious work of 1200 feet; the extension is attended with the advantage of the floods attaining less height, as none have reached since within three feet of the height he noted.—From this point an entirely new channel connected this work with the old line of canal near Búrya, whence its bed was simply cleared or restored as far as Delhi, in the vicinity of which a number of old bridges were repaired and some new ones built, besides which the only other works done were the formation of a new escape dam at Kanjnún towards the head of the canal, and the restoration of an old one near Bowána for the tail of it; both works of vital importance, though still insufficient for want of a more centrical escape (as at Karnál), to pass off the heavy land floods from the north of Karnál, which are added to those of the canal in the rains: the old channel by Búdakhera presents a suitable site for such a work. On Lieutenant Blane's unexpected death in June 1821, the canal was considered finished, and the bills rendered, amounting to somewhat more than half of the estimate—many works noted in them were not even commenced. The canal was, however, in fact, completed, so far as conducting the supply of water then needful was concerned. When this supply came to be increased, and that for Feroz's canal to be also brought down by the same head, the canal was no longer efficient; to prevent inundation, it became necessary to embank the canal nearly from end to end, and when the water became so deep as not to admit of a loaded hackery (or cart) passing through it, it became necessary to build bridges, so that from within a few years of Captain Blane's death, the works of the canal, suited to its present purposes, have been in almost constant progress, and upon an enhanced scale, from the canal being kept full of water during their execution, for the irrigating villages had then become dependent on it for the means of paying their revenue. These works are only now drawing to completion.

Restoration of Feroz's Canal. Main branch, Rair to Bahádera, 151¼ miles in length; Rhotak branch, 45 miles long; Darbah branch, 32 miles long; New Supply Head, 12 miles long. Total length, 240 miles.

The idea of the advantages of this work appears to have presented itself to the mind of Captain Blane, when employed on the Delhi canal, in its vicinity; but

rapid than that of the canal, the level of the latter being maintained to attain the upper surface level of the country, and the maximum rise of the Jamna would suffice to throw about twelve feet water into the canal at height of floods; this would probably cause much damage in times of heavy floods, and might permanently be injurious by sweeping out the bed, and inclining the river to take this course from its lying direct in the line of current. In such case, it would break into the river again either at Kanjnún, or at Kárnal, or both, and its strength of current would suffice to clear for itself such a channel as would remedy the evils it could not fail to bring about in the mean time. The superior slope of the bed of the Jamna is likely to prevent this, and means may be devised to lead off the strength of the current from the bank it has this year so fiercely attacked.

they were first specifically brought to the consideration of Government by the civil commissioner, Mr. Fortescue, through whom I received instructions in May 1820, to make the requisite surveys and estimates; these, added to other duties, were not completed till June 1822, and were then submitted to Government, and sanctioned during that year; and I was honoured, by being appointed to carry my own ideas into effect. The work commenced in March 1823; the excavation of the channel was completed, and, a few necessary works of masonry for regulating the water being finished, the water was turned down the canal in May 1825. This measure may appear precipitate, but water to the country to which this was destined was so valuable a boon to both man and beast, and the soil was generally so good, and the canal relatively to the Delhi one so small, that the extra expense of working in water was of much less moment than the benefits of the supply of water to the country. Since that period the completion of original works, as well as the extension of the advantages of the canal, have been progressive.

The original works consisted in the clearance of the old line of canal from Rair to Channee, with the formation of bridges, as detailed in the abstract of estimates. The extensions are of the main line to Baháderah,—of an additional branch into our newly-settled frontier towards Darbah,—and of the Rhotak branch to Rhotak, with all the works necessary thereon:—these works, like those of the Delhi canal, are close on completion. In reference to the two canals, which have one common head, I may here allude to the formation of the masonry dam across the Sombe, now in execution, to supersede the earthen dam there, premising that this dam is *swept away annually in the end of June, after which, there is no regular supply of* water in the canal, and that it is extending in dimensions. With every exertion, it occupies about twenty-five days in construction, and as it cannot be commenced before the rains are over, it cannot be completed before the 20th October, and in these twenty-five days the fall of the Jamna is between two and three feet (exclusive of temporary rises from floods), so that although there is an abundant commencing supply for the season without any work in the Jamna on the 1st October, it is no longer so on the 25th, and it takes ten days further to stop up the escape channels in the Jamna near Chúharpúr (which can only be commenced after the bunds below are capable of retaining the water); by this time the river is a foot lower, and the channels at the separation of the eastern and western branches have to be cleared out, which brings the full supply into the canal about the 1st December. With the masonry dam, which may be thrown entirely open down to the level of the bed of the Sombe during the rains,* and which may be planked up to full water level in two days, and sanded in front in three or four; this will be ready for the reception of water on the 1st October, at which period also may be ready a single small intermediate dam, then necessary to bring down water, and the other works may be kept in progress according to the fall of the river, so that the supply, being kept steady from the 1st October, will reach the most distant parts by the 10th, just when wanted, and will not fail, as there will then be leisure to have each necessary work in advance ready at the moment it is wanted; these alone are advantages outweighing a[illegible] beyond what this will be; the temporary work, with all its disadvantages, [illegible] about as much as the

* Practice in the management of the dam, if ultimately completed according to the original design, will admit of its being regularly worked in the rains, so as to keep up a constant supply.

interest at four per cent. on the outlay of the permanent one, which supersedes it.

Having detailed, as far as could be done, the former and present state of the canals, and the original expenditure incurred thereon, it remains to notice the purposes for which these canals were reopened, the results to the present period, and the current expenditure for their maintenance in efficiency.

1st.—Of the Purposes for which the Canals were re-opened.

The original and almost sole purpose of the government in undertaking these works appears to have been to convey a large supply of water from the Jamna, for the purposes of irrigation of the crops, 1st, on lines of country where the natural depth of the wells was so great as to render the cost of irrigation from them so heavy as to impede the improvement of the districts, and delay the resettlement of waste villages, as on the Delhi canal. 2nd, To supply the means of cheap and easy irrigation to districts, as on the Doab canal, where, although the wells are not so deep, yet the irrigation from the canal would be so comparatively cheap and easy as to afford the probability of great extension of the benefit: and, 3rd, as on Feroz's canal, to confer the means of irrigation on districts where from the excessive depth of the wells none was heretofore in use, and to convey a supply of good and wholesome water to a country where generally it is brackish or salt; in some districts so much so as to preclude their occupancy, except for a few months grazing in the rains. To these points alone the general instructions of Government tend,—and with such in view, the original estimates of the Delhi canal were framed; with the progress of this work, the advantages derivable from water-carriage, brought prominently forward after the water was first turned in, and the means of using the water as a motive power for machinery, of which the late Capt. Blane, the first superintendent, made a commencement, led to the original designs of the other canals being formed with reference to these ends, which have been followed up on all the canals by further works designed to render one or other of the above purposes more efficient; so that on the completion of the designs either sanctioned or now before Government, little further work can be necessary, excepting such as may be for the extension of these various benefits to new parts of the country.

2nd.—Of the Results to the present Period.

The annexed abstracts will show in a condensed form the results up to the end of the last official year. In elucidation of which, and explanation of comparative small returns with such works, I may possibly be obliged to be more diffuse than I would have wished, to be enabled to convey a correct idea in regard to both the present results shown by these papers and the future prospects, and first I have to notice, as having general reference to all the canals, the often repeated declaration of the Government to the superintendents, as their main rule of guidance, that the object of government in collecting a rent through them was not so much to form a productive source of revenue from the actual price paid for the water, as to give them an efficient control over its expenditure, by making it of

value sufficient to prevent its being wantonly wasted; and that they looked alone to the general improvement of the country as the source from which they should derive the return adequate to the outlay. This announcement completely prevented the superintendent disposing of the water, so far as irrigation was concerned, to the best advantage, and led to the settlement of a fixed rate of assessment, so low that it is not sufficient to prevent carelessness, entailing much waste of water; from which it may be presumed that the instructions of Government have been fully acted up to, and the rates levied are sufficiently moderate. I am unable to state, from want of knowledge, whether the improvement of the revenue in canal villages has been commensurate with the expense: I know the rents of many have been raised, and that others, which were reckoned highly assessed, have been by the canal enabled to pay their revenue; and I also know that tracts of jangal have disappeared in many parts, and are superseded by cultivation supported by the canals. This point might be elucidated on the Delhi canal by a statement showing the revenue derived from all canal villages for a series of years before 1820, and for the subsequent years, compared with an account of the revenue derived during the same years from villages not irrigating from the canal, and in which the wells were equally deep. The length of leases being considered, the advantage I believe would be with the canal villages, and the comparative difference would be fairly attributable to the canals; the improvement which would doubtless appear on the unirrigated villages, as well as a corresponding proportion of that on the canal villages, being attributable to the benefits arising from a settled government superseding an unsettled one. On Feroz's canal a similar comparison might be made, commencing with the year 1826; but the Doab canal is too recently opened to afford any room for comparison. I may be permitted here to observe a fact which has forced itself on my notice in my constant intercourse with the inhabitants of canal villages, that whenever a lease is for any long period of years, of ten or upwards, or even of five years, improvement and the use of the canal water make most rapid strides; and that wherever the settlement is too suddenly raised, or is for a short period, or from year to year,—the sole object of the cultivators appears to be to deteriorate their lands, often until they fall into a state from which it is difficult to recover them; and to this the deadly epidemic of 1829-30 has much added, by leaving valuable villages without hands sufficient to cultivate their lands.* The abstracts show that on the Delhi canal an immediate and satisfactory commencement was made by the cultivators, in availing themselves of the benefits put within their reach; on the other canals this is apparently much less the case, the explanation of which appears to me to be, simply, that, on the Delhi canal and upper parts of Feroz's canal, irrigation from its waters was merely the resumption of an old practice, of which the memory still remained, and the country being intersected by old watercourses, the villagers had merely to follow up their traces to the canal banks, and clear them out, with a tolerable assurance that when opened they would be serviceable, and that their money expended on the clearance would not be thrown away.† On

* This epidemic was not confined to the canals, but extended from Lúdianah to Jaipur, as also east of the Jamna, when the Doab Canal was not opened. The abstracts will show its effects, from which many places have not yet recovered.

† The expense of clearing out the watercourses, from 100 to 200 rupees per mile, is always incurred by the cultivators, sometimes aided by a loan from Government free of interest.

Feroz's canal, below Suffidon and the Doab canal, the case was totally different; no remains of ancient watercourses existed to point out to the inhabitants the mode of drawing the water to their lands; they had not the recollections of such a system of irrigation having existed, and had to buy all their experience of the disadvantages of adopting what was the cheapest mode, a direct cut from the nearest point of the canal to their lands without reference to level; and it was not until they had bought this experience, and failed, that they would listen to the advice given them, and lead their watercourses so as to answer the purposes. On Feroz's canal, the system too led to a perfectly new mode of life: instead of continuing a pastoral people, who depended on the periodical rains raising them grain sufficient for their food with little trouble, they early made the discovery, that, with plenty of good water for their cattle, if they used it for irrigation, they must give up a life of idleness for one of comparative labour, and it was only by very slow degrees they acquired the knowledge, that the advantages derivable from it would compensate them for the labour, and it is only now that the advances are beginning to be rapid, and advice sought as to the best means of availing themselves of the water. It cannot, however, be expected, that the benefits of the canals in Hariána will be developed until the rising generation brought up on the line of canals to labour forms the majority of the inhabitants; and will not be fully so until time and good government does away with the recollections of the life of general inactivity, added to the predatory habits of their forefathers. On the Doab canal the change is not so great, being only of one system of irrigation for another. It is almost too much in its infancy to allow of comparisons, but the results are consistent with the premises, and the progress of irrigation has been infinitely more rapid than on Feroz's canal, though less so than on the Delhi canal; the decrease in the last crop, shown in the abstract, compared with the corresponding one of the preceding year, being solely owing to the excess of rain during the last cold season, diminishing the necessity for water, a cause which has frequently had corresponding results on the Delhi canal. It being a clear matter of course that, where rain falls in sufficient quantity to ripen the crops, they will not draw upon the canal for a supply to be paid for.

It was found, chiefly on Feroz's canal, that many villages were inclined to go on as they had heretofore, without employing the water for irrigation, but freely using it for all village purposes, and for the supply of their cattle, saving themselves the expense and trouble of drawing water or maintaining their wells and tanks efficient. As they benefited considerably by the canal in this way, it appeared reasonable that they should contribute their share to its support; and it was submitted to government, that although villages paying above a certain sum annually (fixed at 100 rupees) in shape of water rent on irrigation, should still have the free use of the water for village purposes, yet those paying less should contribute to the expenses of what they benefited from, by paying a moderate rate on the number of cattle of all kinds belonging to the village. This rate was fixed at six rupees per 100 head of cattle per annum,—a rate so infinitely below the cost of watering from wells, that to the westward, cattle are brought to the canal from villages distant many miles. The distinction made in favour of irrigating villages has led to many irrigating up to, and beyond, the limit which gives free water to the cattle; and in villages within reach of canal irrigation, this source of income will gradually cease, but will still be continued, and go

beyond what it has now attained by the watering of cattle of villages, either so distant, or so situated, as to be unable to irrigate, and it is one so fair and reasonable, that it may safely be continued. The filling of village tanks at certain rates is in fact only a modification of the above, and requires no special notice.

Of the Employment of the Water for moving Machinery.

The only application of the water of the canals for the movement of machinery hitherto put in practice has been of a very simple nature, yet producing what will appear comparatively great results, as a source of revenue. The use of the water is let out to those who offer most for it, and as the rent offered can never exceed a rate which must be under the cost of other modes of doing the same work, the employment in this way of surplus water, or of streams again returned to the canal for irrigation, is a general benefit to the community, and tends to cheapen commodities for which the demand is constant.

The first introduction of the system was by Captain Blane, who permitted the erection of three small mills for grinding flour in Delhi, on payment of an annual rent of 25 rupees. Since these, mills of superior powers have been erected at the cost of government, which in Delhi and its vicinity are rented at rates varying from two rupees to five rupees per day, each mill, according to its power, which depends on the height of head water available at the different sites. The produce of the flour mills in Delhi fluctuates considerably, but with the supply of water now becoming annually more constant, the range will become from 25,000 to 30,000 rupees per annum, beyond which it is not likely to go. Similar mills are being constructed at Karnál, the income from which is expected to realize from 9,000 to 12,000 rupees; as the large cantonment, added to the city, will probably yield abundance of work, and time and leisure will enable future superintendents to select many advantageous spots for the erection of small flour mills suited to the demand, every one of which may be more or less a productive source of revenue, compared with the expenditure, if due attention be paid to suit the supply of mills to the probable work. On Feroz's canal, the only mills erected are those at Hansî, less powerful than the Delhi ones, but as yet two powerful for the demand; their produce, however, compared with their expense is satisfactory, and in such a rising town as Hansî, full employment for them may be anticipated. With exception of the vicinity of Jhînd, no other place holds out work for any extensive sets of mills on this canal, and there the slope of the canal appears sufficient to promise a return of about 15 per cent. on the outlay.

The capabilities of the Doab canal in this respect, as in many others are very great. Flour mills have been erected at Saharánpúr, and near Delhi, and the produce shown in the abstract is the return from them; others are just completed at Shamlî: and there are other large towns capable of affording work for many more, some of which are authorized and others contemplated, the waste water from all being available for irrigation below the mill sites. Besides the above, saw mills are about to be tried at Delhi and Karnál, places which would yield much of such work, being the marts from which the upper parts of western India is supplied with timber, from the forests of the Jamna and the Ganges. Models of oil and sugar-cane mills have also been prepared, which promise not only to be successful,

but likely to find an abundance of employment, the lines of the Delhi and Doab canals producing much sugar-cane with very imperfect modes of expressing the juice.

It will be apparent, that all these modes of employing the water are highly advantageous, and do not interfere with the main purpose of the canals, that of irrigation; the mills being established either where surplus water escapes, or where it is returned below the mills into the canal again, no loss of water is entailed to irrigation, beyond the absorption and evaporation of the mill streams.

Of the Employment of the Canals for the Transit of Merchandize.

This object has as yet been only very imperfectly attained, being chiefly limited to the transit of rafts of timber on the line of canals between the forests of the Jamna, from which the rafts enter the canal at its head, to all intermediate places, along the canal of Feroz Shah, as far as Hissar, a distance of 200 miles. Down the Delhi branch from Rair, few if any rafts, except for canal works, have passed down, as they could not reach nearer to Delhi than twelve miles, from the obstructions presented by the ancient bridges and reduced dimensions of the canal. It is therefore preferable for rafters to use the Jamna for such purposes, conveying their rafts to within a mile of the city, though attended often by great danger in the rains, or delays in the hot weather.

I do not conceive for these reasons, that the Delhi branch will ever come into use for rafting, beyond the demand of the vicinity of the canal, which with so much jungle-wood, available for common purposes, is not likely at an early period to be great. The Doab canal, it is probable, will be so employed as soon as the completion of the works intended to rectify the disadvantages attendant on the heavy fall at head and tail of this canal shall afford means of locking the whole line of strong descent. This canal will ultimately come into use for rafting, not only on account of its safety and more equable depth of water, when compared with the Jamna, but because Saharánpúr is the general mart for all timber brought from the range of hills between the Jamna and the Ganges, and the merchants will doubtless see the advantages of at once rafting direct from Saharánpúr to Delhi by a safe and expeditious line of water carriage, instead of incurring the cost of a land carriage of sixteen miles to the Jamna added to the danger and delays of the river navigation.

In regard to boat navigation, all that has yet been effected has been done by the superintendent, in using boats for the transport of lime, from the upper to the lower parts of the canal, which has been a matter of great convenience, from the difficulty of procuring land carriage; indeed more so than one of saving, on account of the unformed condition of the canal banks for the purpose of trackage. In this respect, the Doab canal is well advanced; to make its banks available nothing beyond a clearance of trees is necessary, when it may become an object to cut them down, on completion of the locks. On the Delhi and Hariána branches the necessary work is rapidly progressing, and the last lock necessary is just completed. To etablish such a novelty, however, will, I fear, require the experiment to be made by the government, of establishing some boats suited to the canals, to ply for the carriage of goods; for instance between Karnál, or Rair and Hansí,

and I think such might shortly be done with advantage. There is at present a most extensive traffic existing across from the Doab, through Pánípat, and Soní-pat to Hansí, for the export of sugar; the return being salt and coarse grain, and Hansí being one of the chief entrepôts in that quarter, for the supply of the western states. It appears to me, it would conduce greatly to the prosperity of Hansí, if the line of trade could be diverted from Pánípat to the canal at Rair, where the Hansí and Delhi branches separate, instead of proceeding direct from Pánípat to Hansí viâ Neaulta, by a land carriage of about seventy miles. From Rair the sugar loaded on the canal boats could either proceed to within twelve miles to Delhi,* saving about forty miles of land carriage, or by Feroz's canal to Hansí; on this latter line a return cargo would always be secure: and north of Karnál, being a great sugar country, it is probable much would be exported thence, independent of that reaching the canal from the Doab, by Pánípat. Another mode in which it is probable such a trade might be established would be the offer of a premium to the individual who should have conveyed the greatest value of imports and exports by the canal, beyond some fixed sum, up to a stated period. Some mode which would give the merchants a knowledge of the advantages to be derived from water over land carriage, without entailing on them present expense and risk, will I think be necessary to set the matter going, after which it may be safely left to its own merits.

Of rafting on Feroz's canal, the knowledge of relative cost and charges was first given, by all timbers for the canal and garrison works at Hansí being rafted by the canal; and the result has been, that the import of timber from Karnál to Jhínd, Hansí, and Hissar, by land carriage, has been completely superseded, the canal being capable of carrying rafts, of the heaviest timbers, including all charges and the canal duty, at a cost of about one-half of the land carriage; and corresponding results may be expected elsewhere, when once the advantages of transport of merchandize by boats is clearly shown. The boats suitable to the canals should be long and narrow, and of burthen from 100 to 200 maunds,† sharp at both ends, and with a falling mast and sail to take advantage of the wind so often favourable for a return passage against the stream. The current, however, is nowhere sufficient to offer any serious impediment to tracking up.

Of sundry minor Items of Revenue.

With the view of preventing waste and discontent, or complaints of partiality it has been made a rule on the canals, that nothing, the produce of the canals, shall be given free of payment of what is deemed an equivalent, and that whoever chooses to give the equivalent may have the right purchased. This leads to sundry small collections, which, individually trifling, are collectively sufficient to pay a most considerable portion of the outlay in improving this source of income, by planting timber trees on the canals. In the rains, the canal bounds produce

* At the cost of a single drawbridge, boats could be enabled to reach within six miles of Delhi, and alterations to three old bridges would take them to within two miles of Delhi.

† One to two hundred maunds of sugar, grain, and such heavy articles would lie inside a boat of three feet depth, of suitable length, and seven to eight feet beam, which might be safely loaded to draw two feet water, so as to pass under the bridges freely at common water level.

annually a strong growth of various descriptions of grasses, and jungle; these have to be cleared annually to admit of repairs and access to the banks; what is unprofitable is burnt, and what is useful is stacked and sold. The bounds are in many parts covered with trees of natural growth, of which such as would impede the ultimate purpose of trackage are disposed of when wanted in the neighbourhood. Licences are also granted for cutting forage from the canal bounds. These together produce the sums stated in the column of "sale of produce of canal bounds," in the annexed abstracts, which, though as yet trifling, will ultimately become of material amount, when the useful forest timber trees, now planting on the canals, shall attain value with age, of which an idea may be formed from the canal banks, west of the Jamna, affording space for about 200,000 trees to attain maturity; they are planted in such numbers that from 10 to 15,000 get past the age of danger annually, at an expenditure limited to 2,000 rupees. At the age of twenty years, the average value of each timber, if only rated at $2\frac{1}{2}$ rupees, would admit a similar number to be cut down annually, being in value, at the above average, 33,000 rupees; though when once the regular cutting commences, it will of course only be picked trees which are felled in number suited to the demand for public and private purposes, and which individually will be far more valuable The produce of the canal bounds may therefore I think be ultimately of considerable importance, and probably much more than I anticipate, from the destruction of the natural forests of the country from want of protection,* and the total absence of any system of plantation in this part of the country.

The only other item of income noticeable as having been one anticipated by Captain Blane is that, from renting out the fishing of the canal; as yet it is hardly worth notice, and can never be of any moment, if I may judge from past experience.

As a source of revenue, fines should not properly be estimated; the object of levying them is to aid in the prevention of waste or wilful misuse of the canal waters;—to protect the embankment from injury, and thereby save its vicinity from inundation;—and to secure the plantations from depredation and negligence.

Abstract of Expenses incurred, or estimated, upon Permanent Works of the Western Jamna Canals, completed up to the 30th April 1847.

Denomination of Work.	Rs.	A.	P.
Masonry Works, viz., Bridges, Dams, Regulators, Overfalls, Stop-Dams, Irrigation Outlets, and Chokies; including Crib Work, &c., at Dadoopoor	638879	13	3
Iron Suspension Bridges	21461	8	11
Earth Work, viz., Excavation, Making Embankments, Clearance of Silt, &c	682560	7	$6\frac{1}{4}$
Experimental Work at Kulsowra	4938	14	0
Plantations	30663	5	7
Mangoe Plantations at Gunga Towli and Kurnal	2520	0	0
Grand Total, Co.'s Rupees	1381024	1	$3\frac{1}{4}$

* The forests of the Jamna are nearly destroyed from indiscriminate cutting, since they fell under our authority any one is allowed to cut what he pleases, and where he pleases, on payment of a

Abstract of the Revenues and ordinary Expenses of the Western Jamna Canals since the period of their restoration, 30*th April* 1847.

Revenue.

From what Source.	Rs.	A.	P.
Rent of Ground under Irrigation	3547643	8	8
Rent of Water Mills	314348	4	2
Rent for Watering Cattle	43394	9	4
Transit Duties on Rafting Timbers	98911	10	6
Sale of Canal Produce, and Sundries, Filling Tanks, &c.	90822	8	4
Fines for Breach of Canal Regulations	110758	2	4
Total Income, Co.'s Rupees	4205878	11	4
Present Annual Income (say)	300000	0	0

Expenditure.

From what Source.	Rs.	A.	P.
Establishment for Superintendence of Works, Collections, &c.	1687434	11	7
Amount of Ordinary Repairs, as per Monthly Bills	655138	2	8
Total Expenditure, Co.'s Rupees	2342572	14	3
Present Annual Expense (say)	120000	0	0

[The above figured statements are substituted for similar ones appended to the original Report, and which were brought up only to the 30th April 1831.]

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merely nominal duty, and the whole country resorts here for supplies. Formerly it was not so: the result is, that now there is not a saul tree fit for public purposes, within six miles of the river; no roads exist, and the cost of timber in consequence in my recollection has doubled.

APPENDIX B.

A Canal Act of the Emperor Akbar, with some Notes and Remarks on the History of the Western Jamna Canals. *By* LIEUT. YULE, *Engineers, First Assist. W. J. C.*

FOR the following translation of a Decree of the Emperor Akbar, forming an interesting Appendix to the History of the Canals, given by Colonel Colvin in the second volume of the Journal of the A. S., I am indebted to the kindness of Captain S. A. Abbott, in charge of the Kythal district, who obtained the Persian copy from the parties named below, residents of Dhátrát, a town on the southern boundary of Kythal, just at the point where the Hansi branch of the Western Jamna canal enters the Chitang Nálá, in the old channel of which, deepened and widened, the canal waters flow to their termination at Baháderá, in the Bikaner territory.

Translation of a Sanad of Akbar Sháh Bádsháh, dated month of Shawál, A. H. 978, [A. D. 1568] at Firozpúr, in the Province of Lahaur. Obtained from Abdul Samad and Abdul Mustakím, Pírzádahs, at Dhátrat, being four leaves abstracted from a book which bears the appearance of considerable antiquity.

"My Government is a tree, the roots of which are firm in the earth, and being watered by the waters of God's grace, its branches reach to heaven. In acknowledgment of God's mercy in establishing this great empire, my desire, purer than water, is to supply the wants of the poor; and the water of life in my heart is larger than the sea, with the wish to dispense benefits, and to leave permanent marks of the greatness of my Empire, by digging canals, and founding cities, by which too the revenues of the Empire will be increased.

"God says, sow a grain, and reap sevenfold.* My desire is to reap one-hundredfold, that my crown may become wealthy, and that the zamindars may obtain double returns.

* "The similitude of those who lay out their substance, for advancing the religion of God, is as a grain of corn which produceth seven ears, and in each ear a hundred grains."—*Sale's Koran*, chap. ii.

" The seeds sown in this world, are reaped in the next.

" The Omnipotent God gives power to whom he pleases.

" The following is the best purpose to which my wealth can be applied, viz :—

" The Chitang Naddí, by which Fíroz Sháh Bádsháh, two hundred and ten years ago, brought water from the nálás and drains in the vicinity of Sádhaura,* at the foot of the hills, to Hánsí and Hissár, and by which for four or five months in the year water was then available, has, in the course of time, and from numerous obstacles, become so choked, that for the last hundred years, the waters have not flowed past the boundary of Kythal, and thence to Hissár, the bed has become so choked, that it is scarcely discernible ; since which time, the inhabitants of those parts have become parched with thirst,† and their gardens dried up.

" Now that I have given the district (Sarkár) of Hissár to the great, the fortunate, the obedient, the pearl of the sea of my kingdom, the star of my government, the praised of the inhabitants of the sea and land, the apple of my kingdom's eye, my son Sultán Muhamad Salím Bahádur,‡ (may God grant him long life and greatness); my wisdom wishes that the hopes, like the fields of those thirsty people, may, by the showers of liberality and kindness, be made green and flourishing, and that the canal may, in my time, be renewed, and that by conducting other waters into it, it may endure for ages.

" For God has said, from water all things were made. I consequently ordain, that this jungle, in which subsistence is obtained with thirst, be converted into a place of comfort, free from that evil.

" Consequently, in the year of the Hijra 977, my Farmán, bright as the sun, and obeyed by all the world, went forth; that the waters of the nálás and streams at the foot of the hills at Khizrábád,§ which are collected in the Sonb river and flow into the Jumna, be brought by a canal, deep and wide, by the help of bunds, &c. into the Chitang Naddí, which is distant from that place about one hundred kos,‖ and that the canal be excavated deeper and wider than formerly, so that all the waters may be available at the above mentioned cities (Hansi and Hissár), by the year 978.

" Behold the power of God, how he brings to life land that was dead.¶

" Truly a canal is opened, and from the source to the mouth, although the zamindars and cultivators take by cuts abundance for their crops, it is still sufficient to meet the demand.

* Sádhaura, a town of the Ambálá district, about twenty miles west of the Jumna. The river flowing past Sádhaura is the Markanda, but the sources of the Chitang are only seven or eight miles distant.

† In Hariáná the springs have been raised, since the canal was re-opened, in some instances as much as sixty feet—*Capt. Baker's Report on the Sutlej and Jumna Canal.*

‡ Afterwards the Emperor Jahángir, who was at this time under two years of age. "The Sirkár of Hissár Firozeh, ever since the conquest of Hindostan by the Moguls, has constituted the personal estate of the heir apparent of the empire."—*Rennel.*

§ Khizrábád, a Sikh town near the debouchement of the Jumna from the Hills, and the present Delhi Canal head.

‖ Dhátrat, where the present canal joins the Chitang, is, by the line of the banks, about 130 miles (pretty exactly 100 kos of the country) from Khizrábád.

¶ " God sendeth down water from heaven, and causeth the earth to revive, after it hath been dead."—*Sale's Koran*, chap. xvi.

"Because this canal was renewed for the sake of my beloved son, in compliment to him, whom, in his childhood, I call Shekho, and because in Hindustani a canal is called Nai, I have called this canal the Shaikh Nai.*

"And whereas Muhamad Khán Tarkhán was superintendent of this work from first to last, I have conferred upon him the office and title of Mír-áb.

[Here follows a flourish of the writer of the Sanad.]

"The following verses have arisen from the ocean of my heart to the shores of my lips:

"Muhamad Akbar Ghazí Jaláluddín.

"He is the king of this age, and equal to king Jamshaid.

"His throne is the throne of Farídún and Kai.

"He is like unto Khizr, and from the waters of his generosity everything has life.

"He is such a king, that from the canal of his liberality, the garden of the world is green all the year round.

"A canal by his orders was carried to Hissár;

"For the sake of the Prince Salìm of blessed steps.

"A canal like milk, and that milk full of fish;

"Its waters like honey, and pleasanter than wine.

"The king in his greatness gave Muhamad Salìm the title of Shekho, because his Pìr (spiritual patron) was a Shaikh.†

"He consequently called this canal Shaikh Nai.

"May the Bádsháh and Prince live for ever.

"The date of excavating this canal is to be found in the following words:—

ا با د شیخ نی

"Tarkhàn obtained the title of Mir-àb for his labours, because he carried the waters of the canal in every direction.

"As long as the new moon, like a boat, sails in the waters of the blue heavens, so long may the waters of this king's generosity irrigate the garden of the world.

"Whereas I have ordered that the waters be collected in this canal, and that it be made so wide and deep to Hissár, that boats may ply upon it in every part; it is my will that the superintendent build bridges and bunds wherever necessary,‡ that at the season of cultivation a sufficient supply of water be given to all who aided in excavating the canal, and they obtain water all the year round.

"Also, that on both sides of the canal down to Hissàr, trees of every description,

* This title appears to have been very short-lived. I am not aware that the word Nai is now applied in this sense in any of our canal districts, but I learn that it is the Panjábí corruption of Naddi, and is commonly applied by the Sikhs to a river or watercourse. The valley of the Ghagar is called Naili.

† It is said that Akbar, having had no child who survived infancy, made a pilgrimage to offer his prayers for posterity at the shrine of Muyínuddin Chishtí, at Ajmir. He was there directed to seek the intercession of the Shaikh Salím Chishti, at Síkrí; and shortly afterwards the favourite Sultana was delivered of a son, who in honour of the saint was called Shekho Salim. A village on the canal near Hissar bears th name of Salíma Shekhopoor.

‡ The only old bridges now existing between the canal head and Hansi are, that called the Gharaunda bridge, near Karnal, and one at Safidan: both massive structures with pointed arches.

both for shade and blossom, be planted,* so as to make it like the canal under the tree in Paradise, and that the sweet flavour of the rare fruits may reach the mouth of every one, and that from these luxuries a voice may go forth to travellers, calling them to rest in the cities where their every want will be supplied, and I trust that, from the blessing attending this charity, the garden of goodness may remain ever green, that the benefits of the blessing may be incalculable, and that from it, I may obtain eternal reward.

"Thanks be to God who has enabled me to do this, which, without his instruction, I should not have performed.

"It is necessary that every one acknowledge the person appointed to this work, and recognise no partner with him.

"Should it be necessary to construct a bund, or any other work on the canal, all Shikkdárs,† Chaudris, Mukaddams, and Rayats, whether of the Khalsa or of other Parganahs, will give the necessary assistance in labourers, &c., and delay not.

"Every Parganah will be satisfied with the number of cuts made by the Mir-àb, and take no more, and on every occasion abide by his directions. He has the power to punish as he sees fit every one who takes water out of season; whoever disobeys his orders will, after investigation, be punished as an example to others.

"The superintendent is particularly cautioned to see that the cuts in every Parganah are equally and justly distributed, and in this matter to consider every one on an equality; not to permit the strong to oppress the weak, and so to act as to please both God and man.

"The inhabitants of both sides of the canal will abide by these orders, and obey all the high, enlightened, concise, &c. &c. farmans of the king."

This document will be regarded as a very curious one by all who take interest in the past history, as well as in the present and prospective utility of the canals of Hindustan, suggesting as it does a fact which history appears to have forgotten, and which we have not ascertained without some degree of pleasure, namely, that the Jumna canals, as a perennial source of supply to a thirsty land, owe their origin to the greatest of Indian princes.

The question, however, is a difficult one, on account of the universal prevalence of the belief that Firoz Shàh drew a canal from the Jumna to Hissàr, and from the obscurity of the accounts of the various channels excavated by that king. The only books bearing on the subject to which I have access, are Dow's Firishta, and Rennel's Memoir on the Map of India.

The words of Firishta are as follows:—"In the year 757, between the hills of Mendouli and Sirmoor, he (Firoz) cut a channel from the Jumna, which he divided into seven streams; one of which he brought to Hansi, and from thence to Raeesen, where he built a strong castle, calling it by his own name. He drew, soon after, a canal from the Cagar, passing by the walls of Sirsutti, and joined it to the rivulet of Kera, upon which he built a city, named after him Firozeabad. This city he watered by another canal from the Jumna."‡

* Excepting a few of the different kinds of *Ficus*, scarcely any old trees now exist on the canal banks.

† Shikkdár, a revenue officer.

‡ Dow's Firishta, I. 305. A more exact translation than Dow's of the passages relating to the

The seven streams I cannot explain. "Raeesen (though this name is not now recognisable), where he built a strong castle, calling it by his own name," is doubtless Hissar Firozah, or "the castle of Firoz." The remainder of the sentence seems almost inextricable from its obscurity, and probably, as Major Rennel suggests,* contains a jumble, arising from the multitude of excavations made by King Firoz, and the number of cities to which he gave his name. There appears, however, no reason to believe, according to Rennel's hypothesis, that a canal was ever brought to Delhi before the time of Shàh Jahàn.

The city of Sirsutti, which Major Rennel is a little puzzled to fix, would seem to be Sirsa, for the following reasons—It was (Rennel p. 76) at the end of Timur's third march from Bhatner to Samána, and four marches distant from the latter place. Now Sirsa lies directly in the road from Bhatner to Samána; it is upwards of forty miles distant from the former and about eighty-five from the latter. This is easily reconcilable with the number of marches given, especially as two of these seven are stated to have amounted to 32 kos; which, if we take somewhat under sixty miles, the remaining five marches would average fourteen miles each, and three such marches would just give the distance from Bhatner to Sirsa. Firishta also states that Timur having taken and pillaged the town of Battenize (Bhatner), and after that Surustti advanced to Futtehabad.† This seems to fix the identity of Sirsutti with Sirsa. But again, Ibn Batuta relates, that on his journey from Multàn to Delhi, after travelling four days from Ajúdahhan, he arrived at the city of Sirsutti, a large place abounding in rice, which was carried thence to Delhi. And from Sirsutti he proceeded to Hansi.‡ Now Sirsa is about 100 miles distant from Ajodin, (or Pák Patan) on the Gharra, in the direct line towards Hansi. And the rich valley of the Ghagar might well supply the abundant rice crops.

The canal then which Fíroz drew from the Ghagar under the walls of Sirsutti, is in all probability the Choyo nálá, which issues from the Ghagar near Mûnak, passes close to Sirsa, and bears evident traces of having been partially, at least, an excavated channel.§ The mention of its junction with "the rivulet of Kera" is indeed unintelligible. The nálá in fact joins the Ghagar again, not far from Sirsa, and a short distance below their union, the Revenue map shows a village called Fírozabad. I should be curious to know if at this village exist any remains of greatness, from which we might suppose it to be the city alluded to by Firishta.

The remainder of the sentence we must leave alone. Hissár Fírozah might

excavations of Fíroz, from a copy of Firishta in the palace library at Delhi, is given by Mr. Seton, Resident at Delhi, in a letter to Government, on the subject of restoring the canals, dated September 11th, 1807. But, in the words quoted, there is no material difference, except in the names of Hansi and Raeesen, which Dow writes Hassi and Beraisen But the system of water carriage on the canals which Dow attributes to Fíroz in the following sentence, appears to be a mere embellishment.

* "It may probably be a jumble of two sentences, which relate to different cities together. The river Kera and Fírozeabad may relate to the city of Fírozepoor, at the conflux of the Sutlege and Beyah, and the canal from the Jumna to Fírozeabad, a city founded by Fíroz in the vicinity of old Delhi. * * * * Capt. Kirkpatrick notices an obscurity in the text of Firishta in this place."—*Rennel*, p 74.

† Dow, II. p. 4.

‡ Ibn Batuta, p. 110.

§ See Capt. Baker's printed report on the Ghagar.

indeed have been watered by a canal from the Ghagar as well as from the Jamna,* but certainly not by a canal from the Ghagar passing under the walls of Sirsutti or Sirsa.

Major Rennel's words with regard to the Hissár canals are as follows: "It appears that previous to the building of Hissár, Fíroz had made a canal from the Jamna, near the northern hills, to Safidún a royal hunting-place; for the purpose of supplying it with water. This canal was in length thirty royal cosses or full 60 geographical miles; and it passed by Karnál and Toghlukpoor. After the foundations of Hissár were laid, he drew two principal canals to it; one of which was a prolongation of the canal of Safidún, the whole extent of which was then eighty (common) cosses, or about 114 G. miles. The other principal canal was drawn from the Sutlege river to Hissár Fírozabad. The outlet and course of this canal is not so clearly defined as the other: Capt. Kirkpatrick, to whom I am indebted for the information concerning Hissár and its canals, had it from a history of Fíroze written by Shumse Seraje, soon after the death of that great monarch which happened in 1388."

With regard to this Sutlege canal to Hissár Fírozah having ever been successfully executed, we may feel sceptical. The only line within possibility would be from the neighbourhood of Rupar to the Sirhind nálá, and thence crossing the Ghagar into the Hissár district, according to the general line sketched by Capt. Baker in 1841. But leaving this and turning to the Safidún canal, we remark that in Hodgson and Herbert's map, a branch of the Chitang is represented as quitting the main channel and passing within a short distance of Safidún.† And this, guided by the Sanad before us, we might suppose to be the original canal of Fíroz, were not the statement so distinct that his canal was drawn from the Jamna. Toghlukpúr I have no knowledge of, but the mention of Karnál points to the existing line of canal, as the Chitang is ten miles distant from that city. It is difficult to doubt this evidence, and yet it is almost equally difficult to throw overboard the clear statement of Akbar's Sanad. It is indeed possible that Fíroz may have connected the Chitang at a much higher point of its course with the Jamna, by a cut which could only convey a supply of water into the nálá when the river was at high levels; or that a canal from the Jamna was by Fíroz Sháh attempted unsuccessfully, upon which recourse was had to the temporary supply derivable from the Chitang, and as the latter flows for sixty miles almost parallel to the Jamna and at no great distance from it, a misrepresentation thus arose. Otherwise we can only suppose that Akbar, in self-glorification, falsely represented his own renewal and repair of his predecessor's work, as an original enterprise of his own.

Singularly enough the Sanad itself does not speak of the new canal having been fed from the Jamna, but "from the nálá and streams at the foot of hills which are collected in the Sonb river and flow into the Jamna." But the Emperor speaks of the canal as capable of supplying water all the year round,

* And probably was; for the late Major Brown traced an old channel from the vicinity of the Ghagar, in the direction of Hissár. This, however, the natives called an old bed of the Sirsutti river. But the Sirsutti has a gift of ubiquity!

† "Of this branch all I am aware of is, that in seasons of heavy rain great floods pour into the canal near Barod, said to be consequent on the destruction of the earthen dams of the Chitang."—*Col. Colvin in J. A. S.*, ii. 106.

and the Jamna is the only accessible source of such a supply. Doubtless then as now, the supply of water crossed the Sonb, that is, flowed into it and again out of it, so that the canal might with truth be said, to be drawn from nálá collected in the Sonb.

It is certainly somewhat singular that Firishta, who flourished in the latter part of Akbar's reign, and has made prominent mention of the ancient excavations of Fíroz, should not have alluded to this work. But the historian residing in the Deccan had probably no personal knowledge of the work, whilst contemporary documents would be less accessible than those relating to past times. It is true also that the Hansi canal is still known universally as the Canal of Fíroz, and the name fondly bestowed by Akbar in honour of his infant heir has been utterly forgotten.* But new names always adhere loosely among the many; Delhi and Agra are likely to outlive the remembrance of Sháhjáhánábád and Akbarábád, and though the canals have had as many names as a Parisian place during the Revolution,† yet Nahr Fírozah, the first name known to the people, keeps its place in their mouths.

There seems no good reason to doubt the genuineness of the Sanad. It is dated in the month of Shawál A. H. 978, from Fírozpúr in the Súbah of Lahaur. Now it appears from Firishta, that Akbar, on the birth of his son Murád, in the first month of 978, went on a pilgrimage to the shrine of Muyínuddín at Ajmír, thence by way of Nagor and Ajodín on the Sutluj to Lahaur, which he quitted for Ajmír and Agra in the second month of 979. So that he might well have been at Fírozpúr on the date given.

It is easy to conceive how the canals fell into decay. In the decline of the imperial power, when the irrigated country was a seat of constant war, and the lands along the banks were alienated among various chiefs, any system of conservancy became impossible, and the works must rapidly have been ruined. The Hansi canal was the first to suffer, as early as 1707, we are told,‡ the Sikhs taking advantage of the weakness of government during the contentions of Aurang Zeb's sons for the empire, converted the whole of the canal waters to their own use. And this at once reducing the country around Hissár to its original sterility, forced almost the whole of the inhabitants to seek a more favourable soil. A hundred years afterwards, in 1807 (as we are told by an officer on Survey in the Sikh States at that time), there was not a single inhabitant in the extensive city of Hissár.§ The Delhi canal, or Ali Mardán Khan's branch, continued to flow to a much later period. The officer just referred to learned, from aged zamindars, that the country had been deprived of the advantages of

* Akbar appears to have been particularly fond of this kind of nomenclature. He called the new Súbah of Kandísh *Dándísh*, after his son Daniel.—*Rennel.*

† Some of these names are—

Nahr Fírozah.
Shaikh Nai.
Nahr Bihisht.
Fyz Nahr.
Sháh Nahr.

‡ Letter dated May 1807, from Lieut. F. White,. Surveyor to the Resident at Delhi. In the office of the G. G. A. N. W. F.

§ Ibid.

this canal since the accession of Alamgír II. in 1753. The same authority informed him that for purposes of canal police, and the ready repair of accidents, a Darogha was stationed at every three or four koss, with peons and beldárs under him. The water rent appears to have been regulated by the time that the outlets remained open. One thousand armed peons and 500 horse, as Mr. Seton was informed by the son of one of the last native superintendents,* were maintained on the establishment. According to a proverbial expression current at Delhi, the net revenue from the canals was reckoned equal to the maintenance of 12,000 horse.†

As Colonel Colvin's paper on the history of the canals contains few dates, it may be worth while to add the following :—

Chronology of the Western Jumna Canals.

A. D. 1351.—Firoz Shàh brought a stream down the channel of the Chitang to Hansi and Hissàr.

About 1468.—The waters of the above named channel ceased to flow further than the lands of Kythal.

A. D. 1568.—Akbar re-excavated the work of Fíroz and brought a supply from the Jumna and Sonb, by the present line, into the Chitang.

About 1626.—From the last named line, Ali Mardàn Khàn drew a canal to Delhi; first by way of Gohànà, and afterwards, on that failing, by the present channel, passing near Paniput and Soneput.

A. D. 1707.—The water ceased to reach Hariàna.

" 1740.—Ceased to flow at Safidún.

" 1753 to " 1760 } The Delhi branch ceased to flow.

" 1817.—Capt. Blane appointed to restore the Delhi Canal.

" 1820.—The water again entered Delhi.

" 1823.—Restoration of Fíroz's, or the Hansi branch commenced.

" 1825.—The water turned down.

Simla, November 1st, 1845.

P. S.—Captain Abbot having, since the above was written, furnished me with a copy of the original Persian of the Sanad, it is enclosed. I have also since ascertained that the Ayin Akberi makes no mention of Akbar having engaged in this work, which is singular.

[Extracted from the *Journal of the Asiatic Society*, No. 171, vol. xv.]

* Letter from Mr. Seton to Government, 11th September 1807.

† Ibid.

APPENDIX C.

REMARKS ON THE POOLCHADUR AQUEDUCT.

THE ground flooring below the Aqueduct extends for about 19 feet up stream, and for the same distance down, measuring from the sides of the structure. The depth of the floor is not known. On the day this sketch was taken (26th March 1848), there was a depth of mud and still water on the floor of about 3 feet. Drainage from the Nujufgurh Jheel.

2. Both side arches are almost entirely choked with earth and deposit; so that the waterway of the Nujufghur Jheel drainage consists of three arches, each 8 feet in span, giving a total of 24 feet. The span of the single arch of the Road Bridge (shown in dotted lines) is 29 feet 3 inches.

3. The Pucca Revetments and flooring of the Aqueduct are produced up (the Canal) stream for 80 feet, and down stream for 85 feet, measuring from the Aqueduct wing walls.

4. When there is a full supply in the Canal, the depth of water on this floor is 8 feet; and on the 26th March 1848 there was on it a depth of silt of about 5 feet.

5. The height of the Pucca parapet walls is only 5 feet 9 inches. On the parapets are piers, 2 feet thick and 1 foot 3 inches high, at distances of about 9 feet in the clear. The two central piers on the left side with reference to the Canal, and down stream side with reference to the Nujufgurh Jheel drainage, are 2 feet 2 inches high, and are furnished with grooves for planks, which can be worked as an escape, should the supply of water in the Canal be excessive.

6. The spaces between the other piers are filled by a mud wall built on the Pucca parapet, and raised to a height of about 3 feet 6 inches above it. This Kutcha parapet requires constant repair, two Bildars being entertained solely for the purpose; and there is, of course, no passage across the Nujufgurh Jheel drainage nullah, in continuation of the Canal banks. To get across, it is necessary to descend from the bank to the Road Bridge by a steep ramp; and, having crossed the bridge, again to arrive at the Canal bank by another steep ramp.

7. There is a small wooden bridge (6 feet wide in the clear) across the Canal, immediately above the Aqueduct. It affords the sole means of passage

along the bank of the Nujufgurh Jheel drainage nullah, and was formerly used as a stop-dam, to raise the water for the supply of mills 23, 24, and 25, which are immediately above it. As, however, it is not probable that these mills will be permitted to run again, the stop-dam is not of much use. With a full supply in the Canal, the water stands up to the beams of the bridge, and the passage of rafts down to the Serai Choki (where all rafts are taken out) is thereby rendered most difficult, and this is now the sole bridge between Rair and the Serai which offers any obstacle to the passage of boats or rafts; neither is it possible conveniently to raise the bridge, in consequence of the great height of the Canal above the level of the country, the present ramps up to the bridge being most uncomfortably steep.

8. I therefore propose doing away with this bridge; and, in its place, forming a ramp (with masonry retaining walls) to go down between the Road Bridge over the Nujufgurh Jheel drainage nullah, and the Aqueduct, under the side arches of the Aqueduct, and up to the bank of the nullah by another ramp cut in its side. I have pencilled this lightly in the sketch (plan).

9. A Pucca parapet, 4 feet high, with a good towing-path on top, in substitution for the present mud walls of the Aqueduct would complete the improvements, and greatly increase the efficiency of the canal as regards the supply of water below this point, the rafting of canal produce, and the passage of boats.

10. It is remarkable that the principal dimensions of the Poolchadur Aqueduct are in English feet. The total length is 80 feet; the span of each arch is 8 feet, and the thickness of each pier the same; the width at base is 25 feet, and at top (exteriorly) 24 feet; the sides having a batten of 6 inches. The cutwaters project 3 feet from the piers, and are triangular in horizontal section, the base of triangle being 6 feet. The length of that portion of the wing-walls at right angles to the structure (*vide* plan) is 16 feet, and of the slanting portion, 10 feet. To this the wing-wall marked A (in pencil) is an exception, it having been rebuilt not long ago, in consequence of a breach made in it by the canal bursting its banks. The width of waterway for canal on Aqueduct is 16 feet below, and 19 feet above; the parapets being four feet thick at the former, and 2½ feet thick at the latter place. The thickness of floor on crown of arches is 3 feet 6 inches.

(Signed) J. W. Dyas, Lieut.
1st Assist. Sup. of Canals W. of J.

29*th Sept.* 1848.

DR. *The Canals West of Jumna Dead Stock and Current Expenses in Account Current, with Returns thereof.* CR.

	Dead Stock			Current Expenses.			Total				Gross Revenue.			Interest at 5 per Cent.			Total.		
	R.	A.	P.	R.	A.	P.	R.	A.	P.		R.	A.	P.	R.	A.	P.	R.	A.	P.
To Dead Stock to 1st May 1845	1120795	8	0				1120795	8	0	By Gross Revenue to 1st May 1845	3771306	14	7	188565	5	6	3959872	4	1
„ Interest on the above at 5 per Cent.				56039	12	5	56039	12	5	„ Do. „ 1845-46	298876	13	3				298876	13	3
„ Current Expenses, Ordinary Repairs, Establishment, per Centage on Water Mills, Rent, Compensation for Land occupied and destroyed, &c. up to May 1845				2337599	2	0½	2337599	2	0½		4070183	11	10	188565	5	6	4258749	1	4
„ Interest on the above at 5 per Cent.				116879	15	4	116879	15	4										
„ Dead Stock for 1845-46	17184	0	3				17184	0	3										
„ Current Expenses, Ordinary Repairs, &c. for 1845-46				142481	6	10	142481	6	10										
Totals	1137979	8	3	2653000	4	7⅓	3790979	12	10⅓										
Deduct Dead Stock Company's Rupees							1137979	8	3										
Balance							2653000	4	7⅓										
Excess Company's Rupees							1605748	12	8⅔										
Total Company's Rupees							4258749	1	4	Total Company's Rupees							4258749	1	4
To Dead Stock up to 1st May 1846	1137979	8	3				1137979	8	3	By Gross Revenue to 1st May 1846	4258749	1	4	212937	7	3	4471686	8	7
„ Interest on the above at 5 per Cent				56898	15	7	56898	15	7	„ Do. „ 1846-47	302885	3	3				302885	3	3
„ Current Expenses, Ordinary Repairs, Establishment, per Centage on Water Mill, Rent, Compensation, &c., up to May 1846				2653000	4	7⅓	2653000	4	7⅓		4561634	4	7	212937	7	3	4774571	11	10
„ Interest on the above at 5 per Cent.				132650	0	3	132650	0	3										
„ Dead Stock for 1846-47	66769	6	5				66769	6	5										
„ Current Expenses, Ordinary Repairs, &c. for 1846-47				137639	13	1	137639	13	1										
Totals	1204748	14	8	2980189	1	6⅓	4184938	0	2⅓										
Deduct Dead Stock Company's Rupees							1204748	14	8										
Balance							2980189	1	6⅓										
Excess Company's Rupees							1794382	10	3⅔										
Total Company's Rupees							4774571	11	10	Total Company's Rupees							4774571	11	10

E E

(True Copy.)

(Signed) W. E. BAKER, MAJOR,
Superintendent Canals N. W P

(Signed) A. D. TURNBULL, LIEUTENANT,
Superintendent Canals West of Jumna.

For CAPTAIN H SIDDONS,
Late Superintendent.

APPENDIX E.

Comparative Statement, showing the progressive Increase of Surplus Revenue derived from the Western Jumna Canals from 1831-32 *to* 1846-47, *inclusive.*

Years.	Gross Amount of Annual Revenue collected by the Superintendent.			Annual cost of Establishment, including Superintendent's salary.			Annual Amount of Expenditure in Ordinary Repairs.			Annual Amount of Contingent Expenses, Compensation, per centage on Mills, and Land Revenue.			Total of Annual Expenditure of every description, excepting that incurred in the construction of New Works.			Deficiency of Canal Revenue compared with Expenditure.			Surplus of Canal Revenue over Expenditure.			Name of Superintendent.
	R.	A.	P.	R.	A.	P.	R.	A.	P.	R.	A.	P.	R.	A.	P.	R.	A.	P.	R.	A.	P.	
1831-32 ..	80881	10	11	79722	14	7	18342	8	5	1941	4	2	100006	11	2	19125	0	3	..	..	..	
1832-33 ..	96111	15	10	82242	5	7	21260	0	0	2770	9	3	106272	14	10	10160	15	0	..	..	..	
1833-34 ..	176831	14	7	81100	0	3	19101	14	10	4515	9	2	104717	8	3	..	..	..	72114	6	4	Colonel J. Colvin, C.B.
1834-35 ..	145253	7	8	77646	8	4	34214	12	5	3954	12	2	115816	0	11	..	..	..	29437	6	9	
1835-36 ..	145141	0	5	78949	5	0	23395	3	9½	5170	7	4	107515	0	1½	..	..	..	37626	0	3½	
1836-37 ..	190809	6	4	65492	5	5	21396	9	7½	7340	0	4	94228	15	4½	..	..	..	96580	6	11½	
1837-38 ..	299670	12	6	58727	7	2	25360	8	4	11341	10	0	95429	9	6	..	..	..	204241	3	0	
1838-39 ..	221400	1	10	58006	12	8	20930	7	9	8596	4	2	87533	8	7	..	..	..	133866	9	3	
1839-40 ..	258826	10	9	56103	13	10	27233	0	8	11153	13	0	94490	11	6	..	..	..	164335	15	3	Captain W. E. Baker.
1840-41 ..	288587	4	2	57066	8	5	25089	2	8	12510	12	7	94666	7	8	..	..	..	193920	12	6	
1841-42 ..	294572	9	3	55425	14	8	28096	2	8	12786	6	4	96308	7	8	..	..	..	198264	1	7	
1842-43 ..	311265	7	10	53883	0	11	42985	4	5	13966	7	0	110834	12	4	..	..	..	200430	11	6	
1843-44 ..	290993	10	5	56670	0	6	31713	3	9	12548	11	8	100931	15	11	..	..	..	190061	10	6	Captain A. H. E. Boileau.
1844-45 ..	260311	15	1	67069	11	3	89689	14	5	12773	10	1	169533	3	9	..	..	..	90778	11	4	
1845-46 ..	298876	13	3	68238	1	4	62559	2	4	12525	12	9	143323	0	5	..	..	..	155553	12	10	Lieutenant James Spens.
1846-47 ..	302885	3	3	71859	4	0	53976	10	6	11803	14	7	137639	13	1	..	..	..	165245	6	2	Captain H. Siddons.

Note.—The diminution of Expenditure on Establishment in 1836-37, and the following years, is chiefly owing to the undermentioned circumstance. Up to August 1836 the allowances of Colonel Colvin, as Superintendent of Canals, N. W. Provinces, were included in the Abstracts of the Western Jumna Canals, but subsequently to that date, and till the abolition of the appointment, these allowances were drawn separately. The decrease due to this cause is about 12,000 rs. per annum.

(Signed) W. E. BAKER, Major,
Superintendent Canals, N. W. P.

APPENDIX F.

STATEMENT of EXPENDITURE and Number of TREES alive, &c., in the PLANTATIONS forming along the Banks of the WESTERN JUMNA CANALS, from the 30th April 1835 to 30th April 1847.

Western Jumna Canal Office, the 29th July 1847.

DATE.	1st, or NORTHERN DIVISION.				2nd, or KURNAL DIVISION.				3rd, or SONEPUT DIVISION.				4th, or SOUTHERN DIVISION.				5th, or ROHTUK DIVISION.				6th, or JHEEND DIVISION.				7th, or HANSI DIVISION.				8th, or WESTERN DIVISION.				TOTAL.				Amount Realized by Sale of Crown Produce			Estimated Value of Trees.		
	Half Yearly Outlay.			Number of Trees at end of Half Year.	Half Yearly Outlay.			Number of Trees at end of Half Year.	Half Yearly Outlay.			Number of Trees at end of Half Year.	Half Yearly Outlay.			Number of Trees at end of Half Year.	Half Yearly Outlay.			Number of Trees at end of Half Year.	Half Yearly Outlay.			Number of Trees at end of Half Year.	Half Yearly Outlay.			Number of Trees at end of Half Year.	Half Yearly Outlay.			Number of Trees at end of Half Year.	Expenditure as per Bill rendered.			Number of Trees							
	Rs.	A.	P.	No.	Rs.	A.	P.	No.	Rs.	A.	P.	No.	Rs.	A.	P.	No.	Rs.	A.	P.	No.	Rs.	A.	P.	No.	Rs.	A.	P.	No.	Rs.	A.	P.	No.	Rs.	A.	P.	No.	Rs.	A.	P.	Rs.	A.	P.
Totals from 30th April 1835 up to 30th April 1846	2928	4	0	23009	4793	8	11	54829	3533	0	3	52107	2329	12	8	34195	3074	3	4	52732	2833	6	8	48162	3258	11	9	55422	1651	12	8	20000	24403	12	3	340456	42214	1	2	534844	5	0
1846 ..... October 31st	161	2	8	22663	228	1	8	55267	287	0	9	51638	171	9	8	34806	226	0	7	53527	169	10	1	50346	146	11	2	54740	82	0	11	22314	1472	5	6	345301	5403	1	4	535935	14	4
1847 ..... April 30th	178	2	6	22978	263	3	3	59335	305	13	3	57173	164	15	2	34586	176	7	6	64835	157	7	6	50238	156	2	8	64063	85	0	0	22184	1487	3	10	375392	2408	10	3	566998	5	4
Totals up to 30th April 1847 ...	3268	9	2	22978	5284	13	10	59335	4125	14	3	57173	2666	5	6	34586	3476	11	5	64835	3160	8	3	50238	3561	9	7	64063	1818	13	7	22184	27363	5	7	375392	52025	12	9	566998	5	4

	Rs.	A.	P.
Cash drawn from Treasuries since April 1835, including Balance in hand on that date	28320	7	6
Amount of Bills rendered as per above	27363	5	7
Balance paid back into Treasuries, Co.'s Rs.....	957	1	11

W. E. BAKER, MAJOR,
Superintendent of Canals N. W. Provinces.

APPENDIX G.

Dr. *Expenditure on the Western Jumna Canals in Account Current, with Direct Canal Revenue derived therefrom.* Cr.

PERIOD.	EXPENDITURE.												INCOME.																							
	Original Works.				Establishment.				Current Repairs.				Total.				PERIOD.	Water Rent on Land.				Rent on Water Mills.				Rent on Cattle Watered.				Rent for Rafting Timbers.				Sale of Canal Produce and Sundries.				Fines for Breach of Canal Regulations.				Total Revenue.			
	Co.'s Rs.	A.	P.		Co.'s Rs.	A.	P.		Co.'s Rs.	A.	P.		Co.'s Rs.	A.	P.			Co.'s Rs.	A.	P.		Co.'s Rs.	A.	P.		Co.'s Rs.	A.	P.		Co.'s Rs.	A.	P.		Co.'s Rs.	A.	P.		Co.'s Rs.	A.	P.	
																	Previous to 1820	876	4	0		..	..	..		..	..	..		..	..	..		..	..	..		..	..	..		876	4	0	
As per Capt. Blane's Bills from commencement up to 18th May 1821	142164	10	9½		52264	9	11		5319	13	7½		199749	2	4		1820-21....	14646	2	1		..	..	..		..	..	..		14	4	0		635	11	0		504	8	5		15800	9	6	
As per Capts. Colvin and Tickell's Bills to 30th April 1822	....	..	..		19095	9	4		6586	11	6		25682	4	10		1821-22....	24618	8	11		..	..	..		..	..	..		84	4	0		1180	9	4		911	8	2		26794	14	5	
1822-23	....	..	..		27612	15	6		9303	2	3		36916	1	9		1822-23....	21458	5	0		3026	13	6		..	..	..		..	..	..		741	7	11		1039	2	10		26265	13	3	
1823-24	....	..	..		43815	5	7½		6743	10	6		50559	0	1½		1823-24....	36015	6	1		6868	10	0		..	..	..		..	..	..		656	0	10		1882	3	8		45422	4	7	
1824-25	....	..	..		53381	2	5⅔		4181	12	5		57562	14	10⅔		1824-25....	26646	9	7		3964	5	4		..	..	..		..	..	..		545	7	7		1082	8	8		32238	15	2	
1825-26	....	..	..		59029	9	2⅓		4580	4	5		63609	13	7⅓		1825-26....	48374	6	9		2991	3	11		..	..	..		..	..	..		370	9	9		2423	4	4		54159	8	9	
1826-27	4141	10	0		64484	13	2		6830	12	5		75457	3	7		1826-27....	33975	0	0		3682	13	2		..	..	..		500	4	0		713	13	11		3283	1	6		42155	0	7	
1827-28	18145	9	10		73141	7	7		7288	13	8½		98575	15	1½		1827-28....	34160	14	7		11676	10	9		..	..	..		1013	1	10		1460	13	9		4471	1	9		52782	10	8	
1828-29	....	..	..		74216	1	1		9661	9	1		83877	10	2		1828-29....	52952	10	7		16267	0	6		3772	10	8		1187	1	10		1289	8	8		2847	6	2		78316	6	5	
1829-30	4938	14	0		74851	15	7		10435	9	3		90226	6	10		1829-30. ..	53375	0	0		19786	3	0		3568	7	10		1932	10	4		1142	15	4		2801	12	4		82607	0	10	
1830-31	....	..	..		77121	1	1		16252	14	2		93373	15	3		1830-31....	57700	0	5		19464	0	0		2968	12	2		2132	8	4		1265	4	8		2508	9	6		86039	3	1	
1831-32	....	..	..		79718	14	7		20401	5	11		100120	4	6		1831-32....	51016	4	11		19002	3	7		4210	9	7		2061	15	0		2127	7	0		2463	2	10		80881	10	11	
1832-33	....	..	..		82242	5	7		22959	8	5		105201	14	0		1832-33....	65804	11	3		19238	2	3		3396	2	5		1611	8	7		2651	2	11		3410	4	5		96111	15	10	
1833-34	72010	15	4		81100	0	3		21402	14	8		174513	14	3		1833-34....	148783	2	6		13882	4	6		1257	3	11		2950	1	6		3894	6	11		6064	11	3		176831	14	7	
1834-35	90278	8	8		77646	8	4		36165	5	3		204090	6	3		1834-35....	114065	8	3		18294	9	9		1669	6	7		3238	9	5		3682	2	10		4303	2	10		145253	7	8	
1835-36	622222	9	3½		78949	5	0		25657	8	6½		726829	6	10		1835-36....	110602	11	3		22837	3	7		2145	15	6		1993	9	0		4957	11	9		2603	13	4		145141	0	5	
1836-37	3383	7	8		65492	5	5		21892	14	10½		90768	11	11½		1836-37....	153176	15	1		26894	10	5		2197	1	7		3365	0	0		2245	6	0		2930	5	3		190809	6	4	
1837-38	31743	2	1		58727	7	2		34804	7	4		125275	0	7		1837-38....	272377	13	5		5782	0	9		760	3	6		6048	9	5		5221	8	8		9480	8	9		299670	12	6	
1838-39	46044	0	11		58006	12	8		21073	11	5		125124	9	0		1838-39....	189644	15	3		9732	7	10		1838	15	3		8228	11	4		6171	4	2		5783	12	0		221400	1	10	
1839-40	6255	14	0		56103	13	10		27758	0	8		90117	12	6		1839-40....	224382	15	3		14566	8	3		2286	13	2		6579	5	1		4822	14	10		6188	2	2		258826	10	9	
1840-41	31181	1	7		57066	8	5		25785	11	3		114033	5	3		1840-41....	255817	15	3		9524	0	6		1955	13	2		9730	4	3		5481	6	0		6077	13	0		288587	4	2	
1841-42	12120	15	9		55425	14	8		28197	9	7		95744	8	0		1841-42....	263068	13	0		8203	14	3		1554	1	8		11505	15	3		5607	3	7		4632	9	6		294572	9	3	
1842-43	25115	14	0		53883	0	11		43915	4	5		122914	3	4		1842-43....	279300	10	11		9882	11	9		1172	5	2		7934	14	9		6756	12	3		6218	1	0		311265	7	10	
1843-44	8408	11	9		56670	0	6		31712	15	9		96791	12	0		1843-44....	260555	8	9		12598	13	0		1680	4	9		5570	12	6		4827	5	2		5760	14	3		290993	10	5	
1844-45	2639	6	4		67069	11	3		89689	14	5		159399	0	0		1844-45....	231022	8	9		8220	6	3		2979	7	2		6598	10	8		5149	11	1		6341	3	2		260311	15	1	
1845-46	17184	0	3		68238	1	4		62559	2	4		147981	3	11		1845-46....	260693	13	2		13250	7	11		2293	3	3		7830	0	4		7056	0	1		7753	4	6		298876	13	3	
1846-47	66769	6	5		71859	4	0		53976	10	6		182605	4	11		1846-47....	262529	13	8		14709	15	5		1687	0	0		6799	9	1		10167	10	4		6991	2	9		302885	3	3	
Total to end of 1846-47	1204748	14	8		1687214	12	5⅓		655138	2	8		3537101	13	9⅓			3547643	8	8		314348	4	2		43394	9	4		98911	10	6		90822	8	4		110758	2	4		4205878	11	4	

APPENDIX H.

Translation of a Puttah, granted to Mujlish, Soheram, and Bhanah; Lumberdars of the village of Hoolumbee Kulan. Purgunna Shumal. Central Division, Delhi Territory.

Inasmuch as you, on your own part, and on that of the other cultivators and shareholders, have presented a Durkhast, containing eight conditions, for the purpose of taking, on lease or contract for eighteen years, outlets from the canal for the irrigation of your lands, at Company's rupees 6,300; the half of which is 3,150; commencing from the Fussul khurreef 1842 (fuslee 1250), and ending in Fussul Rubbee 1859 (fuslee 1267), both inclusive, and payable half yearly at the rate of Company's rupees 350 per annum.

I, on my part, do hereby agree to the same on the undermentioned conditions. 1st. The contract for the outlets being fixed at a sum due to the average quantity of land irrigated, and chargeable at the usual rate of watering, and being for the benefit of the cultivators, it is hereby stipulated that you do not collect a larger amount of water-rent from them than is specified in this Puttah.

2nd. That, as now you have no fear of a larger water-rent being taken, whatever be the quantity of land you irrigate, cultivate your lands to the utmost; and it is hereby agreed, that if you pay the annual demands (including the water-rent, and the usual items of sundry expenses), to the canal authorities, within the prescribed term; viz., at the end of each crop, or within three months of its cutting; the indulgence of Mookudumee, or five per cent. on the collection will be granted to you.

3rd. It is to be clearly understood, that, whether you sow your lands or not, whether you reap a profit or suffer a loss, by this engagement, both the profit and the loss will be yours.

4th. That it be your constant endeavour to keep the cultivators pleased with this contract, and to increase cultivation by these means.

5th. That you will be considered liable for the payment of the water-rent, whether you keep your watercourses running or closed.

6th. That you will enter into arrangements that no delay shall take place in paying the water-rent, and agree, that, should the payment not be made for one year (or two seasons), the outlets are to be closed until such time as the money be paid, according to this Puttah, with interest.

7th. That, should any individual irrigate from any watercourse not specified in this agreement, either by means of duls, churrus, rohut, or any other machine, he shall pay the water-rent due for that description of irrigation, according to the established rate upon each beegah of land irrigated, in addition to the specified contract sum.

8th. That, should the canal be closed at any time for the sake of silt clearance, repairs of works, or other causes, for such a period that no water reaches your lands, in sufficient time to irrigate the standing crop, then, with the sanction of Government, the water-rent leviable according to the terms of this contract may be remitted.

These clauses have, therefore, been written in the shape of an engagement, that it may remain as an authentic document, and be appealed to in case of necessity.

Number of outlets in contract.

One outlet, No. 47, near the Rejmall bridge, at Gungatolee, on the east bank $10'' \times 10''$ measurement.

One outlet, No. 41, on the east bank, near the Chotakhera Bagh, $8'' \times 13''$ measurement.

Total water-rent for eighteen years 6,300 rupees, the half of which is 3,150 rupees; to be paid at the rate of 350 rupees yearly, as follows:—

332	8	0	Water Rent.
17	8	0	Mookudumee.
350	0	0	Total Company's Rupees.

APPENDIX I.

Abstract Statement of the Direct Canal Revenue, with Expenditure on Ordinary Repairs and Establishment, Western Jumna Canals.

YEARS.	PERIOD	INCOME. No. 1. Irrigation	No. 2. Mills.	No. 3. Sundries.	No. 4. Fines.	Half Yearly.	EXPENDITURE. Establishment.	Ordinary Repairs.	Half Yearly.	ANNUAL INCOME.	ANNUAL EXPENDITURE.	DETAIL OF No. 3 ITEM. Transit Duties.	Filling Tanks.	Watering Cattle	Sale of Wood
Up to 1820	From opening to 30th April 1820	Rs. 876 4 0				Rs. 876 4 0				Rs. 876 4 0					
1820-21	1st May 1820 „ 31st Oct. 1820	1751 1 4		180 9 0		1931 10 4	52264 9 11	5319 13 7½		15800 9 6	57584 7 6½	14 4 0			180 9 0
	1st Nov 1820 „ 30th April 1821	12895 0 9		469 6 0	504 8 5	13868 15 2									455 2 0
1821-22	1st May 1821 „ 31st Oct 1821	10308 7 9		513 10 8	366 9 9	11188 12 2	19095 9 4	6586 11 6		26794 14 5	25682 4 10	74 11 0			438 15 8
	1st Nov 1821 „ 30th April 1822	14310 1 2		751 2 8	544 14 5	15606 2 3						9 9 0			741 9 8
1822-23	1st May 1822 „ 31st Oct. 1822	6876 7 6	1790 13 6	467 14 8	533 10 2	9668 13 10	27612 15 6	9303 2 3		26265 13 3	36916 1 9				467 14 8
	1st Nov 1822 „ 30th April 1823	14581 13 6	1236 0 0	273 9 3	505 8 8	16596 15 5									273 9 3
1823-24	1st May 1823 „ 31st Oct. 1823	12937 13 11	4741 6 6	303 14 3	410 2 7	18393 5 3	43815 5 7½	6743 10 6		45422 4 7	50559 0 1½				303 14 3
	1st Nov. 1823 „ 30th April 1824	23077 8 2	2127 3 6	352 2 7	1472 1 1	27028 15 4									352 2 7
1824-25	1st May 1824 „ 31st Oct. 1824	13393 15 11	1483 0 4	283 4 0	315 8 0	15475 12 3	53381 2 5⅜	4181 12 5		32238 15 2	57562 14 10⅜				283 4 0
	1st Nov. 1824 „ 30th April 1825	13252 9 8	2481 5 0	262 3 7	767 0 8	16763 2 11									262 3 7
1825-26	1st May 1825 „ 31st Oct. 1825	25326 5 3	2382 5 2	209 15 9	846 2 7	28764 12 9	19029 9 2¾	4580 4 5		54159 8 9	63609 13 7½				209 15 9
	1st Nov. 1825 „ 30th April 1826	23048 1 6	608 14 9	160 10 0	1577 1 9	25394 12 0									160 10 0
1826-27	1st May 1826 „ 31st Oct. 1826	15428 14 9	1305 11 8	520 9 4	1291 13 3	18547 1 0	64484 13 2	6830 12 5		42155 0 7	71315 9 7	91 0 5			429 8 11
	1st Nov. 1826 „ 30th April 1827	18546 1 3	2377 1 6	693 8 7	1991 4 3	23607 15 7						409 3 7			284 5 0
1827-28	1st May 1827 „ 31st Oct. 1827	17040 8 6	5270 9 6	1557 14 9	3519 7 11	27388 8 8	73141 7 7	7288 13 8½		52782 10 8	80430 5 3½	517 0 3			1040 14 6
	1st Nov. 1827 „ 30th April 1828	17120 6 1	6406 1 3	916 0 10	951 9 10	25394 2 0						496 1 7			419 15 3
1828-29	1st May 1828 „ 31st Oct. 1828	20920 15 8	8477 5 6	3925 1 11	1621 1 10	34944 8 11	74216 1 1	9661 9 1		78316 6 5	83877 10 2	682 13 4		2425 2 9	817 1 10
	1st Nov. 1828 „ 30th April 1829	32031 10 11	7789 11 0	2324 3 3	1226 4 4	43371 13 6						504 4 6		1347 7 11	472 6 10
1829-30	1st May 1829 „ 31st Oct. 1829	27240 15 1	12996 15 0	2914 10 8	1564 11 4	44717 4 1	74851 15 7	10435 9 3		82607 0 10	85287 8 10	731 10 2		1544 4 3	638 12 3
	1st Nov 1829 „ 30th April 1830	26134 0 11	6789 4 0	3729 6 10	1237 1 0	37889 12 9						1201 0 2		2024 3 7	504 3 1
1830-31	1st May 1830 „ 31st Oct 1830	27596 15 0	11781 4 0	3338 2 6	1254 1 7	43970 7 1	77121 1 1	16252 14 2		86039 3 1	93373 15 3	900 0 4		1678 12 11	759 5 3
	1st Nov 1830 „ 30th April 1831	30103 1 5	7682 12 0	3028 6 8	1254 7 11	42068 12 0						1232 8 0		1289 15 3	505 15 5
1831-32	1st May 1831 „ 31st Oct 1831	23318 1 7	12459 1 6	3883 4 11	1215 15 10	40876 7 10	39320 2 2	5664 12 2	44984 14 4	80881 10 11	100120 4 6	876 0 11	248 3 3	1818 3 4	940 13 5
	1st Nov 1831 „ 30th April 1832	27698 3 4	6543 2 1	4516 10 8	1247 3 0	40005 3 1	40402 12 5	14732 9 9	55135 6 2			1185 14 1	68 12 10	2392 6 3	869 9 6
1832-33	1st May 1832 „ 31st Oct. 1832	24656 5 9	8954 3 9	3955 0 5	1955 7 4	39521 1 3	41049 15 5	11242 8 0	52292 7 5	96111 15 10	105201 14 0	724 3 10	316 3 6	1836 6 7	1078 2 6
	1st Nov. 1832 „ 30th April 1833	41148 5 6	10283 14 6	3703 13 6	1454 13 1	56590 14 7	41192 6 2	11717 0 5	52909 6 7			887 4 9	110 9 8	1559 11 10	1146 3 3
1833-34	1st May 1833 „ 31st Oct. 1833	46429 0 2	10096 3 2	5297 4 4	3111 5 1	64933 12 9	40613 0 10	4689 12 2	45302 13 0	176831 14 7	102502 14 11	1723 15 1	348 5 8	652 2 6	2572 13 1
	1st Nov. 1833 „ 30th April 1834	102354 2 4	3786 1 4	2804 8 0	2953 6 2	111898 1 10	40485 15 5	16713 2 6	57200 1 11			1226 2 5	88 9 9	605 1 5	884 10 5
1834-35	1st May 1834 „ 31st Oct. 1834	49488 14 3	8984 10 1	4893 6 8	2733 10 4	66100 9 4	38963 10 10	15080 13 8	54047 8 6	145253 7 8	113811 13 7	1921 5 4	367 10 4	721 5 5	1883 1 7
	1st Nov 1834 „ 30th April 1835	64576 10 0	9309 15 8	3696 12 2	1569 8 6	79152 14 4	38670 13 6	21084 7 7	59764 5 1			1317 4 1	248 7 2	948 1 2	1182 15 9
1835-36	1st May 1835 „ 31st Oct. 1835	53427 10 8	9822 4 0	3751 15 10	1408 1 6	68410 0 0	39512 15 1	7702 0 9	47214 15 10	145141 0 5	104606 13 6½	775 13 11	205 8 10	766 7 6	2004 1 7
	1st Nov. 1835 „ 30th April 1836	57175 0 7	13014 15 7	5345 4 5	1195 11 10	76731 0 5	39416 5 11	17975 7 9½	57391 13 8½			1217 11 1	605 1 4	1379 8 0	2143 0 0
1836-37	1st May 1836 „ 31st Oct. 1836	64263 10 1	14797 9 3	3506 0 1	1287 12 9	83855 0 1	35118 1 10	8560 0 6	43678 2 4½	190809 6 4	87385 4 3½	1581 1 0	302 1 7	832 6 7	790 6 11
	1st Nov 1836 „ 30th April 1837	88913 5 0	12097 1 2	4301 7 6	1642 8 6	106954 6 2	30374 3 7	13332 14 4½	43707 1 11½			1783 15 0	640 9 7	1364 11 0	512 3 11
1837-38	1st May 1837 „ 31st Oct. 1837	103099 6 10	5101 7 10	6836 5 7	3181 12 4	118219 0 7	30267 13 10	13143 12 7	43411 10 5	299670 12 6	93531 14 6	4063 5 0	334 10 8	259 14 8	2178 7 3
	1st Nov 1837 „ 30th April 1838	169278 6 7	680 8 11	5194 0 0	6298 12 5	181451 11 11	28459 9 4	21660 10 9	50120 4 1			1985 4 5	673 1 0	500 4 10	2035 5 9
1838-39	1st May 1838 „ 31st Oct 1838	114616 2 6	3557 10 6	11287 3 7	3476 12 6	132937 13 1	29751 5 1	7831 5 2	37582 10 3	221400 1 10	79080 8 1	5440 9 9	3046 10 1	954 13 6	1845 2 3
	1st Nov. 1838 „ 30th April 1839	75028 12 9	6174 13 4	4951 11 2	2306 15 6	88462 4 9	28255 7 7	13242 6 3	41497 13 10			2788 1 7	270 12 0	884 1 9	1008 11 10
1839-40	1st May 1839 „ 31st Oct. 1839	103341 13 4	8193 6 0	7018 3 7	2777 7 8	121330 14 7	27969 6 4	10246 14 6	38216 4 10	258826 10 9	83861 14 6	3244 5 2	325 8 3	1348 5 5	2100 0 9
	1st Nov. 1839 „ 30th April 1840	121041 1 11	6373 2 3	6670 13 6	3410 10 6	137495 12 2	28134 7 6	17511 2 2	45645 9 8			3334 15 11	700 1 0	938 7 9	1697 4 10
1840-41	1st May 1840 „ 31st Oct. 1840	117825 6 7	6274 9 0	8065 12 1	3192 4 6	135358 0 2	28182 6 3	10788 8 5	38970 14 8	288587 4 2	82852 3 8	4702 7 4	206 8 2	1283 15 9	1872 12 10
	1st Nov. 1840 „ 30th April 1841	137992 8 8	3249 7 6	9101 11 4	2885 8 6	153229 4 0	28884 2 2	14967 2 10	43851 5 0			5027 12 11	552 10 0	671 13 5	2849 7 0
1841-42	1st May 1841 „ 31st Oct. 1841	127785 1 6	3499 12 6	11024 9 1	2909 6 0	145218 13 1	27606 9 10	13229 14 0	40836 7 10	294572 9 3	83623 8 3	6640 7 5	186 3 7	939 0 6	3258 13 7
	1st Nov. 1841 „ 30th April 1842	135283 11 6	4704 1 9	7642 11 5	1723 3 6	149353 12 2	27819 4 10	14967 11 7	42787 0 5			4865 7 10	490 3 4	615 1 2	1671 15 1
1842-43	1st May 1842 „ 31st Oct. 1842	122937 6 7	2093 0 3	7346 7 2	3289 6 4	135666 4 4	27146 13 6	33611 9 7	60758 7 1	311265 7 10	97798 5 4	2902 10 0	348 3 2	763 5 8	3332 4 4
	1st Nov 1842 „ 30th April 1843	156363 4 4	7789 11 6	8517 9 0	2928 10 8	175599 3 6	26736 3 5	10303 10 10	37039 14 3			5032 4 9	985 8 5	408 15 6	2090 12 4
1843-44	1st May 1843 „ 31st Oct. 1843	130788 4 2	5995 0 0	6880 13 0	3007 13 0	146671 14 2	27911 7 9	11194 6 8	39105 14 5	290293 10 5	88383 0 3	3309 0 5	331 0 3	867 6 0	2373 6 4
	1st Nov. 1843 „ 30th April 1844	129767 4 7	6603 13 0	5297 9 5	2753 1 3	144321 12 3	28758 8 9	20518 9 1	49277 1 10			2261 12 1	772 1 4	812 14 9	1350 13 3
1844-45	1st May 1844 „ 31st Oct. 1844	120012 9 11	4440 15 0	5516 14 6	3352 0 10	133322 8 3	31536 7 3	26260 12 2	57797 3 5	260311 15 1	156759 9 8	2025 7 4	215 11 2	1106 12 11	2168 15 1
	1st Nov 1844 „ 30th April 1845	111009 14 10	3779 7 3	9210 14 5	2989 2 4	126989 6 10	35533 4 0	63429 2 3	98962 6 3			4573 3 4	1292 2 10	1872 10 3	1472 14 0
1845-46	1st May 1845 „ 31st Oct. 1845	131502 1 2	4151 10 1	7817 4 0	3956 14 6	147427 13 9	34222 5 7	45268 11 0	79491 0 7	298876 13 3	130797 4 8	3445 1 11	516 14 9	810 10 11	3044 8 5
	1st Nov. 1845 „ 30th April 1846	129191 12 0	9098 13 10	9361 15 8	3796 6 0	151448 15 6	34015 11 9	17290 7 4	51306 3 1			4384 14 5	1081 11 1	1482 8 4	2412 13 10
1846-47	1st May 1846 „ 31st Oct. 1846	118749 3 1	8262 6 11	9200 5 6	3764 8 5	139976 7 11	35615 10 4	28800 4 4	64415 14 8	302885 3 3	125835 14 6	1961 12 6	741 15 10	1093 7 10	5403 1 4
	1st Nov 1846 „ 30th April 1847	143780 10 7	6447 8 6	9453 13 11	3226 10 4	162908 11 4	36243 9 8	25176 6 2	61419 15 10			4837 12 7	1613 14 11	593 8 2	2408 10 3

NOTE —This paper was prepared after I left India, and appears to contain some trifling inaccuracies, which I have not the means of correcting. They are not, however, of amount sufficient to defeat the object of the Statement, which is intended to show general results.—W. E B.

APPENDIX K.

Remarks on the Irrigation of the Lombardo-Venetian Provinces, as compared with that of North-Western India.

N.B.—The information regarding Italian Irrigation is derived from certain printed papers obtained by Major Cautley from the India Board, and presented to the Ganges Canal Library. These papers purport to be copies of two official communications from Consul-General C. G. Dawkins to Viscount Palmerston, dated respectively 22nd February and 25th May 1847.

1. The works of Irrigation in Italy are undertaken generally by private enterprise; rarely at the expense of Government. — Irrigation works generally private property.

2. The employment of Government engineers is restricted to those cases in which Government itself undertakes to conduct water through, or for the benefit of, different territories or provinces. — Government Engineers rarely employed.

3. The water-right, and the questions that may arise out of the use and property of the same, come under the cognizance of the judicial and administrative authority. — Questions regarding water-right adjudicated in the Civil Courts.

4. The water is sold as absolute property at a perpetual rent, or on lease for a definite time. It is measured principally by the discharge through a regulated opening; more rarely by the area of land irrigated. — Mode of selling or renting water for irrigation.

5. The standard of measurement for discharge is the Milanese inch, or "oncia," which corresponds with the quantity of water passing through an aperture 6 inches high, 8 inches wide, open 2 inches below the surface of the water. The rent of such an outlet per annum is equivalent to about 207 rupees of Indian currency (allowing $2\frac{1}{2}$ francs per rupee), or about 166 rupees per annum for each cubic foot of water discharged per second. The contract rate for such an orifice on the Delhi Canal, would be about 120 rupees per annum, or 96 rupees per annum per cubic foot per second. — Standard of measurement and contract rent in Italy and India.

6. Irrigation in Italy is confined almost exclusively to the summer months. The contract rent of an outlet for the summer and winter seasons, respectively, bearing to each other the ratio of about eight to one. — Season of irrigation in Italy.

7. In India the rubbee, or winter irrigation, is more important than that of the summer months, which is always more or less assisted (when not altogether superseded) by the periodic rains from June till September. — Season of irrigation in India

8. The water-rent for summer irrigation in Italy, when assessed on the area of land irrigated, varies in different provinces according to the facilities of obtaining water. In some parts of the provinces of Lodi and Pavia, the water is sold at a rate (5·8 Austrian livres per *pertica*) equivalent to about $9\frac{1}{2}$ rupees per beega of — Rent on measured irrigation in Italy.

3025 square yards, or 15 rupees per acre. In other localities it is rated at about half that amount.

Rent on measured irrigation in India.

9. On the Jumna Canals, the rate on measured irrigation varies with the nature of the crop, from 5 rupees on annual, to ½ rupee on half-yearly crops per acre.

Quantity of water required for rice in Italy.

10. It is generally admitted in Lombardy that, in an average soil, one oncia (about 1¼ cubic foot per second) of water is sufficient to keep flooded from 360 to 400 pertiche (48 to 53 acres) of rice, or 1 cubic foot to 40 acres.

Quantity required for rice in India.

11. In India, a far less quantity of water is requisite for this species of crop, perhaps partly from the more retentive nature of the soil in which only rice is cultivated, but chiefly from the circumstance that it is grown during the periodic rains, which supply a great part of the moisture required. I calculate that a discharge of 1 cubic foot per second is sufficient for 90 acres of rice, under ordinary circumstances, in these provinces.

Quantity required for other crops in Italy.

12. It is elsewhere stated in the printed document, that 3 oncia—say 4 cubic feet per second, is a sufficient quantity for 250 acres (or 62½ acres per cubic foot), of various crops, not including rice.

Quantity required for other crops in India.

13. The average annual irrigation per cubic foot of discharge from the Jumna Canals, is 180 acres; but in comparing Indian irrigation of other crops than rice with that of Italy, it must be borne in mind that we have in India two successive crops in the year, both irrigated.

Description of "Marcite" irrigation.

14. In Italy, a species of irrigation is practised which is quite unknown in India, or only approached to in the cultivation of lucerne, viz., "marcite," or constantly flooded meadow lands, from which five to eight crops of grass may be cut during one summer. This mode of cultivation requires the water to be kept constantly moving in a thin sheet over the surface of the ground, and by this wasteful process, a discharge of 1 cubic foot per second only suffices for 1 or 2 acres, according to soil.

Proportion of surface irrigated in Italy.

15. The proportion of surface irrigated varies, as might be expected, in different localities. Between the Ticino and the Adda, the land is irrigated to the extent of eight-tenths of its surface; between the Adda and Clisio, about five-tenths, and lower down towards the junction of the Po and the Mincio, about one-tenth.

Proportions of surface irrigated in part of the Delhi territory.

16. In the best irrigated sub-division of the Delhi territory (Pergunna, Soneput, Bangur), containing 137,549 acres, about one-third or three-tenths of the surface is under irrigation, according to the measurements taken by G. F. Edmonstone, Esq., preparatory to the revenue settlement of this district.

Length and cost of First-class Canals in Italy

17. The canals of the first magnitude, which issue from the Ticino and the Adda (comprising the Muzza* Canal), may be reckoned at 200 kilometres (124 miles) in length. According to the recent cost of works of a similar kind, they may be valued on an average at from 20 to 25 millions of francs (80 to 100 lakhs of rupees).

* The Muzza Canal leaves the right bank of the Adda near Cassano, and after running a course of about 36 miles, rejoins the parent stream about 5 miles N.W. of Pizzighettone.

18. The expense of a second-class canal, estimated on the average of four specified works (Lorini Marocco, Belgiojoso, Taverna, Borromeo), would be $1\frac{1}{4}$ to $1\frac{1}{2}$ million of francs (5 to 6 lakhs). Cost of second-class Canals in Italy

19. Third and fourth class canals or water-courses, are estimated at about 100,000 francs (40,000 rupees), for each square kilometre of surface (247 acres), or at the rate of 156 rupees per acre. Cost of third and fourth-class Canals in Italy.

20. The Western Jumna Canal is 445 miles long, and cost 1,137,979 rupees. Cost of Western Jumna Canal.

21. The Eastern Jumna Canal is 142 miles long, and cost 801,983 rupees. Cost of Eastern Jumna Canal.

22. The Ganges Canal will be 800 miles long, and is estimated to cost 10,000,000 rupees—a crore of rupees. Estimated cost of Ganges Canal.

23. On the Eastern Jumna Canal, by a comparison of the cost of Rajbuhas (principal water-courses), hitherto executed with the extent of land irrigated from them, we find that 90,614 rupees have been expended in providing irrigation, for 60,511 beegas, or at the rate of $2\frac{1}{3}$ rupees per acre. Cost of Rajbuhas.

24. The current expenses—*i. e.* "preservation of the canals, their cleaning out, repairs of the bridge canals, syphons, &c., as well as the salaries of the engineers, accountants, and others who attend to the administration and preservation of the water"—is stated to amount, on the Muzza Canal (36 miles long), to 40,000 francs, or 16,000 rupees per annum. Current expenses of Canals in Italy

25. The similar expenses, with the addition of that of collecting water-rent, on the Western and Eastern Jumna Canals, on an average of the last three years, are respectively 138,000 rs. and 68,000 rs. per annum. Current expenses of Canals in India.

26. The Italian writer (p. 14 of the communication dated 25th May 1847) estimates that the cost of all the *works* and *operations* necessary to introduce irrigation similar to that of the low Milanese districts into an equal surface of half a million of acres would be a milliard francs, or 40 crores of rupees. Estimated total cost of introducing irrigation over a given surface.

27. The Ganges Canal, estimated to cost 1 crore, and with the largest allowance for Rajbuhas (supposing these to be constructed at the expense of Government), not likely to exceed $1\frac{1}{4}$ crore of rupees, will actually irrigate 1,473,920 acres, and supply sufficient irrigation to support the annual cultivation of, and to secure from the effects of drought, a district containing 8,320,000 acres. Estimated cost of irrigating the Doab by the Ganges Canal.

28. A large proportion of the sum estimated by the Italian writer being calculated for levelling ground, provision of farm-buildings, and other purposes not necessary in the Doab, no proper comparison of the cost of *work* can be deduced from his estimate in paragraph 26. But if his calculations are at all to be relied upon, it will appear that the benefit of irrigation may be diffused over the Doab at about $\frac{1}{5\,3\,2}$ of the cost per acre that would be consumed for a similar purpose in Italy. A general comparison only of the statement admissible

29. The regulations in force in Italy regarding the occupation of land required for the construction of canals, &c., are, *mutatis mutandis*, in accordance with Regulations regarding the occupation of land for Canals.

our practice in India. The following are extracts from a law on this subject, dated Milan, April 20, 1804;—

"Every individual is bound to cede the ground necessary for the channels, embankments, &c., of rivers, canals, and drains, and generally all works connected with waters which have for their object the public good; and fair compensation will be awarded where it is due." . . . . "Any individual wishing to procure water, whether the property of private persons or of the public, for agricultural purposes, or for turning mills, &c., may conduct it through the property of others, paying the value, and one-fourth more, of the land occupied by the water-course."

Sanitary regulations in Italy, and recommendations in India.

30. With regard to sanatory regulations in Italy, as connected with canals, it appears that "permanent irrigation" (*i. e.* rice grounds) is prohibited within five miles of towns. A prohibition of rice cultivation to the same extent, with regard to military cantonments—and more limited with regard to large native towns—was recommended by the Committee appointed to report on the effects of canal irrigation in these provinces in 1846-47.

Effect of irrigation on the health of the Italian peasantry.

31. In describing the condition of the peasantry (pp. 19-20 of the communication dated 25th May 1847), the writer states:—"Their national everyday existence would not be otherwise than prosperous, if at the end of the summer the vicinity of so much water, chiefly in the rice grounds, did not produce fevers and other diseases which shorten their average length of life."

Reference to the annexed Table.

32. Some of the principal statements in the foregoing paragraphs have been condensed in the annexed Table.

STATISTICS OF IRRIGATION IN ITALY COMPARED WITH THOSE IN THE NORTH-WEST PROVINCES OF INDIA.

CANALS.	Original Cost of Canal, in Rupees per Mile of length.	Annual Current Expenses, in Rupees per Mile of length.	Cost of Secondary Channels or Rajbuhas, in Rupees per Acre of Irrigation.	Water Rent on Irrigation, measured by Discharge, in Rupees per Annum for 1 Cubic Foot per Second.	Water Rent on measured Area of Irrigation, in Rupees per Acre.	Area of Irrigated Rice, in Acres per Cubic Foot of Water discharged per Second.	Area of Irrigation, not including Rice, in Acres per Cubic Foot of Water discharged per Second.
Italian Canals	72,580	444	156	166	8 to 15	40	62½
Western Jumna Canals	2,557	310	—	96	1 to 5	90	175
Eastern Jumna Canal .	5,648	477	2½	—	1 to 5	90	184
Ganges Canal (estimate)	11,834	473	—	—	1 to 5	—	218

The greater cost of Canal operations in Italy is probably attributable, in some measure, to the necessity for more numerous bridges; and also to that of paying a high price for land. The latter item in India, though a charge on the Land Revenue, does not appear in the cost of the Canal.

That the current expenses of Canals in Italy do not exceed those of India in the same ratio as the cost of original works, is partly owing to the double duties in the Revenue and Executive Departments, performed by the Canal Establishments in India; and probably, also, to the greater difficulties experienced on the Jumna Canals in crossing the beds of torrents under the hills.

The difference in the ratios of area irrigated to cubic measure of discharge has been accounted for in paragraphs 11 and 13.

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